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Introduction: Advanced Research Findings and Fields for Further Research in Economics and Management of Intellectual Property

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The role of intellectual property (IP), and more precisely the role of patents, is increasingly considered as a major issue for managers and policy-makers. At the firm level, patents are used as a legal protection means for innovative products and processes, and as a strategic tool in technological negotiations. At the country level, the patent system aims at fostering research efforts and innovation, and ultimately economic growth.

The effectiveness of IP systems, and their role in the innovation process is, however, not unanimously recognized, and is far from being well understood. The objective of this book is to shed some light on the effectiveness of patents in stimulating innovation and growth. It is composed of ten chapters that focus on a specific issue of the relationship between IPRs and innovation. The chapters originate from selected papers presented at the AEA Conference on Innovation and Intellectual Property, held in Singapore on INSEAD Campus, in July 2004.

Beside their contribution to the existing literature on intellectual property and innovation, the ten chapters are multidisciplinary in their research methodologies, units of analysis and levels of implications, and international in their scope and content. The various quantitative methods used in the studies range from survey data analysis to econometric techniques and advanced indicators. They are applied at individual, firm, sector and country levels to derive implications in terms of both management of IP and public policy. The international dimension of the book is best assessed by looking at the panel of authors and the various regions they address. Actually, the authors of the ten chapters

Table I.1 Disciplines and geographical scope of the ten chapters

Chapters	Regions studied	Survey data	Quantitative methods	Managerial implications	Policy implications	Analytical level
1	Europe		x	x		Firm/Sector
2	UK		x		x	Firm
3	UK	x		x	x	VCs
4	Italy		x		x	Inventors
5	Belgium		x		x	Sector/Macro
6	Global		x		x	Macro
7	Asia	x		x		Firm
8	Global		x	x		Macro/Firm
9	Belgium	x	x	x		Firm
10	Global		x		x	Macro

originate from eight different countries, from Hitotsubashi University in Japan to Oxford University in the UK and Duke University in the US. Their papers focus either on specific countries or regions, or use panel data including several countries. The geographical scope, research methodology, management versus public policy implications, and analytical level of the various studies are summarized in Table I.1.

The variety of all contributions makes it *a priori* difficult to provide a synthetic overview of the ten chapters. However, a closer look reveals that the different contributions complement each other to a much larger extent than would appear at first sight.

One major field of investigation in this book concerns the effectiveness of patents and the patent systems in stimulating innovation and growth. The contribution of Kang and Seo (Chapter 6) suggests that IPRs are positively and significantly related to innovation once other complementary aspects of the environment are taken into account, such as the stage of economic development, industrial structure, trade regime and institutional environment. This idea is extensively illustrated by De Meyer and Garg in the case of Asian countries (Chapter 7). The authors show that education, training, market data, IP enforcement and managerial practices constitute a different context to innovation in Asia than in the Western world. The issue put forward by Kang and Seo is further discussed by Greenhalgh and Rogers (Chapter 2), who show that the market valuation of patents depends on the type of patents considered (UK or EPO) and on the level of competition within the industrial sector. Pitkethly (Chapter 3) also argues that the patent system should not be extended to business methods inventions, as business methods patents are not valued by venture capitalists. In this respect, the macroeconomic study of Romain and van Pottelsberghe (Chapter 10) confirms that high

technological opportunities, as witnessed by a high number of triadic patents, do attract higher levels of venture capital.

A second broad field of investigation regards the innovation process and its relationship with patents. Relying on the observation that intellectual property rights are increasingly important in determining a firm's value, Harhoff (Chapter 1) provides an original behavioural analysis of oppositions filed against EPO patents and discusses how organizational capabilities in patent documentation and IP management can determine the successful opposition of rivals' patents. Nagaoka (Chapter 8) suggests that it is possible to measure the speed, focus, science base and quality of the innovation process with patent data. He demonstrates that speed, focus and the reliance on scientific knowledge translate into quantity and quality of patent applications. Concerning the business–science relationship, Breschi *et al*. (Chapter 4) find that the majority of Italian academic inventions are patented by business partners. This collaborative process seems to further stimulate the scientific productivity of academic inventors, as they seem to be more productive in terms of publications than their colleagues who are not involved in patenting. Peeters and van Pottelsberghe (Chapter 9) provide further evidence that various dimensions of an innovation strategy affect the patenting portfolio of firms. The propensity to collaborate with universities through contract research has a particularly strong and positive effect. The idea that academic research plays an increasingly important role in business innovation is validated by Cincera (Chapter 5) who shows that the R&D activities of MNEs are directed towards the host country's revealed technological advantage. The presence of such foreign R&D centres is found to reduce the importance of brain drain.

