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***Economic Change: Micro-Foundations
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EconChange

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EU RESEARCH ON SOCIAL SCIENCES AND HUMANITIES

Economic Change: Micro-Foundations of Organisational and Institutional Changes in Europe

EconChange

Final report

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Preface

Within the Fifth Community RTD Framework Programme of the European Union (1998–2002), the Key Action 'Improving the Socio-economic Knowledge Base' had broad and ambitious objectives, namely: to improve our understanding of the structural changes taking place in European society, to identify ways of managing these changes and to promote the active involvement of European citizens in shaping their own futures. A further important aim was to mobilise the research communities in the social sciences and humanities at the European level and to provide scientific support to policies at various levels, with particular attention to EU policy fields.

This Key Action had a total budget of EUR 155 million and was implemented through three Calls for proposals. As a result, 185 projects involving more than 1 600 research teams from 38 countries have been selected for funding and have started their research between 1999 and 2002.

Most of these projects are now finalised and results are systematically published in the form of a Final Report.

The calls have addressed different but interrelated research themes which have contributed to the objectives outlined above. These themes can be grouped under a certain number of areas of policy relevance, each of which are addressed by a significant number of projects from a variety of perspectives.

These areas are the following:

- ***Societal trends and structural change***

16 projects, total investment of EUR 14.6 million, 164 teams

- ***Quality of life of European citizens***

5 projects, total investment of EUR 6.4 million, 36 teams

- ***European socio-economic models and challenges***

9 projects, total investment of EUR 9.3 million, 91 teams

- ***Social cohesion, migration and welfare***

30 projects, total investment of EUR 28 million, 249 teams

- ***Employment and changes in work***

18 projects, total investment of EUR 17.5 million, 149 teams

- ***Gender, participation and quality of life***

13 projects, total investment of EUR 12.3 million, 97 teams

- ***Dynamics of knowledge, generation and use***

8 projects, total investment of EUR 6.1 million, 77 teams

- ***Education, training and new forms of learning***

14 projects, total investment of EUR 12.9 million, 105 teams

- ***Economic development and dynamics***

22 projects, total investment of EUR 15.3 million, 134 teams

- ***Governance, democracy and citizenship***

28 projects; total investment of EUR 25.5 million, 233 teams

- ***Challenges from European enlargement***

13 projects, total investment of EUR 12.8 million, 116 teams

- ***Infrastructures to build the European research area***

9 projects, total investment of EUR 15.4 million, 74 teams

This publication contains the final report of the project 'Economic Change: Micro-Foundations of Organisational and Institutional Changes in Europe', whose work has primarily contributed to the area 'The challenge of socio-economic development models for Europe'.

The report contains information about the main scientific findings of EconChange and their policy implications. The research was carried out by seven teams over a period of three years, starting in November 2002.

The abstract and executive summary presented in this edition offer the reader an overview of the main scientific and policy conclusions, before the main body of the research provided in the other chapters of this report.

As the results of the projects financed under the Key Action become available to the scientific and policy communities, Priority 7 'Citizens and Governance in a knowledge based society' of the Sixth Framework Programme is building on the progress already made and aims at making a further contribution to the development of a European Research Area in the social sciences and the humanities.

I hope readers find the information in this publication both interesting and useful as well as clear evidence of the importance attached by the European Union to fostering research in the field of social sciences and the humanities.

J.-M. BAER,

Director

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Abstract

The project has focused on some of the key organisational changes that are taking place with the advent of the "knowledge-based" economy. Specifically, the main objective of the project has been to provide an analytical contribution to understand the micro-foundations of this new phase of economic growth that appears to depend on organisational changes to the way production and innovation are organised and financed. This implies an important division of labor that can happen either by separating tasks technically, geographically or organizationally. In turn, this implies that technologies can be disembodied from products, allowing the emergence of markets where technologies can be traded. These issues and the implications for the innovation process have been addressed by studying issues such as licensing, the geographic interaction of the innovation process, Silicon valley models and the case of open source software. Apart from changes in the innovations process, important changes in the production itself is being witnessed. The effects on entry and exit of new firms are first analyzed, to later move to the role of large corporations, complemented by the analysis of strategies of small and medium firms, the cumulative nature of innovation and skill-biased technical progress. The analysis is completed by describing the changing pattern of agglomeration of economic activities, and its implications for trade and productivity. New financial instruments and markets have emerged and the role of spin-offs and Initial Public Offerings have to be studied carefully. Finally the institutional setup is important, both from the point of view of intellectual property rights as well as from the political and regulatory environment. Overall, the picture emerging from this project shows important changes in the production and innovation process.

I. EXECUTIVE SUMMARY

1. Objectives

The project has focused on some of the key organisational changes that are taking place with the advent of the "knowledge-based" economy.

2. The changing organisation of the innovation process: division of labour, clustering and integration

The main research questions addressed in this section deal with changes that have been occurring in the organization of the innovation process. These changes can be noticed in the division of labour of the innovative process, where the crucial aspect is the licensing of technologies. Another important aspect is the location of innovative activities. The project also dealt with the case of open source software, where production and innovation adopt a very interesting organization.

Licensing

This research underscores the crucial role of a market for technology in shaping firms' licensing strategy. This research suggests that in some industries it might be problematic, if not wrong, to analyze a firm's licensing strategy in isolation, abstracting from product and technology market dynamics. This contribution is particularly valuable in light of the recent trend towards a more widespread use of licensing agreements for the exploitation of the firm's intellectual property.

Geography of innovation

The two aspects on the location of innovative activities analyzed in this project were on the one hand the analysis of spillovers of research using patents, and the cases of the Indian and Eastern European software industry as interesting cases of emerging technological clusters.

Some regions are better at doing certain types of research activities because of the location of top universities or high-tech companies. They spawn a large number of R&D performing start-ups founded by the personnel employed in the top organisations, and produce a large number of patents together with high citation intensities in the areas.

Two-thirds of the increase in aggregate productivity in the Indian software sector over the 1995-2002 period is due to increases in productivity within existing firms but nearly a third of the increase in aggregate productivity is attributable to the changes in aggregate

productivity due to the entry and exit of firms. The project also compared Bangalore and Cambridge hi-technology regions. The main result highlights the importance of internal migration of skilled workers in tipping the human capital pooling in a region, which in turn emerges as an important factor in sparking the growth of the cluster. With respect to the emergence of a software industry in Eastern Europe, there are striking similarities in ownership, nationality, market orientation, export increases, objectives and several other features of the sample in the firms involved.

Open source software

In a regime of weak IPRs, complementarities with a firm's other assets are a key factor in guaranteeing the appropriability of innovation efforts. On the other hand, the fear of product cannibalization and important changes in distribution channels (Christensen 1997) seem to be the most likely factors explaining the negative relationship between the rate of OSS product introduction and downstream positions in proprietary software.

3. The changing organisation of the production process: entrepreneurship, clustering, and "Silicon Valley" models

The creation of new firms and the role of entrepreneurship has also been analyzed within this project. First at the level of entry and exit, with particular attention to the role of idiosyncratic risk. Second in relation to experiences which are similar to the Silicon Valley model and the role of large corporations and small and medium firms. Finally some insight where contributed with respect to the cumulative nature of innovation and skill biased technical progress.

Entry and exit processes

Two aspects were part of this research: entry in the case of the security software industry and the dynamics of the innovation process in old (car industry) and new industries (software).

Post-entry product strategies of versioning and portfolio broadening are important in explaining survival rates in the security software industry, even after controlling for the standard drivers of viability highlighted by the industrial organization. Post-entry product strategies improve firm viability. There is evidence on a trade-off between strategies that require different learning processes (i.e. exploration vs exploitation).

With respect to the comparison of old and new industries, a positive and contemporaneous relationship between idiosyncratic risk and innovation intensity can be empirically established. While innovation in a mature but innovative industry, like

pharma or computers, may be high (expressed through a high R&D intensity and/or number of patents), its commercial outcome is often less uncertain than in new emerging sectors (like biotech and nanotechnology) or in old sectors where innovation activity is not intense (textiles), and hence causes less of a reaction by market analysts.

Silicon Valley Models

Some lessons for emerging European industries can be learnt from the case of the Indian software industry. A major finding of the project was that the evolution of process capability in Indian software firms that is allowing firms in the industry to bag large outsourcing contracts owes much to the combined circumstance of rising wages in the domestic industry and relatively competitive wages which impart a cost advantage in the international market. Entrepreneurship in the sector has played an important role in uncovering new niches and business models where the cheap software talent could be leveraged for maximum value.

The role of large corporations

The presence of markets for technology facilitates the process of entry into new product markets, especially for those firms with weaker technological competences. The availability of process technologies from independent suppliers lowers the entry (technological) barriers to product markets, and presumably increases the overall level of competition into them. This means that an additional instrument that policy makers can use to facilitate entry and increase competition is to promote the formation of markets for technology-e.g., by strengthening the protection offered by patents to intellectual property, or by creating virtual markets for technology.

Strategies for small and medium firms

The commercialisation of technologies can be the main strategy of appropriation of the returns from innovation and on the easier entry in the market for technology suppliers, in particular in markets where the development of complementary assets is too costly for new and small firms. Understanding if there are geographic patterns of distribution of firms in the market for technologies, if markets for technologies emerge in some areas instead of others, and if relations with large firms, universities, venture capital are important for the emergence and growth of specialised technology producers can be crucial to design SME policy.

The cumulative nature of innovation

Firms' incentives to cluster are the strongest when the following three conditions are met: 1) the value of later innovations is high relative to earlier ones; 2) competition in the product market is relatively soft; 3) the probability of a single firm to develop an innovation is neither very high nor very low.

Weak trade secret protection might not be a prerequisite for clustering and labor mobility as some legal scholars have recently argued. Indeed, a model analyzed in this project has shown that a system of trade secret protection based on punitive damages, except in some extreme cases, is beneficial for firms' profits, stimulates clustering, and is not an impediment to workers' mobility.

Skill biased technical progress

The skill premium can be explained by directed technical and organizational change, and by demand factors. Technical and organizational changes raise because the larger relative supply of educated people induces them to create models of industrial organization based on technology- and human-capital intensive productions, knowledge spillovers, entrepreneurial firms, start-ups, spin-offs, and the like. At the same time, the increase in income per capita produced by the increase in the skill-level of the workforce spawns a greater demand for skill-intensive goods, which further raises the skill premium.

4. Productivity growth, agglomeration economies and the scope for convergent growth in Europe

In this section productivity was analyzed in the context of its relation to trade. Another group obtained agglomeration patterns of economic activities and made a cross-country comparison, and finally there was a contribution on ICT adoption.

Trade and productivity

Real openness is a better measure of trade than openness because the openness measure is distorted by cross-country differences in the price of non-tradable relative to tradable goods. The distortions arise because openness is decreasing in the relative price of non-tradable goods, and non-tradable goods are relatively more expensive in countries where production is more efficient.

Agglomeration of economic activities

Using the statistical information of D& B it can be verified that the concentration level at the 2-digit level has a high variability across countries. This variability is especially high for the *EGI* and *MSI* indices and much lower for the traditional indices. A reason for this volatility can be associated that the sector is defined at an excessive aggregation. Reducing the aggregation level, going from 2-digit sector to 4-digit sectors, implies a higher homogenization of the sectors. Actually it can be observed that, for instance, in the UK within some 2-digit sectors there are 4-digit sectors with very high concentration and very low concentration. The correlations of agglomeration indices are higher for the cases of the Gini and Herfindahl indices, similarly to the analysis at the 2-digit level. These results show that the determinants of industrial concentration are country-specific and that the history and development level of each country (or industrial dynamics) are important to explain firm location at the country level.

Information and communication technology adoption and organisational changes

Large, medium and small firms have different patterns of adoption of (and different productivity gains from) skills, ICTs and especially organizational change.

5. Financial institutions in a knowledge based economy

Two of the main vehicles for financing of new technologies were analyzed in this project, namely Initial Public Offerings and risk capital via new equity markets.

The analysis of Initial Public Offerings (IPOs)

Institutional environments less advantaged in nurturing independent IPOs may partly compensate their weaknesses by being more active in incubating new ventures within established corporations and spinning them off to the stock markets. In a similar vein, it was found that institutional environments less conducive to radical innovations and the creation of technology-based new firms may partially overcome this shortcoming by being more active in the listing of technology-based spin-offs to stock markets.

Young and technology-based firms are over-represented in the sample of spin-offs to stock markets in the institutional settings less favorable to the independent start-ups going public and the development of radical innovations, thus representing an alternative form of entrepreneurship hitherto neglected by the entrepreneurship literature.

The provision of risk capital via the new equity markets

Despite similar regulation (e.g. similar listing requirements), the different EuroNM markets - such as the French Nouveau Marché and the German Neuer Markt - managed to attract very different types of firms. This suggests that similar types of regulation can lead to very different outcomes.

The majority of French and German firms decided to choose lock-in contracts exceeding the minimum requirements. Firm and shareholder characteristics influence the choice of contract. For example, for both countries, shareholders of firms subject to more uncertainty (smaller and younger firms) are locked in for longer periods.

6. Intellectual property rights

From a policy perspective it is crucial to understand the reasons for this mismatch between supply and demand of technologies, and how markets for technologies could be improved. One possible reason is the presence of frictions, or transaction costs in the market for patented technologies. In this perspective, policies aiming at facilitating technology transactions would certainly contribute to a broader use and diffusion of patented innovations.

7. Regulation, de-regulation, political and labour market institutions in a knowledge based economy

New technologies such as broadband Internet pose a significant risk to copyright owners, but copyright owners probably exaggerate the monetary losses (by valuing every pirated copy at the list price rather than consumers' willingness to pay) and underestimate the possible beneficial effects (say, the potential network externalities due to wider usage).

Digital Rights Management is likely to increase the market power of producers and distributors over consumers. This is likely to reflect in greater use of price discrimination strategies. While this is not necessarily economically inefficient, it will translate into higher prices for some consumers.

From the political science point of view, policy innovation and the corresponding party advantage are limited by the role of political parties in providing "packages" of policies and the requirement of developing not very costly communication with voters through ideological consistency. Parties place themselves on a policy area along an ideological dimension encompassing multiple issues, such as the left-right axis, and have to stay within.

II. BACKGROUND AND OBJECTIVES OF THE PROJECT

Information and communication technologies appear to have contributed to growth and productivity in countries like the US and the UK with a dramatically new set of complementary organisational and institutional transformations. The growing importance of production by small firms often in technology intensive industries, the emergence of the venture capital institutions as a source of corporate finance, the increasing use of intellectual property regimes due to the emergence of markets for technology and the phenomenal growth of an intermediate services sector are some such changes that are associated with the growth of these economies in recent years. Collectively, these changes in the institutions and organisation of production have been termed variously as the "knowledge based " economy or the "new" economy.

Against this background, the project has focused on some of the key organisational changes that are taking place with the advent of the "knowledge-based" economy. We have not tried to separate the institutional aspects from the changing organisation of production and innovation in any systematic way. This is primarily because several organisational changes in turn involve firms and markets, which are institutions themselves. Specifically, the main objective of the project has been to provide an analytical contribution to understand the micro-foundations of this new phase of economic growth that appears to depend on organisational changes to the way production and innovation are organised and financed. In turn this has had some implications for how much and in what form entrepreneurial activities can form the basis for longer term growth and productivity. The spread of these organisational changes and the incidence of entrepreneurial activity has been uneven. Our main objective was to study the evolution of these organisational changes, and their differences across countries. Though our primary focus was to understand change in Europe, we have also engaged in comparisons with other countries, such as the US or India.

The motivation for our topic is straightforward. At Lisbon, in March 2000, the European Council stressed that the strategic goal for the next decade would be "to become the most competitive and dynamic knowledge based economy capable of sustainable economic growth with more and better jobs and greater social cohesion". However, several difficulties and constraints remain, and it is noteworthy that quite a few of the priorities for Europe reported by the Lisbon Report or the Presidency Speech regard the need for organisational and institutional changes as more important than technological changes.

Studying all the institutional and organisational changes that have been taking place since the 1980s when new information and communication technologies are thought to have begun their revolutionary impact on production and the economy is, of course, a Herculean task. Furthermore it is a task that many research teams from the EU and elsewhere have been attempting in parts for some time now. We have not aimed on replicating or repeating these studies, but we drew upon some of their findings and conclusions in informing and interpreting our own. Our attempt in this project has been to select a narrowly focused set of six themes, which relate in one way or another to one basic change. This change is the slow and uneven institutional and organisational evolution that the European economy is experiencing through the emergence of technology markets across different sectors of industrial activity in Europe and the US.

The emergence of technology markets in the industrial economy has been denied for a long time now by scholars who believe technologies cannot be traded in an arms length market, but reside in the capabilities of firms alone. This is a misunderstanding of the role of technology market, which in turn has prevented a full analysis of the impact of such markets upon the organisation of production and innovation in Europe. Thus we have focused on the role of new institutions like IPRs and venture capital in encouraging the growth of such markets by facilitating entrepreneurship. We have also studied the direct impact of the emergence of such technology markets upon the division of labour between large and small firms and for technology based growth through the diffusion of technologies. Lastly, we have examined the impact of such technology markets upon competition and the scope of regulation in carefully chosen user industries.

This project was organized around the following six research themes:

- 1) The changing organisation of the innovation process: division of labour, clustering and integration;
- 2) The changing organisation of the production process: entrepreneurship, clustering, and "Silicon Valley" models;
- 3) Productivity growth, agglomeration economies and the scope for convergent growth in Europe
- 4) Financial institutions in a knowledge based economy;
- 5) Intellectual property rights;
- 6) Regulation, de-regulation, political and labour market institutions in a knowledge based economy.

III. SCIENTIFIC DESCRIPTION OF PROJECT RESULTS AND METHODOLOGY

1. The changing organisation of the innovation process: division of labour, clustering and integration

The main research questions addressed in this section deal with changes that have been occurring in the innovation process. It has been argued, for instance by the work of Rosenberg and others, that innovation is an interrelated process where different actors interact through different methods. This implies an important division of labor that can happen either by separating tasks technically, geographically or organizationally. In turn, this implies that technologies can be disembodied from products, allowing the emergence of markets where technologies can be traded. In this section these issues and the implications for the innovation process have been addressed studying issues such as licensing, the geographic interaction of the innovation process, Silicon valley models and the case of open source software.

1.1. Licensing

One of the main vehicles for a more efficient division of labour in the innovation process is the use of licensing. This project has researched the increasing importance of licensing of technologies.

The main output of this section is the paper by Fosfuri (2006) "The Licensing Dilemma: Understanding the Determinants of the Rate of Technology Licensing". This research examines the licensing strategies of large firms by focusing on some of the determinants of their rate of technology licensing. In particular, it aims to shed light on the relationship between competition in the market for technology and the licensing decisions of firms. It is argued that a firm's rate of technology licensing can be explained by the interplay of two effects that licensing produces on the licensor's profits: the profit dissipation effect and the revenue effect (Arora and Fosfuri, 2003). Indeed, technology licensing forces a trade-off: Licensing and royalty revenues net of transaction costs (the revenue effect) must be balanced against the lower price-cost margin and/or reduced market share implied by increased competition (the profit dissipation effect) from the licensee. The presence of multiple technology holders, which compete in the market for technology, changes such a tradeoff and triggers more aggressive licensing behavior. In addition, this research focuses on two other potentially important determinants of a firm's rate of technology licensing: the licensor's market share in the product market and the degree of technology-specific product differentiation.

The aforementioned theory is tested on a sample of large chemical firms that possess technological competencies in a set of 107 chemical products by examining their licensing strategies over the period 1986-96. The chemical industry has a long tradition of technology licensing (Arora, 1997) that allows us to gather reliable data. In addition, there are often several technologies available from different licensors to produce the same chemical product, which helps us to underscore the effect of competition in the market for technology. There is an established market for polyolefins production processes, for instance, with about 25 polyethylene and 8 polypropylene technologies available. Large, established chemical producers like Dow Chemicals, BPA-moco, Exxon-Mobil, Union Carbide, Univation, and Basell, along with independent technology suppliers like Novolen and Engelhard, compete face-to-face in the licensing market.

This work contributes to the relatively underdeveloped empirical research on licensing. This lacuna is understandable. In many industries, licensing is a recent phenomenon, so available data are scattered. In addition, firms tend to conceal information about licensing deals, which are typically considered to be strategic decisions that are not publicly disclosed.

Anand and Khanna (2000) provide one of the few econometric investigations of the rate of licensing. Their study is aggregated at the level of the sector, and they do not attempt to explain inter-firm differences in the rate of technology licensing. Arora and Ceccagnoli (2006) analyze how patent effectiveness affects a firm's patenting behavior and its propensity to license. They do not look, however, at the interaction between licensing decisions and competition in the market for technology, which is crucial in this research. Recently, several scholars have directed their attention to the analysis of licensing practices by universities (Mowery and Shane, 2002). For instance, Sine, Shane and Di Gregorio (2003) have shown that the rate of licensing by universities is an increasing function of their prestige. However, university licensing decisions differ considerably from those made by large firms, primarily because universities do not have stakes in the product market.

1.2. Geography of innovation

The issue of localization and externalities at the local level is being studied from different angles. In this project there was an attempt to use patents, which gather a lot of information on the localization of research, to provide further empirical evidence on the importance of geographical issues in the innovation process.

One example is the work by Myriam Mariani, "What Determines Technological Hits? Geography vs firm competencies", published in *Research Policy*. The aim of this work was

to explore empirically how much of the value of an innovation is affected by the affiliation of the patents' inventors to the same organisation, as opposed to spillovers that arise when the inventors are geographically close to each other and to external sources of knowledge. There is consensus in the literature about the importance of firm competencies in the production of innovations. The affiliation to an organisation with unique capabilities, internal communication systems, and specific routines is an effective mechanism for the production and transmission of knowledge (e.g. Nelson and Winter, 1982; Dosi et al., 1988; Klepper, 2001). Moreover, there is evidence of the importance of competencies that pertain to territories and regions rather than specific firms. By facilitating the transfer of knowledge among close-by individuals and companies, the geographical cluster is another organisational form for innovation. Recent contributions confirm that knowledge spills over, and that the cost of acquiring knowledge is lower when individuals and firms are geographically close. This explains the tendency of innovative activities to cluster (Jaffe, 1986; Jaffe et al., 1993; Saxenian, 1994; Audretsch and Feldman, 1996; Swann et al., 1998; Caniels, 2000). While the literature has typically focussed on either the firm or the geographical cluster, little work has been done to compare them. This was the goal of this work.

The methodology involved the econometric analysis based on a new dataset. For the empirical investigation developed in this work, a detailed dataset was constructed specifically for analysing this issue. The dataset is composed of a randomly selected sample of 4262 chemical EPO patents applied by 693 firms and invented in 208 European regions during 1987-1996. To test the effect of firm and regional characteristics on the probability of producing technological hits, negative binomial regressions were performed. The number of citations received by the patents in the 5 years after the application date up to the year 2000 was used as a proxy for the value of the innovations (excluding self-citations, i.e. citations from patents applied by the same applicant). This was used as the dependent variable in the estimation procedure (CITS) and it was regressed on project and firm variables, scientific and technological characteristics of the regions in which the patents are invented, and a set of controls.

