

Executive summary:

The FINNOV project was a timely and relevant research project. Understanding the links between financial markets, innovation and economic growth helps us see how what initially seemed to be a financial crisis contained in the US subprime mortgage market, was transformed into a broader economic crisis that penetrated various industrial sectors and geographical regions, with devastating social consequences on a global scale.

Defining and promoting effective arrangements to supply finance and monitor and redistribute the returns to innovation was our central concern. FINNOV approached the issue from several angles. An interdisciplinary approach was followed to analyse different kinds of bank and venture funding, the operation of equity markets and innovation, the evolution of markets, and the consequences of the varied forms of finance in Europe on income distribution and employment generation. Empirical techniques include econometric studies, using time series and panel data analysis, as well as survey based case studies across different sectors and countries were used. Finally, although much of the current debate on financing of innovative companies in Europe is based on models and data derived from experience in the USA, we argue that Europe needs to develop its own approach, adapted to its own circumstances. In this report 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.

With a final conference held at the House of Commons of the UK parliament FINNOV concluded successfully its activities by presenting its findings and policy recommendations to British MPs, EU officials, the international press and other distinguished guests. Key findings suggest that instead of supporting innovation that would lead to long-term, sustainable and equitable economic growth, the financial system creates financial bubbles which then bust with devastating consequences, and it also perpetuates and intensifies inequality. Our policy messages are:

1. Redirecting the financial system in the economy
2. De-financialising the economy through re-regulation of finance
3. A more targeted approach to financial reform that takes into account the heterogeneity and differences in firms and sectors
4. Re-invigorating demand for innovation finance.
5. An 'Entrepreneurial State' role for governments.

Our innovative dissemination strategy and engagement activities, which combine traditional (academic publications, policy briefs, conference attendance etc.) with more unconventional methods (YouTube, Twitter, various media), have ensured that even prior to its completion, FINNOV started having an extremely high impact in policy circles. In the UK, for example, FINNOV has been cited by the UK Business, Innovation and Skills (BIS) Department as one of the most important EU-funded projects analysing financial-real connections and their impacts on innovation (Innovation and Research Strategy for Growth, BIS Economics Paper No.15, December 2011). FINNOV results were also featured in a wide host of international print and visual media (e.g. The Financial Times, The Independent, BBC, Bloomberg, Al Jazeera), and thus making our research known even to the broader public. Dissemination and engagement activities will continue after the end of the project to ensure long-term impact and a FINNOV legacy.

Project Context and Objectives:

A SUMMARY DESCRIPTION OF PROJECT CONTEXT AND OBJECTIVES

FINNOV (see <http://www.finnov-fp7.eu> online) was a research collaboration between seven European institutions aimed at understanding the relationship between changing financial markets, innovation dynamics, and economic performance. The project studied how these relationships influence economic growth as it is experienced by individuals, businesses and the wider economy. Our main goal with this research was to assist policy makers to better coordinate innovation policy with financial market reform policy.

The nature of the current crisis and also the means for recovery are not only financial but touch broader economic structures. Indeed, as FINNOV researchers have shown, crises like the one we are currently experiencing are a regular occurrence - at least every three decades - and are not accidental; they are rather endogenous to the market system (Perez, FINNOV DP 2.12). However, the realm of finance plays a quite important role both in the emergence of these regular crises but most importantly during the phase of exiting them and entering a period where future potential for new economic growth are deployed. In other words, in every economic crisis throughout history, a major financial collapse seems to mark the start of an era of reform which opens new possibilities for economic and social development. We live in such an era right now and the role of governments and policy makers is quite crucial in taking action and creating a more sustainable and equitable future for Europe. In doing so, new knowledge on the role of the financial system in the economy and society is absolutely crucial.

Financial innovations, indeed, have major impacts in the economy but as the recent financial crisis and current economic downturn show these are poorly understood and difficult to manage. The long-term economic performance of Europe depends not only on its ability to generate new knowledge and inventions, but crucially in translating invention into innovation and innovation into economic growth. Business experimentation is central to these processes, and fostering this ability must be a central focus of industrial policy in an enlarged European Union. It is in relation to their role in the exploration, manufacturing and commercialisation of novelty that the analysis of credit and financial markets is of the first importance.

The financial system, however, does not currently help towards this direction. More specifically, in recent years, it seems to be abandoning its role to support the financial needs of the 'real' or 'productive' economy. Indeed, with the decline of 'managerial capitalism' and the rise of 'shareholder capitalism' (Dore, 2008), the financial system has gradually become a self-reproducing institution, disjointed from the real economy and a vehicle for inequality. This phenomenon is known as 'financialization', the practices of which at the firm, sector and institutional levels create significant discontinuities at the economic system and more particularly, in the relationship between innovation - economic growth - and social development. FINNOV researchers, who are world-leading innovation experts and acknowledge the significance of innovation in society and economy, observe that due to financialization of the economy, instead of the financial system supporting innovation that leads to value creation and economic growth, we have innovation supporting the financial system, through value extraction (and in some cases value destruction).

Defining and promoting effective arrangements to supply finance and monitor and redistribute the returns to innovation was our central concern. FINNOV approached the issue of business experimentation and economic growth from several angles. These included the analysis of different models of bank and venture funding, the response of equity markets to innovation, and the effects of finance on the selection dynamics of market growth and evolution. Crucially, FINNOV also focused on the consequences of modes of financing innovation for the distribution of income and employment generation (gross and net employment dynamics - that is job creation and job destruction - across different types of firms and across different sectors).

As much of the current debate on financing of innovative companies in Europe is based on models and data derived from experience in the USA, we argue that there is now powerful evidence to suggest that the European situation is in fact different. Indeed, Europe needs to develop its own approach, adapted to its own circumstances. In this report 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 was 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). Along with differences in firm size dynamics and industry structure, therefore, we observed sectoral differences in the ways that innovation is introduced (scale-based, science-based, supplier-based). For the institutional dimension, FINNOV built on 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, 2007).

Thus the key themes explored within FINNOV were:

- Finance and the Economics of Risk and Uncertainty;
- The Interaction between Financial Institutions, Modes of Financing, and Innovation and Growth;
- Links between Economics of Innovation and Inequality.

PROJECT OBJECTIVES

Our research objectives were formulated based on the pragmatics of the current economic situation in an EU context and the associated policy challenges outlined above. Indeed, the financial crisis has dramatically changed the economic environment, perceptions of it and the priorities of policy-making. While short-term objectives are crucial to stabilise the economy in this phase of turmoil, long-term objectives are equally important for a resumption of growth and for the competitive future of firms and nations. The EU 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.

The overall purpose of FINNOV research was to contribute to the above strategy by improving economists' and policy makers' understanding of the interaction between financial markets and innovation-led growth and the effect of such growth on the social distribution of risks and rewards. Given the strong negative effect of the recent financial crisis on many European economies, a central element of the FINNOV research programme was to determine how European governments and institutions can ensure that the financial system supports investment in innovation in sustainable and equitable ways. The project did so in the context of three broad aims:

First, by linking innovation dynamics to financial dynamics, FINNOV contributed to the development of a Schumpeterian analysis of finance. This differs from those studies of finance that focus on 'efficient markets', or at the opposite extreme, on behavioural dimensions of finance. Bubbles, for example, are understood as intimately related to how expectation formation is affected during technological revolutions—very different from the 'rational' bubble view, or from that which depends on 'irrational exuberance'.

Second, pushing well beyond the original Schumpeterian framework, the project addressed the political economies of different institutional arrangements linking the mechanisms of finance allocation with real market dynamics and industry evolution.

Third, the political economy of finance allocation and corporate governance is far from being neutral in terms of income distribution, obviously between innovative vs. laggard firms but also within firms (between owners and managers and between managers and workers). Since the structure of national finance/industry arrangements affects the balance between 'creative accumulation' vs. 'creative destruction' of both knowledge and corporate competitive abilities, there are significant implications for employment creation and destruction. Thus, another objective for FINNOV was to yield novel comparative knowledge on these dynamics based on detailed longitudinal micro data.

The FINNOV project has now been successfully completed. It concluded its activities in an emphatic manner with a final conference held at the House of Commons of the British Parliament. FINNOV researchers presented findings and policy recommendations to British MPs, EU officials, the international press and other distinguished guests. Our findings suggest that there are several problems with the role that the financial system

plays in the 'real' or 'productive' economy and its relation to innovation. Indeed, FINNOV shows that the financial system does not support innovation that leads to smart, sustainable and equitable economic growth. Instead, it penalises the most innovative firms because it lacks the mechanisms and tools to target firms with the greatest potential. Additionally, financial innovation creates financial bubbles that lead to economic crises with tendencies for contagion and with devastating social consequences. Finally, through the widespread use of financialization practices, the financial system contributes to the privatization of financial profits on the one hand and to the socialization of the losses, on the other. This way, the financial system perpetuates and intensifies inequality.

To overcome these problems, FINNOV suggests that policy efforts should be aimed at:

- 1) Redirecting the financial system in the economy;
- 2) De-financialising the economy through re-regulation of finance;
- 3) A more targeted approach to financial reform that takes into account the heterogeneity and differences in firms and sectors;
- 4) Re-invigorating demand for innovation finance;
- 5) Move away from a free market-based economy and towards an 'Entrepreneurial State' role for governments.

FINNOV findings were received with an extreme interest in policy circles. This early success was mainly due to our innovative dissemination strategy and engagement activities, which combined traditional channels (academic publications, policy briefs, and conference attendance) with modern technology (YouTube, Twitter, various media). As a result, FINNOV researchers have achieved early recognition and success. In the UK, for example, FINNOV has been cited by the UK Business, Innovation and Skills (BIS) Department as one of the most important EU-funded projects analysing financial-real connections and their impacts on innovation (Innovation and Research Strategy for Growth, BIS Economics Paper No.15, December 2011). FINNOV results were also featured in most major international print and visual media (Financial Times, Independent, BBC, Bloomberg, Al Jazeera etc.), and thus making our research known even to the broader public. Dissemination and engagement activities will continue after the end of the project to ensure long-term impact and a FINNOV legacy.

FINNOV AT A GLANCE

EC Contribution: 1,493,870 EUROS
Project Start Date: 1 March 2009
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FINNOV website: <http://www.finnov-fp7.eu/>

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Project Results:

DESCRIPTION OF THE MAIN S&T RESULTS

INTRODUCTION

In the midst of a global economic crisis that continuously changes form (from banking to sovereign, and now to EuroZone crisis) and threatens global economic stability with potentially major social consequences, the FINNOV research results come in to offer insights to policy makers that will help them design ways to exit the crisis and create a sustainable and equitable model of economic growth in Europe (EC, 2010).