In what follows the main findings of each of the ten contributions are summarized. For each chapter we attempt to highlight the most remarkable arguments and conclusions, and make suggestions in terms of interesting issues for further research.

Firms Differ Significantly in Their Ability to Handle Patent Oppositions (Chapter 1)

Given the increasingly important role of intellectual property in building and maintaining corporate value, firms are likely to fight hard in the battle for patent rights. Dietmar Harhoff analyses several aspects of this 'battleground' and attempts to shed some light on three particular issues. The first one concerns the extent of oppositions filed against patents granted by the EPO. The second one relates to the determinants

of this opposition activity. And the third one has to do with the success factors in undertaking patent oppositions and in defending against such attacks.

The author relies on opposition data for all patents granted by the EPO between 1980 and 1995 in two main industrial sectors: cosmetics and detergents. The following results emerge from the empirical analysis:

- A total of 7.9 per cent of patents granted by the EPO between 1980 and 1995 have been opposed. About one third of opposed patents were revoked, another third was amended, and only 27 per cent of oppositions were rejected. This indicates that the EPO opposition mechanism has a strong corrector effect.
- Opposition is more likely to occur for highly valuable patents and is more frequent in more uncertain technical and market fields. Conversely, opposition is less likely in the case of firms with large patent portfolios and less frequent for independent inventors than corporate applicants.
- Some companies (e.g., Henkel) attack more frequently than other firms do, and there is no notable reduction in its opposition success that would point to a trade-off between frequency and success of opposition.
- Firms differ significantly in their ability to handle opposition to their patents. Some firms seem also better at opposition than others. The latter might be explained by differences in organizational capabilities related to patent documentation and IP management.

Further work into what particular organizational capabilities enable firms to be more successful than others in patent opposition would extend the present study in a very interesting way. In that respect, it would be relevant to investigate more deeply the pros and cons of developing large in-house documentation centres versus using end-user tools rendered largely accessible through the Internet and commercial patent databases. Timing issues in the probability, extent and success of filing patent oppositions might also open valuable areas for further research.

EPO Patents and a Low Level of Competition Improve Market Valuation (Chapter 2)

Christine Greenhalgh and Mark Rogers study the market value of intellectual property activities and investigate how the degree of competition

influences such valuations. Firms may use the IP system to temper competition, raising the value of their innovations. As a result, the level of competition, as well as the nature and efficiency of the IP system, will determine the expected value of innovations. The chapter seeks to shed some light on these issues by analysing the stock market value of R&D and IP on a sample of UK firms.

The empirical analysis relies on a new panel dataset (from the Oxford Intellectual Property Research Centre Database) on R&D and IP activities of UK production firms covering the period 1989 to 1999. The authors extend the traditional approach to analysing the market value of innovative firms in a number of ways. First, they investigate whether the market valuation of firm-level innovation varies across sectors and firms. Second, in contrast to previous studies, the analysis includes the role of both trade mark activity and UK and European Patent Office patent activity. Third, the authors build two alternative proxies of the firms' competitive environment. At the sector level they use profit persistence analysis to capture the extent of competition, a new approach in the literature on market value. At the firm level they use market share, a traditional proxy for market power and an inverse proxy for competition.

Several interesting results emerge from their empirical analyses. They can be summarized as follows:

- Using Pavitt's typology of sectors, which is based on differences in the process of technological change, large differences appear in the market valuation of R&D and IP activity across sectors.
- On average, higher R&D, EPO patenting and UK trade marking (relative to firm size) all tend to increase market value, but UK patenting does not have a straightforward impact. Although UK patenting is more prevalent than EPO patenting for UK-based firms (it is expensive to extend a patent internationally), EPO filings seem to be a better indicator of value.
- A higher market share improves the valuation of UK patent activity (although the strength and significance of such an effect varies across sectors).
- The results support Schumpeter much more than Arrow concerning the hypothetical relationship between market structure and innovation. The market valuation of R&D is indeed higher in sectors with relatively low competitive pressure.