The results obtained highlight two models of innovation. A distinction between biotechnology and the more traditional chemical sectors was considered in the work. Both sectors are indeed research intensive, but while biotechnology is a modern research sector that arose only a couple of decades ago, chemicals are the oldest high-tech industry in modern economies. Moreover, while the latter hinges upon large established companies, the former is associated with smaller firms that are often agglomerated geographically. The results obtained suggest that R&D intensity at the firm level and the scale of the research projects are important for developing valuable innovations in the

chemical sectors. External knowledge spillovers and the technological characteristics of the area in which the firms are located play no role. By contrast, the drivers of valuable innovations in biotechnology are the technological characteristics of the regions and the technological specialisation of the firms. These results are consistent with earlier work in the literature on the importance of knowledge spillovers and agglomeration economies in research-intensive sectors in general, and biotechnology in particular (Audretsch and Feldman, 1996; Klepper, 1996; Zucker et al., 1998a, 1998b). At a higher detail level, the results obtained from this work show that in traditional chemicals the probability of producing valuable patents depends on firms' internal R&D effort. The probability of developing technological hits is higher also when a research project involves a large network of inventors and different organisations. By contrast, the size of the firm and the fact that the inventor is co-located in the same NUTS region do not add anything to the expected value of traditional chemical innovations. The results also show that only the technological specialisation of companies is significantly and negatively correlated with CITS but, rather than the effect of the technological diversification of the companies, the negative correlation is suggestive of the high propensity to patent in the chemical sector. Traditional chemicals is indeed populated by large firms that have the financial strength to apply for patent protection not only for important innovations, but also for less valuable ones. As the number of patent applications in the specific sector raises their average quality decreases, leading to a lower expected number of CITS. Another interesting result was that the technological characteristics of the regions in which the inventors are located do not raise the probability of developing technological hits in traditional chemicals. This result holds both for the proximity to higher education laboratories and for the location in technologically-intensive regions. Summarising the results that emerged from this work, apart from economies in R&D internal to the firm, the model of innovation that leads to high expected value patents in traditional chemicals seems to be dominated by large firms that invest heavily in internal R&D activities and large scale projects, with no role for the spillovers from near-by research laboratories or from the general technological environment in which the research is conducted.

As far as biotechnology is regarded, the results showed that firm characteristics still matter. Specifically, technological specialisation matters. The expected value of innovations also rises when firms carry out R&D projects in collaboration with other institutions. The fact that the patent is the output of collaboration among different institutions (a proxy for the breadth of the project that goes beyond the firm boundaries) also showed to be positively affecting the value of the innovation. Moreover, consistently with the more basic nature of biotechnology research compared to traditional chemicals, the science linkage (which was measured by the number of citations made by each

patent to the non-patent literature like scientific journals, books and proceedings) also showed to play a positive effect on the value of the innovation. But the real distinct feature of biotechnology vis-à-vis traditional chemicals that emerged from this work is the importance of the regions. The technological environment in which the research is carried out influences the probability of developing biotechnology hits. Surprisingly, however, the expectation that the geographical proximity to university laboratories is correlated with the probability of inventing important innovations in biotechnology was not confirmed. This is probably due to the fact that the number of patents coming from a region is a proxy for the general scientific and technological environment in which the inventors are located, and measure the output of the research carried out by both public and private institutions in the area. These results suggest that the regional effect is a "true" effect: although biotechnology and traditional chemical patents are produced to a good extent in the same regions, the proximity to external sources of knowledge affects the probability of developing valuable innovations only in the former.

1.3. Silicon Valley models

The first project in this section aimed at providing more recent experiences resembling the Silicon Valley example, and particularly the software industry development in India and in Eastern Europe.

Some of the results can be found in the papers by Suma Athreya: 'Indian software industry and its evolving service capability' published in *Industrial and Corporate Change*, 'Role of transnational corporations in the evolution of a high-tech industry: the case of India's software industry- A comment' published in *World Development*, as well as three other papers still in the working phase, which can be found in the references.

The study of the Indian software industry was aimed at understanding the relevance of Silicon Valley models in the growth of hi-technology industries in emerging regions and the lessons that they hold for east European countries. This included an investigation into the role of entrepreneurship and of clustering in the growth of hi-technology industries. To this end, the sub-project on the Indian software industry was aimed at collecting data and information on these aspects of the industry's growth and compare them to similar data on East Europe and other European regions.

The project collected three types of data:

- detailed interviews with about twelve large Indian firms to assess the strategies and trajectories of growth (conducted in December 2002 in India and again in July 2003

in the US where there was a meeting of Indian software firms with branches in the US);

- creation of a panel dataset using the Trade registers published by the industry association, NASSCOM (completed in July 2004);
- a detailed survey on the origins of firms with a view to understanding the roles played by entrepreneurial firms in the industry's growth, which yielded data on software origins for 204 Indian software companies (collected by a market survey company through face-to-face interviews and final data received in April 2004).

The three types of data were used to address different types of questions in order to get a holistic picture of the factors that influenced the growth of the software industry in India. Thus, the interview data combined with the data from business registers was used to highlight the factors behind the growth of process capabilities in the software industry in Athreye (2005a) and the role played by foreign firms in the growth of the industry in Athreye (2004).

The panel created by combining the NASSCOM registers was used to study the sources of increase in aggregate productivity in Athreye (2005b). This paper uses an innovative approach to decomposing the sources of growth of aggregate productivity starting from an evolutionary framework.

More work is in progress using the survey data and matching it to information in the registers in order to probe the existence of economies of scale in software production in India, the characteristics of entrepreneurial firms when compared to non-entrepreneurial firms in Indian software and hi-technology industries world-wide and lastly, to examine the internationalisation activities of entrepreneurial and non-entrepreneurial firms. These are issues where no evidence is available and the survey data will help to shed useful light on the role that entrepreneurial firms play in growth and the uniqueness of strategies adopted by such firms.

Another part of the project consisted on studying the emerging software industry in Eastern Europe. This is represented by the work of Slavo Radosevic and Helena Hannula and in the report "Software Enterprises In Central And Eastern Europe". From the perspective of the project, research on software in the Central and Eastern Europe (CEE) has been important due to several reasons. First, low barriers to entry in this industry facilitate links to the global economy. This is especially important in the case of previously closed economies. Second, good human capital base of these economies is presumed to be an additional contributing factor suggesting that these economies may

develop comparative advantages in this industry. Third, there is a literature which suggests that software offers opportunities for knowledge spillovers between export and local production. For a review see Commander (2005). It is interesting to see whether software in CEE shows patterns of enclave or integrated sector. Fourth, software is an essential infrastructure of the knowledge based economy and its progression can be considered a good proxy of the extent to which the European Union has made progress towards the Knowledge Based Economy. Fifth, research on software in the European Union may indicate whether there are any signs of an emerging division of labour in the wider Europe similar to automotive and electronics industries. Finally, patterns of divergence/convergence in software industry may indicate whether there is a 'tiering' of the European Union along lines noted in electronics and automotive vs. clothing and wood which goes along Central vs. Eastern Europe

In addition to these Europe oriented questions one could hope to contribute to better understanding of several general questions regarding globalisation and industrial networks. For example, some of the important questions are:

- 1) What is the role of international cooperative agreements (ICA) in firms' growth and what are their features? Software industry is very 'intensive' in terms of international cooperative agreements and it is of interest to explore what is the contribution of ICA to firms' growth.
- 2) What are determinants of productivity, quality and complexity increases at firm level? Are these intra-firm factors (resource based) or factors related to networking variables (inter-organisational)?
- 3) What are functional (area of cooperation), firm, and country determinants of knowledge spillovers from export to local production, or if any?
- 4) Which factors distinguish between local markets oriented vs. export oriented and between technologies vs. services oriented firms?

The research is based on a firm based questionnaire of 25 questions. Data are collected from 234 firms in six European Union countries. See table below. These firms employ 13984 people in several countries and they represent very significant part of the overall software industry.

Table 1. Number of firms and number of employees in eight countries

	No of firms	No of employees
Slovenia	23	1116
Czech	34	4775
Estonia	38	739
Serbia	38	974
Romania	41	2021
Bulgaria	50	3355
Hungary	4	479
Latvia	6	525
Total	234	13984

Descriptive statistics have been computed in base of t initially collected data for 3 countries. However, overall data have been checked and tabulated and it is expected that complete descriptive analysis will be available during March/April 2006. This will be followed by econometric testing and by multivariate data analysis. The results presented here are based on the first three analysed countries: Estonia, Czech Republic and Slovenia.

The common features of the sample of software firms in 3 CEEC are:

- 1) These are dedicated software firms i.e. software is their main line of business in three quarter of cases.
- 2) They are mainly independent firms (75%).
- 3) With highly concentrated ownership (first 3 owners = 74%).
- 4) In terms of nationality, majority of firms are domestic private (77%) with smaller share of foreign controlled firms (21%).
- 5) In terms of market orientation firms are mainly (77%) local market oriented while share of export is 23%.
- 6) There are significant differences between countries in terms of age of firms. In Estonia firms are mainly young, in Czech Republic old, while in Slovenia dominate old & middle aged firms.

- 7) There are also significant differences in terms of size. In Estonia 91.8% of firms are small firms (1-50 employees). In Slovenia, size structure is quite similar with 95.4% small firms. In Czech R 94.1% firms are in between 11-1000 employees.
- 8) Shares of firms with quality certificates is also different across three countries with share of 81% (EE), 64% (CZ), and 55% (SI).
- 9) There are also notable differences in terms of types of ICAs (sales, technology, production related).
- 10) Major areas of activities are:
 - Products and product related services (application SW, consulting, implementation)(63%);
 - Maintenance and infrastructure services (system infrastructure SW, support services) (20.3%);
 - Tools and others (16.7%).

Among other interesting descriptive results, the following results can be highlighted:

- 1) There is an increasing gradual orientation towards export as export share increased from 11-13% in 1999 to 19-40% in 2003.
- 2) Firms have reported 'substantial' increases in productivity (63.9-84.8%), complexity (75-85%) and quality (62-84% of firms).
- 3) The factor of competitive advantage of firms in export is price while on local market it is programming capabilities.
- 4) Competitive weaknesses are poor marketing, high costs, lack of programmers and designers
- 5) Links with foreign partners are extremely/very important in design (37.7%), quality (47.5%), marketing (55.4%) and sales (for 65.1% of firms)
 - 60-75% of firms participate in training programs organized by foreign partner;
 - 70-100% offer training to local clients;

- 77-88% have formalised relationship with local partners through cooperative agreement;
- Areas and number of partnerships (cooperation) are:
 - Sales related (authorised distributor, VA reseller, authorised system reseller + licensee 16) = 155;
 - Sourcing related (subcontracting 32, co-production agreement 10) = 42;
 - Technology related (joint product dev, R&D) = 32;
 - Ownership related (J-V, FDI) = 33;

In later stages the following models will be explored:

- Determinants of change in productivity, quality, complexity;
- Size, market orientation, ownership, concentration of ownership, nationality, (in)dependence, age, year of entry into SW, country dummy, quality certificates, types of ICAs, participation in training, labour turnover;
- Determinants of export spillovers i.e. transferability to local projects;
- Age, size, nationality, country dummy, type of ICAs, type of product, (in)dependence, no of foreign partners, participation in training programs, labour turnover, (market orientation, productivity increases);
- Compare determinants and differences between:
 - Sales oriented vs technology production oriented ICAs (firms)
 - Export vs. local market oriented firms

1.4. Complementarity of innovation strategies

The node in charge of the research on the complementarity of innovation strategies was IESE Business School. This node dealt with the changing organization of the innovation process. In particular, it has been observed that the innovation process has gradually become more "open". Firms can no longer rely solely on internal information sources for their innovation process. As a result firms tend to combine different innovation activities such as internal R&D, licensing, R&D contracting and cooperation in R&D. The papers

document these changes in the innovation process and the open innovation design and the related performance effects within different contexts.

The first piece of work is related to the publication "In search of Complementarity in the Innovation Strategy: Internal R&D and External Knowledge Acquisition" by Cassiman and Veugelers, forthcoming in Management Science.

Successful innovation depends on the development and integration of new knowledge in the innovation process. In order to successfully innovate, the firm will combine different innovation activities. In addition to doing own research and development, firms typically are engaged in the acquisition of knowledge on the technology market. This paper provides evidence consistent with complementarity between these different innovation activities, i.e. the marginal returns to one activity are increasing in the other activity. Using data from the Community Innovation Survey on Belgian manufacturing firms, first it is shown that firms that are only engaged in a single innovation activity, either internal R&D activities or sourcing technology externally, introduced fewer new or substantially improved products compared to firms which combine internal and external sourcing. Next, it is found that the different innovation activities are strongly positively correlated and identify the reliance on basic R&D as a source of complementarity between internal and external innovation activities. Furthermore, given that the effectiveness of strategic protection only directly affects the incentive to source internally, it provides evidence for the existence of complementarity because of a positive (indirect) effect on external knowledge acquisition. While the results should be interpreted cautiously, taken together they do provide more convincing evidence for complementarity between different innovation activities.

The second publication is "Optimal Project Rejection and New Firm Start-ups" by Cassiman and Ueda, forthcoming in Management Science. Start-up companies are often the result of rejection of an idea by an established corporation. For example, Wal-Mart came about when the management of Ben Franklin declined Sam Walton's idea to locate discount stores in small towns in the south-western United States.

Similarly, when General Electric declined the idea of one its engineers to create a B2B marketplace for suppliers, the engineer founded FreeMarkets in his basement. While analyzing the case histories of various new ventures, it was noted that many successful entrepreneurs first share their innovative ideas with their employer. Only once the employer has rejected the idea do they go out on their own. This raises the question of why established firms sometimes forego innovative, good projects that are later successfully launched by start-up firms. Contrary to the widespread belief that good

projects slip away because of poor management or weak protection of property rights, it is argued that established and start-up companies simply adopt different types of projects due to an optimal project allocation mechanism. Hence, established firms tend to wait for projects that complement their existing assets, while start-up firms benefit from more innovative, radical projects that fall outside the scope of an established firm's likely portfolio. However, established firms can substantially improve the performance of their innovation process by consciously managing the efficient allocation of internally generated new ideas between internal innovation projects and start-up firms.

The third publication is "The Impact of M&A on the R&D Process. An Empirical Analysis of the Role of Technological and Market Relatedness" by Cassiman, Colombo, Gerrone and Veugelers, 2005, *Research Policy*, 34(2), p. 195-220. Using information on 31 in-depth cases of individual M&A deals, it is shown that technological and market relatedness between M&A partners distinctly affects the inputs, outputs, performance and organizational structure of the R&D process. While the findings in the literature on the effect of M&A on R&D are quite mixed, results can be sharpened by analyzing data at the level of the R&D process. This comes at the price of a smaller sample and more qualitative data, for which caution in the interpretation is necessary. M&A between partners with ex-ante complementary technologies result in more active R&D performers after the M&A. In sharp contrast, when merged entities are technologically substitutive, they significantly decrease their R&D level after the M&A. Moreover, R&D efficiency increases more prominently when merged entities are technologically complementary than when they are substitutive. These two findings on the R&D level and the performance support the scope economy effect of M&A, on the one hand, and reject the scale economy effect of M&A, on the other. Next, for cases in which partners were active in the same technological fields before the M&A, the reduction of R&D is more prominent, while the R&D efficiency gain is smaller if merged entities were rivals in the product market prior to their merger than if they were non-rival. This suggests that rival firms reap little technology gains from mergers.

Another publication is "R&D Cooperation between Firms and Universities: Some empirical evidence from Belgian manufacturing" by Bruno Cassiman and Reinhilde Veugelers 2005 *International Journal of Industrial Organization*, 23 (5-6), p. 355-379. This paper presents an econometric analysis of firm and industry characteristics conducive to cooperation with universities, using Community Innovation Survey data for Belgium. It is found that large firms are more likely to have cooperative agreements with universities. These agreements are formed whenever risk is not an important obstacle to innovation and typically serve to share costs. Consistent with the open science paradigm, no evidence is found for the importance of the capacity to appropriate the returns from

innovation for explaining cooperative agreements with universities. It is argued that cooperating with universities is complementary to other innovation activities such as performing own R&D, sourcing public information and cooperative agreements with suppliers and customers. Therefore, the decision to cooperate with universities cannot be analyzed in isolation from the overall innovation strategy of the firm.

Another paper is "Shifting the boundaries of innovation: why, when and where" by Cassiman, Di Guardo and Valentini, published in *Iniciativa Emprendedora* (Spanish Version: "Abrirse para Innovar," fall 2004, p.25) This paper exploits the findings of the working paper "Organizing for innovation: R&D Projects, Activities and Partners" for a more lay-management audience. The paper discusses how organizing for innovation by opening up the innovation process can be beneficial to the firm.

In "M&A and Innovation" by Cassiman, 2005, *Universia Business Review*, p.56-69, it is shown that with both M&A and innovation being centerpieces of today's competitive strategy development, it is important to understand the consequences of M&A transactions on the innovative potential of firms. In this article it is argued that the impact of M&A on R&D and innovation depends on the technology and market relatedness between the target and the acquirer and that the key to realizing the innovation potential of the M&A lays in a careful understanding of how the integration process affects the innovation process depending on this relatedness between the M&A partners.

A pilot study is proposed to examine the performance of text-based profiling in recovering a set of validated inventor-author links in "Measuring Industry-Science Links through Inventor-Author relations: A Profiling Methodology" by Cassiman, Glenisson, Van Looy and Arnold Verbeek, forthcoming in *Scientometrics*. In a first step patents and publications are matched solely based on their similarity in content. Next, inventor and author names are compared on the highest ranked matches for the occurrence of name matches. Finally, these candidate matches are compared with the names listed in a validated set of inventor-author names. The text profile based methodology used here performs significantly better than a random matching of patents and publications, suggesting that text-based profiling is a valuable complementary tool to the name searches used in previous studies.

Another piece of research was published in "The Organization and Performance of R&D Projects" by Cassiman, di Guardo and Valentini, which is in a revise and resubmit stage for *Long Range Planning* Faster technological development, shorter product life-cycles, and more intense global competition have transformed the current competitive

environment for most firms. This new competitive landscape forces organizations to actively acquire knowledge since a firm's competitive advantage is now more dependent on continuous knowledge development and enhancement. Therefore, knowledge has become a central theme in strategic management. Along these lines, it is argued that the knowledge characteristics of R&D projects are fundamental variables to explain governance decisions. Drawing upon the case of STMicroelectronics, some evidence is provided showing that partnering or contracting with universities for innovation is common practice for developing new -original- knowledge as opposed to applying existing knowledge to a problem. But the firm is more reluctant to partner, especially with another firm, when this knowledge directly enhances its competitiveness. Moreover, it is found that R&D projects' performance is a bi-dimensional construct. One dimension picks up project efficacy and immediate benefits, while the other includes learning and long-term benefits. Though spanning the boundaries of the firm for innovation does not seem to have appreciable effects on the perceived projects efficiency, it nonetheless brings about intertemporal benefits related to learning and capabilities development. In a dynamic environment, building knowledge may be more important than protecting it. Thus, an open innovation process can constitute an exceptional means to build and develop the firm's technological future.

An important issue is the governance of R&D projects. This was researched in "Organizing for innovation: R&D Projects, Activities and Partners" by Cassiman, di Guardo and Valentini. It is explored how R&D project characteristics condition the governance of an R&D project and its individual activities. Prior literature has tried to understand the factors - both at the industry and at the firm level - that influence the way in which firms partner for innovation. In this paper, through the analysis of detailed data at the R&D project and activity level from a subsidiary of ST Microelectronics, the main drivers of partner selection for innovation are identified. Consistent with prior literature, it is found that the majority of R&D projects span the boundaries of the firm through R&D partnering or contracting. Partnering or contracting with universities for innovation is common practice for developing new -original- knowledge as opposed to applying existing knowledge to a problem. But the firm is more reluctant to partner, especially with another firm, when this knowledge directly enhances its competitiveness. However, conditional on partnering with a university, the firm is more likely to have the university lead individual activities when the project is strategically important, exploiting the university's resources. Contracting for innovation as opposed to partnering with universities or research centers happens for more experimental projects, where very original knowledge is developed and typically early on in the project.

The relation between the organization of innovation and performances is studied in "Spanning the Boundaries of the Firm in Innovation: R&D Projects Organization and Performance" by Cassiman, Di Guardo and Valentini. A first question that needs to be addressed is how to measure performance. Two project performance measures are constructed: a first one related to efficiency and a second one related to learning. Next cooperation with firms and universities are related to both of these measures taking care of endogeneity of the organization decision.

The relation between M&A and technological indicators is analyzed in "M&A and Technological Performance" by Valentini. This paper analyzes the effect of M&A on technological performance as measured by patenting output and patents quality. I propose a model of the innovation process in which the process output depends on the resources available and on the incentives to employ them. I then discuss how M&A can provide new resources and modify the incentives. I identify the consequential effects on technological performance and test the predictions on sample of deals that took place in the U.S. "Medical devices and photographic equipment" sector between 1988 and 1996. Preliminary results indicate that M&A have a nonsignificant or positive effect on patenting output, but decrease patents importance, originality and generality.

There is also an old research issue that analyzes the relation between innovation and exporting performance. This issue has been tackled in "Product Innovation and Exports. Evidence from Spanish Manufacturing", by Cassiman and Martínez-Ros. Does innovation spur export activities by firms? And if so, which type of innovation - product or process-matters? The analysis uses a panel of Spanish manufacturing firms for the period 1990-1999. Results suggest that innovation is a very important driver of exports; in particular, it is found that product innovation activities positively affect the decision to export. In addition, a strong nonlinear relation between the firm's size and export behavior is found, suggesting an optimal size for top export performance. Foreign owned firms are more likely to export due to lower sunk costs as they presumably form part of an international network.

1.5. Open source software

An interesting case of the changing nature of the innovation process is the case of open source software. The process of innovation in this area is very special, since it does not depend on property rights on the knowledge produced by on know-how and the sale of services.

This issue has been tackled by Fosfuri and Ronde (2004), "High-tech clusters, technology spillovers, and trade secret laws". The objective of this work was twofold. First, it

provided original evidence on the commercialization of Opens Source Software (OSS) products by profit-oriented organizations. Second, it attempted to explain what motivates firms to take different strategic postures vis-`a-vis OSS. In this respect, different streams of literature posit that, when faced with a new industry scenario, some of the firm's assets are critical to guarantee the return on investment, while others might hinder the movement into the new competitive arena (Tripsas 1997; King and Tucci 2002).

OSS constitutes a new mode for organizing innovation and writing software code because it originates from the interactions of a network of loosely related developers brought together by thousands of seemingly independent projects. At the heart of OSS is a license, which, under different terms, waives the principal rights granted to the original creator by copyright law. Therefore, OSS grants users the right to access, modify and redistribute the source code, usually without imposing any conditions on the software product distributed along with the licensed code. These characteristics contrast sharply with the dominant model for proprietary software where firms conceal their source codes and use license contracts to deprive users of the ability to share and modify the original programs.

Although there are no fully reliable data, both anecdotal evidence and experts' assessments seem to suggest that, over the last decade or so, OSS development began to have a tangible impact on the competitive dynamics of the overall software industry (Lerner and Tirole 2002). This trend has coincided with the upsurge in economic and management research focused on understanding the OSS phenomenon. In particular, a substantial effort has been made to study the allocation of rewards within OSS projects and the overall incentive structure of independent developers (e.g. Lerner and Tirole 2002; von Hippel and von Krogh 2003). Yet, very little is known about the actions and strategies adopted by profit-oriented firms with respect to OSS.

This view contrasts with the increasing commercial attractiveness of OSS that the specialized press has highlighted recently. Indeed, companies such as IBM, Sun Microsystems and Oracle, have invested in and legitimized the use of Linux for enterprise applications (Koenig 2004). For example, Novell realized Linux-related product revenues of USD44 million in the first quarter of 2005; this accounted for 15% of its total sales in that period (eWeek 2005).