The nature of the current crisis and also the means for recovery are not only financial but touch broader economic structures. Indeed, as FINNOV researchers have shown, crises like the one we are currently experiencing are a regular occurrence - at least every three decades - and are not accidental; they are rather endogenous to the market system (Perez, FINNOV DP 2.12). However, the realm of finance plays a quite important role both in the emergence of these regular crises but most importantly during the phase of exiting them and entering a period where future potential for new economic growth are deployed. In other words, in every economic crisis throughout history, a major financial collapse seems to mark the start of an era of reform which opens new possibilities for economic and social development. We live in such an era right now and the role of governments and policy makers is quite crucial in taking action and creating a more sustainable and equitable future for Europe. In doing so, new knowledge on the role of the financial system in the economy and society is absolutely crucial.

But what is the role of the financial system in the current crisis? Although this is a broader economic growth crisis - rather than just financial - we observe a changing (or changed) role of the financial system within the economy. More specifically, in recent years, it seems to be abandoning its role to support the financial needs of the 'real' or 'productive' economy. Indeed, the financial system has become a self-reproducing institution and a vehicle for inequality. This phenomenon is known as 'financialization', the practices of which at the firm and market levels create significant discontinuities at the economic system and more particularly, in the relationship between innovation - economic growth - and social development. FINNOV researchers, who are world-leading innovation experts and acknowledge the significance of innovation in society and economy, observe that due to financialization of the economy, instead of the financial system supporting innovation that leads to value creation and economic growth, we have innovation supporting the financial system, through value extraction (and in some cases value destruction). This shift in the relationship between financial dynamics and industrial dynamics has been the source of a series of economic and social problems:

- 1) The financial system does not support innovation that leads to sustainable and equitable economic growth.

The long-term economic performance of Europe depends not only on its ability to generate new knowledge and inventions, but crucially on translating invention into innovation and innovation into economic growth. It is in relation to their role in the exploration, manufacturing and commercialization of novelty that the analysis of credit and financial markets is of the first importance. Defining and promoting

effective arrangements to supply finance and monitor and redistribute the returns to innovation is our central concern.

Financialization however by shifting the role of financial markets away from the real economy, has created a growing gap between the two. Questions are raised, therefore, on whether the financial system rewards or penalizes innovation. Do innovative firms receive more finance than non-innovative ones? Do they grow more? Do they get better credit ratings? How does the shareholder revolution affect R&D spending? And do some well-positioned economic actors reap significant returns even when their actions result in value destruction rather than value creation?

As we found in FINNOV, what is interesting and relevant to policy makers about this gap between financial markets and the real economy, is that it is hugely affected by the differences amongst financial agents and institutions (Demirel & Mazzucato, FINNOV DP 2.2). Indeed, market selection seems to operate on a broad mix of firm characteristics rather than on innovation per se. Currently, the financial system and EU industrial policy seem not to take into serious consideration the wide diversity in the relationship between innovation and finance across firms, sectors and countries. As a result, financial markets instead of rewarding the most innovative firms, they tend to penalise them, thus, undermining growth prospects.

FINNOV addressed this issue in its first policy brief (Do financial markets reward innovation?) and provided the following important lessons for policy-makers:

- Understanding what is the broad mix of firm characteristics based on which market selection operates, and how they differ between sectors, is crucial for innovation-led growth targets.
- Financial reform should aim to help credit markets create valuation tools which reward the most efficient firms, rather than penalize many of them. In particular, the tradition of linking the economic and financial soundness of a business activity to a single "rating" measure should be abandoned in favour of more structured assessment devices.
- The 'credit crunch' itself tends to penalize the most innovative firms. In order to make sure that post-crisis growth is achieved, financial reform should aim to help not penalize the most innovative firms during the post-crisis recovery.
- The EU must ensure that this highly financialized business model of stock buybacks cannot take root in Europe.
- In terms of the relationship between financial markets and innovation, the key lesson is that one size will not fit all the important actors in this policy space. Policy must be guided by models which adequately take heterogeneity into account, and which study the co-evolution between heterogeneity and the competitive selection mechanism.

2) Financial innovation creates financial bubbles and crises with tendencies for contagion and with devastating social consequences. A financial bubble is an event in which the processes that connect the price and fundamental value of an asset malfunction and fail to self-correct, causing price and value to diverge to the point that the pricing mechanisms undergo a catastrophic failure, causing widespread societal and economic damage.

Financial bubbles can occur when speculation drives the price of a financial index (like NASDAQ), or stocks (like dot.com firms), or commodities (like wheat) far higher than the intrinsic value of the

object in question. Most of the time the mechanisms that connect price and value are self-correcting, and when something is overpriced either new sellers are attracted into the market, or producers increase production to drive prices down. However, these mechanisms are the result of social actions, rather than fundamental laws of nature, and as such can go wrong and fail. The historical evidence clearly shows that such failures are regular, significant in their impact and increasing in severity. The recent development of the financial crisis from a liquidity crisis in banking, to a sovereign debt crisis of European nations, to a political crisis over the social distribution of risks and rewards in the EU, highlights the political and economic importance of understanding financial bubbles.

Financial innovation seems to play a pivotal role in the emergence and bursting of such bubbles. While all technologies have historically been prone to failure, financial technologies are associated with particularly extensive and socially damaging failures, often related to the creation and bursting of financial bubbles. Financial innovations played a major role in the financial crises of 1987, 1998 and most recently 2007, where some 4.6 trillion dollars had to be spent bailing out the financial system. The cost of this latest bailout is larger than the entire cost of NASA (including the moon landings), the Marshall Plan, the wars in Korea, Vietnam, Iraq, the New Deal, the 1980s Savings and Loan crisis and the Louisiana Purchase combined (Lanchester, 2010). What is puzzling about this most recent failure is that the key technology involved - mortgage backed securities - were considered a particularly safe class of assets that were well understood (having existed for some 25 years), and where expected to increase in value in the event of a crisis. Why and how did such financial innovations lead to a financial meltdown? To answer this question, FINNOV research looks into the nature of financial innovations and shows that they may contribute to the emergence of bubbles because of the dependence of their value on 'collective acceptance' (Nightingale & Spears, FINNOV DP 8.1). The more diffused traditional technologies are, the more reliable they are, while the opposite is true with financial technologies. Indeed, some financial investment strategies only generate a return for their early adopters, losing profitability as they diffuse. The assumptions underpinning risk-hedging and risk management strategies - that actors will act independently and that there will be buyers for each seller - cease to be true and the system can undergo catastrophic failure (MacKenzie, 2001).

The role of financial bubbles in innovation is addressed in our second policy brief (Dynamics of financial bubbles) where FINNOV researchers made the following suggestions that would help harness the dynamics of financial bubbles and their impact on innovation and growth:

- The costs of financial bubbles are often huge in both financial and social terms. Financial bubbles have occurred repeatedly throughout history, and there is nothing in FINNOV research to suggest they will disappear. Indeed, evidence suggests they are getting more regular and more damaging. Financial innovations designed to promote the measurement, management and efficient trading of risk did not defuse the most recent bubbles, and actually contributed to them.
- Policy makers in the EU should be suspicious of financial institutions claiming that they will move country if they are more tightly regulated. Herding behavior, whose prevalence and potentially adverse impact are confirmed by this research, undermines self-regulation and strengthens the case for external regulation of the financial sector.

- Financial crises can in some instances be predicted as bubbles show themselves at the macro level in increased activity in untraded services such as finance and construction. Rising prices for real estate and financial products may indicate a mispricing problem that may be getting out of hand.
- To mitigate the devastating effects of financialization and the possibilities for the emergence of bubbles, industrial innovation policy needs to incorporate more effectively policies on the management of financial innovation.
- The liquidity drought following market crisis and bubbles adversely affects young and potentially fast growing firms. Regulatory interventions are recommended to facilitate access to credit to high-potential innovating firms.
- In order to reduce large price fluctuations, policy makers need to mitigate the herding effect on stock markets.
- In case of synchronization and positive feedbacks, policy makers must not underestimate the impact that noise traders have on price dynamics.
- There are a number of mechanisms that can cause major failures in financial markets, through synchronization of actors' behaviour and herding.
- On the real estate markets, there should be no preferential treatment of owning vs. renting. For example, interest on mortgages should not be exempt from taxes.
- Mortgage backed securitization should be restricted. The originators (mostly banks) should keep at least 51% of the mortgage to make sure they have an incentive to check borrowers' creditworthiness thoroughly and monitor closely how the loan is performing.

3) Based on the creation and perpetuation of certain 'myths', the financial system creates dysfunctional incentives and opportunities across a range of sectors that can undermine productive investment.

This dysfunction goes beyond simple short-termism, to situations where unproductive value extraction is encouraged at the expense of value creation. Big part of the problem is that our collective understanding of financial markets remains stuck in the past, at a time when financial technologies for pricing and (re)trading assets and risk were immature, national markets were relatively unconnected, and banks and firms did not have electronic markets to assist them in the allocation of resources. Under such conditions, private and public risks and rewards were generally aligned, and conventional economic theory could reasonably assume that markets would self-correct and that market-based trading, combined with private ownership of assets, would ensure the convergence of public and private benefits. Today, however, changes in markets and financial technologies have allowed risks and rewards to be separately managed, creating the potential for strategically positioned actors to make substantial profits while transferring risks to other stakeholders - notably employees, small savers and the state (Nightingale and Spears, FINNOV DP 8.1). Haldane (2010), for example, has suggested that the social wealth transfer generated by banks in the UK being 'too big to fail' amounted to approximately 50bn GBP in 2009, on top of approximately 140bn GBP of lost GDP generated by the crisis. These changes, combined with an ideological bias against regulation, have dramatically altered 'the social distribution of risks and rewards' (Lazonick and Mazzucato, FINNOV DP 2.11; Nightingale and Poll, 2000). The idea of self-correcting markets, therefore, proves to be a myth and markets do not seem to be the most effective and socially just way to coordinate economic activity.

A focus on efficient markets has led to a neglect of the role of the government in innovation. Indeed, Governments are falsely not recognised as important actors in innovation, although Government investment often operates in technological and market landscapes that the business sector does not dare to enter (Mazzucato, FINNOV DP 2.8). A similar myth has created on the role of private vs public venture capital (VC) funds on innovation, where private VC is usually seen as a driver of innovation while public VC is not.

Finally, innovation policy and financial reform in Europe seems to have misunderstood the role of various other types of economic actors and their practices in innovation. For example, there is the impression that more SMEs are needed to drive economic growth and innovation, or that the stock market only moves funds from investors to firms, or that the creation of best practice risk management techniques will make the financial system safer, and so on. FINNOV research debunks these myths and suggests alternative views.