Chapter 2 opens various avenues for further research. Among these, it would be of particular interest to take into account the international

activities of the firms included in the sample. Indeed, taking into consideration foreign sales performances might significantly affect both the measurement of market shares and the statistical relationship between market valuation and patenting activity. Another research opportunity is suggested by the authors. It consists in taking into account the spillover effects induced by the R&D activities of the science-based sector, and test whether such spillovers would affect the complex relationship between the market valuation of R&D and the competition level of a sector.

Business Methods Patents are Not Valued by Venture Capitalists (Chapter 3)

Robert Pitkethly opens his chapter with a historical review of the controversial role of patent systems. The controversy concerns in particular the effectiveness of IP systems as a policy tool used to foster investments in innovation. The author refers to Penrose's statement that uncertainty about the consequences of a patent system counsels against implementing one where none exists, as well as against abolishing any existing system. According to Robert Pitkethly, this argument which is often used in discussions on the scope of individual patents can further be applied to debates on the creation of new fields of patent protection where none have existed previously.

One such recent debate concerns the granting of patents for business methods. Currently, 'methods of doing business' are excluded from patentability under European and UK Patent Law. There are no corresponding restrictions in the Patent Law of the United States and patents are being granted on business methods. Drawing on a UK-based survey the chapter discusses implications of granting business method patents (BMPs). Rather than merely revisiting past debates, changes in patent law and the IP environment give reason enough to raise old questions in the light of new circumstances.

The effectiveness of patents as incentives to invest in R&D does after all not only depend on what the patent system can and does provide but also, at least to some extent, on what investors believe or perceive that it provides. This research investigates the effect of possession by companies seeking venture capital (VC) funding of IPRs, and in particular patents and BMPs, on the willingness of VC investors to invest in them. It is particularly informative about the benefits patents, and BMPs especially, might or might not provide to society.

The empirical implementation of the research relies on a survey addressed to executives who directly or indirectly participate in VC

investment decisions or advise those who do. The main objective of the survey was to assess whether the possession of intellectual property rights by companies seeking investment affects VC investment decisions:

- The data show quite clearly that IPRs can increase the attractiveness of an investment opportunity in the eyes of venture capital executives and those advising business angels.
- However, this attractiveness-enhancing effect differs significantly across sectors, and not just as a result of different legal environments.
- Patent applications in the chemical/pharmaceutical and biotechnology sector do substantially increase investment attractiveness.
- The overwhelming response seems to be that business method patents (BMPs) would have at most some, but in general very little, effect on investment decisions.
- These findings have implications for both firm IP management and national IP policy regarding patents, and business method patents in particular.

The quotes from two survey respondents provide some clear explanations as to why BMPs would not attract venture capitalists. One of them underlines 'tacit knowledge' as the most valuable form of intellectual property. The other one emphasizes much higher priorities than BMPs, such as market opportunities and a skilled team of sales, marketing and support people.

In view of his research findings about VC investment incentives and several considerations regarding the other potential benefits of BMPs, Robert Pitkethly concludes that their costs are almost inevitably going to outweigh their benefits.

Further investigation would be welcome in this promising area of research. First, such cost/benefit analysis should be performed more frequently and extended to other technological areas, such as the software industry, to cite only one. In addition, it would be legitimate to wonder whether the venture capitalist's perception is not biased by their view of the current patent system. In this respect, a similar analysis for the US VC industry – where BMPs are allowed and frequently used – would be informative. Finally, this research focuses on later-stage investment incentives, while patent systems are designed to stimulate inventions. It would therefore also be interesting to survey the perceptions of the inventors of new business methods.