Specifically, the paper investigated the role played by a firm's downstream (market) and upstream (technology) assets as drivers for the rate of OSS product introduction. Two theoretical contributions inspired this approach. First, as suggested by Teece (1986), when IPRs are weak, firms can only rely on the control of complementary downstream

assets to guarantee the appropriation of their innovation investments. The argument enriches this view by distinguishing between hindering and favoring assets (Tripsas 1997). Second, since OSS can be viewed as a repository of public knowledge, absorptive capacity must dictate the ability to identify, assimilate, and exploit information that is freely available outside a firm's boundaries (Pennings and Harianto 1992). If so, pre-existing technology assets should be critical to assess the level of a firm's absorptive capacity (Cohen and Levinthal 1990; Ahuja and Katila 2001). The paper will test this prediction.

To tackle this issue, the work used a novel dataset of firms that have announced releases of products based on an OSS license in the specialized press (Source: Infotrac PROMT). All the most important economic variables of the firms that introduced a product were added (size, age, sector). In the econometric estimation, the paper predicted the number of OSS product releases through a firm's endowment of pre-entry assets. The choice of the dependent variable was based on a consolidated view in management literature (e.g. Garud and Kumaraswamy 1993) that highlights how competitive advantages in open system environments are reliant upon the continual introduction of new products. The dataset was rather comprehensive and tracked down all OSS product introductions from 1995 to 2003 in the two major software niches: Operating systems and applications. 461 different companies that have introduced at least one software product released under an OSS license scheme were identified.

With a corrected Poisson model (Terza 1995) the results showed that the rate of OSS product introduction was correlated positively to hardware downstream assets, and negatively to software downstream assets. Moreover, a large endowment of pre-entry software technology assets favored the shift to the new paradigm.

2. The changing organisation of the production process: entrepreneurship, clustering, and "Silicon Valley" models

In the previous section the main research theme was focused on the innovation process, while here the attention is turned towards the production process itself. The effects on entry and exit of new firms are first analyzed, to later move to the role of large corporations, complemented by the analysis of strategies of small and medium firms. Two other issues that were analyzed in this section were the cumulative nature of innovation and finally skill-biased technical progress.

2.1. Entry and exit processes

Industries which are shaken by radical innovation are prone to entry and exit processes which last longer than what traditional theories predict. This issue has been addressed in the research reported in the paper by Fosfuri and Giarratana "Product Strategies and Survival in Schumpeterian Environments: Evidence from the US Security Software Industry".

This research addressed the question of the drivers of success in such turbulent and constantly morphing environments by empirically examining the drivers of a firm's survival in a Schumpeterian environment, i.e. an environment where entry and exit barriers are small, economies of scale play a marginal role, product innovation paces fast, and firms' competences are placed under a fierce selection process (Covin and Slevin 1989; Schmalensee 2000). Schumpeterian environments might sometimes constitute the DNA code of some specific industries. Examples include laser, software, semiconductors and biotechnology (Barnett and Freeman 2001; McKendrick et al. 2003), which have shown little sign of consolidation across time.

Specifically, the contribution of this work was to underscore the impact of post-entry product strategies on a firm's survival beyond "at entry" factors and initial conditions - which have been identified as determinants of survival by the industrial organization literature (Audretsch 1991; Klepper 2002), and after carefully controlling for environmental and demographic conditions (Hannan 1997). In Schumpeterian environments the rapid pace of product innovation and the great dynamism and uncertainty make entry factors and initial conditions less consequential and product strategies more vital.

To address the research question, the work drew on a population of 270 firms that have entered the US Security Software Industry (SSI) since its inception in 1989 till 1998. SSI is a relatively recent segment of the software industry, and constitutes a quintessential example of a Schumpeterian environment. SSI was an interesting test-bed for several reasons: i) it is a technology-based industry where product innovation plays a major role; ii) it displays an important level of entry and exit, with little sign of consolidation around a few large players; iii) entry and exit barriers as well as scale economies are rather low; iv) competition takes place mostly among young ventures, whereas mature de alio entrants are marginal players. A distinguished feature of this research setting compared to previous industry studies, e.g. computer hardware (Sorenson 2000), cars and tires (Carroll et al. 1996; Dobrev et al. 2002; Klepper 2002), was the peculiar nature of the products, which makes product strategies even more interesting. Software

products tend to depreciate in value over time much faster than physical products. Additionally, software manufacturers typically have more horizontally differentiated offerings within a product category because of the low marginal cost of increasing scope (Gandal 2001).

The population sample was composed by all firms that have introduced at least one product in the US SSI. Product introduction data were taken from Infotrac's General Business File ASAP and PROMT database (former Predicast) that, from a large set of trade journals, magazines and other specialized press, reports several categories of events classified by industrial sectors. All press articles that reported a "Product announcement", a "New software release" and a "Software evaluation" in SSI (SIC Code 73726) from 1980 to 1998 were scanned. Then, from each article, the name of the company, the event date and the six digit SIC code of the product was extracted. The first product was introduced in 1989. From 1989 to 1998, there were 270 different entrants that have introduced 1,125 different products. About the exit, 78% of the exits represents a complete termination of a firm's activity and the remaining 22% constitutes exit from the US SSI. The final sample is formed by 604 company-year observations with 162 exit events.

With a hazard model, the paper found evidence that surviving entities were those that more aggressively adopted versioning and portfolio broadening strategies. Versioning is a strategy that implies the generation of multiple releases of a product within one niche, whereas portfolio broadening occurs when a firm's product strategy covers several industry niches. Moreover, the paper showed that focusing on one of the two product strategies commanded a higher survival probability than adopting a mixed strategy, which involved both a versioning and a portfolio broadening strategy. So, a unique strategic orientation helped firms to increase their survival probability. Interestingly enough, other things being equal, pioneers did not command a significantly higher likelihood of surviving, whereas technological capabilities played an important role.

A second line of research within this section produced the paper "Entry and Survival in Foreign Markets: Technology, Brand Building and International linkages" Giarratana and Torrisi, under a first invited resubmission on *Journal of international business studies*. The work offered a conceptual framework and novel empirical evidence to explain and predict the patterns of entry and survival in foreign markets by firms of emerging regions. More precisely, it explored the effects of firm-specific and location-specific characteristics on entry and survival in the US market for a sample of 875 Irish, Indian and Israeli firms. The regions selected were an ideal test-bed for several reasons. First, scholars and the specialized press have noticed the rising importance of the software

industry in these regions in recent years (Arora et al., 2004; Arora and Gambardella, 2004). Second, because of the limited size of their domestic software market, the access to foreign markets represents a necessity for domestic firms of these regions. As a matter of fact, fast growing firms of these regions have gone international quite soon after their start up. Third, historical linkages with the communities of expatriates and the abundance of English-speaking software engineers have reduced the cost of access to foreign markets like the US.

The methodology was based on building upon the potential differences between entry and survival, the empirical analysis addressed two broad questions. First, the work highlighted which factors affect the firm decision to enter the US market, separating different factors that may affect the entry decision and also the speed of entry into the US. The second question was about the factors that determine firm survival in the US market, if these factors are similar or different from those affecting entry.

In the empirical part, the work employed data from US Software trademark registration and renewal. To this purpose, the work considered the year when the firm registers its first trademark at the USPTO dataset as a proxy for market entry. The small size of many firms in the dataset made it very difficult to obtain reliable data on the exact time of entry into the US. The covariates included proxies for firm's technological assets and international alliances, country-specific characteristics and other controls. Then, the work used trademark renewals and new trademark applications as a proxy for survival in the US software market. Trademarks imply direct monetary and indirect administrative costs - the owner must file a trademark application for each class of goods/services, pay application fees and renewal fees, file a statement of use, demonstrate that it uses the mark in commerce and file requests for time extension. Maintenance costs include attorney fees. Trademark's owners who continue to register new trademarks or renew existing trademarks then must enjoy some positive net benefits from their investment. The duration of trademark registration in the USPTO seems to be a fairly good proxy for firm survival in the US market.

The work presented three main results. First, firms based in countries that have strong ties with foreign markets tend to have limited entry costs. This is suggested by the fact that many firms have entered the US market without possessing significant technological capabilities measured by patents. However, amongst firms that have entered the international markets, those which have greater technological capabilities entered before others. Second, international alliances, most of which with US firms, are a good predictor of entry decision and the speed of entry. This is because they reduce the cost of access to foreign markets and help establishing a reputation. Third, the work found that survival

is positively associated with firm technological capabilities and international alliances. The scope of factors that explain survival is much wider than that which accounts for entry and this is clearly due to the variety and complexity of resources and capabilities required to grow in competitive markets. The positive effect of international alliances in particular suggested that beyond the strong historical ties between the home country and the US, the firm's capacity to establish linkages with foreign markets represents an important determinant of success.

Marco Giarratana contributed a study on the behaviour of incumbents and the creation of new markets. The results are summarized in the working paper "Missing the Starting Gun? Incumbent Entry Decision into New Market Niches". The aim of this work was to tackle the issue whether imitators take advantage of the knowledge developed by technology pioneers and by their eventual strategic mistakes. In answering this question, entry timing takes central stage as one of the most important variables of firm choice, at least as well critical as the decision of where' to enter. This represents an underestimated approach given that large part of the existing literature has focused on the relationship between incumbent competencies and the trajectories of firm diversification (see for a survey Silvermann, 1999), almost ignoring how entry timing decisions could affect this process. Two are the essential regularities observed across many industries. One is that large established firms carry out the most important part of R&D investments to explore new technological trajectories and to build a diversified technological portfolio. They also produce by far the largest part of world innovations and patents (Pavitt and Patel, 1997). Second, by the same token, a wide collection of industry cases (Henderson, 1993; Schnaars, 1994; Shane, 2001) shows how often incumbents that own the required technological and commercial assets prefer to adopt wait-and-see and catching-up strategies, leaving to new ventures the task to open new markets. In addition, empirical evidence (Christensen, 1997; Bhide, 2000) suggests that not only founders of innovative start-ups are often former employees of large established firms, but that they also shaped their projects exploiting "sleeping" resources of mature organisations. Taken this viewpoint, the creation of new markets and the diffusion of innovations are generated by the interaction between the ability of late-comer incumbents in leapfrogging market pioneers and first mover advantages gained by first product developers that were imitators of the leading technology. It is straightforward that incumbent entry timing decisions are at the foundations of the process, since they could explain how and when a new industry emerges and what organizations are the main actors in the different industry phases.

The aim of this work was to understand if, aware of these "rules of the game", incumbents take strategic entry decisions exploiting all their existing resources. Or,

conversely, if firm entry decisions are more driven by “rule of the thumb” mechanisms that fail to take in account all the information available.

For the empirical part of the work, an extensive database on the Encryption Software Industry (ESI) was constructed. ESI is an ideal case study, because it shows how first innovators could not (or do not want to) exploit all the technological competencies they created and to some respect, they could lose their initial advantage to the benefit of new comers. During the mid 1970s, the market opportunities arising from the military sector spurred established electronic firms to accumulate knowledge in Encryption. But then, first technological movers were late to enter into downstream markets, leaving newcomers the opportunity to dominate the industry. The work relied on a sample of 174 established firms which could be defined as potential entrants in ESI. Potential entrants could be firms that were granted at least a patent in 380 class from 1976 to 1999, or firms that signed at least a marketing alliance in ESI in the period 1990-1999, or firms that entered in ESI. The covariates were divided in two different groups. The first is composed by general sector and economic variables that, not directly linked with the ESI market, are neither directly controlled by firms nor modifiable in the short run. The second was formed by variables that could be defined as assets tailored specifically to influence the entry in ESI and that firm could easily modify in the short run. A Tobit model estimated the entry time decision in terms of year of lag entry. The results showed that firm specific competences, alliances and patents, do not play a significant role in incumbent entry timing strategies.

The work by Marianna Mazzucatto has also dealt with the effect of risk on firm growth and industry turbulence. For instance in “Innovation and Idiosyncratic Risk: an Industry and Firm Level Analysis” (jointly with M. Tancioni) to gain further insights into why IR has increased over time, they use industry level data (for 34 industries from 1976 to 1999) and firm level data (for 5 industries with different levels of innovativeness, from 1974 to 2003) to study if industries considered very innovative (in sectoral taxonomies of innovation a la Pavitt 1984) and R&D intensive firms are characterized by higher IR due to the greater uncertainty regarding their expected future profits (successful innovation leading to high growth and “dry holes” leading to low growth). The industry level results prove inconclusive: the hypothesis of greater IR for innovative industries holds only for some industries in the extremes of the taxonomy, i.e. for very innovative and for low innovative industries. The firm level results are encouraging: a clear relationship is found between a firms R&D intensity and the volatility of its returns. The results provide new insights into how differences in innovation effort affect the dynamics of stock price volatility.

In further work, Mazucatto and Tancioni have related firm idiosyncratic risk with stock market volatility, in the study "Patent Citation Dynamics and Stock Prices: the case of Pharma-Biotech". The paper studies the relationship between the level and volatility of firm level stock prices and firm level innovation. It does this by studying whether firm specific returns are more volatile for firms whose patents are more important. Importance of patents is measured through their citation intensity. By relating firm stock price volatility to firm-specific innovation activities it tries to better understand recent increases in the level of idiosyncratic risk, which have been attributed to the impact of the IT revolution (e.g. New Economy factors), with little empirical evidence for this.

2.2. The role of large corporations

Fabrizio Cesaroni has contributed in this section of the project with his paper "Technological outsourcing and product diversification: do markets for technology affect firms' strategies?", published in *Research Policy*. The aim of this work was to analyse the influence that technology markets play on firms' technological and diversification strategies. While the managerial literature has discussed the causes and motivations of diversification and of technology outsourcing for a long time, it has only recently discovered the importance of markets for technology and the influence that they play on corporate strategies (Arora et al., 2001; Gans and Stern, 2003). These recent studies have mostly explored the supply side of markets for technology. In this study the opposite perspective was taken into account. The aim was to assess how the possibility to purchase (not commercialise) technologies on the open market affects firms' technology sourcing decisions, and their propensity to enlarge their product portfolio by entering into new product markets. Specifically, two hypotheses were tested in this work. The first hypothesis was intended to assess whether a larger market for process technologies induces chemical companies to substitute internal technology development with the acquisition of technologies from external suppliers. The second hypothesis was intended to assess whether a larger market for process technologies increases the propensity of chemical companies to diversify into new market segments within the chemical sector.

The empirical analysis developed in this work has been performed by using plant-level information drawn from the Chemintell database, which lists all the production plants built worldwide from fifties to late nineties. It was possible to consider the production plants of a sample of 96 chemical corporations from the US, Europe and Japan. Information on the chemical compound produced in each plant was used in order to define the firm's product portfolio, and hence to determine the firm's diversification choices. Information on the technology supplier which provided the process technology

used in each plant was used in order to define the firm's sourcing decisions. Additional information on firms characteristics was collected from the Standard & Poor's Compustat database. The econometric estimation has been conducted by using different specifications. The principal aim was that of assessing the behaviour of the companies over time. The production plants owned by the sample companies were split into two sub-groups, before and after 1983. From the first group the explanatory variables were obtained (e.g., the size of the market for technologies), and from the second group it was possible to obtain the dependent variables (the technology source and the novelty of the production). Hence, the dependent variables were regressed against conditions existing in the past. In order to reduce potential problems of autocorrelation arising from the use of lagged variables, two other solutions were tried. Moreover, the behaviour of the companies across countries was assessed. Because all the companies are from OECD, the dataset was split up into plants located in OECD and plants not located in OECD, but always owned by the companies in the sample. Again, the information from non-OECD plants was used in order to obtain the dependent variables, and information from the OECD plants to obtain the explanatory variables. For the analysis of the first hypothesis a three-level index was used as the dependent variable, which takes into account firms' plant-level decisions concerning the source of the process technology used in each plant. Specifically, this variable takes the values 0, 1 and 2, meaning the situations of New Licensor, Repeated Licensor and Internal Staff, respectively. A multinomial logit specification was used to test this hypothesis. As far as the second hypothesis is concerned, a binomial index was defined, which identifies the novelty of the production in each plant located in non- OECD or built after 1983. The variable takes on value 1 if the chemical compound produced in the plant is new to the company, i.e. it is a product that the company does not produce in any other OECD plant, or that the company did not produce before 1983. On the contrary, the variable takes on value 0 if the same chemical compound is also produced in another plant located in OECD or built before 1983, by the same company. This variable was regressed against the set of explanatory variables by using a Probit model.

The results that emerged from the Multinomial Logit model show that the probability of purchasing the technology from an external licensor (both through a one-shot or a repeated contract) increases as the size of the market for process technologies enlarges. In the presence of a large number of potential technology suppliers, a division of labour at the level of the industry is a feasible solution. As a specialised upstream sector of independent technological suppliers arises, the advantages of an internal engineering division become less important. Hence, companies tend to substitute in-house technology development with technology outsourcing. However, this relationship is not linear.

Apparently, from a certain number of licensors onward, the advantages of the market for technology decline, probably due to emerging diseconomies. It also emerged that, particularly relevant is the role played by the firm's technological competences. It appears that firms substitute in-house technology development with outsourcing, especially when they lack the appropriate competences and know-how. Conversely, firms which invest a large amount of their sales in research activities, or that have largely invested in plant setting-up by using proprietary technologies tend to exploit those investments by using the same technologies in their plants, and do not have enough incentives to switch to technology outsourcing. Finally, another result that emerged from the multinomial model shows that as the size of the licensor increases, the probability of repeated outsourcing increases as well, while the probability of new licensors decreases. The results that emerged from the Probit model show that, first, a company is more likely to set-up a plant to produce a chemical compound, which is new to its product portfolio the higher the number of technology licensors. This result seemed to confirm that the extent of the market for technology does affect firms' diversification strategies. Although it was not possible to take into account organizational or cost dimensions into the model, it is presumable that larger markets for technology offer to companies the opportunity to overcome internal technological constraints at lower costs. Second, this pattern seems particularly relevant in the case of smaller companies. Third, as suggested by the managerial literature, internal technological competences seem to affect firms' diversification choices. In particular, the result that emerged in this sense revealed that the propensity to diversify increases the higher the resources that are allocated to product R&D, and decreases the stronger the firm's competences in process technologies. In this latter case, the company prefers to exploit its technological competences by replicating plants using the same process technology.

Another line of research on the role of large corporations addresses the issue of the capacity of large corporations to absorb external knowledge. The work is reported in "Fingerprints of the Visible Hand. Chandlerian Organizations and their Inward Looking Malaise", by A. Gambardella and M. Giarratana. This work has complemented the studies on the nature and the formation of the outward potential absorptive capacity (AC) by studying the determinants of the inward realized AC. In so doing, the work has contributed to a thorough understanding of the different facets of the knowledge of the firm. Already when Cohen & Levinthal (1990) introduced the concept of absorptive capacity (AC), they distinguished between inward AC, which relates to the ability of the firm to exploit intra-organization knowledge, and outward AC, which refers to the firm's attitude to absorb knowledge produced outside its boundaries. Since then the notion of AC has been widely discussed under different perspectives (Lane & Lubatkin, 1998;

Sheremata, 2000; Lenox & King, 2004). However, recently, most studies have focused on the outward side. An important reason is that during the past two decades or there have been broad changes in the structure of firms which have increased their attention towards knowledge and resources outside their boundaries. Correspondingly, the literature has highlighted the factors that underpin the firms' ability to learn from the external environment, and a good deal of work has discussed AC in the context of the formation and development of firm networks and alliances (Arora & Gambardella, 1990; Ireland, Hitt, & Vaidyanath, 2002). The growing attention towards external knowledge has not diminished the need to understand how internal knowledge is formed and managed. For example, no trend towards "hollow" corporations can be seen, and internal knowledge still plays a central role in the production of the firms' innovations, capabilities and performance. At the same time, the interaction between inward and outward AC is central to the understanding of the overall knowledge base of the firm, whether because internal and external knowledge are complementary (e.g. Cassiman and Veugelers, 2005), or because the over-utilization of the firm's internal knowledge can produce "rigidities" that prevent it from taking advantage of emerging external opportunities (Christensen, 1997; Tripsas and Gavetti, 2000; Ahuja & Lampert, 2001). Nonetheless, the relationship between the two faces of AC has received limited attention. Moreover, only Zahra & George (2002) have highlighted the difference between potential and realized AC, viz. knowledge that the firm is able to assimilate and correctly understand vis-à-vis the knowledge that it actually exploits. In this respect, the link between the firm stock of knowledge and its AC produces a natural tension. On the one hand, the extent of the firm knowledge base determines its ability to absorb new external knowledge (Cohen & Levinthal, 1990): The larger the firm, the greater its outward potential AC. On the other hand, substantial empirical evidence shows how the large firms with diversified competence portfolios are more likely to exploit their existing internal resources and established R&D or product trajectories (Henderson, 1993; Levinthal & March, 1993; Dougherty & Heller, 1994), unlike the small and young firms which make greater use of external knowledge and resources (Tallman, Jenkins, Henry & Pinch, 2004; Owen-Smith & Powell, 2004). This suggests that the larger the firm, the greater its inward realized AC.

The work has isolated two main determinants of the inward realized AC: Firm size and organization divisionalization. The question was relevant both from a theoretical and an empirical perspective. From a theoretical point of view, the two concepts are different. Yet, the underlying differences are seldom highlighted. In fact, the concepts are related, as the larger firms are typically more divisionalized. This arises because, as Chandler (1977) taught us, divisionalization is the way to govern the firm when increases in its

scale make it hard to manage it in a centralized fashion. But the reasons why they affect the formation and use of internal knowledge are different. From an empirical perspective, because the two concepts are correlated, it is hard to find separate proxies for them. However, this work succeeded in this goal. Finally, the analysis lied at the intersection between the behavioral approach (March, 1988; Levitt & March, 1988; Levinthal & March, 1993) and innovation studies, particularly those related to the evolutionary theory of the firm (Nelson, 1961, 1982). Both streams of the literature have highlighted how size and organizational forms model the type of information used and affect the firm decision of projects' and investments' selection.

The work discussed two hypotheses. The first one stated that the propensity to use internal knowledge assets increases with the size of the firm. The rationale is that the increase in sunk costs, which is more pronounced as the firm size increases, creates firm-level economies of scale on existing trajectories or economies of scope among them, which produces a bias towards improving existing trajectories rather than launching new ones (Henderson & Cockburn, 1996). The second hypothesis was that a more extensive divisionalization is associated to a more intense hierarchical selection of projects, inducing a greater use of internal knowledge. The work proposed that, for an equal total investment, a more intense hierarchical divisionalization induces a firm to invest more resources per launched project. This implies greater scale and learning effects at the level of the individual projects or trajectories, which reinforces the bias in favour of established product or innovation lines. Moreover, this attitude is reinforced if the upper managers who select projects and research trajectories have cognitive biases that favour activities in which they have greater experience (Burgelman, 1994). To test the hypotheses, two regressions were presented: i) A firm-level regression using data on 7,500 US firms; ii) a regression using aggregate data for the US States. The rationale for the two regressions was the following. The hypotheses were grounded on a firm-based theory and therefore the firm-based regression was the core test of the analysis. A serious problem, however, was that it is hard to find good measures of the firm inward realized AC. In this respect, one of the few good measures was patent self-citations. The citations of the company to its own patents are ideal because they are a specific measure of how much the company employs its own earlier technological knowledge. Moreover, not only are patent and citation data nowadays widely available, and their use has been tested in several applications, but it has also been argued that patent self-citations are a good measure of the firm's reliance on its internal knowledge (Sorensen & Stuart, 2000; Hall et al., 2001; Nerkar & Paruchuri, 2005). Yet, patent self-citations have an inherent limitation. A firm-level sample based on them can only be composed by firms that patent. This may produce a sample selection bias because the firms that patent may also

be larger and more divisionalized. To address this concern, this work checked the robustness of the firm-level findings by averaging out, for each US State, the same dependent and independent variables employed in the firm-level analysis. The work did so by employing a database that covers a very large sample of US firms (Bureau Van Dijk). Both firm- and State-level regressions showed that the measure of the inward realized AC, the share of the firm patent self-citations normalized by the share of world patents assigned to the firm, was positively correlated with a measure of firm size and two measures of firm hierarchical divisionalization.