The dysfunctionality of the financial system and sustainable routes to financial reform were addressed in our third policy brief (Reforming a dysfunctional system). Policy recommendations, which envision a more realistic understanding of the role of the markets, of the State and of other economic actors (i.e. SMEs) and their practices (VC, stock buybacks, risk management methods etc.) included:

- Government policy-makers should reject 'the myth of the market economy' and recognize the important role played by the State in supporting and encouraging innovation.
- Current financial indicators have a bias against innovative, high potential firms. Governments may therefore wish to adopt selective policies to support firm growth.
- Governments should audit and regularly evaluate the channels that they use to support R&D, innovation and other business investment. Evaluations should be transparent and independent. They should take into account long-term and distributional effects, as well as identifiable social returns.
- Without Government support, a society will have to forego innovation. Governments have a key role in investing strategically over the long term in areas where businesses do not, or cannot, invest, such as pre-competitive stages of technology development.
- The role of VC has to be considered within the overall architecture of innovation financing, which includes complementary and alternative instruments. Among them, corporate venture capital, technology development contracts and intermediate R&D organizations can be effectively used to remedy the limitations of the pure VC model.
- Public input to hybrid VC is, in effect, a way to recapture for the taxpayer a return on state-funded early stage research that could otherwise be captured entirely by private VC funds.
- Blanket public support for 'SMEs' via subsidies and tax breaks is misguided and is often based on unrealistic expectations of their role in the economy.
- Bank lending to innovative firms of all sizes will increase only when credit scores do not penalize the higher risk associated with long-term productivity enhancing investments.
- Stock buybacks and other short-term modes of resource allocation can create perverse incentives. They were considered a manipulation of the market and banned in many European countries before the late 1990s. Such constraints should be reconsidered.

- Far from being myopic, institutional investors can influence firms to be more innovative.
- Policy makers should avoid 'in-breeding' and encourage diversity in risk management practices.
- Regulation should return to simple, enforceable rules that rule out certain forms of risk-taking or risk-transfer, and be aware of the limits of quantification of risk.

To summarise the above, the following five messages to EU policy makers were drawn from FINNOV research in relation to the role of the financial system in innovation and growth:

1. De-financializing the economy through re-regulation of finance (i.e. separate investment activity from banking activity);
2. Redirecting the financial system in the economy towards aligning its practices with real, productive economy value-creation. For example, revisit biased financial indicators, discourage short-termism, develop better tools for evaluation of financial products and so on.
3. Embracing and fostering heterogeneity and diversity;
4. Re-invigorating demand for finance;
5. Rejecting the 'myth of the market economy' and recognizing the important entrepreneurial role played by the State in supporting and encouraging innovation (i.e. Mazzucato, FINNOV DP 2.8).

Due to the complexity and the multiple dimensions of our research topic, FINNOV research was broken down into seven different but mutually complementing research areas that covered different aspects of the links between finance, innovation and growth. They covered multiple levels of analysis as well as different stages and practices of innovation finance in different sectors. More specifically, WP 2 (SELECTION) focused on the industry and firm-level of analysis and explored the co-evolution between financial dynamics and industrial dynamics in the productive economy. WP 3 (EXPERIMENTATION) focused on the early stages of firm development and growth and different ways such activities are financed. WP 4 (PERFORMANCE) assessed the extent to which the financial structure of European business firms has any impact (and if so how) on their performance and competitiveness. WP 5 (GOVERNANCE) addressed the links between corporate governance and the management of innovation. WP 6 (ASSETS) explored the housing markets in new EU countries. WP 7 (AGENTS) used Agent-Based Modelling (ABM) techniques to capture the economy and the role of the financial system in it, and finally, WP 8 (TRAJECTORIES) explored changes in technological trajectories in financial innovation and their impact on the economy and society.

Combined/integrated findings from all these areas confirmed that the role of the financial system in the economy is/has been shifting, with important consequences for innovation and for economic growth. In what follows, we present in more detail findings from our seven work packages, as well as, our policy suggestions for new ways to re-align finance with industrial innovation towards sustainable and inclusive paths for growth.

DESCRIPTION OF MAIN S&T RESULTS FROM SEVEN WORK PACKAGES

WP 2: SELECTION: Co-evolution of Industry Dynamics and Financial Dynamics
A main objective of FINNOV research was to explore the co-evolution between industry dynamics and financial dynamics. WP2 was devoted to this endeavour.

WP 2 Summary

The stock market's valuation of innovative vs. non-innovative firms affects resource allocation in the economy, and therefore represents a key transmission mechanism from finance to the real economy. WP 2 focused on this interplay between firm level innovation and financial performance.

WP 2 research extended existing work on finance and innovation by exploring which types of firm level characteristics are essential catalysts for achieving better stock-market valuation via innovation. Traditionally the literature has shown that firm level innovation (measured by firm's stocks of R&D and patents) positively affects market value. However, recent work from members of this work package, has shown that the relationship between R&D and firm growth is far from clear (Demirel and Mazzucato, FINNOV DP 2.1). Firms that invest in innovation do not always grow more than non-innovative firms. Only firms with certain types of characteristics benefit from their innovative efforts (Demirel and Mazzucato, FINNOV DP 2.2). To what degree is this also true for financial performance? That is, are the firm level characteristics needed for innovation to translate into growth the same as those needed for innovation to translate into higher market value? How does this differ between sectors and periods in the 'industry life-cycle'?

WP2 Detailed description of work and policy implications

While exploring the co-evolution between financial and industry dynamics, WP 2 made a significant contribution to our knowledge in three areas: the relationship between R&D and growth, between R&D and stock prices and finally on the role of VC in the clean-tech industry. More specifically:

1) R&D and Growth

To explore the relationship between R&D and growth, we studied firm growth dynamics in the US pharmaceutical industry between 1950 and 2003 (Mazzucato and Demirel, FINNOV DP 2.7; Mazzucato and Parris, FINNOV DP 2.4). We chose this particular industry to study the properties of firm growth because it is a particularly innovative sector which has undergone intense changes in its knowledge base over the last 50 years. We asked whether the (time series) patterns of firm growth, as well as the evolution of the firm size distribution, has changed alongside such transformations, and in particular, whether the degree to which firm growth can be described as 'random'-as opposed to more 'structured' (e.g., due to various types of increasing returns) - has changed over time. Central to this question was the different growth behaviour of (a) small and large firms and (b) firms located in different regions of the US. One of our key results, not found in the existing literature, concerned the facts that the presence of 'structure' is not a static characteristic of growth dynamics but emerges in a specific period of time (post-1980s), and that differs between geographic regions. Another key result was that regional differences only matter for the innovative firms. More particularly, we have found that the growth advantage of small pharmaceutical firms increases after the 1980s as small firms become more active in patenting and their patenting activities become

more 'persistent'. Location was found to affect growth differences only for the most innovative firms (i.e. for non-innovative firms, location does not matter). The bimodal shape of the firm size distribution was found to emerge towards the end of the 1970s precisely when a new division of labour between large and small firms set in. Implications of location dynamics for firm growth and the non-Gaussian behaviour of the size distribution were highlighted.

2) R&D and Stock-Prices

Focusing on the pharmaceutical industry, A sector with one of the highest sectoral R&D intensities and patenting rates, we explored at the evolution of the relationship between stock returns and innovation over time (between 1974 and 1999), both over the industry's life-cycle and over the course of time as the intensity of innovation investments change (Mazzucato and Tancioni, FINNOV DP 2.3). In recent finance literature the role of technological change is highlighted in increasing firm specific (idiosyncratic) and aggregate stock return volatility, yet innovation data is not used in these analyses, leaving the direct relationship between innovation and stock return volatility untested. We used firm-level patent data to investigate the relationship between volatility and innovation and we asked whether firms which invest more in innovation (more R&D and more patents) and/or which have more important innovations (patents with more citations) experience more volatility in their returns. Given that returns should in theory be higher, on average, for higher risk stocks, we also looked at the effect of innovation on the level of returns. To take into account the competition between firms within industries, firm returns and volatility were measured relative to the industry average. Results suggested that there is a positive and significant relationship between volatility, R&D intensity and the various patent related measures—especially when the innovation measures are filtered to distinguish the very innovative firms from the less innovate ones. Indeed, we found that volatility is higher in the case of small firms (proxied by market share) and in the post 1985 period which is characterized by a more guided search regime. The higher volatility in the latter period was most likely related to the fact that this period was characterized by an 'inflation' of patents, which reduced their reliability as a 'signal' of real innovation (hence more mistakes made by investors). More broadly, our results confirmed that innovation variables are important in capturing the levels of 'risk' embodied in firm performance and as such have an impact on both returns (risk-return) and volatility (risk-volatility).

3) VC and Clean-Tech

Driven by political pressures to cut down CO2 emissions and to find cheaper and renewable alternatives to fossil fuel based technologies, the clean technology sector (cleantech) has risen as an important target for VC investments in recent years. While the economic recession has led to a significant decrease in VC funding across sectors in 2009, cleantech was least affected by the adverse economic conditions, accounting for roughly 25% of all VC investments worldwide and 20% of VC investment in the US (Baker 2010; Thomson 2010). Using a broad definition of cleantech aimed at alternative energy production and/or providing solutions to environmental problems we studied the relationship between innovation and venture capital (VC) funding for 239 UK firms (Parris and Demirel, FINNOV DP 2.6). Our analysis was based on a unique combination of three datasets; (1) FAME, (2) UK Intellectual Property Office patent data and (3) Cleantech Network's Venture Investments data. We found that the majority of VC backed UK cleantech firms do not patent or patent very

little. This initial research suggested the venture capital sector may not be supportive of radical new cleantech innovation; a potential concern for the UK's vision of achieving a low carbon economy. Indeed, our results suggested investors appear to be experimenting with their investment models and avoid taking big risks associated with funding the most radical and risky cleantech innovations.

Besides these three areas, WP2 made a significant contribution to several relevant debates. We have examined, for example, what we call the 'risk-reward nexus' in the innovation-inequality relationship and we found that when collective contributions are matched by collective reward system, innovation tends to reduce inequality (Lazonick and Mazzucato, FINNOV DP 2.11). When instead the collective contributions map into a narrow, and not collective, distribution of rewards, then innovation increases inequality. FINNOV also found that the indicators that governments, financial regulators and industry analysts are using are misleading and are leading to distortions in public and corporate policy (Mazzucato and Shipman, FINNOV DP 2.10). Finally, we have explored in great depth the nature of the current crisis and we provided evidence that despite popular belief, it is the State that can play a significant entrepreneurial role towards exiting the crisis and entering a sustainable and equitable future (Perez, FINNOV DP 2.12; Mazzucato, FINNOV DP 2.8). More details on these ideas are outlined in the introduction of this report.