Academic Patenting Seems to Improve Publication Performance (Chapter 4)

Stefano Breschi, Francesco Lissoni and Fabio Montobbio address the issue of university patenting and its impact on the scientific activity of academic researchers. The relationship between patenting and publishing may be negative for two main reasons. First, there may be a 'publication delay' effect and/or a 'basic-applied trade-off'. Publication delays may be induced by the novelty step requirement in patent legislations: ideas that enter the common pool of knowledge through a published output are not new. In other words, academic researchers that aim to (or must) file a patent should keep their inventions secret as long as the patent application has not been filed. Second, the diversion of a researcher's attention from basic research to more applied targets may result in lower rates of publications in international scientific journals. This can exert non-negligible effects if patenting is non-occasional and if it results from business-oriented research.

The authors also provide three arguments as to why there might be no such publishing–patenting trade-off: the 'resource effect', the 'productivity-fixed effect' and the 'augmented Matthew effect'. These arguments suggest that patenting by scientists would contribute further to raise contract research (i.e., increase the level of academic research), and that patents and publications are both part of a research quality indicator and a researcher's reward and incentive system (visibility, reputation, access to further resources, financial incentives).

The issue is addressed empirically with data at the individual level. The number of scientific publications of a sample of 296 academic inventors is compared to a sample of 296 matched controls, with patenting as a treatment variable. A new longitudinal dataset of 592 Italian professors is used to compare matched pairs of patenting and non-patenting individuals. The authors enquire whether a trade-off is caused by publication delays or a shift from basic to applied research, or whether a 'resource effect' occurs, by which academic inventors access superior resources as long as they take care of IPRs over their research results.

The empirical work exploits two data sources. One contains information on Italian 'academic inventors' (available in patent data). The other is based upon the *ad hoc* collection of publication data on both these 'academic inventors' and a sample of 'non-inventor' colleagues, from the on-line version of ISI's *Science Citation Index*.

The econometric analysis leads to the following results:

- Academic inventors are highly productive scientists, even more productive than their non-inventor controls.
- The difference is particularly relevant for persistent inventors, namely those scientists who patent more than once over a long time period.
- Patents have a significantly positive impact in terms of increased number of publications within the scientist's academic career. Holding other variables constant, being an inventor improves scientific productivity by about 14 per cent.
- It is, however, not possible to exclude the existence of some 'publication delay effect'.

An important institutional specificity of the Italian case is that 75 per cent of patents signed by at least one academic inventor belong to business companies. These patents are often the result of research contracts, by which the business company retains all the intellectual property rights over the research results. The above findings suggest, therefore, that contract research may generate a positive 'resource' effect on the academic inventors' publication rate, in particular when it expands over long time periods.

The conclusions of the three authors open several fields for further research. One important research question relates to national academic systems. One might wonder to what extent these results would hold in the case of academic patents applied for by universities (as opposed to business firms). Indeed, the patenting process requires a lot of time, resources and competences, which might affect an academic inventor's behaviour. The methodology developed in Chapter 4 could be used to validate the positive publishing–patenting relationship in other countries than Italy. As suggested by the authors, another issue would be to investigate whether by patenting their research results, academic inventors reduce the accessibility of their inventions to other scientists, hence reducing the pace of innovation.

R&D Activities of Foreign MNEs Seem to Reduce the Risk of Brain Drain (Chapter 5)

Michele Cincera opens his chapter with striking evidence put forward by the European Commission about brain drain flows among industrial economies. For instance, about 75 per cent of EU-born US doctorate

recipients who graduated between 1991 and 2000 had no specific plans to return to the EU. The most important reasons which keep EU-born scientists and engineers abroad relate to the quality of work, better prospects and projects, and easier access to leading technologies.