2.3. Strategies for small and medium firms

The changing conditions of the innovation and production process also imply important consequences for the organization and management of Small and Medium Enterprises (SMEs). Some of these implications have been studied in "Commercialisation Strategies of Technology based European SMEs: Markets for Technology vs Markets for Products" by P. Giuri and A. Luzzi. This work investigated the characteristics and the patterns of growth of technology-based SMEs who serially innovate in Europe. In particular it provided an empirical basis to answer the following questions: how the serial innovators are distributed across countries, sectors and size? how important are the technologies of the large and small serial innovators? What are the strategies of small serial innovators? The aim of this work was to add novel empirical evidence on one area that is still largely unexplored, that is the strategies and the patterns of growth of the upstream specialized technology producers. In particular, it aimed at understanding if small technology-based firms can grow by implementing business strategies focused on the development and commercialisation of their core technologies, i.e. by operating in the markets for technology, or if they also need to move downstream by investing in manufacturing and distribution assets and capabilities to compete in the markets for products and services and appropriate the returns from their innovations (Teece, 1986).

The empirical analysis that was developed in this work relied on a self-assembled database. First, the European Patent Office (EPO) database was used to select the sample of serial innovators in Europe, characterized as European firms with at least five EPO patents for which they applied in 1990-1995. Then, the REFI database on patent citations and complementary sources like Who Owns Whom and Dun & Bradstreet Europe to collect company level data on sectors, number of employees, parent and subsidiaries were used. The analysis of these data showed the country and sectoral distribution and the relative importance of technologies of serial innovators by size classes (small, medium and large). Second, several information sources (Promt, ASAP, Hoovers, SDC, EPO databases and the companies' web sites) were used in order to

empirically assess the relative importance of the strategy adopted by the small firms, that is if they simply sell their technologies or if they invest in complementary assets to become a micro-chandlerian firm. From the analysis of the sample of small technology based firms, the work proposed a taxonomy of three main groups of competitive strategies in the "market for technologies", in the "market for embedded technologies" or in the "market for products". Moreover, several firms' case studies were built with the aim of supporting the validity of the classification of different types of technological strategies.

The classification of serial innovators by industrial sectors (SIC 2-digit) showed that the largest share of companies is concentrated in the industrial machinery and equipment sectors (SIC 35), electronics and other electrical equipment sectors (SIC 36) and in the chemical and allied products sectors (SIC 28). This was observed both for the small-medium and for the large firms. 49% of the patents in the sample showed to be applied by firms in SIC 36 and 28 sectors, where the average number of patent per firm is very high for the large ones. The obtained distribution is in line with previous contributions which highlight two main patterns: first, serial innovators are concentrated in industries in which technical innovation and patent protection are important (Hicks and Buchanan, 2003); second, the bulk of licensing activity is concentrated in the SIC 35, 36 and 28 industries (Anand and Khanna, 2000). The classification of patents by technological class for groups of firms in different class size showed that all firms own a high share of patents in organic fine chemistry, analysis, measurement & control, electrical devices, electrical engineering and electrical energy, while firms with less than 250 employees and with 251-500 employees are relatively more present in civil engineering, building, mining, medical, pharmaceutical and mechanical sectors. Large firms have a relatively higher share of patents in the transportation and communication sectors. In some sectors like chemical engineering and medical instruments only medium firms show a relatively higher presence.

To check for the relative technological specialization of groups of firms in different size classes the RTA (Revealed technological advantage) indicator was computed as the percentage of patents in the size class relative to the percentage of patents from each firm in the period 1990-1995.

From this analysis, it was interesting to observe that the technological classes in which small firms are specialised are often different from medium but especially from large firms. Even when firms in different size classes show a positive RTA, their level of specialization is quite different. This different pattern of technological specialization may suggest a division of inventive labour across these groups of firms. In particular, most of

the technologies in which SMEs are more specialised are relative to chemical and engineering activities, mechanical elements and tools, materials and processes, which are technologies commonly supplied to larger firms. An interesting comparison could be done with the situation in the US (Hicks and Buchanan, 2003), in which most of the patents from serial innovators with less than 500 employees in 1996 - 2000 are in pharmaceutical technologies and in biotechnologies and medical instruments and equipment. Moreover, as emphasised in Rosenberg (2002), many new science based firms spun-off from universities have been created in the medical and biotechnologies. It emerged from this work that also in Europe a relatively large presence of small and medium serial innovators in these technologies can be observed but the relative quality is not very high.

From the classification of technology based SMEs according to their strategy, the work has showed that the presence of small firms lacking the commercialisation capabilities to compete in the final market and specialized in technology trading in the early 90' was quite limited while the bulk of European serial innovators have to be found indeed in the 'embedded technology' strategy.

The largest share of firms showed to be equally distributed in the Market for embedded technologies (MfET) and in the Market for products (MfP) strategies. Few firms emerged as adopting a pure strategy in the market for technologies (MfT) and a modest number of firms as having a mixed strategy. The distribution of firms by sector showed that almost half of the firms adopting the MfET strategy are in the machinery sector, firms in the electrical sector have mainly a MfP strategy while the pure MfT strategies are in the chemicalpharmaceutical and in the business and engineering service sectors. It is also interesting to note that all firmswith Mixed T-P strategies are in the chemical-pharmaceutical sector. Some interesting differences could be found in terms of specialization and value of technologies. Firms in the MfT and in the MfET showed to be less focused than firms in the MfP, as shown by the Herfindhal index calculated on patent technological classes according to the ISI - INIPI - OST classification at the type of strategy level and at the firm level. The average number of citations is larger for patents used in the MfT. Moreover, citation intensity is greater for patents of firms in mixed strategies.

2.4. The cumulative nature of innovation

One of the aspects that were researched in this section deals with the cumulative nature of innovation, agglomeration and spillovers and intellectual property rights. The results can be found in Fosfuri and Roende, "High-tech clusters, technology spillovers, and trade secret laws". During the 80s and the 90s Silicon Valley has been the prototypical example of a successful local industrial district. The clustering of many technology companies in a circumscribed geographical area generates two important effects. First, there is a market expansion effect: on the one hand, this allows providers of inputs to achieve higher degree of specialization and lower their prices; on the other hand, technology companies can deepen their own capabilities by relying on external sources for the supply of skills, technologies, and other resources. Second, there is a technology spillover effect. Technological knowledge and information, more in general, are extremely difficult to keep confined within the boundary of the firm. The empirical evidence shows that firms' productivity increases thanks to spillovers and that the beneficial effect of such spillovers tends to decrease with geographical distance. This provides an argument for spillover driven agglomeration. However, this argument, after a second thought, appears a bit puzzling. When technological knowledge is widespread at the level of the industry, an important source of competitive advantage is levelled out - firms must compete on equal foot. Especially when product market competition is intense, firms might try to locate in distant areas in order to minimize technology spillovers and preserve their competitive advantage and differentiation. Ultimately, the presence of technology spillovers might turn out to be a reason against agglomeration and industrial clustering.

The goal of this research was to deepen in the theoretical analysis of the issues discussed above. In particular, it has clarified what is the relationship between agglomeration and industry structure and how agglomeration incentives change under different IPRs regimes. This research builds a bridge between workpackage 3 where Silicon Valley models are analysed and workpackage 6 where the role of IPRs in fostering markets for technology is studied.

The study has used theoretical modeling based on a game theoretical approach where firms will have to decide whether to agglomerate or locate separately, anticipating the future consequences of their. Another piece of work can be found in the work of Garcia-Fontes and Gonzalez, "Spillovers at the Research Unit Level". Quantifying the extent and impact of knowledge spillovers is crucial for the design of an adequate scientific and technological policy. Theoretically, it is clear that knowledge may have a public good nature, due to non-rivalry in consumption and non-appropriability of research returns.

This may lead to external benefits of private investments in knowledge creation, and a market failure that justifies government intervention by subsidization of R&D investments or the creation of public research laboratories Jaffe (1986,1988) discusses on the options of technological and scientific policies to face the possibility of knowledge spillovers. There has been extensive research in the identification and quantification of knowledge spillovers, at least since the seminal contribution of Griliches (1979), where he proposed different strategies to measure the contribution of R&D to economic growth. The main lines of research have dealt with the construction of "knowledge pools", by finding "close" firms, using geographical, technological or firm characteristics as distances. But most researchers recognize that spillovers cannot be measured exactly, because there are almost no observable that can be associated with the appropriation of external knowledge, and different sources that increase the knowledge pool of a firm cannot be identified separately, see for instance Krugman (1991). In a recent paper, Kaiser (2002) tried to compare different approaches to the identification of spillover pools, and he found that pools based on uncentered correlations of firm characteristics seem to fit best.

One line of research that has tried to overcome this unobservability of knowledge flows is the one advocated by Jaffe (1986,1988) and his coauthors, who have proposed to use patent citations to identify knowledge flows between firms. The main assumption is that patent citations are sufficiently correlated with knowledge flows to identify spillovers. This approach is subjected to the shortcomings of patent statistics indicated by Griliches(1990), who questioned the quality of patents and related indicators, such as citation on patents, due to the heterogeneity of these indicators as a measure of the intensity of innovation activities.

Within this fairly vast literature, there has been fewer examples of attempts to identify spillovers looking at the particular mechanisms of communication that actually permit knowledge to flow. An exception can be found in more recent work by Jaffe et. al. (2000). Through a more detailed survey on inventors, these authors look at modes and mechanisms through which knowledge flows actually take place.

This paper also looks at the possibility of knowledge flows using a survey of inventors. The main objective is to try to assess the existence of spillovers at the research unit level, defining as such the network of inventors that arises from the research done to create new patentable knowledge. The main idea is to value a research unit in a novel way, using valuation techniques similar to the ones used in the theory of the firm, and therefore the measure can be interpreted as the renewal cost of intellectual capital. The approach is first to determine the optimal rule of capital accumulation for the research

unit. For this, a stochastic dynamic program for the production of ideas is constructed and the interaction of knowledge spillovers and knowledge capital accumulation is allowed. Secondly, it is attempted to assess empirically the importance of spillovers at the research unit level, by estimating the effect of spillovers on the present discounted value of the research unit adjusted by the replacement cost of intellectual capital.

2.5. Skill-biased technical progress

Some effort was directed towards the understanding of skill-biased technical progress. An example of this work can be found in "Direct Technical Change: An Empirical Investigation", by A. Gambardella and M. Giarratana.

Several studies have documented the growing inequality of earnings between skilled and unskilled workers in the US (e.g. Gottschalk, 1997; Gottschalk and Smeeding, 1997; Aghion, Caroli, Garcia-Peñalosa, 1999). A leading explanation has focused on skill-biased technical change (e.g. Berman, Bound and Machin, 1998; Machin and Van Reenen, 1998; Galor and Moav, 2000). In this context, Acemoglu (2002a and 2002b) has shown that while the classical effect of an increase in the relative supply of an input is to reduce its relative price, it also induces "directed technical change", viz. investments to make the input relatively more productive prompted by the opportunity to spread the higher productivity on a larger scale. Thus, an increase in relative supply can ultimately increase rather than decrease the relative marginal productivities of the inputs, and therefore their relative price. The goal of this work was to estimate these effects. Specifically, the work estimated an equation in which the relative compensation of skilled and unskilled workers is a function of their relative supply and of variables that induce technical change biased towards one or the other input. The work provided two contributions. First, it studied the impact of the relative input supply on inequality, and particularly whether directed technical change offsets the reduction in the relative productivity of the skilled workers produced by the increase in their relative supply. Second, it highlighted the importance of the organizational dimension as a source of skill-biased productivity improvements. Bresnahan (1999) pointed out that organizational design is crucial to understand skill-biased technical change (see also Bresnahan, Brynjolfsson and Hitt, 2001). Acemoglu himself (1998) noted that the dominant production technologies or organizational forms of a given era have been biased towards skilled or unskilled workers (see also Goldin and Katz, 1998). The work took these issues one step further. It argued that in the past two decades directed technical change has unfolded its full effects when associated with a new decentralized model of production and invention hinging on technology-based companies, entrepreneurship, clusters of firms, along with a focus on design, innovation, and skill-intensive activities (e.g.

Audretsch and Feldman, 1996; Bhid' e, 2000). This provided a natural contrast with the more traditional organization of the large integrated firms. The new model, which is epitomized by Silicon Valley (Saxenian, 1994), has spread to many industries, as well as to many regions of the world, including non-G8 ones (e.g. Bresnahan and Gambardella, 2004; Arora and Gambardella, 2005).

The empirical investigation developed in this work drew on a dataset of 146 US cities. City-level data - as opposed to firm-level - were necessary because this study is centered on market wages. Moreover, cities were an appropriate level of aggregation because systems of technology-based firms are typically geographically localized, like Silicon Valley or the other regional clusters in or outside the US. The work employed the share of citations in the patents of a given city to patents produced in the same location as a proxy for the extent to which the area is characterized by a technological entrepreneurship model. Patent citations are often used to measure knowledge flows (e.g. Jaffe, Trajtenberg and Henderson, 1993; Hall, Jaffe and Trajtenberg, 2001). Local citations were taken as evidence of knowledge spillovers and interactions among organizations in the same locations. Then the work used this proxy along with others capturing the importance of technological activities in the area, like trademarks, number of patents, and share of high-tech output of the region. These variables are common to Large-Firm and Silicon-Valley cities, as they account for the importance of technological activities. The work employed variables that account for the importance of the large firms. The key proxy was the share of firms with more than 1500 employees located in the city. Alternatively, the work employed the average firm size in the city, but this variable was less informative because the average firm size is affected by the many very small operations that one can find in all cities, and thus varies less markedly with the presence of larger firms. In addition, the share of trade union members on the total employment in the State of the city was used because trade union members was another proxy for the presence of large firms, as unions are more important in companies of larger size. The work also employed two key instruments for the relative supply of skills, measured by the ratio in 2000 of the population in the city with a four year university degree and its total population net of the population with a four year degree. The first one was a composite variable that summarizes a set of State laws for allowing children to obtain a work permit. The second variable was the percentage of population in the city with English ancestry over the city share of white non-Hispanic population net of the share of the population with English ancestry. Finally, the creation of proxies for the wage of skilled and unskilled workers was proxied by the wages of managers and production workers. Precisely, the work employed the 1998-2000 averages of the US Bureau of Labor Statistics (BLS) data on occupational wages by metropolitan areas (MA)

under the categories "management occupations" and "production workers". To build the database, different data source were used, the most important: US Patent and Trademark Office DataBase, BLS Labor Statistics, Icarus Database, Economagic, Epodunk and CityData.

3. Productivity growth, agglomeration economies and the scope for convergent growth in Europe

This section gathers studies on the changing pattern of agglomeration of economic activities. This in turn has important implications for trade and productivity, which was the focus of another study within this section.

3.1. Trade and productivity

A research produced in this section has looked at the role of international trade in productivity growth and convergence. Alcalá and Ciccone (2003) find that international trade has an economically significant and statistically robust positive effect on productivity. The trade measure that they use is imports plus exports relative to purchasing power parity GDP (real openness), which they argue is preferable on theoretical grounds to the nominal measure conventionally used. They also find a significantly positive aggregate scale effect. Their estimates control for proxies of institutional quality as well as geography and take into account the endogeneity of trade and institutional quality. For example, the elasticity of productivity with respect to real openness is around 1.2 with a standard error around 0.35 when they control for country size, geography, and proxies of institutional quality. This estimate implies that an increase in real openness taking a country from the 30th percentile to the median value raises productivity by 80 percent, an increase from the 20th percentile to the median value raises productivity by 160 percent, and an increase from the 20th percentile to the 80th percentile raises productivity by a factor of six. Moreover, they find significantly positive aggregate scale effects, confirming the results of Frankel and Romer (1999) and Alesina, Spolaore, and Wacziarg (2000). The elasticity of productivity with respect to population size is around 0.3 with a standard error around 0.1 when real openness, geography, and institutional quality are controlled for. Their analysis of the channels through which trade and scale affect productivity yields that they work through total factor productivity.

3.2. Agglomeration of economic activities

The relation between industrial concentration and externalities caused by productive factors (especially human capital and technology) has been taken into account by economists since long ago. In this project this issue has been approached by the work of Garcia-Fontes and Garcia-Montalvo at Universitat Pompeu Fabra. Nevertheless, the lack of adequate data in terms of detail and disaggregation as well as adequate theoretical measures has reduced the analysis of the relation between productive externalities and industrial concentration to a case discussion of some industries and specific localizations. Despite this fact some of the initial descriptions of the effects of externalities on industrial concentration are still very influential, and even if limited, represent very adequately the basics of this phenomenon. See for instance the description of Marshall (1890) of the cutlery or pottery industry.

The economic literature has used a large diversity of indicators to measure the degree of concentration in industries. The use of a particular index depends on the purposes sought and the specific characteristics of each index. Using these different indices there is now a vast literature that studies industrial agglomeration and its determinants for different countries. They mainly show that most concentrated and less concentrated industries are not uniform across countries. On the one hand while in France and Spain the high-tech sector is highly concentrated, in the United Kingdom they are classified among the less concentrated industries, while in the US the situation is intermediate. There may be several reasons for these differences. First, industry structure may be different since productive processes may be different across countries, according to historic determinants (about initial location of the industry), a different stage in the dynamic process of concentration, the structure of the transport system, etc. Nevertheless it is difficult to think that these factors can produce big differences in the levels of industrial concentration since:

- Very often industries depend on the concentration of natural or human resources. This does not depend on the countries but on the industries.
- New information and communication technologies favour the homogenization of tastes (demand) which makes quite unlikely that industries at different stages of concentration can be found.

There are at least two other motives that can justify the observed differences in the concentration rankings of industries across countries. First industries are defined differently and there is not an exact correspondence of industries across countries. On

the other hand there are big differences in the reference population and in the sample design of industrial surveys of different countries. To overcome these problems an analysis is presented which is based on a homogeneous database both in terms of design and in terms of industrial classification used. The Dun & Brandstreet (D& B) database is used. This is the only one available at an international level with industrial disaggregation at the 5-digit level and with very detailed information on firm localization.

3.3. Information and communication technology adoption and organisational changes

One of the questions that this project tried to address is the effect of the diffusion of Information and Communication Technologies (ICT) on the scope for productivity and firm agglomeration. By Paola Giuri, Salvatore Torrìsi and Natalia Zinovyeva addressed some of these issues in "ICT, Skills and Organisational Change: evidence from Italian manufacturing firms". This work has explored the organizational and economic implications of the adoption of ICT (information and communication technologies) at the firm level. More precisely, it analysed the relationships between the adoption of ICT, skills and organizational change and the implications of different adoption strategies for firms' productivity. Earlier studies on the demand for skilled labour and productivity growth have primarily focused either on skill-biased technical change (SBTC) or skill-biased organizational change (SBOC). Recently the empirical literature has started to analyse the increasing relative demand for skilled labour in the broad context of corporate change by looking at the labour and productivity implications of both technical and organizational change (Bresnahan, 1999; Bresnahan et al., 2002; and a recent survey by Arvanitis, 2005). Several earlier empirical works on complementarity share three methodological problems: the simultaneity of intra-firm processes, the presence of firms' unobserved heterogeneity, and the measurement of productivity effects arising from the joint adoption of more than two innovative activities.

This work tried to account for these problems by adopting several estimation methods.

This work tested the theory of complementarity between ICT, skills and organizational change using data from a survey conducted by a leading Italian bank, Mediocredito Centrale (now Capitalia), in two waves - 1995-1997 and 1998-2000. Each survey includes data on a sample of Italian manufacturing firms, with at least 10 employees, belonging to different sectors, geographical areas and size classes.

The analysis performed in this work has focused in particular on a panel of 540 manufacturing firms, which participated in both waves of the survey. Following earlier studies of the SBTC and the SBOC hypotheses, two approaches for studying the

complementarity in the context of the production function were used. One is based on the analysis of the productivity effects of pair-wise interactions between ICT, human capital and organizational change (e.g., Bresnahan et al., 2002; Caroli and van Reenen, 2001). Then, a production equation with a treatment effect model to account for possible sample selection of the decision variables was also estimated. The second utilised approach accounted for the complexity of interactions among three innovation activities by introducing different clusters of activities in the production function (Athey and Stern, 1998; Arvanitis, 2005). These clusters were used to identify different groups of firms - from the most 'traditional' one (no adoption of ICT, no organizational innovations and limited investments in human capital) to the 'innovative' firm, which ranks high on the scale of all the complements. The results obtained from this work showed to be robust to the different econometric methods and model specifications. They pointed out that complementary differs across large, medium and small firms. In small firms organizational change associated with either ICT or human capital investments does not produce any effects on firm productivity. Although almost 30 percent of small firms have tried some organizational change, the limited scale of operations reduces the scope for productivity improvements based on formal organizational changes. Organizational change yields insignificant marginal productivity gains for medium sized firms as well. Overall, the results showed a strong evidence of complementarity only between ICT and skills. The joint adoption of the three co-inventions showed to have a negative effect on firm productivity. In particular, the results have shown that in medium-sized firm the introduction of organizational change reverses the ICT-human capital complementary effect on productivity. Apparently, then, the costs of innovation tend to increase when different dimensions of the organization are involved in the process of change. The work has showed that these costs overcome the benefits. This escalation of organizational costs calls the attention to a 'classical' tension between stability and modification of organizational routines (Nelson and Winter, 1982 p. 99). The results have suggested that inertia and a limited absorptive capacity call for an incremental, gradual adoption of multiple co-inventions as opposed to a strategy of contemporaneous adoption. This is not in contrast with the theory of organizational complementarity which does not make any assumption about the sequence of adoption of different co-inventions. The data used in this work cannot clearly answer the question as to whether large firms have a comparative advantage versus their smaller counterparts in the introduction of a cluster of complementary innovations. In theory large firms have probably a greater absorptive capacity compared to smaller firms but they may suffer from greater organizational inertia. Moreover, smaller firms may need a longer time to learn how to manage (and benefit from) a complex cluster of complementary innovations. This may explain why a

decline of the marginal productivity of ICT with the increase in the intensity of skills in medium firms which have introduced organizational change was observed.

4. Financial institutions in a knowledge based economy

4.1. The analysis of Initial Public Offerings (IPOs)

In this section the main contributions came from teams in the Scandinavian countries and in the United Kingdom.

Part of the work was done by the team in IMIT Sweden with contribution by Parhankangas and Lawton Smith. The aim of the project was to analyse and compare the nature and importance of corporate venturing and sponsored-spin-offs in different regions. Earlier research has found that there are considerable differences in the frequency of sponsored spin-offs traded on the stock exchange in the US and Japan (Ito 1995). At the same time, the American culture is usually considered as a very entrepreneurial one, while the Japanese entrepreneurial culture is much less developed. In this project, sponsored spin-offs in Europe were compared to sponsored spin-offs in the US and Japan. The results obtained suggest that there are both differences similarities between the different cultures and institutional settings. The main contribution of this project is the empirical assessment of the role of large firms as sources of new technology-based spin-off ventures in different countries. More specifically the project has compared the role of independent start-ups to the role of large firm sponsored spin-offs in different geographical regions.