WP2 POLICY IMPLICATIONS

- Market selection operates on a broad mix of firm characteristics rather than on innovation per se. Understanding what these characteristics are and how they differ between sectors, is crucial for the EU's goal of increasing investment in innovation. Otherwise, public spending on innovation support will be inefficient and fail to target the firms with the greatest potential. In particular, the ''Lisbon Agenda's'' goal of increasing R&D intensity across EC countries will be informed by greater understanding of which firm specific characteristics must be in place for R&D investment to affect growth.
- The finding that it is the most innovative firms that cause growth distributions to be 'fat tailed' implies that innovation policy must be very careful not to be derived from studies that assume representative agents and normal distributions.
- In agreement with WP3, WP2 findings indicate that policies must help to develop models for financing innovative firms that include alternatives to the widely adopted venture capital model, especially in order to support the development of radical new environmental technology.
- There needs to be a greater understanding of the appropriate measures for monitoring the innovative performance of small and medium sized companies in the cleantech and nvironmental sector. Approximating the innovative activity in a sector according to signals of investment activity from sources such as venture capital, may overestimate the actual amount of innovative activity occurring.
- Location is found to affect growth differences only for the most innovative firms (i.e. for non innovative firms, location does not matter).
- Innovation variables are important in capturing the levels of 'risk' embodied in firm performance and as such have an impact on both returns (risk-return) and volatility (risk-volatility).
- Public funding could be especially important to support emerging innovation in the cleantech sector

WP 3: EXPERIMENTATION: Capital Markets and Innovation: Financing Business Experimentation in Europe

The work in this package explored ways in which early development and subsequent growth of firms is financed and what are the consequences for innovation. We explored the nature of different innovation financing models and investigated the link between business financing and the characteristics of innovative firms. Our theoretical contribution is the development of a Schumpeterian perspective on the financing of business experimentation. Our empirical contribution consists of a set of novel analyses of the financial foundations of entrepreneurship and the process of creative destruction.

WP 3 Summary

Finance is recognised as a major innovation constraint that closely interacts with the strong uncertainties associated with new products, new services and new business models. A variety of responses and associated financing instruments have been developed in different countries and sectors. Until recently, a large proportion of studies on innovation finance has been focused on the US. While many lessons have been drawn from it that might foster, for example, more effective deployment of VC policies in the European context, much still needs to be learnt in order to: 1) understand the firm- and system- level effects of different modes of innovation finance 2) identify their complementarities (static and dynamic) and limitations and 3) appropriately match policy instruments to the needs of heterogeneous economic contexts.

Bearing in mind the general macro-economic background (the financial crisis) and recent shifts in the framing of innovation policy (incl. mounting pressures on higher education institutions to generate wealth directly through the commercialisation of new knowledge), the Experimentation work package addressed the state of the art of the innovation finance literature; the sources of financing for early technology development; the co-determinants of financial backing of new firms and innovation; the characteristics of the venturing process; the dynamics of knowledge generation and commercialisation at the public-private interface; emergent trends in innovation investments, business experimentation and related policy needs.

WP 3 Detailed description of work and policy implications

In analysing the financial foundation of innovation it is important to remember the fact that the vast majority of innovation-related expenditures are financed by firms' internal resources and that firm will typically seek external finance when internal capital is not sufficient or not available. The outcome of financing behaviours is - as a whole - significantly influenced by the borrower's profile as innovators and the lender's ability to evaluate uncertain latent market opportunities against the quality of potential investments (Mina, Lahr and Hughes, FINNOV DP 3.5).

Our comparative analyses of the demand and supply of external capital in the UK and US before the crisis revealed somewhat limited evidence of financing constraints in SMEs. At a time of normal operations of markets the demand for external capital of R&D-intensive firms did not appear to be higher than less R&D intensive firms. There are indications that uncertain innovation activities of the potential borrower negatively affect the supply of finance, in line with the expectation that businesses undertaking risky projects will incur higher costs of capital and will have access to suboptimal levels of financial resources.

However, while indicators of innovation output (as opposed to input, such as R&D) did not make any difference on the demand for capital, they did exert strong and significant effects on the probability that lenders will provide finance. This finding confirmed that the supply of finance would respond in different ways to projects with different risk profiles and growth opportunities. However, with the exception of VC and angel finance will tend to reward realised innovation (product and process) over R&D investments. Importantly, US investors seem to be more reactive to innovation signals than their UK peers. We also found that the likelihood of obtaining finance is positively affected by firm size and the acquisition of technology inputs through the market, both reflections of higher informational transparency. On the contrary, long pay-off periods and intangible capital exert a negative effect on the likelihood of obtaining external finance because they signal greater business risk and are sources of significant information asymmetries firms and potential investors.

Overall, we found evidence in support of the life cycle theory of SME finance which suggested that firms favour equity and internal sources of capital in their early years of operations, whereas access to debt and public equity markets becomes easier as firms grow older and larger. Venture capital shows a strong tendency of being obtained mainly by young firms, as we would expect, but not necessarily the smallest firms. Results for the type of finance obtained by firms further emphasize the importance of risk and informational transparency. Young firms and firms with low profits, long pay-off periods and knowledge-intensive businesses tend to favour equity over debt, which again supports pecking order theory. Firms with intangible assets such as patents seek equity more often. We found the same effect of patents on the likelihood of obtaining specific kinds of capital in our results for venture capital finance. This especially strong result confirmed very recent findings on the powerful signaling role of patents in the venture capital investment process.

The lion's share of studies on the supply of finance for innovation has focused precisely on this form of external finance, broadly been portrayed as an essential ingredient for the creation and growth of new high-tech firms (Sharpe, FINNOV DP 3.1a). We have therefore investigated the extent and effectiveness of this model of innovation investment through in-depth longitudinal analyses of European private equity markets. The profitability of the venture capital model and its long-term sustainability has recently been called into question and seriously tested by the current financial crisis. During the crisis years 2008 and 2009, several authors drew a gloomy picture for the future of the venture capital industry not only because of the dramatic changes in the macroeconomic framework and recent tightening of exit channels, but also because of the weak returns recorded over the whole 2000-2010 period. Our analyses of European markets revealed great unevenness in the geographical, sectoral and stage distributions of investments (Mina and Lahr, FINNOV WP 3.2).

Driven by growth in large buyouts, PE market have recovered well after 2009, but seed and early stage investments are at low levels, with the smallest proportion of seed/early VC deals by volume recorded in 2010. This is the lowest value in 20 years. Testing for time effects on likelihood of investment stage showed that the decline of early stage financing is not a consequence of the financial crisis but instead the result of a long-term structural problem. In terms of exits, overall

after a substantial drop in 2009 venture capital exit volume declined further in 2010. Evidence from our multivariate analyses showed that it has become highly unlikely for a VC firm to develop a company from start-up to a size that makes it possible to float the company within the usual ten-year fund life time. Venture capital investments are increasingly sold through secondary transactions first, before being taken public much later in the company's life-cycle. Sales to industrial buyers remain the most important exit channel by far but recovered only slightly after the crisis to below-2008 levels. In contrast to late stage private equity exits, venture capital exit volume and deal number are decreasing. The jury is out on the crucial performance of VC investments made over the period 2002-2004 which have to be realised over the next few years. The positive first-year average IRRs for funds raised in 2008 and 2009 are an encouraging sign, but overall the evidence points to a VC landscape with smaller, if more stable, funds.

The VC investment model has had a mixed record of success. This can be a consequence of the uneven cross-sectoral distribution of technological opportunities, which generate different risk-rewards landscapes. Or it can be the path-dependent outcome of a set of early successful events that have given momentum to some areas and not others. The evidence remains that venture capital cannot be the solution to growth in all high-tech sectors, at least not on its own. Crucially, the successes that the VC model has had point to the fact that the contribution of VC cannot be assessed in isolation from the overall innovation-finance architecture in which it operates. This includes: long term public sector investments (especially in the case of general purpose technologies) in the research base and also demand/client-driven technology development mechanisms, which might take the form of grants or contracts.

In the UK there are especially interesting examples of contract-based model of technology development: the Cambridge technology development consultancies (Probert, Connell and Mina, FINNOV DP 3.7). These have been key to the emergence and growth of one of the most successful technology clusters in Europe in the Cambridge area. This subsector for the service economy has been very effective at developing technologies which usually require long lead development times. This is interesting because, as we have said, the financing of early stage technology development is recognized as a difficult problem to overcome in many countries, including the US, where in fact the contribution of venture capital to this investment phase has been in decline. Secondly, while the presence of the University of Cambridge is clearly acknowledged as a fundamental component of the Cambridge innovation cluster, most notably because of its capacity to attract and nurture highly skilled human capital, the process through which several of the cluster's most successful high-tech product businesses have emerged was quite independent of the University and its - however good - technology transfer office. This is a point worth stressing because of the rising expectations placed upon higher-education institutions to extract value from their research activities through direct commercialisation of its science and technology. Cambridge is often cited as an exemplar case of entrepreneurial university, but the Cambridge Phenomenon is not all about the University and a broader view of the ecology of the Cambridge cluster is necessary to understand how and why it works.

An alternative model of technology de-risking which can be used for exploratory (strategic) and exploitative (financial) is also a variant of the venture capital model where large corporates nurture the development

of new technologies indirectly via their financial and strategic support to new firms: the corporate venturing model (Mina, FINNOV DP 3.1b). Our analysis of the CVC model revealed that corporates use CVC to create a window on new technologies, to enrich their understanding of new market opportunities and to exploit untapped or underutilised resources (Mina, Probert and Metcalfe, FINNOV DP 3.4). The objectives of CVC vary significantly both across firms and over time, an aspect significantly underestimated in prior studies. Overall, while returns on investments are seen, rather predictably, to drive the survival and development of CVC units with a primary financial goal, leadership changes tend to act as selection mechanisms for units with predominantly strategic objectives. These changes reflect broader shifts in the objectives of the corporate - not simply its venturing unit - and changes in organisational design related to contingent macroeconomic frameworks and market outlooks. We also found that learning through CVC does not only involve technologies. It involves market demand and it involves the innovation investment process itself. Business interactions through CVC seem to be especially effective when the corporate acts as a customer of - or lead user for - the investee. Finally, beyond its use purely as a means to an end, interaction with the unit is identified as a way to foster the broader set of dynamic capabilities of the firm.

Also in this case we found that key to successful innovation is an intermediation function where complementary assets are brought together and incentives aligned across organizational boundaries. A similar function, and one that also combines the element of contract R&D, can be performed across the public-private divide. As we have suggested a number of strategic responses can be developed to exploit the challenge of technology development at a stage where venture capital does not typically invest and banks would not be willing to sponsor uncertain R&D projects. One instrument is the support by government of some form of intermediate research organisation, with a much more commercial, mission driven modus operandi than universities, backed with a mix of public and private funding (Mina, Connell, Hughes, FINNOV DP 3.3).

In our comparative study of intermediate research organisations, we found that the common themes underlying successful technology developments in intermediate research institutions include

- 1) Long-term co-funding by the public sector linked to periodic evaluation;
- 2) Commitment and size of investments required to make a difference, especially at the outset of technological trajectories
- 3) strong relationships with industrial partners, keeping the organisation's activities close to demand and to customers' input into the innovation process, as a complement to the research remit of higher education institutions.