The purpose of this chapter is to shed some light on one aspect of this international mobility of factors by examining the interactions between the emigration of highly skilled workers and the presence of subsidiaries of foreign MNEs in a small open economy like Belgium. Based on European and US patent statistics, the author performs an empirical analysis of R&D activities carried out by foreign MNEs in Belgium over the last two decades. He investigates the role of demand-pull and technology-push determinants of the MNE's decision to delocalize its R&D in a host country as well as the impact of these activities on brain drain of Belgian R&D personnel. The empirical analysis leads to four main observations:

- The scientific fields where Belgium holds comparative advantage with respect to the OECD are characterized by a strong presence of foreign firms.
- The relatively low value of patents applied for by foreign subsidiaries suggests that the main objective of MNEs' R&D units may be the transfer and adaptation of existing knowledge to the host country (i.e., Belgium).
- Higher R&D internationalization is associated with lower rates of emigration of highly educated workers across countries. In other words, the importance of brain drain is smaller in highly internationalized countries.
- There seems to be a positive 'brain gain' (higher number of new inventors in patents applied for by foreign subsidiaries and MNEs as compared to domestic firms) associated with the presence of foreign MNEs.

These results suggest that MNEs invest in R&D in Belgium mainly in order to gain access to the local science base. The presence of these companies positively affects the demand for highly skilled workers and hence reduces the importance of brain drain. Important policy implications are suggested by the author, especially regarding policies aiming at increased openness and attraction of foreign R&D laboratories.

This chapter induces several fields for further research. One of them would be to validate these results with data on other small open economies like Sweden, Finland and Switzerland. Another interesting

analysis would be to assess the extent to which foreign MNEs enter into collaborative R&D with local firms and especially with local universities.

Stronger Intellectual Property Rights Do Not Always Lead to More Innovation (Chapter 6)

There is an ongoing debate on whether stronger IPRs encourage or retard innovative activities. W. D. Nordhaus initiated the economic analysis of patent systems, showing that granting innovators temporary monopoly power for the exploitation of their inventions enhances R&D efforts and innovative activities. However, recent empirical and theoretical analyses put forward more mitigated, and sometimes opposite, conclusions.

Professors Sung Jin Kang and Hwan Joo Seo study this issue empirically over a large number of countries. Their contribution aims at testing whether the strengthening of intellectual property rights would effectively stimulate innovation. The authors argue that such empirical exercise must be performed by taking into account complementary factors such as industrial structure, social capability and trade regime.

The quantitative analysis, which relies on a long-run panel dataset of about 110 countries, draws the following conclusions:

- There is no evidence that stronger IPRs alone boost innovation, as measured by the number of patent applications.
- IPRs are positively and significantly related to innovation once other complementary aspects of the environment for innovation are taken into account, such as the stage of economic development, industrial structure, trade regime and institutional environment.
- Even when complementary conditions are taken into account, some countries are negatively affected by stronger IPRs.

These results suggest that the effectiveness of IPRs in fostering innovation varies across countries according to national economic and institutional contexts. For example, only countries with a per capita GDP above about US$ 9,000 seem to gain from the strengthening of IPRs. The authors conclude with a discussion of the potential implications of their results for current international policy debates regarding TRIPs (Trade Related Intellectual Property).

This issue is indeed of critical importance for less developed economies. Further research would be required to shed more light on the debate. A first avenue for future empirical investigation would be to use another indicator of innovation effort than patent data. IPR regimes are

designed to spur innovation. In this respect, the number of researchers or R&D outlays might be appropriate to assess the effectiveness of IPR regimes. Another field of research would be to assess what component(s) of an IP policy design (e.g., scope, length, quality, enforcement etc.) plays the most important role in stimulating innovation.

Asian Firms have Specific Perceptions and Competences as Regards the Innovation Process (Chapter 7)

The starting point of the chapter by Arnoud De Meyer and Sam Garg originates from Asian managers' view regarding the management of innovation. These managers argue that the application of the lessons learned in the Western world may well be different in Asia. The argument is not that the lessons do not apply, but rather that the specific circumstances in East Asia are such that their implementation would be radically different.

The study presented in Chapter 7 aims at understanding how the implementation of innovation management concepts is indeed different in Asia. The research methodology consisted first in collecting data on 30 innovative firms or innovative clusters in order to specify a large number of hypotheses about innovation management in Asia. In a second step the authors developed a questionnaire that was sent to 336 senior managers in East and South Asia. Numerous observations are derived from this study. The most compelling ones can be summarized as follows:

- On top of the shortage in training, companies in Asia are confronted with a lack of quality of training.
- Asian financial markets miss the sophistication and the willingness to invest in innovation.
- The mindset of many managers in Asia drives them towards cost-reduction strategies, as opposed to the creation of new value.
- The average Asian company has a limited understanding of, or experience with, marketing. Brand building is often neglected and there is an absolute lack of reliable market data.
- The regulatory environment favourable to innovators and entrepreneurship is often lacking: innovators need good IPR protection and in particular the enforcement of these rights.
- Local governments tend to be conservative in their procurements and do not favour local innovators over well-established international brands.