The research method was based on an initial literature review. A second step was to identify all IPOs (Initial Public Offerings) in Sweden, UK and Finland between 1992 and 2001. IPOs are analyzed mainly for two reasons. First, an IPO is one way to manifest the successful advancement of a business concept and entrepreneurship that may affect future industrial growth and change. The stock market plays an important role as an exit market for venture capitalists as well as for diversified industrial firms spinning off non-core activities. Second, by its nature, i.e. a public announcement, publicly available data is relatively easy to access, especially in comparison to other entrepreneurial ventures or start ups. Thus, by using an IPO sample international comparisons were made possible.

The third step was a Swedish pilot study where definitions, operationalisation, and methods were tested. The Swedish pilot-study was also followed up by both a case study and a survey of sponsored spin-offs on new Swedish stock-markets. The final step was the identification and analysis of IPOs made to the American and Japanese stock-markets. In all, the project consisted of three empirical sub-studies:

- 1) Identification of IPOs in Sweden, UK and Finland;
- 2) Swedish pilot study, including;
- 3) IPOs at the Stockholm Stock exchange;
- 4) IPOs at the new Swedish stock markets;
- 5) Case study of SAAB VCC;
- 6) Spin-offs to US, Japanese and UK stock markets.

The methods applied in each of these are described in the appended papers, but will shortly be summarized here.

- 1) Identification of IPOs in Sweden, UK and Finland** The empirical work of the project started with identifying all IPOs in Sweden, UK and Finland between 1992 and 2001. Publicly available data on some 300 Swedish, 60 Finnish and 1,000 British IPOs were collected. At this point it was not possible to identify spin-offs, or sponsored spin-offs, among the IPOs. One important result of this initial survey was that the Finnish case was dropped. A total sample of 60 Finnish IPOs was considered as far too small for any further analysis.
- 2) Swedish pilot study** The Swedish pilot-study included three different sub-studies. The first consisted of a sample of IPOs at the Stockholm Stock Exchange, the second of a sample of IPOs at the new Swedish stock markets. Finally, a case study of SAAB VCC was included. The Swedish pilot study was published in the licentiate thesis of Martin Wallin in October 2005. Further details on the method can be found in Wallin (2005).
- 2a) IPOs at the Stockholm Stock exchange** Based on the identification of Swedish IPOs in sub-project 1, a survey of IPOs at the Stockholm Stock Exchange was made. In this sub-study a sample of the older IPOs, listed between 1992 and 1996, were selected. This resulted in a sample of 101 Swedish IPOs (i.e. out of the 300 IPOs identified between 1992 and 2001). This sample was used for a test of the definitions, operationalisations, and method. The result of the sub-study was published in Wallin and Lindholm Dahlstrand (forthcoming), where further information on the method can be found.

The research design was a cross-sectional, or survey, design. Historical firm quantitative data was collected from publicly accessible sources. A quantitative method was chosen because there was the explicit purpose in mind to address the question of how frequent

this phenomenon (sponsored spin-offs) was and the scale of its effects. In order to analyze the contribution of the sponsored spin-off mechanism to industrial growth and change, the selected sample was a consciously truncated sample of successful firms in that they have survived and attracted external investors. Firms listed on the Stockholm stock exchange represent the bulk of all large technology-based firms in Sweden, i.e. firms that today have a great economic impact (i.e. on the Swedish economy). In other words, they represent a major part of what can be considered well-established firms in Sweden, especially when it comes to R&D; c.f. three quarters of all R&D in Sweden is carried out by private firms and the majority by a few large firms, many of whom represented in the IPO sample. An additional reason for using an IPO sample was to provide for the later international comparison. Although the research design only provided for the identification of divestment spin-offs, there was no way to know the maturity of the IPO firms in advance. The fact that few of the IPOs to the Stockholm Stock Exchange were found to be entrepreneurial ventures was the reason why a second sample of Swedish IPOs was constructed, that is, the IPOs at the new Swedish stock markets (see below).

In the study of IPOs at the Stockholm Stock exchange, pre-IPO ownership data was collected from IPO prospectuses, and helped to classify the firms as either non-spin-offs, spin-offs or sponsored spin-offs. Also, using the prospectuses, the spin-off parents were classified as financial or industrial owners. Organizations like banks, insurance companies, mutual funds, venture capitalist firms and investment (holding) companies were considered financial owners. The prospectuses were found at different investment banks, the Finansinspektionen (the Swedish Financial Supervisory Authority) and/or the firms themselves. IPO prospectuses were collected for 92 of the IPOs. Four additional IPOs could be classified making use of other reliable data sources such as the Swedish National Tax Board. In total, 96 of the 101 IPOs could be classified. In five of the IPO firms, classification was not possible due to failure of finding IPO prospectuses or other reliable source. These firms consist of two medium sized firms, two large firms and one real estate company of unknown size. On average, these firms are smaller than the average IPO firm.

An IPO firm was classified as a spin-off if it had one, and only one, corporate shareholder before the IPO. Sponsored spin-offs are spin-offs where the sole pre-IPO owner retains an equity share after the IPO. The spin-offs were also categorized with respect to what kind of parent organization they originated from. Spinoffs with an industrial owner are categorized as 'industrial spin-offs', and spin-offs with financial or investment company owners, are classified as 'investment company spin-offs'.

Simple measures used to analyze the contribution to industrial growth and change were: the size at IPO (measured as number of employees and used as a proxy for static contribution), the growth in size (used as a proxy for dynamics) and the technological sector of the IPO firm. This contribution can be seen either as an absolute number or in relation to other IPO firms. Data on the number of employees at IPO, year of exit and/or year 2002 was collected from the Swedish database Affärsdata, which covers all Swedish firms. Since some firms have exited, data was only available for 87 of the 96 classified IPOs. Firms were classified as exits if they either merged, were acquired or if they closed down their business. Data on industrial sector and year of foundation was collected from the annual publication Sveriges Största Företag (Sweden's Largest Companies, 1992-1997).

2b) IPOs at the new Swedish stock markets The second Swedish sub-study was based on an empirical study of new ventures introduced on the new Swedish stock markets NGM and Aktietorget, between 1996 and 2001. This sample was selected in order to complement the earlier sub-study (IPOs at the Stockholm Stock Exchange) with more entrepreneurial spin-offs. Traditional stock markets, like the Stockholm Stock Exchange, do not seem to be populated with new technology-based firms. Instead, sponsored spinoffs made to these markets are mostly due to strategic restructuring in parent firms, and not the result of recent venturing activities (Wallin and Lindholm Dahlstrand, forthcoming). The newer stock markets, such as NGM and Aktietorget in Sweden, are specialised at trading new early stage entrepreneurial firms. A sample of firms listed on these new stock markets was used in order to analyse the extent to which established Swedish corporations spin off successful entrepreneurial ventures, and to what extent these spin-offs have been sponsored by their parent corporations.

The sample of firms analysed in this study consisted of IPOs to either the New Growth Market (NGM) (former SBI, Stockholm Börsinformation) or Aktietorget. These new stock markets were established during the second half of the 1990s, and between 1996 and 2001, a total of 142 new firms made an IPO here. After cleaning out acquired firms, bankruptcies or changing lines of business the sample was reduced to 99 IPOs. In 2004, 20 of the IPO-firms in the sample had been acquired (in 2005 this figure raised to 24 firms), 17 had went out of business and an additional two made a substantial change of their major line of business. An electronic questionnaire was sent to the 103 remaining firms. The questionnaire was sent to one of the founders or to the CEO. After a remainder this resulted in 27 usable answers. During fall and spring 2004/05 complementing telephone calls were made to all non-replying firms. This resulted in an

additional number of 24 firms answering the questionnaire in a telephone interview. In total 51 of the IPO-firms have answered, which correlates to a response rate of slightly over 50 percent (52%). Further information on the method of this sub-study can be found in Lindholm Dahlstrand and Wallin (forthcoming).

2c) Case study of SAAB VCC The project included a number of Swedish (and Finnish) case studies, both of spin-offs from large corporations and of large corporations' venturing activities. Interviews with spin-offs from large Finnish and Swedish corporations were made in: Panipol (a spin-off from Fortum developing the conductive polymer technology), Finex (a spin-off from Danisco Finland developing specialty resins), Bioka (a spin-off from Danisco Finland developing the enzyme-based oxygen absorbent technology), Gyros (a spin-off from Pharmacia developing the minituarization technology), Biacore (a spin-off from Pharmacia developing the biosensor technology), MS Composite (a spin-off from SAAB VCC), SMM Medical (a spin-off from SAAB VCC). Five case studies of Finnish, Swedish and US corporations and their venturing practices included interviews with: Danisco (Finland), Fortum (USA), Perstorp (Sweden), Saab VCC (Sweden), and Volvo Technology Transfer (Sweden). The case study of SAAB VCC was published by Noura and Wallin (forthcoming).

3) Spin-offs to US, Japanese and UK stock markets The sample of US, Japanese and UK spin-offs was based on initial public offerings to Japanese, UK and US stock markets between the years 1989-2003. Of 9120 IPOs extracted from the SDC New Issue Database, 6164 (67.6%) were based in the United States, 1431 (15.7%) in the United Kingdom and 1525 (16.7%) in Japan. The average age of firms at the time of the IPO was 15 years. Most of the IPOs took place during the years 1993-2000. The sample consisted mainly of manufacturing (30%), finance, insurance and real estate (17%) as well as service firms (28%). All three countries showed a fairly similar distribution of industries, except for the fact that the wholesale and retail trade accounted for a relatively bigger share in the Japanese sample. In addition, insurance and real estate firms accounted only for 9 percent in the Japanese sample. At the time of the study, 55% of the sample companies were still active, while 15% of them were acquired by or merged to another company. Of the total sample, 5.1 percent went bankrupt and 5.8 percent were delisted by the time of the study.

Following the example of prior literature (see, for instance, Carpenter et al. 2003, Eisenhardt & Schoonhoven, 1990), the definition of entrepreneurial firms was firms younger than ten years of age at the time of the IPO. Spin-offs were defined as

subsidiaries of existing corporations listed separately on the stock markets, and they were identified relying on SDC Platinum New Issue database. Because of the focus on corporate spinoffs, spin-offs from venture capital firms or other investor groups were excluded. Spin-offs younger than 10 years of age at the time of the IPOs are labelled as entrepreneurial spin-offs. The web was searched to identify information about the founding date of all firms in the sample.

Colclough & Tolbert (1992) definition was used based upon the Bureau of Labor statistics and Butchard (1987) classifications to identify technology-based industries. The study is different from the OECD (2005) classification in the sense that selected service industries were added, such as computer programming, data processing, as well as research and development laboratories to the selection of technology-based industries.

The full sample was used in the analysis presented by Parhankangas and Lindholm Dahlstrand (2005), and the UK sample for an additional paper by Lawton Smith, Parhankangas, and Lindholm Dahlstrand (2005).

4.2. The provision of risk capital via the new equity markets

This section is based mainly in the work by Marc Goergen and Arif Khurshed.

The first deliverable of the project, by Goergen, Khurshed and Renneboog, "Why are the French So Different from the Germans? Underpricing the IPOs on the Euro New Markets", first analyses the characteristics of initial public offerings (IPOs) on the two main markets of the former EuroNM alliance, that is the French Nouveau Marché and the German Neuer Markt. It then proceeds by studying the short-term performance of initial public offerings (IPOs) on these two markets. Although the two markets had fairly similar regulation in place, there was a substantial difference in the initial underpricing with the French IPOs being on average underpriced by 21 percent as compared to the German IPOs being underpriced by 53 percent.

IPOs on both markets were characterised by the presence of lock-up agreements, the use of the bookbuilding procedure for their valuation, venture-capital backing, the existence of over-allotment options and high levels of underpricing. The paper first documents some of these idiosyncrasies and then focuses on how - if at all - they influenced the level of underpricing in the two largest members of EuroNM network, namely the Neuer Markt of Germany and Nouveau Marché of France.

All IPOs (except for one German IPO) used the book building procedure for their pricing. IPOs from both markets had lock-up periods in place which exceeded the compulsory minimum. IPOs from these two markets were also venture-capital backed and a large

number of venture capitalists (VCs) did not sell any of their holdings in the IPO. Data on the German market show that a number of IPOs were either brought earlier to the market or had their flotation postponed. The majority of the IPOs that went public earlier than planned were VC backed. Therefore, it seems that VCs were able to time their issues well.

An analysis of the determinants of underpricing suggests that underpricing in these two markets was neither driven by insider selling behaviour nor by the dilution of insider ownership in the IPO. IPOs were highly underpriced if they were risky and if the offer price was revised upwards. Lock-up agreements seem to act as substitute devices to underpricing for French IPOs. For French firms, if the VCs were locked up beyond the minimum requirement, then the underpricing was lower. Further, the more stringent the French lock-up, the smaller was the level of underpricing. The presence of underwriters as shareholders had a positive impact on underpricing in Germany but a negative one in France. This suggests that German underwriters might have been willing to suffer wealth losses resulting from underpricing in order to capture future business. In contrast, French underwriters might have been more concerned about minimising their personal wealth losses due to underpricing. Finally, the reasons for the large difference in underpricing between the German and French EuroNM markets were explored. German firms were relatively more underpriced than French firms because they were more risky, used larger price revisions, had less stringent VC lock-up contracts and mostly went public during the hot issue period of 1999-2000 when the general level of underpricing in all IPO markets was substantially higher.

The second deliverable, by Goergen, Renneboog and Khurshed, "Explaining the Diversity in Shareholder Lockup Agreements", compares the German and French financial markets in their capacity to finance new firms. Whereas virtually all the published literature has focused on lockup contracts in UK and US IPOs, this paper contributes to the IPO-literature by analyzing these contracts for IPOs on the French Nouveau Marché and the German Neuer Markt. Contrary to UK IPOs and to most US IPOs, firms going public on the French and German new markets are subject to compulsory lockups. While the German market imposes a minimum lockup of 6 months on all the pre-IPO shareholders' shares retained immediately after the flotation, the French market requires insiders to be locked up with 100% of the shares for 6 months or 80% of the shares for 1 year. About 52% of the shares that are locked up and held by the pre-IPO shareholders of French firms are subject to lockups which exceed the minimum requirement. For Germany, the equivalent percentage is 59%. Whereas negative abnormal returns on the day of the expiry of lockup contracts have been reported for the US, UK research has not found a significant market reaction. This paper confirms the absence of significantly abnormal

returns at the expiry for the main Continental Europe an markets. An important contribution is provided to the lockup literature as we examine lockup contracts at the shareholder level rather than at the firm level. Consequently, it is possible to study more refined hypotheses about the differences in lockup contracts across shareholders, across firms and across countries. It is demonstrated that lockup contracts are not only determined by firm characteristics but also depend on the shareholder type.

The paper uncovers some marked differences in terms of the role of venture capitalists in German and French IPOs. First, there is a significantly higher proportion of French firms that are VC-backed. Second, VCs in French firms are more likely to have board representation (via executive and non-executives) than their counterparts in German firms. Third, French VCs sell a smaller fraction of their holding at the flotation. It is found that the shareholders of firms characterized by more uncertainty (small and young firms) are locked up for longer and for a higher proportion of their shares in both Germany and France. When the free-float at the IPO is high, more stringent lockup contracts are used (especially by the executive directors) to signal pre-commitment. Venture capitalists in German IPOs prefer a quick exit after the flotation as they have short lockups (usually identical to the legal minimum). In contrast, founders, and executive and non-executive directors who retain shares after the flotation are locked up for longer periods. In France, the situation is similar: VCs are unlikely to be subject to lockup contracts exceeding the minimum requirements. Furthermore, they tend to be subject to the less stringent of the minimum requirements.

It has been also examined whether the presence of a venture capitalist has a negative impact on the lockup duration as it is possible that VCs certify firm quality and thus reduce the need for long lockups on other types of shareholders. It is found that this certification role is not supported by the analysis.

It is also shown that German IPOs with reputable underwriters are subject to more stringent lockup contracts. This implies that underwriters protect their reputational capital rather than provide a certification role. Also for Germany, no evidence is found that high-quality firms opt for more stringent lockup agreements and are thus able to revise their offer price upwards or reduce the degree of underpricing. In contrast, it is found that, in France, the market perceives a more stringent lockup as a signal of firm quality as it is a substitute to the initial underpricing.

The paper shows that although the French regulator gives firms a choice of two minimum lockup specifications, firms are clearly not indifferent between the two options. Overall, the lockup agreement of 6 months covering all of the shares is perceived to be less

stringent as it is chosen by firms with less uncertainty about their value. For VC-backed firms, all the shareholders tend to be locked up although the probability that VCs themselves are subject to lockup contracts stricter than the minimum requirements is small. Young and small firms tend to use more stringent lockup contracts. Finally, no evidence is found that firms that signal their superior quality by locking up their shareholders for longer or with a higher proportion of their shares are able to revise their offer price upwards.

The third deliverable, by Goergen, McCahery and Renneboog, "The Impact of Stock Exchange Regulation on Corporate Performance of the European New Markets", provides an overview of the development of the European New Markets. There has been considerable discussion on the importance of developing independent, second-tier stock markets to develop a vibrant venture capital market in Europe. Section B of the paper reports that the new markets provided a combination of stricter disclosure rules and less strict entry requirements than companies face on first-tier markets, which led to the development of very active IPO markets in Europe. While the early growth of the markets was impressive, the markets have suffered from the decline in technology stocks. Section C argues that the competition among stock exchanges has led to the creation of a new market segment that have listing and disclosure regulations that enhance the capital raising process for high-growth start-up companies. The early success of the EuroNM markets was due partly to the convergent listing and disclosure rules that attracted issuers and investors. Section D examines the level of short-term underpricing and long-run underperformance of the Euro.NMs. Underpricing is 2-3 times higher than that on the main markets, and that the distribution of returns is also very different than on the established markets. Differences in firm and industry characteristics, rather than differences in regulation, are the primary determinants of the underpricing. Finally, the evidence on the long-run underperformance of Euro.NM IPOs is reviewed. Differences in IPO performance over time and across markets are mainly due to differences in firm and industry characteristics.

4.3. IPOs financing of the software industry

This section of the project presents the work by S. Vitols and L. Engelhardt. It includes a final econometric analysis of the structural characteristics and performance of British and German software companies, focusing on those companies that had done IPOs (Initial Public Offerings, or first-time listings on stock exchanges) between 1996 and 2001

Further work and analysis of the financial microfoundations (venture capital and new stock markets specially designed for startup companies) for high tech startups in

Germany and the UK in comparative context. The particular focus here was to analyze the causes of the failure of Germany's Neuer Markt, a special stock market segment established in 1997. The experience of the Neuer Markt has contrasted greatly with the experience of the UK's AIM (Alternative Investment Market).

Both members of the project team (Sigurt Vitols and Lutz Engelhardt) participated in the EconChange project workshop in Barcelona at the beginning of 2005. Two discussion papers were published at the WZB based on project research results:

5. Intellectual property rights

The effect of patents and other intellectual property rights on innovation is a long-standing issue. Some groups in this project have addressed this issue from different angles.

Gambardella, Giuri and Luzzi present some results in "The market for patents in Europe". This research investigated the effect of different covariates on the willingness to licence a patented innovation and on the probability of actual licensing a patent by drawing on a novel dataset on European patent inventors. Licensing was lengthily represented as an important issue in the industrial economics and management literature. One reason is that markets for technologies help the diffusion and use of patented inventions. However, a crucial problem is that a large fraction of patents are kept unused by their owners for strategic reasons like blocking competitors or simply because firms developing inventions do not invest in the complementary assets necessary for transforming the inventions into final products to be placed in the market. These patents would have a commercial value if sold or licensed. The fact that technology licensing facilitates the diffusion of technologies has already been pointed out in the literature (Shepard, 1987; Grindley and Teece, 1997). Licensing also avoids unnecessary duplication of research efforts and enhance competition in the product market (Gallini, 1984), unless licensing is exclusive. A growing body of literature has also shown that licensing encourages entry and technology development by upstream specialised technology producers and improve efficiency through the emergence of a division of innovative labour (Arora, Fosfuri and Gambardella, 2001; Arora and Merges, 2004). Notwithstanding the richness of the theoretical literature on licensing, the existing empirical evidence is still scattered in several respects, mainly because of limited availability of adequate data. This research was possible thanks to a new dataset based on a survey of inventors of 9,017 European patents (PatVal-EU, see Giuri, Mariani et al. 2005 for details on the survey) granted at the EPO with priority date in 1993-1997. The full scale PatVal-EU survey was conducted from May 2003 to January 2004, and was directed to the inventors of 27,531 EPO

patents located in France, Germany, Italy, the Netherlands, Spain and the United Kingdom.

The PatVal-EU dataset allowed analysing the impact on licensing of several key variables: strength of intellectual property, generality of knowledge, presence of complementary knowledge, linkage with science, organization in which the innovation is developed (large, medium or small firm), entrepreneurship, sector, geographic localization and other controls. Supplementary variables at the patent and firm level were added by drawing on other EPO datasets and firm level datasets like Amadeus and WOW. In the sample about 11% of patents were licensed out.

The research carried out a logit estimation of the probability to licence a patent and a probit estimation with sample selections of the determinants of licensing controlling for the willingness of the firm to license its technologies. The work corroborated the main theories and findings of the previous literature about the role of patent protection, complementary assets and nature of knowledge: It found that licensed patents: a) are broader in scope; b) have more citations; c) are more likely in the case of smaller firms; d) are less likely when firms also own complementary assets. Finally, it also highlighted that having external relations – geographical or organizational - with other actors positively affect the probability of licensing.

This work represented the first extensive analysis conducted on surveyed patent-level data and has contributed to the existing empirical literature on licensing in several directions. First, by using patent level information, it allowed to analyse each decision conditioned to the characteristics of the single invention, taking into account for example the variability in the strength of intellectual property, or the presence of complementary knowledge for innovation which is specific to the single innovation, still controlling for firm specific characteristics. Second, a large number of observations covering six European countries, different sectors and technologies and large, small and medium firms were utilized. One of the most important findings of the work was that firms are willing to license broad and general patents, or patents that are not the outcome of their core activities. In these cases it is likely that firms are not active in the downstream markets and therefore they are willing to license their technologies to non competing actors. However, both large and small firms may eventually find it difficult to actually license those patents.

Another way of looking at patents is to assess the actual value that they have. This issue has been addressed by M. Mariani and M. Romanelli in "Quantity vs. quality: how to read the inventor CVs". By relying on the novel and detailed information of the same survey of

European inventors used in the previous research, this work explored the determinants of the productivity of industrial inventors in terms of quantity and quality of the innovations they produce.

Innovation and human capital are key factors for the growth of firms, and for economic growth more generally. Yet, little is known about the key actors of this process, the industrial inventors, and the determinants of their productivity. Traditional contributions focus on scientists and use scientific publications as a measure of their research output (for an overview, Stephan, 1996). They show that the distribution of scientists' productivity is skewed (Lotka, 1926; de Solla Price, 1963; Allison and Steward, 1974; Turner and Mairesse, 2005), and that vintage and age matter with scientists becoming less productive as they become older (Oster and Hamermesh, 1998; Levin and Stephan, 1991). This holds after controlling for individual fixed effects that proxy for differences in motivation and ability. The knowledge about industrial inventors is sparser. The difficulty to obtain information about the individual inventors prevented previous research from performing systematic empirical studies on this matter. The existing evidence is based on small scale samples, specific industries and firms (e.g. Narin and Breitzman, 1995; Ernst et al., 2000).