The broad message we gain from our analyses of different innovation finance mechanisms was that none of them work effectively in isolation from one another, that there is an important role to be played by government in particular at the pre-competitive and early stage of technology life-cycles and that the policy approach that is most likely to deliver positive results towards innovation-led growth is a systemic, granular and adaptive approach which does not simply focus on the supply of finance but also actively looks at the development of demand for innovation.

WP 3 POLICY IMPLICATIONS

- PE markets are not at all dead
- The distribution of VC investments and their performance is very uneven across sectors.
- If VC is the engine of the high-tech economy it should support a higher share of early stage investments. On its own, the VC model is not delivering.
- The contribution of VC cannot be assessed in isolation from the overall innovation-finance architecture in which it operates.
- This includes: long term public sector investments (especially in the case of general purpose technologies) in the research base; demand/client-driven technology development mechanisms (grants and contracts).
- Internal finance is clearly the most important source of finance for R&D.
- Our comparative study of the UK and US markets for external finance shows that US investors are more selective (but operative on a larger scale) and more reactive to innovation signals.
- Very difficult to find strong evidence of finance gaps at least at times of normal operation of markets. Note as well that at the inception of the current crisis UK firms expressed more concerns about D than access to finance.
- Leadership changes at corporate level impact CVCs with strategic objectives
- Crucial knowledge-broking function of CVC unit with strategic objectives - most effective where corporate is customer/lead user
- CVC unit plays role in fostering corporate long term dynamic capabilities
- Systematic neglect in literature of the evolution over time of a CVC unit focus - recognising variations over time is crucial to reliable assessment of CVC role and performance - explains inconsistency of results of prior CVC research - business model applicability may vary (different sectors/same period; same sector/different periods)

WP 4: PERFORMANCE: Finance, Constraints to Growth, Bankruptcy, and Employment Dynamics

WP 4 studied the transmission mechanisms from credit markets to the real economy. The research contributed to this broad question by looking, from different angles, at the relationship between financial institutions and business firms, and the effects produced by such interactions on a range of key dimensions of firm performance.

WP 4 Summary

A first objective concerned an assessment of the empirical evidence on how differential financial structure and differential sources of financing affect innovative activities of firms, from a comparative perspective across Europe. What are the sources of finance used by European firms, and by small innovative firms in particular? What types of financing have shown more effective for innovation? What is the relative merit of private vs. public funding? An important part of the efforts within this objective are devoted to also understand the role of differential financial markets' institutional set-up in facilitating or hampering innovation.

A second objective questioned the actual 'efficiency' of credit allocation by financial institutions, which is crucial in fostering reallocation of investment and growth opportunities and market shares across heterogeneous firms. What is the evidence on the phenomena of misdirected credit provision? Are financial or liquidity constraints

binding? To what extent differential financial structures correlate with actual growth patterns of the firms? To what extent can one observe that financing costs and conditions imposed by financial institutions to financed firms correspond to a 'sound' screening of industrial firms, thereby contributing to an aggregate process of selection of the best performers?

Finally, WP 4 explored the interplay of financial and real side of firms' activity in determining the most extreme case of financial distress leading to firm default. More particularly, we asked whether solid predictions about the probability of default events can be safely assessed, by investors or institutional actors, without considering the real side of firms' industrial characteristics and performance. Thanks to collaboration with people from CERGE - Economics Institute mainly working in WP6, we also explored default dynamics of firms in transition economies of Eastern Europe.

WP 4 Detailed description of work and policy implications

The WP began with a review of some key characteristics of the empirical relationship between finance and innovation in Europe (FINNOV DP 4.1). European innovative firms, and small innovative firms in particular, primarily rely on internal funds to finance investment, due to massive capital market failures. Alternative sources of finance appear to be either ineffective or at least much less important. First, although European venture capital has caught up with US venture capital (mainly due to the growth in UK venture investments) European venture capital appears to have failed to certify the quality and enhance the growth of funded companies. Second, compared with the NASDAQ, there has been little development of trading in high-technology stocks in Europe: the so-called 'New Markets' established in the 1990s have collapsed in the wake of the Internet bubble crash. Conversely, public venture capital as well as R&D tax incentives seems to have positively affected the performance of high-tech firms.

Related to this, a further research paper provided a study of the historical evolution, the organizational forms, and the performances of the stock exchanges and market segments catering to technology-based small firms (TBSFs) in Europe (FINNOV DP 4.4). The study questioned the role of public and private interests in market emergence and in shaping market architectures, the costs and benefits of light stock market regulation, and the use of stock markets to support technology-based small firms. Drawing from detailed analysis of the experience with the Alternative Investment Market (AIM) set up by the London Stock Exchange, which is relevant because of its long-lasting dimensional growth that led it to be recognized as a possible organizational model of a financial market, the study provided several useful insights. First, there is no unique model for the stock market for growing companies, and each organizational architecture displays both advantages and drawbacks for TBSFs. Second, the different forms of market organization result from adaptive responses of public and private actors to the threats and opportunities posed by the changing macroeconomic and technological environments. The variety of the actors involved may induce conflicting views and the market design may result from severe negotiations, or appear as a compromise. Thirdly, the emergence and development of financial markets dedicated to TBSFs is crucially shaped by regulatory changes, which can also produce unintended consequences. Fourthly, the history of financial markets dedicated to TBSFs sheds light on the issue of replicating a market. In the case of the 'New markets' created during

the 1990s in continental Europe, 'copying' Nasdaq turned out to be a failing strategy, as the complexity of market architectures, compounding many highly interdependent elements, combined together through the heavy use of tacit knowledge, makes the replication of a market a very difficult task.

Concerning the role of financial constraints to the growth dynamics of firms, a general weakness of the incumbent literature concerns the little attention devoted so far to heterogeneity in firms' behavior. The bulk of the literature has indeed adopted statistical methods that can only identify the effect of financing constraints on the average performance within economies or industries. The conclusion is usually that financial and credit constraints negatively affect firms' dynamics, and that this effect is stronger for younger and smaller firms (see Angelini and Generale, 2008). The analysis by Giulio Bottazzi, Angelo Secchi and Federico Tamagni showed that effects of credit shortages are more complex and asymmetrically impact on fast growing and shrinking firms (FINNOV DP 4.2). On one hand, limited or no access to external credit increases the probability of observing large negative growth rates, inducing a further deterioration in growth performance of already slow growing or shrinking firms. On the other hand, financial constraints decrease the probability of observing large positive growths, preventing fast growing firms from fully seizing their growth opportunities. While the first effect can be seen as an efficiency enhancing effect, akin to the Schumpeterian destruction, as market shares get re-allocated away from already troubled firms, the second effect signals the presence of relevant inefficiencies in the market for credit. The evidence suggested that especially young and potentially more dynamic firms are more affected by this second distorting effect, supporting the need of a stricter monitoring of, if not a direct regulatory intervention into, the lending activity of banks.

The results of the research on default dynamics pointed in the same direction. We have shown that industrial characteristics and performance of firms (productivity, operating margins, size, growth) do play a relevant role in predicting default, even in the short run, when financial variables are commonly conceived to be strong predictors of default (Bottazzi, Grazi, Secchi and Tamagni, FINNOV DP 4.3). Moreover, their predictive power is still high when we add among the regressors two indicators of default probability widely used among investors and practitioners, such as a Distance to Default index and an official credit rating index. The results, beyond suggesting severe capital markets imperfections and contrasting with standard assumptions of complete and fully informed capital markets, support the view that the accuracy of standard risk assessment devices, such as official credit ratings or internal risk management practices maintained by financial institutions, might be biased, devoting too little attention to important industrial/economic factors. Such a tendency can be seen as one of the reasons behind the financialization and short-termism which can be, and has been, invoked among the features of contemporary capitalism which concurred to ignite the current crisis.

A preliminary assessment of firm default dynamics in Eastern European countries was performed in the study on Czech Republic firms (Lizal and Schwarz, FINNOV DP 4.5). There we showed that the main bankruptcy determinants indeed change between period of economic growth and distress. We also showed that the large and small firms have a different set of determinants of distress. Finally we assess effects of various

corporate governance indicators of the enterprises on predicted possibility of default.

The above results also related to previous research on firm demography, highlighting the different dynamics behind different form of distress, from default, to restructuring, to the various modes of exit typically captured in standard business register data. While previous evidence revealed that firm size is inversely related with exit probability, we found that default rates increase with size. Corroborated by deeper investigations, our findings, altogether, demanded much finer analyses on the relationship between the bankruptcy events and the subsequent dynamics of restructuring vs. sheer liquidation (Bottazzi and Tamagni, FINNOV DP 4.7). The two processes are not equivalent. The higher incidence of bankruptcy without exit among bigger firms might either suggest greater efforts to preserve specific assets and capabilities or, conversely, a greater ability to "cushion" crashes.

WP4 POLICY IMPLICATIONS

- Public venture capital and R&D tax incentives provide an effective policy to sustain innovation and growth of European firms suffering from shortage of financial resources.
- Challenges in designing such policies are, first, an effort to harmonize public programs across regions and countries, since heterogeneity in programs is very likely to produce coordination and communication failures between the many actors involved. Second, and relatedly, efforts should be put in place towards a more effective integration between national and regional programs.
- Capital markets imperfections create a wedge between financial and industrial performance of firms and, thus, financial indicators alone do not represent a good predictor of firms' default. From the point of view of the strategies of financial institutions, results entail a general advocacy for "financial patience": short-termism is not a good guide for the exploitation of the growth and innovation potential of firms, and even less so the exclusive reliance in financial indicators for the assessment of corporate potential performance.
- Asymmetric effect of credit shortages on firm growth suggest a positive role for selective policy to sustain growth and innovation, as well as support for regulation and policies that enhance effectiveness of capital allocation.
- While previous studies found probability of exit is smaller for larger firms, we show here that the probability of default increases with size.

WP 5: GOVERNANCE: Corporate Governance and Innovation: Implications for Stable and Equitable Economic Growth

A critical aspect of the current financial crisis is the relationship between corporate governance and innovation. In this context, the analysis of the role of stock markets in the innovation process becomes all the more relevant and urgent.

WP 5 Summary

WP5 is focused on the relationship between innovation and corporate governance practices of European firms. The crisis calls into question the liquidity of stock markets, the investment behaviour of institutional investors and distribution of shareholder value within the context of the role of finance in the processes of resource allocation and value creation. In this context, the GREThA-led team mainly carried out industry studies with different levels to examine the impact of financial schemes on corporate practices related to innovation and stable and

equitable economic growth. Various levels of analysis aimed at revealing the varied role of financial mechanisms in investment and growth strategies of firms of different sizes. The research team approached the issue both from the industry side and finance/investors side. Pharmaceutical and biopharmaceutical industries constituted the major context of the industry-level analysis of WP5 with respect to the competences of the research team.