As a matter of fact, inventors' productivity may assume different aspects. While the number of patents that they develop is one of them, inventors often acquire visibility for the "value" of their innovations, and sometimes their reputation depends on one or few major innovations (Jones, 2005). This calls for an indicator of the quality or importance of the innovations. In this work the number of citations that the patents receive within five years of the publication date (i.e. forward citations) was used. Alternatively, by combining different patent indicators a composite index - i.e. a common component? that proxies for the technological and economic importance of the innovations as in Lanjouw and Schankerman (2004) was extracted. Then the determinants of the inventors' productivity measured were studied as follows:

- 1) Number of patents that the inventors contributed to invent and that were applied for at the EPO in 1988-1998;
- 2) Average quality of these innovations as measured by the average number of forward citations across each inventor's patents and, alternatively, by the average common component indicator;
- 3) Maximum quality of the patents invented by the individual inventor, i.e. the inventor's patent with the largest number of forward citations and, alternatively, with the highest level of the indicator.

Three equations were estimated at the inventor-level with 1)-3) above as dependent variables. The covariates are individual (i.e. age, academic degree, gender), firm (large firms, small and medium enterprises, universities and other public research organisations) - including the propensity of the organisation to apply for patent protection and the average size of the research project in which the inventors were involved -, industry, and country characteristics. Seemingly unrelated regressions were employed to estimate the effect of each variable on the probability to develop a large quantity of innovations as compared to produce high quality innovations.

The empirical investigation used a sample of 793 European inventors selected by taking all the German, Italian, Dutch and English inventors that responded to the PatVal-EU questionnaire on patents invented in five technological classes - Information Technology, Chemical Engineering, Civil Engineering, Optics, and Biotechnology - one "micro" technological class for each of the 5 ISI-INIPI-OST "macro" classes (respectively, Electrical Engineering, Process Engineering, Mechanical Engineering, Instruments, Chemicals and Pharmaceuticals). Then the database Delphion was employed to collect all the patents either applied for or granted by the EPO in 1988-1998 that the 793 inventors in the sample contributed to invent. This searching procedure conducted to data on 4,396 patents invented by the 793 PatVal-EU inventors. For each patent information on the number of claims, the number of states in which the innovation is patented, the name and location of the applicant organisation, the IPC classes in which the patent was classified, and the number of forward and backward citations was used.

The results of the empirical analysis have suggested an intriguing story about the driving forces of inventors' productivity. Individual and organisational characteristics affect quantity after controlling for countries and sectors. Specifically, the number of individual patents showed to increase with the inventors' age and academic degree, their involvement in large research projects, and the employment in large firms that apply for many patents. Surprisingly, however, none of these factors produce a direct effect on the quality of the innovations (both average and maximum). Only the scale of the research project leading to the patents showed to have a small impact on quality when this is measured by the composite indicator.

Further investigation, however, revealed that there is an additional factor to take into account in order to explain quality: the quantity of the inventors' patents indeed plays a crucial role for increasing the probability to develop a technological hit. Therefore, while the results showed that quantity depends on a few systematic factors, quality is the output of a stochastic process, where inventor and firm characteristics enter only indirectly through quantity. This implies a sort of hierarchy in the effects studied in this

work. Individual characteristics or other factors affect the number of patents that the inventors produce, and this, in turn, affects (positively) their maximum quality. Differently, apart from a weak effect of the scale of the research project, the average quality of the inventor's patents is not correlated with any of the factors that were controlled for. Moreover, no evidence of regression to the mean (i.e. no decreasing returns) in the innovation process at the level of the individual inventor was found. To identify the effect of the number of patents on the expected average and maximum quality of the innovations the information contained in the variance-covariance matrix of the residuals of the system of three equations was then exploited, without making restrictions on the observed factors that affect the three measures of productivity.

A very interesting development of intellectual property rights is the Open Source model. This issue has been researched within this project and some results are reported in "Skills and Openness of OSS Projects: implications for performance" by P. Giuri, M. Ploner, F. Rullani, S. Torrisi. This work investigated the role of skills and the division of labor among participants in collective inventions. In more details, the work focused on the creation of Free Open Source Software. As it emerges from previous contributions, skills are of fundamental importance for innovation and organizational learning (Cohen and Levinthal, 1989; Mohen and Roller, 2005; Leiponen, 2005).

Diversity of competence is also important for innovation and performances (Lippman and Rumelt, 1982; Bantel and Jackson, 1989; Galunic and Riordan, 1998). Skill diversity delivers benefits in terms of adaptation to new environments, problem solving, creativity and mutual learning. However, communication at the group level becomes more problematic when a higher degree of heterogeneity is involved. This work tested the hypothesis that the level of skills of participants to a project and the variety of their skills are important for project performance. Various pieces of information on the survival and the activity of the group are employed in the empirical analysis as a measure of performance. At the organizational level it must be noticed that skill heterogeneity across participants is in line with two fundamental organizational features of the open source development model: team production and modular design. Modular design has been defined as a strategy for "building a complex product or process from smaller subsystems that can be designed independently" (Baldwin and Clark, 1997). The hypothesis that the level of modularization of project activities is an important predictor of project performance was tested.

The contribution of this work to the literature was twofold. First, unlike many previous works that have focused on one or few open source projects, an empirical investigation based on a large sample of open source software projects was provided here. This work

represents the first attempt at providing a systematic empirical overview of multiple dimensions of projects hosted by SF.net, the world's largest repository of open source software activity. Second, unlike many earlier works this work did not try to compare open source software with proprietary software. Instead, the determinants of performance in a cross-section of source projects were explored with the aim of understanding in particular the role of skill level and composition, and a key organizational dimension that is modularity.

The empirical analysis was conducted employing data stored in the large database of the internet repository SourceForge.net. The activity covered by this analysis spans over a period that goes from November 3rd 1999 to January 10th 2003. The dataset provides us with a total sample of 65,535 projects and 544,669 users.

The data provided by SF.net have been cleaned and organized for the purposes of the analysis. In order to understand the meaning of some key variables and the working of a typical open source project hosted by SF.net a random selection of e-mail messages between project contributors extracted from SF.net 'project forums' were first analyzed. Then, a random sample of 58 SF users-developers was surveyed to ask questions about the procedure adopted for admit a new contributor to a registered project, the criteria for assigning tasks and roles to projects' members and those for reviewing the inputs submitted by various categories of contributors. Also, information about the most appropriate measures of individual contribution (bugs assigned, new feature request assigned, lines of code etc.) and project performance (new releases, bugs or patches fixed, CVS commits) were asked to the sample. The goal of the statistical analysis developed in this work was to study the effects of skills and modularity on project survival and performance. To this purposes two sets of equations were estimated. First, a survival equation with a logistic regression was estimated. The dependent variable in this estimation phase is equal to 1 when at least one of the following events has occurred during the period October 2002 to December 2002: a fixed bug, a fixed patch, a fulfilled feature request, a CVS commit message sent to the CVS repository, a new file release. The probability of positive counts is a function of covariates that include measures of skills, modularity and other regressors. Performance was analyzed by estimating two zero-inflated negative binomial equations. The dependent variables are counts of respectively file releases and CVS commits during the last 3 months of the sample period.

Results provided support to the hypothesis that skill level is important for the survival of Open Source projects. In particular, the analysis showed that skills have a positive and significant effect on the probability of new product releases and additions to the project

code archive. Some support to the hypothesis that skill heterogeneity is positive for innovation was found. Moreover, modularization of the design process showed to be important for the performance of the project. Although system modularity is a basic characteristic of open source products in general, there may be substantial differences across projects in the level of process modularity. The measure of process modularity was based on the number of different subprojects identified by the project team. Clearly, process modularity is an organizational dimension that reflects the development strategy of the project team. Projects that are similar on many respects, like size and the average skill level of the team, may differ in the degree of process modularity for reasons associated to the type of software developed, the type of applications/users addressed or the unobserved ability of project leaders.

6. Regulation, de-regulation, political and labour market institutions in a knowledge based economy

The project dealt with implications of new ICTs for the design of regulatory and institutional frameworks, mainly by the work by S. Kapur. The first piece of research is "Digital Rights Management: Emerging Regulatory and Competition Policy Issues", joint work by S. kapur and C. Cowie. Digital Rights Management (DRM) provides a technological solution to the issue of protecting intellectual property rights in the age of the internet. The emergence of the internet, especially broadband, has increased the instances of piracy. DRM, in combination with more stringent legal enforcement, is seen as a crucial element of copyright protection.

This piece of research involved the following steps

- Identifying a suitable definition of DRM, and carrying out a survey of associated technologies (ranging from rights expression languages to watermarking and secure containerisation of valuable content).
- Assessing the extent of piracy and its implications for copyright owners and consumers through economic modelling, especially in light of EC's Copyright Directive (2001).
- Assessing the impact of DRM on intermediaries, especially in the context of pay TV, through economic modelling.
- Assessing the impact of DRM on pricing, and the implications for competition and regulatory policy.

As DRM is an emerging set of technologies, there was not much prior research in this area. The crucial research innovation was to identify the key economic elements of these developments, to model the interaction between the relevant elements (prices, welfare), to collect and process the relevant data, to assess the impact of recent legislation (such as the EC Copyright Directive), and policy implications for the future.

In the political science area there were some contributions by Josep Colomer. Part of the work was in the area of the emergence of political parties and its relation to social cleavages and policy issues. This work was published in "Cleavages, Issues and Parties: a Critical Overview of the Literature". The relation between social cleavages, policy issues and political parties has been one of the most extensively studied subjects in comparative political science, since at least the 1960s. The subject seems to target one of the core areas of politics, but different approaches and schools of thought have not reached a single consistent, generally accepted and empirically successful analytical framework. An overview between two groups of contributions is distinguished. The first takes political parties as the dependent variable to be explained, by pre-existing social cleavages and issues, as in the classical works of Lipset-Rokkan and Lijphart. The authors of the second group take political parties as an independent variable with strong explanatory power regarding policy issue choices, electoral campaigns and political party competition, and includes different approaches represented by Riker and by Budge et al. The critical review of the existing literature concludes with a new analytical proposal integrating the variables mentioned, in which it is emphasised that the initiative of party leaders as the origin of the politicisation of issues through public policy design, as well as the indirect formation of social structures.

A second piece of research can be found in "Can Presidentialism Work Like Parliamentarism?", by J.M. Colomer and G.L. Negretto. This work deals with the discussion on the advantages and disadvantages of democratic regimes based upon separate elections and division of powers. Certainly, none of these potential inconveniences do exist in parliamentary regimes, in which governments emerge from and remain responsible to the legislature. In a parliamentary regime, there is usually political consistency between the majority of the parliament and the cabinet. Even a cabinet formed by parties with less than a legislative majority is forced to secure sufficiently broad support in Parliament to win confidence or censure votes and pass legislation. If the parliament is elected by proportional representation, then political consistency can also be achieved between the parliamentary multiparty system and voters' preferences, thus favouring efficient representation and social satisfaction with political outcomes.

However, since about half of present democracies in the world are organized as presidential or semi-presidential regimes and will probably keep this kind of regime for the foreseeable future, the objective is to discuss the conditions of good governance when elections are separate and powers are divided. It is chosen to focus mainly on Latin American presidential democracies because, in contrast to the United States, they usually have divided government in the context of multiparty systems, a feature that several students of Latin American political institutions have considered to be especially difficult to combine with presidential democracy.²

The approach differs from the two main answers given to this question. First, the supporters of the so-called 'checks and balances' model, as was elaborated during the discussion of the United States Constitution, argue that mutual controls between the president, the two chambers of congress and the supreme court can prevent arbitrary collective decisions. In this perspective, the politics of 'negative powers' has been praised for its ability to prevent a 'majority tyranny', 'populist government' and the formation of socially inefficient 'redistributive coalitions'. This option, however, usually implies the acceptance of low governmental performance in policy-making and even 'gridlock'.

IV. CONCLUSIONS AND POLICY IMPLICATIONS

1. The changing organisation of the innovation process: division of labour, clustering and integration

1.1. Licensing

Two contributions are particularly worth emphasizing. First, this research underscores the crucial role of a market for technology in shaping firms' licensing strategy. This finding has implications both for the literature that has addressed the rationales behind a firm's decision to license (Gallini, 1984; Rockett, 1990; Anand and Khanna, 2000) and for the literature on innovation and technology exploitation (Teece, 1986; Hsu, Gans and Stern, 2002). In the former case, this research suggests that in some industries it might be problematic, if not wrong, to analyze a firm's licensing strategy in isolation, abstracting from product and technology market dynamics. Indeed, most of this literature has assumed that the licensor is a monopolist technology holder, implying that the analysis of all potentially interesting interactions in the market for technology has not been considered. In the latter case, this research offers an approach better suited to understanding a firm's rate of technology licensing rather than the extant transaction costs framework, although it is still claimed that transaction costs are important, *ceteris paribus*. Second, and perhaps most important, this research provides one of the few large-scale studies of the determinants of the rate of technology licensing. This contribution is particularly valuable in light of the recent trend towards a more widespread use of licensing agreements for the exploitation of the firm's intellectual property.

1.2. Geography of innovation

There are important policy implications emerging from the work by Myriam Mariani, "What Determines Technological Hits? Geography vs firm competencies." Indeed, following Zucker et al. (1998a, 1998b) and Klepper and Sleeper (2002), an interpretation of the obtained results could be that some regions are better at doing certain types of research activities because of the location of top universities or high-tech companies. They spawn a large number of R&D performing start-ups founded by the personnel employed in the top organisations, and produce a large number of patents together with high citation intensities in the areas. In this case spillovers are not produced by the technological environment as proxied by the number of higher education laboratories or the number of patents invented in the region, but come from the initial technological characteristics of the regions in which these firms are located. Still, this work has showed that this would

happen in biotechnology and not in traditional chemicals. In short, the sources of spillovers could be generic knowledge spillovers, or they could stem from human capital mobility or the foundation of new firms. Whatever the sources, there are sectors in which such external factors are important, and others in which they are not.

1.3. Silicon Valley Models

Here the main conclusions and policy implications of the work by Suma Athreye and the Indian Software Industry are presented.

A major finding of the project was that the evolution of process capability in Indian software firms that is allowing firms in the industry to bag large outsourcing contracts owes much to the combined circumstance of rising wages in the domestic industry and relatively competitive wages which impart a cost advantage in the international market. Entrepreneurship in the sector has played an important role in uncovering new niches and business models where the cheap software talent could be leveraged for maximum value. Foreign firms have largely followed the emergence of the software industry due to indigenous efforts, though there is some evidence to believe that the offshore prototype business models were first developed within large multinational firms such as GE, Citibank and Texas Instruments which were looking for scarce software talent from Indian to meet their growing internal software needs. These arguments are made in Athreye (2004 and 2005a) and offer new insights into the factors that induce the development of process capability and the role played by foreign firms. In particular the important role of macroeconomic factors and entrepreneurship in capability building is of considerable interest to scholars studying other developing regions. Athreye (2005b) also develops a novel method to measure the roles of selection and creative destruction in the evolution of productivity in the Indian software sector. The paper shows that two-thirds of the increase in aggregate productivity in the Indian software sector over the 1995-2002 period is due to increases in productivity within existing firms but nearly a third of the increase in aggregate productivity is attributable to the changes in aggregate productivity due to the entry and exit of firms.

The papers in progress look at some of the wider implications of the growth of entrepreneurial models of outsourcing from India. The paper on Institutional emergence employs a historical approach to documenting and analysing the slow adaptation of financial and labour market institutions to entrepreneurial growth. The paper comparing Bangalore and Cambridge hi-technology regions shows the importance of internal migration of skilled workers in tipping the human capital pooling in a region, which in turn emerges as an important factor in sparking the growth of the cluster. It also

develops the notion of 'selection environments' to examine the relative effect of infrastructure rationing in Cambridge and infrastructure scarcity in Bangalore in affecting the growth of firms and the subsequent growth of hi-technology industry in the two regions.

Another set of conclusions can be drawn from the work by Radosevic and Hannula on the Software Industry in Eastern Europe. First, there are striking similarities in ownership, nationality, market orientation, export increases, objectives and several other features of the sample. This points to very strong common sectoral features of this system which is very much in line with the logic of sectoral systems of innovation literature (Malerba et al) Second, there are strong similarities across three countries in terms of function of software industry. In all three countries software firms are operating as knowledge localisers. This knowledge localisation function is present in 70% of firms and across all three countries with knowledge export being around 30%. This is essential function in knowledge based economy and it suggests critical importance of relatively small industry as software in this process.

1.4. Open source software

This article contributed to the literature on innovation management and absorptive capacity in several ways. First, not only did the results point to the crucial role of complementary downstream assets, but they also distinguished between favoring and hindering factors. The findings suggested that in a regime of weak IPRs, complementarities with a firm's other assets were a key factor in guaranteeing the appropriability of innovation efforts (Teece 1986). On the other hand, the fear of product cannibalization and important changes in distribution channels (Christensen 1997) seemed to be the most likely factors explaining the negative relationship between the rate of OSS product introduction and downstream positions in proprietary software. Second, the research revealed that proprietary software technology assets were crucial drivers of the rate of OSS product introduction. OSS seemed to be an ideal test-bed for proving the importance of absorptive capacity and its intrinsic relationship with a firm's technology assets, since most of the valuable information is freely available outside a firm's boundaries. Provided that proprietary software and OSS share similar knowledge bases, firms endowed with strong technological capabilities in proprietary software found that the identification and assimilation of such external knowledge is much easier (Ahuja and Katila 2001). The practical relevance of this finding was also endorsed by the fact that proprietary software firms all owed their engineers to contribute to OSS communities, as a means of monitoring external knowledge development and building

the necessary absorptive capacity to exploit potential opportunities (Lerner and Tirole 2002).

Third, the paper also contributed to the literature on the dynamics of industries characterized by network externalities (Bresnahan and Greenstein 1999). The findings revealed that in the applications niche, firms that have previously released OSS operating systems showed a higher rate of product introduction. This result was consistent with an early phase of the OSS market, where, lacking a structured supply of OSS applications, firms that have launched OSS operating systems needed to release in-house applications so as to increase the value of their operating systems.

The contribution in terms of measurements is also worth mentioning. Recent literature has provided several innovative ways of using patent data to measure different constructs of knowledge (Henderson and Cockburn 1994; Stuart and Podolny 1996). In this study, patent accounts to measure a firm's knowledge base are firstly used and then another vast source of publicly available data, the US Trademarks dataset, to measure a firm's market position (Seethamraju 2003). This dataset allowed to make a fine-grained assessment of a firm's downstream position by using information on individual elements of its trademarks' portfolio.

2. The changing organisation of the production process: entrepreneurship, clustering, and "Silicon Valley" models

2.1. Entry and exit processes

The research reported in the paper by Fosfuri and Giarratana "Product Strategies and Survival in Schumpeterian Environments: Evidence from the US Security Software Industry" empirically investigated the determinants of firm survival in the US Security Software Industry, a prototypical example of a Schumpeterian environment, where the young venture is the dominant organizational form.

Its findings suggested that post-entry product strategies of versioning and portfolio broadening were important in explaining survival rates even after controlling for the standard drivers of viability highlighted by the industrial organization (Audretsch 1991; Geroski 1995; Klepper 2002) and the population ecology traditions (Freeman and Hannan 1989; Carroll et al. 1996; Sorenson 2000; Dobrev et al. 2002).

The work highlighted that focus in post-entry product strategies improve firm viability. These findings were consistent with the common wisdom in the organizational learning literature that advocates a trade-off between strategies that require different learning processes (i.e. exploration vs exploitation, March 1991). In addition, such a trade-off

provided the micro-dynamics for the partition of the population of SSI firms in two different groups (Dobrev et al. 2001; Kim et al. 2003). In fact, resource partitioning theory postulates that mixed strategies reduce viability (Carroll 1985). As a matter of fact, the demand for security software products was segmented in high-tech customers (who demand the best product in the market) and low-tech customers (who need a comprehensive security package), so that the negative effect of the interaction of the two product strategies could be explained as the result of this bi-modal resource distribution. This result should be not confined only into SSI borders, but could be extended and tested in other high-tech industries, especially when the costumers' distribution shows a similar shape and versioning is a main driver of viability (e.g. hardware, semiconductors).

As secondary findings, firm age and size at entry played a marginal role, whereas was confirmed the importance of pre-entry technological capabilities and post-entry market experience. These stylized facts were to be related to the particular features of SSI, where entry and exit barriers are low, scale economies limited, but market experience, learning from users, technological competences and reputation are a key to achieve success (Torrise 1998).

Another piece of research in this section is by Giarratana and Torrisi, "Entry and Survival in Foreign Markets: Technology, Brand Building and International linkages".

The contribution of this research can be summarized as follows. First, most empirical studies on international business focus on manufacturing while relatively few works have been made in the field of services (e.g., Zaheer and Mosakoswi, 1997; Contractor et al., 2003), while the share of services in GDP is substantial for both developed and developing countries. This paper filled this gap. Second, it highlighted the impact of firm intangible assets like networking and technological capabilities mostly on small and young firm's foreign activity. When dealing with small-to medium sized, non-listed firms from emerging countries data on foreign sales, employees or assets are scarcely cooperative. This is why most studies on entry into foreign markets focus on large multinational firms. This work aimed to fill this gap in the literature by relying on a novel indicator of foreign activities that can be particularly useful in international business studies focusing on small, non-quoted firms. Then, the importance of a traditional technology indicator (patents) in a field was analyzed in software and IT services, where patents have become increasingly important during the 1990s. Finally, the work showed that the factors affecting firms' decision to entry into international markets with a trademark differ from those that explain survival. This result is in line with a key finding

in the industrial organization literature according to which firm entry is quite easy - even in industries with high entry barriers - while survival is not (Acs and Audretsch, 1989)

Marco Giarratana work on the behaviour of incumbents and the creation of new markets, "Missing the Starting Gun? Incumbent Entry Decision into New Market Niches" contributes several policy implications. First, incumbents, especially large firms with consolidated catching-up strategies, tend to enter late into new product fields. Opening and testing new market niches is not a job that every firm wants to perform. But if latecomers are also the owners of the technology required in new markets, and they strongly protect their technology against use by potential entrants, this could lower the diffusion of innovations and the pace of new market generation. Particular attention should be given to the breadth and the length of patent protection, in a way that it should not harm both the incentives to innovate and the innovative application of existing knowledge by other firms (Merges and Nelson, 1990). The case of ESI was a good example: patents that act as a technological base for further enhancements in cryptology are twenty years old, without any strong protection from other firm applications. This point should be linked to the recent trend of some high-tech firms to place barriers on the mobility of high-skilled personnel not allowing for example their researchers to form spin-offs. Literature indicates that the exploration and testing of new markets is one of the most important roles performed by start-ups, a role that large established firms do not always want to play. This startup function could be slowed down through an excessive protection of proprietary knowledge by incumbents. In ESI the most successful founders had work experience in large ICT firms, with high technological and organization capabilities. Another point is that if firms are inertial, they will take their entry decisions looking mainly to pre-determined, quasi-fixed variables. According to these predictions, firm entry decisions could easily collide. This is not against the evidence that entry occurs in waves. Homogenous entry decisions could convey congestion in markets with an excess of competition in some phases of industry history, causing a replication of investments and research projects, and increasing the rate of firm failure. A suggestion emerging from this work is that policy interventions and venture capital strategies should be redirected to sustain entry not only when new markets are fashionable, but whenever firm entry is grounded on sound and innovative competences.

Finally the work by Mazucatto and Tancioni has found that results concerning the relationship between innovativeness and stock return volatility is rather mixed. Results using industry level data find no coherent pattern between innovation and idiosyncratic risk. While some of the innovative industries conform to the predicted behavior of higher idiosyncratic risk (e.g. semiconductors), other innovative ones do not (e.g. aircraft). The same holds for the low innovative industries. In fact, their expectations seem to be only

fulfilled in the extremes of the categorization. More clear results concerning idiosyncratic risk emerge using firm level data. Here they find that firms with the highest R&D intensity, clearly have the highest idiosyncratic risk, a confirmation of their main hypothesis. A positive and contemporaneous relationship between idiosyncratic risk and innovation intensity can be empirically established and this result is robust to model extensions, such as the control for firm dimension, and - with the exception of the agricultural industry - to the particular subsample employed. Interestingly, it is not true that this relationship is stronger for firms in industries that are more innovative. They find, for example, that the relationship holds stronger in textiles (low-innovative) than in pharmaceuticals (high innovative). They hypothesize that this is because the low average R&D intensity in textiles makes innovative firms in that industry 'stick out, and hence for the reaction (by market analysts) to their innovativeness to be stronger. Furthermore, while innovation in a mature but innovative industry, like pharma or computers, may be high (expressed through a high R&D intensity and/or number of patents), its commercial outcome is often less uncertain than in new emerging sectors (like biotech and nanotechnology) or in old sectors where innovation activity is not intense (textiles), and hence causes less of a reaction by market analysts. A look at how volatility changes over time, shows that idiosyncratic risk is highest precisely during those decades when innovation is the most radical and competence destroying: e.g. computers (1989-1997) and biotechnology (1995-2003). They also show that the discrepancy in results obtained with the industry and firm-level analyses are not attributable to aggregation biases, even if the results obtained here do not rule out their role for other specific aspects of the analysis. Instead, the inconclusiveness of the industry level results is mostly attributable to the fact that the innovation measure used there (the sectoral taxonomy) was static, so that it does not allow consideration of how innovation changes over time, (e.g. an industry may be highly innovative in one period and less so in another when the life-cycle becomes mature), or when the knowledge regime changes (Gambardella 1995). Even if in the firm level analysis it has been possible to establish the existence of a direct link between R&D intensity and volatility, the analysis that they develop cannot be employed for explaining the heterogeneity found across industries, only the heterogeneity within industries, i.e. at the firm level. This may be due to the fact that R&D intensity is only an indicator of innovative input not output. Nevertheless, they believe their results represent a further step in linking stock price volatility and innovation dynamics at the firm and industry level.

In the second study reported here by Mazucatto and Tancioni "Patent Citation Dynamics and Stock Prices: the case of Pharma-Biotech", rather than using abstract innovation data as in their previous work (e.g. dividing industries by their level of innovativeness

using sectoral innovation taxonomies, or hedonic based quality change data), they use firm level patent citation data. The main aim is to see whether the degree of excess volatility and the dynamics of idiosyncratic risk are indeed higher for firms which are characterized by more “important” innovations. The intuition here is that since news about firm specific innovation changes investors expectations about future firm growth, market valuation dynamics are related to innovation dynamics due to the latter's effect on uncertainty and expectation formation. The results obtained are encouraging since they point to the right direction and show that the New Economy has implied fundamental changes in industry dynamics through firm idiosyncratic risk.

2.2. The role of large corporations

Another set of policy implications can be found by the research contributed by Fabrizio Cesaroni, “Technological outsourcing and product diversification: do markets for technology affect firms’ strategies”. The work presents relevant public policies and managerial implications. From the policy perspective, this study has confirmed that the presence of markets for technology facilitates the process of entry into new product markets, especially for those firms with weaker technological competences. The availability of process technologies from independent suppliers lowers the entry (technological) barriers to product markets, and presumably increases the overall level of competition into them. This means that an additional instrument that policy makers can use to facilitate entry and increase competition is to promote the formation of markets for technology-e.g., by strengthening the protection offered by patents to intellectual property, or by creating virtual markets for technology. From the managerial perspective, this study has shown how two alternative strategies can be pursued in order to gain competitive advantages. On the one hand, those companies with distinctive capabilities in process technologies have strong incentives in exploiting their capabilities in-house, by replicating plants that make use of the same technology. This choice maximises the returns from investments in technology development. On the other hand, if markets for technology operate, companies lacking distinctive technological capabilities can implement processes of product diversification by acquiring the required technologies from external suppliers. Clearly, this strategy becomes attractive if other assets, such as marketing capabilities, can be exploited among diversified markets. In this case, economies of scope, rather than economies of scale, become the core of a successful strategy.

The second piece within this section is “Fingerprints of the Visible Hand. Chandlerian Organizations and their Inward Looking Malaise” by A. Gambardella and M. Giarratana. This work provided the following contributions to the literature. First, it introduced the

concept of inward realized AC and tried to isolate its two main determinants. This was the first work that used and measured the notion of inward realized AC. There is an empirical literature that correlates size with the inward-looking attitude of firms (Krishnan & Ulrich, 2001), but there have been only few attempts to explain why we should observe it, namely the organization aging effect (Sorensen & Stuart, 2000) and the managerial cognition limitations (Tripsas & Gavetti, 2000). The argument of this work enriched these views by encapsulating some structural features partly independent from the firm age and experience with concepts such as routines and capabilities, and a dynamic capability, that is AC. Second, the work proposed one of the few empirical attempts to validate the idea that "organization matters", and particularly that the knowledge used by a large divisionalized firm can be structurally different from the one exploited by a flatter organization, even if the firms have the same experience and has access to the same pool of knowledge. According to a behavioural approach (March, 1987; Levitt & March, 1988; Levinthal & March, 1993), this is a consequence of the fact that different organizational forms are bounded to use particular types of information. Finally, even if previous work (Sorensen & Stuart, 2000; Hall et al., 2001; Nerkar & Paruchuri, 2005) has suggested that patent self-citations are a good proxy for the firm inward-looking attitude, this measure has until now received scarce attention. This study helped understanding how to use it.

2.3. Strategies for small and medium firms

One of the main concerns in Europe is the support and development of Small and Medium Enterprises (SMEs). Some policy implications can be drawn from the "Commercialisation Strategies of Technology based European SMEs: Markets for Technology vs Markets for Products" by P. Giuri and A. Luzzi. Starting from the classification of the small serial innovators according to their strategies, an important follow up of this work will be to investigate the evolution and the strategic patterns of these firms trying to assess the relations between technological strategy and the related performances. This analysis could allow to answer some of the initial questions on the probability of entry and growth of companies focused on the commercialisation of technologies as a main strategy of appropriation of the returns from innovation and on the easier entry in the market for technology suppliers, in particular in markets where the development of complementary assets is too costly for new and small firms. Moreover, understanding if there are geographic patterns of distribution of firms in the market for technologies, if markets for technologies emerge in some areas instead of others, and if relations with large firms, universities, venture capital are important for the emergence and growth of specialised technology producers represents relevant lines for future research in this framework. Finally, a broader comparison of the characteristics of

small-medium serial innovators in Europe with the US serial innovators, as described in Hicks and Buchanan (2003), would represent an important issue.

2.4. The cumulative nature of innovation

The research by Fosfuri and coauthors has shown that the story of Silicon Valley, as told by economic geographers and other scholars, is consistent from an economic point of view. The formal model, however, has pinned down the crucial assumptions behind the argument. It has shown that firms' incentives to cluster are the strongest when the following three conditions are met: 1) the value of later innovations is high relative to earlier ones; 2) competition in the product market is relatively soft; 3) the probability of a single firm to develop an innovation is neither very high nor very low. Especially the first condition is important for empirical research. It suggests that clustering and technology spillovers are more likely to be observed in industries with high growth potential. Hence, a standard OLS regression aimed at quantifying the benefits of clustering and technology spillovers on firms' profitability might produce biased estimates, if it does not control for this characteristic. This finding also warns policy makers against the attempt of trying to 'clone' the success of Silicon Valley in industries that have structurally much smaller growth potential.

In addition, the research predicted that in industries where clustering is driven by technology spillovers, labor turnover is high and skilled workers receive, *ceteris paribus*, higher wages. These findings seem to fit well with the stories of industries such as semiconductors and biotechnology.

Interesting enough, the research also suggested that weak trade secret protection might not be a prerequisite for clustering and labor mobility as some legal scholars have recently argued. Indeed, the model has shown that a system of trade secret protection based on punitive damages, except in some extreme cases, is beneficial for firms' profits, stimulates clustering, and is not an impediment to workers' mobility. However, trade secret protection that prevents technology spillovers from arising (post-employment covenants not to compete, injunctive relief, or excessive damages) does not affect clustering. Instead, profits are reduced because, although firms have clustered, technology spillovers do not materialize.

Another line of research is provided by Garcia-Fontes and Gonzalez, working with networks of inventors. In this paper they try to assess the extent and impact of spillovers at a fairly disaggregated level which has not been treated, the research unit level. After developing a theoretical framework based on the valuation research unit, they propose to estimate a model where the dependent variable can be interpreted as the value of the

research unit adjusted by the replacement cost of intellectual capital. Their main results show that spillover pools, constructed under three alternatives across technological classes, turn out to be positive and significant. Under the current specification it is not easy to come up with a quantitative assessment of the size of spillovers, but a rough approximation shows that the size is on the high end. Future refinements of the current model should include the inclusion of firm characteristics, to try to account to the unobserved heterogeneity that may be present in the current data. This is possible by crossing the survey of inventors with data from firm databases.

2.5. Skill biased technical progress

The main result of "Direct Technical Change: An Empirical Investigation" by A. Gambardella and M. Giarratana was that the skill premium is explained by directed technical and organizational change, and by demand factors. In this story, technical and organizational changes raised because the larger relative supply of educated people induces them to create models of industrial organization based on technology – and human-capital intensive productions, knowledge spillovers, entrepreneurial firms, start-ups, spin-offs, and the like. At the same time, the increase in income per capita produced by the increase in the skill-level of the workforce spawned a greater demand for skill-intensive goods, which further raised the skill premium. Ultimately, the estimated sum of the effects produced by directed technical or organizational change and by demand offset the reduction in the skill premium due to an increase in the relative supply, and could explain the growing inequality in earnings between skills.

3. Productivity growth, agglomeration economies and the scope for convergent growth in Europe

3.1. Trade and productivity

The analysis of the effect of international trade on aggregate productivity across countries emphasizes real openness (imports plus exports in exchange rate $US_{relativetoGDPinpurchasingpowerparityUS}$) as a measure of trade. We argue that real openness is a better measure of trade than openness because the openness measure is distorted by cross-country differences in the price of non-tradable relative to tradable goods. The distortions arise because openness is decreasing in the relative price of non-tradable goods, and non-tradable goods are relatively more expensive in countries where production is more efficient (the Balassa-Samuelson effect). Cross-country differences in the relative price of non-tradable goods do not affect real openness because the production of non-tradable goods in different countries is valued at the same prices.

Using the real openness trade measure, it is found that the causal effect of trade on productivity across countries is statistically and economically significant as well as robust. It is also found that productivity is affected in an economically and statistically significant way by the size of countries once international trade is taken into account. Regarding the channels through which international trade and scale affect average labor productivity, the findings indicate that they work through total factor productivity.

3.2. Agglomeration of economic activities

The increasing availability of data on the industrial structure of countries and the effect of new information and communication technologies has generated a fast-growing literature on the level of sectorial concentration and the influence of externalities on location. The literature has proposed various indices to measure the level of concentration which are an alternative to traditional indices such as the Gini and Herfindahl indices. The new indicators, for instance the ones proposed by Ellison and Glaeser (*EGI*) and Maurel and Sedillot (*MSI*), try to reflect not only the absolute concentration of firms in a specific industry but also relative concentration with respect the rest of the reference area.

A review of the empirical evidence on industrial concentration levels measured by these indices show that there is a lot heterogeneity in their values for the same sectors across different countries. There are several reasons that may justify these disparities. First, data sources are quite different, in most cases local specificities are important. Second, sector definition may vary between countries. Finally, it is possible that a given sector may have a very different structure in different countries depending on the initial location of productive inputs or the stage of development of the specific sector.

The first two problems are statistical while the third is conceptual. If the problem is purely empirical (industries have a similar concentration level across countries but the data are insufficient to observe this) then using a data with a single source and an homogeneous definition of sectors may solve this problem.

This is the approach adopted in this project. Using the statistical information of D& B it can be verified that the concentration level at the 2-digit level has a high variability across countries. This variability is especially high for the *EGI* and *MSI* indices and much lower for the traditional indices. A reason for this volatility can be associated that the sector is defined at an excessive aggregation. Reducing the aggregation level, going from 2-digit sector to 4-digit sectors, implies a higher homogeneization of the sectors. Actually it can be observed that, for instance, in the UK within some 2-digit sectors there are 4-digit sectors with very high concentration and very low concentration. Nevertheless, it is shown that the correlation of the indices of industries across countries using *EGI* and *MSI*

indices is still very low at the 2-digit level. The correlations are higher for the cases of the Gini and Herfindahl indices, similarly to the analysis at the 2-digit level. These results show that the determinants of industrial concentration are country-specific and that the history and development level of each country (or industrial dynamics) are important to explain firm location at the country level.

3.3. Information and communication technology adoption and organisational changes

An important implication of the by Paola Giuri, Salvatore Torrisi and Natalia Zinovyeva addressed some of these issues in "ICT, Skills and Organisational Change: evidence from Italian manufacturing firms" is that assessing the impact of multiple innovation strategies on productivity requires a long time window. The shortness of their panel did not allow studying the intertemporal adoption of complementary strategies and their long run productivity effects. A full test of the organizational complementarity hypothesis should be carried out in future research. A longer panel would allow seeing whether medium firms that gradually introduce innovations have the possibility to learn by experimenting different dimensions of organizational change without completely disrupting existing routines.

Many are the contributions which were drawn from this work. First, unlike earlier studies that have mostly focused on large firms, the issue of complementarity was explored also in small and medium firms. There is only sparse evidence about the impact of educated personnel on the adoption of ICTs in Italian SMEs (e.g., Lucchetti and Sterlacchini, 2004). It also remains quite unexplored the problem of multiple interactions among firm size, skills, adoption of ICTs, and reorganization of business processes (Fabiani et al., 2005). Moreover, the few existing studies on the topic do not examine the implications of these interactions for firms' productivity.

Second, earlier studies on different European countries have mostly focused on either the SBTC hypothesis or the SBOC hypothesis (e.g., Caroli and Van Reenen,,2001; Piva et al., 2005) while only few have addressed the issue of complementarity among ICT, human capital and organizational change (Arvanitis, 2005). Here the hypothesis of "organizational complementarity" between ICT and skills in a production function framework was tested and the differences between large firms and SMEs were analysed. The results have showed that large, medium and small firms have different patterns of adoption of (and different productivity gains from) skills, ICTs and especially organizational change.

4. Financial institutions in a knowledge based economy

4.1. The analysis of Initial Public Offerings (IPOs)

The work on spinoffs provided different results with interesting policy implications.

The literature on spin-offs to stock markets focus on spin-off triggering factors, share price reactions associated with corporate spin-offs and longer-term changes in restructuring firms (Parhankangas, 1999; Lindholm, 1994). Prior literature suggests that spin-offs to stock markets might be used to correct problems associated with inadequate corporate control and/or poor strategy formulation (see for instance, Bergh, 1995; Hoskisson et al., 1994). Less attention has been paid to the role of spin-offs to stock markets in industrial renewal. This project has added to the existing knowledge by exploring whether the role of spin-offs to stock markets may vary depending on the characteristics of their respective institutional environments. The results of this study demonstrated that institutional environments less advantaged in nurturing independent IPOs may partly compensate their weaknesses by being more active in incubating new ventures within established corporations and spinning them off to the stock markets. In a similar vein, it was found that institutional environments less conducive to radical innovations and the creation of technology-based new firms may partially overcome this shortcoming by being more active in the listing of technology-based spin-offs to stock markets. The results show that young and technology-based firms are over-represented in the sample of spin-offs to stock markets in the institutional settings less favorable to the independent start-ups going public and the development of radical innovations, thus representing an alternative form of entrepreneurship hitherto neglected by the entrepreneurship literature.

This has been the first empirical study systematically analyzing the role played by spin-offs to stock markets in industrial renewal in different institutional settings. With the results of this study, it is possible to challenge earlier, rather simplistic assumptions according to which American spin-offs to stock markets tend to be divestments of poorly performing, mature business units (Woo, Willard & Daellenbach, 1992), whereas Japanese corporations do not hesitate to spin-off their innovative, high growth businesses (Ito & Rose, 1994; Takahashi, 1995). The findings have given some support to this, but, perhaps more importantly, also showed that institutional environments conducive to the formation of independent start-ups are also more likely to produce a larger number of entrepreneurial ventures incubated within established corporations being spun off to the stock markets. As such, this finding were not surprising: the conditions working against the formation of independent start-ups are also likely to be

felt by the aspiring managers of spin-off firms. Of the countries included in the analysis, the UK was found to have the highest proportion of both entrepreneurial IPOs and entrepreneurial spin-offs to stock markets. In both the UK and Japan, the spin-offs to stock markets tended to be younger than other IPOs. In the US, on the other hand, this was found to be the other way around. The finding might suggest that US parent corporations do make use of the spin-off mechanism to divest older, and perhaps poorly performing, units. However, the result may also reflect the differing functioning of the venture capital market in the countries of interest. The more advanced early stage venture capital of the United States might encourage American corporations to benefit from venture capital investments in entrepreneurial ventures without having to make a public offering. Not until later, these venture capital investors may initiate an IPO as an exit strategy. The less advanced venture capital markets of the UK and Japan might instead make an early spin-off to stock market a more attractive route for established corporations in these countries. Besides this explanation, it has been argued that both the UK and Japan have weaknesses in their support system for technology-based ventures. Instead, the incubation process of large parent corporations might have an especially important role for industrial renewal and growth in these countries. It has, for example, been suggested (Ito, 1995) that Japanese parent organizations tend to sponsor their own spin-offs to a higher degree than their American counterparts. It was interesting to note that Japan, ranked as the least entrepreneurial country in the world, (Acs et al., 2005), produces a significantly larger share of entrepreneurial spin-offs to the stock market than its entrepreneurial activity would suggest. The obtained results suggested that Japan has, in fact, a higher share of spin-offs among entrepreneurial IPOs than the United Kingdom, and nearly as high as the United States. Even though the actual number of entrepreneurial spin-offs was not found to be very high, the Japanese spin-offs to the stock market were also relatively often technology-based ventures, indicating a potential for creating innovative businesses and industrial renewal. This suggested that the spin-off mechanism may be especially important in a collectivistic, uncertainty avoiding institutional setting with a low mobility of skilled personnel.

To policy makers, the message is rather simple: one size does not fit all. Even though the number of independent start-ups may be increasing in countries less active in new business formation partly due to government intervention (Brown & Ulijn, 2004), it would be foolish not try to capitalize on the areas of entrepreneurship where these economies are naturally strong. Based on the results of this project, it seems particularly likely that the incubation within a large corporation and a subsequent spin-off to the stock market may help aspiring entrepreneurs overcome some of the obstacles to technology-based entrepreneurship present in institutional environments characterized with high levels of

uncertainty avoidance, rigid labor markets and a dearth of funding. Therefore, support mechanisms geared towards the formation of corporate spin-offs are called for to complement the more traditional measures supporting the independent start-ups in general.

This project has focused the very "high end" of entrepreneurship by taking IPOs as the point of departure. Therefore, a future study should examine the role of independent start-ups and corporate spin-off firms among newly founded firms in general in different institutional settings. Second, expanding the geographical scope of the study would increase the robustness of the findings. Third, earlier studies have come to the conclusion that entrepreneurial spin-offs firms have higher rates of survival, growth and technology transfer compared to independent start-ups (Lindholm-Dahlstrand, 1997, Roberts & Wainer 1968; Utterback, 1974; Oakey, 1995). Therefore, a fascinating avenue for future research would be comparing the performance of independent startups and the corporate spin-offs in different institutional settings. To link the performance of corporate spin-offs to the sponsoring and nurturing by parent corporations might also contribute to an increased understanding of the spin-off phenomenon and its importance.

4.2. The provision of risk capital via the new equity markets

In this section the main conclusions from the work by Goergen and Khurshed are provided.

This project advances several important policy implications. First, despite similar regulation (e.g. similar listing requirements), the different EuroNM markets - such as the French Nouveau Marché and the German Neuer Markt - managed to attract very different types of firms. This suggests that similar types of regulation can lead to very different outcomes. Second, the project has uncovered at least two major policy implications concerning the minimum requirements for lock-in periods. First, the majority of French and German firms decided to choose lock-in contracts exceeding the minimum requirements. Firm and shareholder characteristics influence the choice of contract. For example, for both countries, shareholders of firms subject to more uncertainty (smaller and younger firms) are locked in for longer periods. Second, regulation in France influences the choice of the lock-in agreement. In contrast to Germany, France provides firms with a choice between locking in 100% of the shares for 6 months and locking in only 80% of the shares but for 1 year. Although the regulator treats the two choices as equivalent, the market is not indifferent between the two minimum requirements. Overall, the former is perceived to be less stringent than the latter as it is chosen by firms with less uncertainty about their value. Shareholders of older and larger firms are

locked in for 6 months and with 100% of their shares. There is some evidence that VCs choose the 6-month lock-in covering 100% of their shares whereas executives are subject to the more stringent minimum requirement locking in 80% of their shares for 1 year. All in all, this suggests that regulators should impose minimum requirements to ensure a minimum level of investor protection, but that the minimum requirements should be set at an appropriate level to enable better quality firms to exceed the requirements to signal their better quality. In France, until 1 December 1998, firms were required to lock in 100% of the shares of their directors and founders for the 3 years following the IPO. Given the stringency of the minimum requirement during that period, firms were not able to exceed it and signal their better quality.

5. Intellectual property rights

Some of the research results in this area can be found in the paper by Gambardella, Giuri and Luzzi, "Market for patents in Europe". Given the results in the paper, from a policy perspective it is crucial to understand the reasons for this mismatch between supply and demand of technologies, and how markets for technologies could be improved. One possible reason was the presence of frictions, or transaction costs in the market for patented technologies. In this perspective, policies aiming at facilitating technology transactions would certainly contribute to a broader use and diffusion of patented innovations. This would be particularly relevant for science-based and general patents, as pointed out by Merges and Nelson (1990) and other scholars. However, this analysis has shown that these patents are available for licensing, but are not finally licensed on average more than other patents. Another possible explanation of the mismatch between demand and supply of technologies was that there is not a demand for that patented technologies which are considered of low quality or "un-useful" by potential buyers. The main policy implication of this research is represented by an unresolved dilemma: Understanding how to increase the actual licensing is relevant both for small firms, who are on average more willing to license, and may find more difficulties in selling their technologies, but also for large firms. They are in fact less willing to license, but their share of patenting is very large and intensifying patents' licensing would provide a sizeable contribution to the use and diffusion of patented inventions.

The work Quantity vs. quality: how to read the inventor CVs by M. Mariani and M. Romanelli has some interesting policy implications. In sum, the story showed by the obtained results is that highly educated inventors are employed in large firms that give them the opportunity (and the incentive) to produce a large number of innovations and to apply for many patents. In turn, the larger the number of trials, the higher the probability to develop a valuable innovation: more ideas lead to better ideas.

Still, it is not possible to infer from the results whether the effect of "quantity" on the maximum quality is the result of a stochastic process where the larger the number of draws, the higher the probability to get a success, or whether this is the output of a learning process through which knowledge accumulates and raises the probability to invent a high quality patent. Some heuristic investigation on the distribution of patent quality at the individual inventor level suggested that also the technological hit is not the outcome of a systematic learning process that takes place as the number of trials increases. As a matter of fact, the data used in this work are consistent with a story in which "fortune" leads to the inventor's best innovation, where fortune depends on the number of draws. However, an in-depth investigation of this issue is a topic for future research.