WP 5 Detailed description of work and policy implications

The main results from WP 5 emerged from the following three studies:

1. The influence of institutional investors on R&D spending in Europe
A group of WP5 researchers implemented an empirical study designed to examine the relationship between ownership structures of large European companies and their innovative efforts in terms of R&D spending (Brossard, Lavigne, Dupuy and Sakinc, FINNOV DP 5.3a). The analysis was performed on a sample of 325 highly innovative companies belonging to manufacturing and other industries, over a 8-year period (2002-2009). Contrary to the view that institutional investors have a negative influence on R&D spending, the researchers found a positive impact of these investors on R&D expenditures. This result is particularly robust when firms' ownership structure is not over-concentrated. They also examined the effects of investors' short-termism on R&D. The results provided evidence that the entry of short-term investors in the ownership structure has a negative impact on companies' R&D spending. This is consistent with the view that independent long-run investors would motivate and reward managers so that they allocate adequate corporate resources adequate long-term investments such as R&D. The research team caution that these results only hold for the sample that is selected, which is not a representative sample of all European firms. In the research, the team only studied the most highly innovative European firms ranked in the annual EU Industrial R&D Investment Scoreboards prepared jointly by the Joint Research Centre and Research Directorates-General of the European Commission. Nevertheless, the results provide support for fiscal policies that would encourage long term institutional investors to take an equity stake in innovative corporations and that would discourage the activities of investors only seeking short-term gains.

2. Pharmaceuticals and dynamics of corporate strategies

The pharmaceutical and biopharmaceutical industries were the major focus of WP5 in terms of sectoral analysis. Along the course of global corporate restructuring in conjunction with the rising role of financial markets, pharma-related industries became major fields of academic research to observe the impact of new institutional and organizational settings over industry performance, however the changing role of finance over such settings has remained an under-researched field. Focused on specific topics directly linked to the main research proposal, WP5 researchers have first analyzed the financialization of large pharmaceutical firms and the transformation of their business model (Montalban, and Sakinç, FINNOV DP 5.2b). Along with their corporate restructuring through mergers and acquisitions, internalization of new technologies and R&D reorganization, large US, European and Japanese companies have increased significantly their distribution of dividends and their share repurchases as a part of corporate financial strategy, and have focused on producing blockbuster drugs to generate more revenue out of existing productive activities. The study aimed to show the interlink between productive reorganization and financial motives based on a shareholder perspective. Paradoxically, however, the pharmaceutical

industry has had increasing difficulty to develop new innovative drugs. Therefore, large pharmaceutical companies are now trying to change their business models by investing more in orphan drugs, personalised medicine, vaccines and generic drugs.

In another study, WP5 researchers tried to explain the institutionalization of the orphan drug market (Gorry and Montalban, 2009). This market is largely the outcome of political support of governments in the US through Orphan Drug Act or in Europe through orphan drugs regulation, combined with the political work of patient associations. The development of this market has largely been a success story. The research showed that very different business models are competing in this market. However, interestingly, large pharmaceutical companies are becoming the leaders of the market to develop new 'nichebusters' (blockbusters for subgroups of patients) or to recycle old blockbuster drugs. Large pharmaceutical companies are exploiting orphan drug regulation and market exclusivity to increase their protection on drugs and are engaged in 'salami slicing', i.e., the creation of multiple orphan designations for the same drugs. The 'economies of scope' achieved through salami slicing are not being passed on to the consumers, but rather are a source of excessive profits for the drug companies. Given the high prices of, and the strong indirect government support for, orphan drugs, plus the fact that some of these drugs are based on 'old' molecules (discovered in the 1970s or 1980s), the research raise the possibility that the development of some of those products by state-owned firms would be less costly. Thus a recommendation of the creation of state-controlled companies focused on the development of orphan drugs is valid.

Another focus of WP5 was on the roots of major dynamics prevalent throughout the global pharmaceutical industry today. Again WP5 researchers have shown that, at least until the financial crisis of 2008-2009, the US biopharmaceutical industry attracted large amounts of private equity despite the industry's general lack of profitability because of a combination of a) government funding of the knowledge base through the National Institutes of Health, b) government subsidies to drug development such as those available under the Orphan Drug Act, c) R&D contracts from big pharma, which typically include equity stakes, and d) the possibility of doing productless IPOs on NASDAQ in periods of heightened stock-market speculation (Lazonick, and Tulum, FINNOV DP 5.5). Detailed case studies of the financial evolution of biotech companies have shown how, through this financing model, financial interests, including biopharma executives with stock-based pay, often extract large incomes from biopharma companies even when the companies remain unprofitable. In the United States, there is a need to regulate this 'impatient capital', while in Europe there is a need to eschew the US business model for the sake of one that rewards financial interests only if and when real returns on productive investments are forthcoming (Lazonick, W. and Sakinc, FINNOV DP 5.2a).

One final research attached to the industry-level analysis of our work package have compared the industrial policies of France and Germany to sustain their biopharmaceutical industries. Researchers show that the results of those policies have been quite successful, but governments need to insure the consolidation (through integration) of domestic biotech firms to avoid acquisition by foreign competitors, and to ensure better funding for the development. More generally, there is a need for Europe to increase public investment in biotech through, for example

sovereign funds such as France's Fonds Stratégique d'Investissement. In addition, business enterprises should be given tax incentives to increase R&D expenditures (Cárdenas, Sakinç and Montalban, 2011).

3. Stock buybacks, executive pay, and investment in innovation

In a number of papers, Lazonick has shown how stock buybacks have become a prime mode of corporate resource allocation in the US economy (Lazonick, FINNOV DP 5.6 and Lazonick, DP5.7). The only purpose of stock buybacks is to boost a company's stock price. Especially given the scale and systematic way that buybacks are done in the United States, this practice should be viewed as stock-market manipulation. Since 1982, however, the US Securities and Exchange Commission has given corporations a 'safe harbor' to do large-scale repurchases with fear of manipulation charges being lodged against them. With superior corporate performance defined as meeting Wall Street's expectations of steadily rising targets of quarterly earnings per share, companies turned to massive stock repurchases. Trillions of dollars that could have been spent on innovation and job creation in the US economy over the past three decades have instead been used to buy back stock, the sole purpose of which is to manipulate a company's stock price.

Legitimizing this 'financialized' mode of corporate resource allocation has been the ideology, itself a product of the 1980s and 1990s, that a business corporation should be run to 'maximize shareholder value'. Through their stock-based compensation, prime beneficiaries of this focus on rising stock prices as the measure of corporate performance have been the very same corporate executives who make these financialized resource allocation decisions. In the process, the research argues, the financialized US corporation is ignoring investments in innovation. Lazonick and Sakinç have developed a database of 350 large European corporations for purposes of a comparative study with the US experience.

WP5 POLICY IMPLICATIONS

- Ban stock repurchases by established business corporations so corporate financial resources that could be allocated to innovation and job creation are not wasted for the purpose of manipulating a company's stock price.
- Index employee stock options to an indicator of innovative performance so that executives cannot gain from speculation in and manipulation of their companies' stock prices.
- Regulate the employment contract to ensure that people who contribute to the innovation process share in the gains to innovation.
- Creation of work programs that make productive use of and enhance the productive capabilities of educated and experienced workers whose human capital would otherwise deteriorate through lack of other relevant employment. Companies should consider allocating accumulated capital and experienced labor to spinoff enterprises rather than throw the capital on the stock market through buybacks and the workers on the labor markets through layoffs.
- Implementation of taxes on the gains from innovation to fund those government agencies that need to invest in the public knowledge base required for the next round of innovation.

WP 6: ASSETS: Asset Prices, Consumption, and Income Distribution

The current financial crisis was initiated by speculation around subprime mortgage loans in the US housing market. WP 6 conducted an analysis of asset prices, consumption and income distribution in the context of

housing markets in newly admitted members of the European Union, starting with the Czech Republic where Micro Census data was readily available.

WP 6 Summary

Prior to a recent decline, property prices had risen dramatically in many European countries. This phenomenon may have been demand driven due to lower mortgage rates and desire of foreigners to own property in new member countries of the European Union. Alternatively, it may well be that lowering barriers to cross-border lending, arising from the liberalising services directive of the EU, or that particular wealth effects arising from housing bubbles in one country (e.g. the UK) are transferred to other countries with the subsequent ramp-up of localised house prices. In other words, we looked for causes of the burst real estate bubble. A (potentially rational) bubble on the housing market can be identified by analyzing a discrepancy between market prices and corresponding fundamentals, e.g. rents. WP 6 analyzed this phenomenon using regional panel data within individual countries.

Finally, the research studied the mechanism via which property prices affect consumption and consequently welfare. A calibrated finite life-cycle model was used for such purpose. An important part of the calibration exercise was the life-cycle distribution of income. Our work package also investigated a reverse causality and quantify the effect of changing house prices on the income distribution, taking into account the differential impact these changes have across cohorts.

WP 6 Detailed description of work and policy implications

WP 6 focused on the impact of various innovations on asset markets and on households. Since a large portion of the household wealth is tied to real estate, we initially concentrated on property prices. Our first step was to determine whether the real estate prices are too far from values implied by fundamental factors (Zemcik, FINNOV DP 6.1, also published in Czech Journal of Economics and Finance). We used the Czech Republic as a methodological blueprint. From the theoretical perspective, there are two widely used models. In a present value model, a real estate price is calculated as the discounted stream of future cash flows, i.e. rents. A structural model is typically based on a standard demand-supply analysis and included factors affecting both sides of the market. Given that we had access to regional rents in the Czech Republic, the present value was the natural choice in our study. As compared with the behavior of rents, apartment prices exhibit bubble-like behavior in 77% of considered Czech regions and in 52% of the Prague's districts. Testing for bubbles is relevant even after a decline of the housing prices in many countries, including Spain, UK, and Netherlands. When rents and income are compared to the real estate prices in these and other countries, the housing prices still appear overvalued in these and other European countries.

In the next step, we focussed on the rent deregulation process started in the Czech Republic in 2006 mainly due to a pressure from European courts (Tsharkyan and Zemcik, FINNOV DP 6.2). The process was gradual and it was completed in 2010. We studied this natural experiment and used the fact the maximum regulated rent appreciation had depended explicitly on real estate prices since 2006. We tracked the tenure choice of households from consumption surveys for subsequent years. Rent deregulation makes households in regulated apartments more likely to purchase property while the opposite is true for owners and other renters. In addition, the net present value of buying property vs. renting is an increasing function of the real estate price appreciation for renters in regulated apartments.

We used their tenure choices to generate the distribution of property price expectations. Resulting expectations were fairly conservative overall though recent home buyers are more optimistic than continuing renters. The income of households in regulated apartments was actually higher than incomes of households in non-regulated ones, indicating existence of regulated apartments did not help poor families as intended. However, since many of the regulated apartments were privatized, the governments should think of steps to re-establish a rental market in the Czech Republic where only some 20% of apartments are rented.