It is also worth noticing that the findings do not diminish the importance of firm and individual characteristics in producing high-quality innovations. Although indirectly through quantity, they affect quality. This suggests, for example, that a key resource for fostering innovation is the availability and the hiring of highly educated researchers, which, in turn, depends on the investment in high level and post graduate education and training. Moreover, the importance of the inventors' education and the fact that their productivity distribution is very skewed reinforce the "retaining the best" policy (Narin and Breitzman, 1995): if ability is concentrated in a few key individuals, the organisations in which they are employed should make their best to retain them. This is most important if these individuals are responsible for both the quantity (directly) and quality (indirectly) of the innovations developed by the organisation, and if, at the inventor level, there is no regression to the mean in the average value of the innovations.

The work reported in P. Giuri and M. Ploner and F. Rullani and S. Torrisi, "Skills and Openness of OSS Projects", has also important conclusions. This work represents one of the first attempts at exploring a large cross-section of open source software projects. The limitations of the data did not allow using dynamic panel data models or other techniques to treat unobservable fixed effects. The main regressors, however, were predetermined to moderate the problem of endogeneity. Further research should try to refine the measure of modularity in open source projects relying also on aspects different than the number of subprojects.

6. Regulation, de-regulation, political and labour market institutions in a knowledge based economy

One of the hottest are in regulatory and competition policy in Europe is the one related to new ICTs.

S. Kapur (jointly with C. Cowie), has drawn some implication in his work "Digital Rights Management: Emerging Regulatory and Competition Policy Issues". The findings of the research on Digital Rights Management came to the following conclusions:

- New technologies such as broadband internet pose a significant risk to copyright owners, but copyright owners probably exaggerate the monetary losses (by valuing every pirated copy at the list price rather than consumers' willingness to pay) and underestimate the possible beneficial effects (say, the potential network externalities due to wider usage)
- DRM provide a valuable channel for protecting copyrights against the risk of piracy.
- EC Copyright Directive (2001) has provided significant legal support to DRM-based protection, but given the technological ambiguities, national courts in various European countries have not always been able to implement it in a consistent manner.
- DRM is likely to increase the market power of producers and distributors over consumers. This is likely to reflect in greater use of price discrimination strategies. While this is not necessarily economically inefficient, it will translate into higher prices for some consumers.
- If so, national and supra-national agencies will need to monitor the regulatory aspects of aggressive DRM and to assess a suitable competition policy.
- There is also the risk of excessive market power in the market for DRM-enabling technologies.

Another set of conclusions can be drawn from the work of Josep Colomer and his coauthors. A number of contributions to the conceptualisation and analysis of the relations between social cleavages, policy issues and political parties have been reviewed in the work "Cleavages, Issues And Parties: A Critical Overview Of The Literature". Two bodies of literature have been distinguished, according to whether they take political parties as dependent or independent variable in their analyses. From both schools, the conceptual difference between social cleavages and policy (politicised) issues can be

clarified, as well as the connection between the latter and political parties. The first group emphasised a line of causality from social cleavages to political parties. By contrast, the findings of the literature reviewed in the second part can be summarised the following way:

- 1) Social cleavages do not appear in the analytical framework. It could be inferred from the analysis that they are a product rather than the origins of public policy decisions and enforcement.
- 2) The potential of issues to be politicised in a complex society with a working government is immense, not restricted to a handful of controversies nor determined by deep cleavages associated to long-term social structures.
- 3) Policy innovation and the corresponding party advantage are limited by the role of political parties in providing “packages” of policies and the requirement of developing not very costly communication with voters through ideological consistency. Parties place themselves on a policy area along an ideological dimension encompassing multiple issues, such as the left-right axis, and have to stay within.
- 4) In electoral campaigns and, more generally, in shaping the public agenda, parties choose to give salience to those issues on which they have an advantage before the electorate. Such advantage is typically based on the trust and credibility their previous performance has gained them. In an unstable multi-dimensional policy space parties can give salience to different issues. A single-issue discussion is also likely to become a multi-dimensional value space.
- 5) On the basis of some previous process and experience, different policy proposals are submitted to the proof of public evaluation. If successful, they are associated with specific political parties, augmenting their trust and credibility.

Another line of research dealt with the relation of presidentialism and parliamentarism, and its results were presented in “Can Presidentialism Work Like Parliamentarism?”. The main conclusions show that while some types of presidential regimes with separate elections and divided powers have negative effects on the quality and performance of democratic regimes in comparison with multiparty parliamentary regimes, relatively good governance could be achieved thanks to appropriate institutional arrangements. Regarding the electoral system, they emphasize the advantages of personalized forms of proportional representation for the single or lower chamber of congress and inclusive rules for presidential elections. These formulae, which are consistent with moderate

multiparty systems actually existing in most presidential regimes, depart significantly from plurality and other restrictive electoral rules advocated by some students of presidentialism in Latin America. While the later rules might produce unified forms of presidential government (which would be expected to be associated with effective government), they would either need two-party systems –which do not exist in most Latin American countries - or would break the correspondence between governments and electoral majorities.

7. Deliverables

7.1. Publications and Working Papers

Angenendt, P.-P., Goergen, M. And L. Renneboog, 'Shareholder lock-in contracts: Share price and trading volume effects at the lock-in expiry' forthcoming in L. Renneboog (ed), *Advances in Corporate Finance and Asset Pricing*, Amsterdam: Elsevier. This paper is also published as working paper: European Corporate Governance Institute Working paper 102/2005 (with same title), CentER (Center for Economic Research) Discussion Paper 115/2006 (with same title), TILEC (Tilburg Law and Economics Center) Discussion Paper 30/2005 (with same title)

Arora, A., Fosfuri, A. 2005. Pricing Diagnostic Information. *Management Science* 51(7), 1092-1100

Athreya, S. (2004) 'Role of transnational corporations in the evolution of a high-tech industry: the case of India's software industry- A comment' in *World Development*, Vol. 37, no.3, pp.555-560.

Athreya, S. (2005a) 'Indian software industry and its evolving service capability', *Industrial and Corporate Change*, Vol. 14(3), 2005: 393-418.

Athreya, S (2005b) 'The evolution of productivity in outsourced services: empirical evidence from the Indian software sector'. Paper presented to the Summer 2005 Annual Conference of the Danish Research Unit for Industrial Dynamics (DRUID) at Copenhagen. Downloadable from <http://www.druid.dk/ocs/viewpaper.php?id=598&cf=3>

Athreya, S (2006a) 'Institutional adaptation to entrepreneurial growth'. Mimeo

Athreya, S (2006b) 'Selection environments and the growth of regions; a study of Bangalore and Cambridge hi-technology areas'. Mimeo.

Cesaroni, F. (2004), "Technological outsourcing and product diversification: do markets for technology affect firms' strategies?", *Research Policy*, Vol 33 (10), pp. 1547-1564

Colomer, J.M. and R. Puglisi (2005), "Cleavages, Issues And Parties: A Critical Overview Of The Literature", *European Political Science* 4, pp. 502-520.

Colomer, J.M. and G.L. Negretto (2005), Can Presidentialism Work Like Parliamentarism?, *Government and Opposition* 40(1), 60-89.

Cowie, C. and S. Kapur (2006), "The Management of Digital Rights in Pay TV," forthcoming in Martin Cave and K Nakamura (eds), *Digital Broadcasting*, Edward Elgar.

Espenlaub, S., Goergen, M., Khurshed, A. and L. Renneboog, Lock-in agreements in venture capital-backed UK IPOs, in *Venture capital contracting and the valuation of high tech firms*, J. McCahery and L. Renneboog (eds.), Oxford University Press, 2003, 396-436. This paper is also published as the following working papers: European Corporate Governance Institute Working paper 26/2003 (with same title), CentER (Center for Economic Research) Discussion Paper 46/2002 (with same title), TILEC (Tilburg Law and Economics Center) Discussion Paper 25/2002 (with same title).

Lutz Engelhardt (2005) "Geschäftsmodelle und nationale Institutionen: Ein Vergleich britischer und deutscher Neuemissionen aus der IT-Service- und Softwareindustrie 1996-2002", WZB Discussion Paper SP II 2005 -1.

Lutz Engelhardt (2004), "Entrepreneurial Models and the Software Sector", *Competition and Change* 8(4): 391-410, December.

Fosfuri, A. (2004). Determinants of international activity: Evidence from the chemical processing industry. *Research Policy* 33, 1599-1614

Fosfuri, A., Roende, T. (2004). High-tech clusters, technology spillovers, and trade secret laws. *International Journal of Industrial Organization* 22(1), 45-65

Fosfuri, A. (2006). The Licensing Dilemma: Understanding the Determinants of the Rate of Technology Licensing. Revised and Resubmitted at the *Strategic Management Journal*

Fosfuri, A., Giarratana, M. (2006). Product Strategies and Survival in Schumpeterian Environments: Evidence from the US Security Software Industry. Revised and Resubmitted at the *Organization Studies*.

Fosfuri, A., Giarratana, M., Luzzi, A. (2006). The penguin has entered the building: The commercialization of open source software products. Submitted at the *Management Science*.

Gambardella, A, Giuri, P, and A. Luzzi (2006), "The market for patents in Europe", mimeo.

Gambardella, A. and M. Giarratana (2006), "Directed Technical Progress: An Empirical Investigation", submitted to Review of Economics and Statistics.

Gambardella, A. and M. Giarratana (2006), Fingerprints of the Visible Hand. Chandlerian Organizations and their Inward Looking Malaise, LEM Working Paper, Sant'Anna School of Advanced Studies.

Garcia-Fontes W. and R. Gonzalez, "Spillovers at the Research Unit Level", Working Paper, Universitat Pompeu Fabra.

Garcia-Fontes W. and, "Spillovers at the Research Unit Level", Working Paper, Universitat Pompeu Fabra.

Giarratana, M, (2003), "Missing the Starting Gun? Incumbent Entry Decision into New Market Niches", Working Paper (2003/29) at LEM, Sant'Anna School of Advanced Studies, Pisa.

Giarratana, M. (2004). The birth of a new industry: entry by start-ups and the drivers of firm growth: The case of encryption software. Research Policy 33(5), 787-806

Giarratana, M and S. Torrissi (2006), "Entry and Survival in Foreign Markets: Technology, Brand Building and International linkages", first invited re-submission on Journal of International Business Studies.

Giuri, P. and A. Luzzi (2006), "Commercialization Strategies of Technology Based European SMEs: Markets for Technology vs Markets for Products", LEM Discussion Paper, Sant'Anna School of Advanced Studies.

Giuri, P., M. Ploner, F. Rullani and S. Torrissi (2006), "Skills and Openness of OSS Projects", LEM Working Paper, Sant'Anna School of Advanced Studies.

Giuri, P, S. Torrissi and N. Zinovyeva (2005), "ICT, Skills and Organisational Change: evidence from Italian manufacturing firms", Working Paper (2005/11) at LEM, Sant'Anna School of Advanced Studies, Pisa.

Goergen, M., Khurshed, A and L. Renneboog (2006), 'Why are the French So Different from the Germans? Underpricing of IPOs on the Euro New Markets' submitted to the Journal of Corporate Finance. This paper is also published as the following working papers: European Corporate Governance Institute Working paper 121/2006 (forthcoming

with same title), CentER (Center for Economic Research) Discussion Paper 24/2006 (with same title), TILEC (Tilburg Law and Economics Center) Discussion Paper 8/2006 (with same title).

Goergen, M., Renneboog, L. and A. Khurshed (2006), 'Explaining the Diversity in Shareholder Lockup Agreements', *Journal of Financial Intermediation* 15 (2), 254-280. This paper is also published as the following working papers: European Corporate Governance Institute Working paper 48/2004 (with same title), CentER (Center for Economic Research) Discussion Paper 121/2004 (title: Shareholder lockup agreements in the European new markets), TILEC (Tilburg Law and Economics Center) Discussion Paper 12/2004 (title: Shareholder lockup agreements in French nouveau march´e and German neuer markt IPOs).

Goergen, M., McCahery, J. and L. Renneboog (2003), 'The Impact of Stock Exchange Regulation on Corporate Performance of the European New Markets', *Journal of Corporate Law Studies* 3 (2), 379-399.

Goergen, M., Khurshed, A., McCahery, J. and L. Renneboog (2003), 'The rise and fall of the European New Markets: on the short and long-term performance of high tech initial public offerings', in J. McCahery and L. Renneboog (eds), *Venture Capital Contracting and the Valuation of High Technology Firms*, Oxford: Oxford University Press, 464-487. This paper is also published as the following working papers: European Corporate Governance Institute Working paper 27/2003, (with same title), CentER (Center for Economic Research) Discussion Paper 101/2002 (with same title), TILEC (Tilburg Law and Economics Center) Discussion Paper 20/2002 (with same title).

Helena Hanula and Slavo Radosevic (2005), *Software enterprises in central and eastern Europe: Estonia, Czech Republic, Slovenia, Results of questionnaire survey*, mimeo, Project report, SSEES UCL.

Mariani, M. (2004), "What Determines Technological Hits? Geography vs firm competencies", *Research Policy*, Vol 33 (10), pp. 1565-1582

Mariani, M. and M. Romanelli (2006), "Quantity vs. Quality: How to Read the Inventor CVs", mimeo.

Mazzucato M. and M. Tancioni (2006), "Patent Citation Dynamics and Stock Prices: The Case of Pharma-Biotech, mimeo.

Mazzucato M. and M. Tancioni (2006) "Innovation and Idiosyncratic Risk: An Industry and Firm Level Analysis" mimeo.

Vitols, S and L. Engelhardt (2005), "National Institutions and High Tech Industries: A Varieties of Capitalism Perspective on the Failure of Germany's 'Neuer Markt'", Berlin: WZB Discussion Paper SP II 2005-03, February.

7.2. Data bases

- Data base for the software industry:

Originally we aimed to collect a database containing information 1,700 Irish, Indian, Hungarian and Italian firms with similar variables and information. This effort had to be abandoned because of problems in accessing Hungarian and Italian firms and the departure of a key Irish contact from her academic base in Ireland to a job in the banking sector in Canada.

What we have instead is two databases one containing information on Indian firms and another containing information on East European firms from several regions but excluding Hungary.

Database containing data of Hungarian firms. Status: completed in modified and expanded form by collecting data for 6 CEE countries.

- Data base for the study of agglomeration:

There is information on a total of 8.72 million firms. The data include multiple indicators on the location of firms and they have a lot of detail: the database includes the region, the province, the municipality, the zip-code and the exact address (city, street and number) of each firm. This information on location usually has a lot of missing data in the standard databases.

7.3. Ph. D. Dissertations

- Lutz Engelhardt:

A Ph.D dissertation thesis analyzing differences in structure and developmental paths of the German and UK software industry was completed and submitted to faculty members in the social sciences at the Free University Berlin. The dissertation is currently under the evaluation procedure. A commitment has been made by the WZB to publish the dissertation through it's 'house press', the Sigma Verlag.

- Raul Gonzalez:

Raul Gonzalez prepared a thesis while working as a research assistant in this project where he analyses the determinants of the use of newly created knowledge within firms. He finds that firms have the option to exploit newly created technology themselves, or wait until the uncertainty around the new technology has been resolved and again exploit the technology themselves or license it. He characterizes how uncertainty influences these decisions and tests his predictions empirically.

V. DISSEMINATION AND EXPLOITATION OF RESULTS

Conference Presentations

Andrea Fosfuri

EARIE, Annual Meeting, Oporto, September 1-4, 2005.

International Conference of Product Innovation Management, Annual Meeting, Copenhagen, June 2005. Andrea Fosfuri has presented the paper "The penguin has entered the building: The commercialization of open source software products."

Workshop on Transaction Costs and Business Administration, Universidad de Valencia, October 21, 2004, Andrea Fosfuri presented the paper "The Licensing Dilemma: Understanding the Determinants of the Rate of Licensing."

Suma Athreye

Suma Athreye presented at seminars in the following institutions: Science Policy Research Unit (SPRU), London Business School, Carnegie Mellon University, University of Manchester and the University of Bocconi, (CESPRI group) and University of Cambridge.

Suma Athreye visited Columbia University and presented a preliminary version of her research done there a workshop organised by the Open University titled, 'Bridging the gap: innovation approaches and development'. Papers from this workshop are planned to be published as a special issue.

A third paper titled 'Selection environments and the growth of regions; a study of Bangalore and Cambridge hi-technology areas' has also been developed. This was presented at the University of Cambridge in October 2005 where it received critical but useful comment.

Bruno Cassiman

European Association for Research in Industrial Economics, Helsinki, August 2003, presented "R&D Cooperation between Firms and Universities: Some empirical evidence from Belgian manufacturing."

Conference Jornadas de Economia Industrial, Castellón, September 2003 "Product Innovation and Exports. Evidence from Spanish Manufacturing."

Universita Catolica de Lisboa, January 2004 presented "In search of Complementarity in the Innovation Strategy: Internal R&D and External Knowledge Acquisition."

Universitat Jaume I en Castell ´on, March 2004, presented "R&D Cooperation between Firms and Universities: Some empirical evidence from Belgian manufacturing."

HEC Paris, April 2004 presented "In search of Complementarity in the Innovation Strategy: Internal R&D and External Knowledge Acquisition."

NewEcon Network meeting in London, March 2004 presented "Organizing for innovation: R&D Projects, Activities and Partners."

University of Copenhagen, Economics Department, January 2005 presented "Product Innovation and Exports. Evidence from Spanish Manufacturing."

Triple Helix Conference in Torino, May 2005, presented "Measuring Industry-Science Links through Inventor-Author relations: A Profiling Methodology"

Reinhilde Veugelers

Conference Jornadas de Economia Industrial, September 2004, "R&D Cooperation between Firms and Universities: Some empirical evidence from Belgian manufacturing."

Giovanni Valentini

Universita Nova de Lisboa, December 2004 presented "M&A and Technological Performance."

Strategic Management Society Conference, October 2004, presented "Organizing for innovation: R&D Projects, Activities and Partners."

Myriam Mariani

October 2005, Innovations and Intellectual Property Values, Econometrics Studies, Paris (France).

October 2005, EconChange - Economic change: Micro-Foundations of organisational and institutional changes in Europe, Open Dissemination Workshop, Louvain (Belgium).

September 2005, 2nd ZEW Conference on Economics of Innovation and Patenting, Mannheim (Germany).

November 2004. Gli effetti economici dell'innovazione, Camerino University.

October 2004. Global technology: multinational corporations and innovation processes, Torino University and IRES.

June 2004. Schumpeterian Society Conference, Bocconi University, Milan.

April 2004. Workshop on patent indicators and European innovations, Pompeu Fabra University, Barcelona, (SP).

October 2003. Berkeley Seminar Series: The value of innovations in the EU chemical industry, Berkeley University, CA (USA).

September 2003. The impact of institutions on innovation: the case of biotechnology, CEPR conference, Barcelona (SP).

April 2003. Conference on the new challenges to the patent system - European policy for intellectual property, University of Munich (DE).

April 2003. MERIT Seminar Series: Competencies, geography, and the value of EU innovations, University of Maastricht (NL).

March 2003. Innovation, growth and market structure: biotechnology and pharmaceuticals, Open University, London (UK).

Marco Giarratana

February 2003, EconChange - Economic change: Micro-Foundations of organisational and institutional changes in Europe, Open Dissemination Workshop, Barcellona (Spain).

April 2003. MERIT Seminar Series: Missing the Starting Gun? Incumbent Entry Decision into New Market Niches, University of Maastricht (NL).

March 2004, EconChange - Economic change: Micro-Foundations of organisational and institutional changes in Europe, Open Dissemination Workshop, London (UK).

October 2004, Annual Strategic Management Conference, San Juan de Puerto Rico (USA).

Fabrizio Cesaroni

April 2005, seminar at the Department of Business Administration, Universidad Carlos III de Madrid, Madrid (Spain).

Paola Giuri

March 2004, EconChange - Economic change: Micro-Foundations of organisational and institutional changes in Europe, Open Dissemination Workshop, Open University, London (UK).

November 2004, Workshop on "Firms, Markets and Technologies", Università Commerciale Luigi Bocconi, Milan (Italy).

September 2005, EARIE Conference, University of Porto (Portugal).

July 2005, Workshop on Heterogeneity, Diversification and Performance - University of Calabria (Italy).

July 2005, R&D Management Conference Scuola Superiore Sant'Anna, Pisa (Italy).

February 2005, Meeting Economic Change: Micro Foundations of Organizational and Institutional Changes in Europe, IESE Business School, Barcellona (Spain).

Alfonso Gambardella

November 2004, Workshop on "Firms, Markets and Technologies", Università Commerciale Luigi Bocconi, Milan (Italia).

October 2005, IHP Meeting Economic Change: Micro Foundations of Organizational and Institutional Changes in Europe, University of Leuven (Belgium).

November 2005, seminar at IGIER, Università Commerciale Luigi Bocconi, Milan (Italia).

November 2005, seminar at Tilburg University, Tilburg (NE).

November 2004, seminar at Stanford University, Stanford (USA).

September 2003, seminar at Berkeley University, Berkeley (USA).

Alessandra Luzzi

July 2005, Workshop on Heterogeneity, Diversification and Performance - University of Calabria (Italy).

November 2003, Pavitt Conference, Brighton (UK).

December 2003, SIEPI Workshop, Urbino (Italy).

March 2004, EconChange - Economic change: Micro-Foundations of organisational and institutional changes in Europe Open Dissemination Workshop, Open University, London (UK).

May 2004, EURAM Conference, St. Andrews (UK).

May 2004, seminar at MERIT, Maastricht (Netherlands).

June 2004, Schumpeter Society Conference, Milan (Italy).

August 2004, Academy of Management Conference, New Orleans (USA).

Slavo Radošević

Paper presented at the project conference at IESE Business School, Barcelona - February 25th and 26th, 2005.

Marc Goergen and Arif Khurshed

Third Workshop on Economic Change: The Microfoundations of Institutional and Organisational Change, University of Leuven, Leuven, summer 2005.

2005: within a lecture series on 'Convergence and diversity in corporate governance regimes and capital markets', at the Colegio Universitario de Estudios Financieros (CUNEF, Madrid), Oct.

Second Workshop on Economic Change: The Microfoundations of Institutional and Organisational Change, Open University, London, March 2004.

2004 annual meetings of the European Financial Management Association in Basel.

2004 annual meetings of the European Finance Association in Maastricht.

2004: within of a lecture series on 'Convergence and diversity in corporate governance regimes and capital markets', at the Colegio Universitario de Estudios Financieros (CUNEF, Madrid), Oct.

2005 European Financial Management Symposium on Corporate Governance at Leeds University Business School.

2005 Workshop of the Corporate Governance and Investment Network in Palma 2005: within a lecture series on 'Convergence and diversity in corporate governance regimes

and capital markets', at the Colegio Universitario de Estudios Financieros (CUNEF, Madrid), Oct.

2005 annual meetings of the Multinational Finance Association in Athens.

First Workshop on Economic Change: The Microfoundations of Institutional and Organisational Change, Universitat Pompeu Fabra, Barcelona, January 2003.

Within a lecture series on 'Convergence and diversity in corporate governance regimes and capital markets', at the Colegio Universitario de Estudios Financieros (CUNEF, Madrid), Oct. 2003, Oct. 2004, Oct. 2005.

VI. REFERENCES AND BIBLIOGRAPHY

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