Existence of mortgage markets is a necessary condition for real estate markets to work properly. Modern mortgages have been a well-established form of financing property ownership in Western continental Europe, UK, US, and elsewhere at least since the middle of the last century. This is not the case for the Czech Republic and majority of countries in Central and Eastern Europe where mortgages were essentially not available until the late 1990s. The Czech mortgage market has evolved rapidly since then, and Czech banks now offer a wide range of mortgage loans. There are two major types of mortgages contracts, the fixed-rate mortgages (FRMs) and the adjustable-rate mortgages (ARMs), respectively. As the contract name suggests, the interest rate in the FRMs is fixed for the entire period of the mortgage loan, typically some 20-30 years. The interest rate on ARMs is given as a premium over some reference rate and changes over time. Historically, the simpler FRMs were popular in the low-inflation, steady-growth 1950s, especially in the US. The ARMs started to appear in the 1980s and were frequently used in the pre-crises era in the early 2000s. Introducing mortgage contracts is a major innovation which can have a strong impact on household balance sheets and consequently on banks and country's macroeconomic performance. We compared ARM's and FRM's in the Czech Republic using a calibrated life-cycle model with a finitely-lived household and risky labour income (Rybar and Zemcik, FINNOV DP 6.3). ARM is preferred by households regardless of their risk aversion, as they can afford to face the risk of unexpectedly higher interest rates.

In another part of our investigation of asset markets, we focused on stock markets which have emerged in Central and Eastern Europe (Morgese-Borys and Zemcik, FINNOV DP 6.7). The existence of stock markets is a major financial innovation in the region. Our first objective was to test for the presence of the size and book-to-market value effects in the Visegrad countries (the Czech Republic, Hungary, Poland, and Slovakia). Such effects have been found in the United States and many other developed stock markets. We demonstrated that size and value do in fact explain the expected return/cost of capital in Eastern Europe. Based on this result, we proceeded by constructing regional size and book-to-market portfolios for a combined Visegrad market. Returns on these portfolios served as factors in addition to the market portfolio. The regional three-factor outperforms country-specific versions of the model and it can be estimated for a more current sample in Prague, Warsaw, Budapest, and Bratislava. This result can be also used as an argument in favor of a joint stock market for the joint countries, which is interesting from regulatory perspective and plausible if all the countries are in the euro zone.

Finally, we concentrated on the economies in Central and Eastern Europe (CEE) and in the Commonwealth of Independent States (CIS) that replaced most of the former Soviet Union. They provided a useful laboratory, having experienced major changes in the values of many relevant variables as they changed their economic system. In this respect these countries

provided evidence for creative destruction of the formerly state enterprises and their transformation into private companies (Estrin, Hanousek, Kocenda and Svejnar, FINNOV DP 6.6, also published in the Journal of Economic Literature). The transformation of the former communist countries from almost completely state-owned to mostly privately-owned economies is one of the fundamental events in recent economic history. Given the relatively poor performance of the centrally planned economies before the transition, most academics and policy makers expected privatization to result in greatly improved economic performance. As it turned out, the post-communist countries went through a deep recession in the first three to eight years of the transition, a period that usually coincided with the launch of privatization. The key results of this process can be summarized in the following way. First, privatization to foreign owners is found to result in considerably improved performance of firms virtually everywhere in the transition economies - an effect that is best characterized as a fairly rapid shift in performance rather than a gradual improvement over an extended period of time. Second, the performance effect of privatization to domestic owners has on average been less impressive and it has varied across regions. The effect has been smaller, often delayed, but positive in CEE; it has been nil or even negative in Russia and the rest of the CIS.

The results highlighted the importance of good management and corporate governance, access to world markets, and the presence of a functioning legal and institutional framework. The most important policy implication is that privatization per se does not guarantee improved performance, at least not in the short- to medium-run. Type of private ownership, corporate governance, access to know-how and markets, and the legal and institutional system matter for firm restructuring and performance.

WP6 POLICY IMPLICATIONS

- The development of the mortgage market may have contributed to the creation of real estate bubbles. A more prudent approach to providing credit to households is preferable.
- It is important to identify asset bubbles at an early stage to diminish the impact of their potential collapse on household consumption.
- Private ownership of property may be achieved by de-regulation of the rental market as opposed to easy access to credit.
- Preferential treatment of ownership over renting should be abandoned and the legal framework for rental housing should be changed more in favour of landlords
- Foreign ownership tends to have a positive effect on performance. The positive effect of privatization to domestic owners, to the extent that it exists, takes a number of years to materialize. This finding can serve as a lesson for governments that have to sell some of their assets in distress.
- Our results also suggest there could be benefits from a joint stock market for several relatively small countries

WP 7: AGENTS: Modelling Micro Macro Links and Policy Implications

The main goal of WP7 was to provide a framework to investigate the relationship between innovation, investment, financial fragility, public policies and macroeconomic performance in the presence of heterogeneous financial conditions.

WP 7 Summary

The economy can be conceived as a complex adaptive system which can therefore be studied by means of Agent-based Modelling (ABM) techniques.

In order to address the above objectives, then, a multi-agent setting appeared to be the most appropriate environment. In this context WP 7:

- Studied the extent to which the decision to innovate and expand/contract the scale of production by investing or hiring/firing of employees are affected by: i) the availability of finance and ii) the degree of financial fragility/robustness.
- Analysed the impact of different types of financing sources on the firms' profile and explored the impact of different public policies on the financial structure of firms and on their resulting innovation, growth and employment performance.

WP 7 Detailed description of work and policy implications

The recent vicissitudes of the credit market are a natural research issue to be analyzed with ABM and graph theory. If the firms/banks were "isolated units", the bankruptcy of a borrower would be almost unimportant in the credit system. However, given the strong interdependence in credit and interbank markets, the default of one agent can bring about phenomena of financial contagion. Three types of propagation of systematic failure have been studied in the economic literature and investigated in our deliverables.

First, the bank runs, known as self-fulfilling panic (see Diamond and Dybvig, 1983). This line of research was investigated and we proved how self-fulfilling panic may arise from simple imitative phenomena, also known as herding (Gallegati, FINNOV DP 7.1; Tedeschi, Iori, and Gallegati, DP 7.5). In particular, these studies employed agent-based modeling methods to show how herding happens and its effect on panic and on agents' choices.

Second, the asset price contagion (see Edison et al., 2000; Allen and Gale, 2000). Price contagion and bubble were also explored and we showed that synchronization among agents' strategies plays a large role in the growth and 'popping' of bubbles (Tedeschi, Iori, & Gallegati, FINNOV DP 7.5; Vitali, and Tedeschi, FINNOV DP 7.2). Asset bubbles occur when asset prices are driven too high by sufficiently large numbers of traders who lack widely shared knowledge of mispricing. Under these conditions even traders who think the asset is overpriced have an incentive to buy into a rising market if they think they can get out with a profit before the bubble bursts. Moreover the resulting public knowledge about rising prices can cause a feedback loop to drive speculative bubbles by providing cognitive reinforcement to investors who think the asset's value will rise further.

Third, the inter-locking exposures among financial institutions (see Allen and Gale, 2000; Iori et al., 2006; Battiston et al., 2007; Battiston et al., 2009). Following this last line of research, we were explicitly concerned with the potential of the interbank market to act as a contagion mechanism for liquidity crises and to determine macroeconomics outcomes such as bankruptcies (Gallegati, FINNOV DP 7.1; Tedeschi, Mazlounian, Gallegati and Helbing, FINNOV DP 7.3). Allen and Gale (2000), Thurner et al. (2003) and Iori et al. (2006) have shown that, modelling the credit system as a random graph, when increasing the degree of connectivity of the network, the probability of bankruptcy avalanches decreases. However, when the credit network is completely connected, these authors have proven that the probability of bankruptcy cascades goes to zero. The explanation for this result is that, in credit networks, two opposite effects interact. On one hand, increasing the network connectivity decreases the banks' risk, thanks to risk sharing.

On the other hand, increasing the connectivity increases the systemic risk, due to the higher numbers of connected agents which, in case of default, may be compromised. According to the three cited models, the impact of the risk sharing plays a leading role. So, in these models there is a benefit in creating links between agents, because they allow to diversify risk.

We dealt with the correlation between risk sharing and connectivity in the interbank system (Gallegati, FINNOV DP 7.1; Tedeschi, Mazlounian, Gallegati & Helbing, DP 7.3). In view of the recent economic crisis, in fact, the linear relationship between connectivity and systemic risk should be reassessed. Spreading the risk around the globe may indeed improve stability in good times thanks to risk sharing. However, in times of crisis, we believe that the effect of critical perturbations can spread across the whole system. Therefore, the credit market as a network with interdependent units, is exposed to the risk of joint failures of a significant fraction of the system, which may create a domino effect such as bankruptcy cascades.

Our model represents a simple three-sector economic system (considering goods, credit and an interbank market), involving firms and banks. Two types of credit are considered: loan and interbank credit. According to the economic situation, companies may ask for money from financial institutions to increase their output. In this case, firms enter the credit market and consult with a fixed number of randomly chosen banks. Banks consider the investment risk and finally decide whether to offer the requested loan and define interest rates. After this first consultation meeting, each firm asks the banks it links with for credit, starting with the one with the lowest interest rate. If this bank faces liquidity shortage when trying to cover the firms' requirements, it may borrow from a surplus bank. In the interbank market, we assume a random connectivity among banks. If one or more firms are not able to pay back their debts to the bank, the bank's balance sheet decreases. To improve its own situation, the bank rises the interest rate offered to other firms, eventually causing other defaults among firms. The bad debt of companies, affecting the equity of financial institutions, can lead to bank failures as well. Since banks, in case of shortage of liquidity, may enter the interbank market, the failure of borrower banks could lead to failures of lender banks. The interest rate, thus, can bring about a cascade of bankruptcies among banks.

The source of the domino effect may, on one side, is due to indirect interactions between bankrupt firms and their lending banks through the credit market and, on the other side, due to direct interactions between lender and borrower banks through the interbank system. Using three interacting markets we can study the impact of the sharing and systemic risk not only on the agents' dynamics such as their financial fragility, but also on the business cycle and economic growth. In this regard, we studied the effect of an exogenous shock on a specific firm by increasing the connectivity in the interbank system and we observe that the systemic risk prevails over the advantages of risk sharing. Although the demand of loans and the number of granted loans stay almost the same by changing the connectivity in the inter-bank system, surprisingly, with higher connectivity we observe larger cascades of bankruptcies among banks. We found that the root of avalanches lies in the agents' heterogeneity.

Furthermore, we also found that the holding of large liquid reserves, while generally stabilising in the interbank market, reduces the growth

of aggregate output by decreasing granted loans and therefore firm investments.

Results: Default cascades in the interbank market

The first question concerned the role of reserve requirements, reflected by the β parameter (higher β means higher reserves). As the reserve ratio increases, the rate of bank failures clearly falls. Obviously, increasing reserves contribute to the stability of individual banks, as shown by a lower value of average bank leverage. However, increasing reserves somewhat reduce the output growth rate, since many firms do not get loans in the credit market. We analyzed how different degrees of linkage in the interbank market affect the bankruptcy of financial institutions.

By increasing linkage, the systemic risk raises in the sense that in any period, more banks fail. Indeed, with 100 percent linkage, the system collapses completely, analogously to a tragedy of the commons (see Hardin, 1968). While the earlier empirical literature on the systemic risk, in line with Allen and Gale's result on the risk sharing role, found a very little evidence of global vulnerability (see Furfine, 2003; Boss et al., 2004; Summer et al., 2002; Bartram et al., 2007). Strong evidence has been collected after the default of Lehman Brothers, showing that interbank linkages strongly impact systemic risk (see Battiston et al, 2009; Castiglionesi and Navarro, 2007) through a high probability of domino effects. So, in line with these new empirical and theoretical works, we found that the default of an agent may increase the systemic risk by increasing the connectivity. In line with our hypothesis that a higher connectivity generates a higher systemic risk, not offset by a lower credit risk. To understand if different linkages in the interbank market have some effect on the real economy. One can immediately see that increasing the interbank connectivity has no effect on system growth. Companies have no benefits from a more strongly linked interbank market. In fact, it does not facilitate the granting of loans to enterprises, but it merely transfers liquidity among financial institutions.

WP7 POLICY IMPLICATIONS

- Agent-based modelling (ABM) can reproduce firm leverage. Leverage is a useful indicator to reproduce business cycle dynamics and to forecast recessions.
- ABM can describe, and so forecast, variations of the tradeoff between inflation and unemployment, that is, the Phillips curve.
- ABM can describe, and so forecast, the negative relationship between the output growth rate and the unemployment growth rate.
- A higher banks connectivity not only increases the agent's financial fragility, but also generates larger bankruptcy cascades due the larger systemic risk.
- High interbank linkages have no effect on economic output, even during boost/boom.
- Higher bank reserve requirements stabilize the economic system, not only by decreasing financial fragility but also dampening avalanches. However, holding in reserve a larger percentage of banks' equity somewhat affects the aggregate output growth by reducing credit to companies. Our simulation results also indicate that heterogeneity alone contributes to instability.
- Interbank lending relationships should be restricted to banks that share similar liquidity characteristics. These results may be specific to our model, but they offer stimulating insights into the nature of contagion.

WP 8: TRAJECTORIES: Modelling Micro Macro Links and Policy Implications
This Work Package reviewed and analysed financial service innovation in the light of current policy concerns about the financial crisis. More particularly, it explored 'technological trajectories' in banking and their relation to regulation.

WP 8 Summary

WP 8 aimed to improve understanding of how shifts from the current trajectory based around re-engineering the risk of default, to one that takes more account of liquidity risks will take place. This analysis integrated research on financial technology within an evolutionary framework that informs public and academic debates and the effective generation and regulation of financial innovations within Europe. There was a particular focus in the project on risk management technologies, and particularly those technologies, such as CDOs and CDSs whose collective failure helped create the recent financial crisis. WP 8 has produced a number of interesting findings and high-level policy interventions, including work that was cited in the recent Vickers Inquiry report into the regulation of the UK financial sector.

WP 8 Detailed description of work and policy implications

WP 8 explored the nature of financial innovations within large financial institutions. Its key focus was on technological trajectories within financial technologies and how financial innovation differed from traditional forms of innovation and what this meant for the social distribution of risks and rewards. The research project built on prior work on financial risk management technologies, and the potential threats that they posed to the financial system. By 2003, building on research on financial crashes, we had already noted that financial technologies were being developed that had the potential for catastrophic failure, and that the then current regulations were making that failure more likely.

"The increased complexity and interdependence of the contracts made possible by improved control changes the social distribution of risk. This makes banking regulation and internal auditing increasingly difficult as it is harder to work out the extent of risk exposure. Traditional methods of regulation involve requiring banks to hold enough capital to cover their risk exposures. Unfortunately, this has the perverse incentive of encouraging them to move low risk contracts off their book and take on higher risk contracts that exceed the returns of low risk strategies. As understanding exposures has become more difficult alternative plans to allow banks with more sophisticated risk management technologies to lower their Capital Adequacy Requirements - and therefore make more profit on their capital - have been proposed. These have the positive or negative consequence (depending on your point of view) of encouraging further concentration in the sector. An alternative proposal involves forcing banks to issue low-interest bonds whose value would fluctuate depending on the market's trust in the risk management capabilities of the issuing institutions. Thereby, using a market based approach to make up for the increased difficulty of measuring exposure." (Nightingale et al. 2003, p. 506).

Moreover, we highlighted that CAR regulations were having the unintended effect of moving high risk financial transactions off banks' balance sheets, and that market based approaches to risk regulation might work better. Since we wrote this there has been a major move in Basel III to use CDSs, effectively "low-interest bonds whose value would fluctuate

depending on the market's trust in the risk management capabilities of the issuing institutions" where the reference entity is a bank, The new Basel III rules use credit spreads from CDS to measure default risk instead of credit ratings, suggesting European and global financial regulation is moved towards the system we highlighted before the crisis.

Building on this work WP8 explored the nature of financial innovations in more detail. Looking at their fundamental nature and how they might generate different kinds of risks that could potential generate catastrophic failures (Nightingale and Spears, FINNOV DP 8.1).

One of the main results of WP 8 is that financial products are 'social' objects whose function depends, in part, upon market participants' beliefs and expectations about their status as objects of value (Nightingale and Spears, FINNOV DP 8.1). They are therefore different from traditional technologies, where functions depend largely upon their intrinsic design and 'brute' physical properties. This creates the possibility for feedback loops during which correlations can converge so that the assumptions underlying financial risk management technologies fail to hold, creating the potential for catastrophic failures. This work provides a basis for understanding the importance of regulating financial technologies themselves, as opposed to conventional forms of financial regulation that focus on incentives, information asymmetries, and capital adequacy requirements.

WP 8 also looked at how mathematical models are used in finance and their impact on social and economic relations in financial markets (Spears, FINNOV DP 8.2). Mathematical models are essential to both financial valuation and risk management. However, in certain circumstances, the use of a model by market participants can cause markets to behave in ways contrary to the model's predictions. Models are thus codified bodies of knowledge that under certain circumstances are capable of becoming "self-falsifying". Recently economists and sociologists have noted this property of financial models, yet there has been little systematic classification of social and market conditions under which models can become self-falsifying, and how these conditions interact with the technical properties of models themselves. The paper reviewed the relevant economics and sociology literature to build an initial taxonomy focusing on two broad classes of models: statistical models and arbitrage-free models.

We have also developed the empirical case study of the banking crisis and provided a theoretical focus that draws on the regulation and trajectory literatures (Nightingale and Spears, FINNOV DP 8.1). We showed, through a detailed analysis of primary and secondary sources how seemingly safe technological trajectories in finance can converge into a technology that can create substantial agency failures and incentive problems, drawing on the ideas in the second deliverable.

Moreover, we discussed how financial technologies create uncertainty (Spears, FINNOV DP 8.2). With traditional technologies, uncertainty decreases with experience: as more people and firms use a technology, its risks and performance bounds become known and quantifiable. However, because financial technologies change the social structure of financial markets, their uptake can increase the uncertainty of their risks and performance. This suggests that novel financial technologies can significantly affect the social distribution of risks and rewards, concentrating benefits within a small proportion of the population who

work in financial services, while socializing the risks to the general population. This provides a justification for public intervention in the market.

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Relationship with WP 3

In addition WP8 team have been conducting research, related to WP 3, on how financial markets can be restructured to better support innovative firms. From this research two working papers have been produced that are due to be submitted to the *Journal of Business Venturing and Research Policy* when we get approval for data release from BIS:

'The UK VCT Scheme: An Evaluation' J. Siepel, G. Murray, M. Cowling and P. Nightingale. The paper evaluates the UK VCT scheme which is the largest VC support scheme in Europe and finds that it performs positively but that the extent of improvement in firm performance from funding is very small and may not be worth the considerably financial support it requires.

'From Funding Gaps to Thin Markets' P. Nightingale et al. The paper evaluates the full sample of all hybrid VC funding schemes in the UK against a control sample of 8000 matched firms. The paper finds positive evidence of improvements in performance and draws policy conclusions for

the design of schemes in the future that suggest that such public support for VC investment should focus on national or European funds (not regional funds), that such funds should be large (preferably over 50-100m EUROS) and should be specialised.

WP 8 POLICY IMPLICATIONS

- Recent suggestions that a variant of clinical trials should be adopted to test the systematic risks of financial innovations (for example by Elizabeth Warren, former head of the Consumer Financial Protection Bureau in the United States), are unlikely to be successful.
- The establishment of a particular model as a 'market standard' method of pricing risk can create destabilizing feedback loops.
- Public policy that encourages 'inbreeding' in risk management approaches may enhance rather than mitigate risk.
- Financial regulators might need to step outside of their traditional passive roles of making and enforcing market rules and ensuring disclosure, toward undertaking more active coordination between large financial services firms.
- Regulators and central banks must be attentive to the ways in which different classes of financial models can lead to market instability in order to effectively intervene where it is appropriate to do so.

Potential Impact:
FINNOV IMPACT

FINNOV explored the link between the financial sector and the real economy, analysing to what extent financial activities promote or impede innovation and economic growth (at the firm, sector and national level).

FINNOV research has improved policy makers' understanding of the interaction between financial markets and innovation-led growth and the effect of such growth on the social distribution of risks and rewards. Given the strong negative effect of the recent financial crisis on many European economies, a central element of the FINNOV research programme was to determine how European governments and institutions can ensure that the financial system supports investment in innovation in sustainable and equitable ways. FINNOV results will help policy makers design ways to exit the crisis and create a sustainable and equitable model of economic growth in Europe (EC, 2010).

FINNOV findings suggest that EU policy makers should consider:

1. De-financialising the economy through re-regulation of finance (i.e. separate investment activity from banking activity);
2. Redirecting the financial system in the economy towards aligning its practices with real, productive economy value-creation. For example, revisit biased financial indicators, discourage short-termism, develop better tools for evaluation of financial products;
3. Embracing and fostering heterogeneity and diversity;
4. Re-invigorating demand for finance; and
5. Rejecting the 'myth of the market economy' and recognizing the important entrepreneurial role played by the State in supporting and encouraging innovation.

List of Websites:

<http://www.finnov-fp7.eu>