A set of factors are specific to Asia and influence the implementation of innovation management practices developed in the Western world. It is worth mentioning that not all companies/respondents evaluate the factors specific to Asia in the same way. A typology of four groups of companies/respondents is put forward by the authors: the innovation starters, the tradition fighters, the poor in knowledge resources, and the stuck in the muck. The chapter extensively documents the different types of support required by the four groups. This discussion should help policy-makers and educators in the field of management to customize their action to each of their specific targets.

From this chapter it seems that our understanding of the innovation process in Asia would particularly benefit from two main fields for further research. The first one would be to conduct a similar survey in Europe, Japan and the US in order to test whether the above results are really specific to Asia. Another interesting field of investigation would be to measure the extent to which the four typologies correlate with the financial performance of surveyed firms.

Speed, Science Linkage and Focus Affect R&D Performance (Chapter 8)

Sadao Nagaoka examines how the speed, science linkage and focus of corporate R&D as well as new entry matter as determinants of R&D performance in the IT (information technology) sector. He discusses the recent R&D performance of US, Japanese and European firms from this perspective. The author relies on the number of forward patent citations per patent and the number of patents as proxies for the quality and for the quantity of innovation respectively. He uses these measures as indicators of the performance of R&D.

The two measures show that, in the 1990s, the R&D performance of US firms in the IT sector improved significantly relative to the rest of the world. Several hypotheses may explain this improvement. One is better management practices and organization of US firms (more emphasis on speed). Second, many US firms may have chosen a vertical disintegration strategy. The third reason is the increasing dependence of the IT industry innovation on scientific research. Fourth, a more entrepreneurial culture would translate into the entry of more new technology firms. The 1990s were indeed characterized by a sharp increase in the contribution of small firms to aggregate R&D outlays in the US.

Sadao Nagaoka attempts to assess quantitatively the significance and the contribution of the above four factors as determinants of R&D

performance. The speed of the innovation process is measured by the time lag between a patent and its underlying patent literature. The frequency of references made by a patent to scientific journals would provide a measure of the propensity of firms to exploit scientific knowledge. The degree of concentration of the patent portfolio of a firm is used to measure the extent to which a firm has a focused research agenda. New entrants are defined as firms that are major patentees in the most recent period (1998–2002) but do not have patents granted in the previous periods.

There is clear evidence that in IT areas patenting performance of US firms compared to Japanese firms has improved in both quantity and quality. The econometric analysis provided in Chapter 8 attempts better to understand the determinants of this improved performance. The results can be summarized as follows:

- There is a positive effect of speed on research productivity. That is, higher speed of R&D measured by citation lag improves R&D performance in terms of both the quality and the number of patents granted.
- There is a positive effect of science linkage on research productivity. That is, a stronger science base, as measured by citations to the scientific literature, improves the R&D performance of a firm in terms of both quality and number of patents granted.
- A focused research agenda tends to improve patent quality in the IT core sector, but does not lead to a higher quantity of patents. A firm that patents in a single technology domain has a patent quality indicator 11 per cent higher than a firm that patents in two technology domains.
- New entrants have higher patent quality than incumbents, only part of which can be explained by an average higher speed and stronger science linkage.

The above findings suggest that the higher performance of US firms is due to their increased R&D speed, intensification of science linkage and a substantially higher rate of new entries. This result is consistent with the idea that the increase in patenting in the US has been driven by changes in the management of innovation by US firms, which brought a real burst in innovation.

The methodology developed by Sadao Nagaoka is a good example of how quantitative analyses can be used to assess the management of R&D. Three avenues for future research can be raised to improve or

validate this methodology. First, it would clearly be interesting to extend the analysis to other sectors or technologies. Second, the robustness of the indicators presented by the author could be further tested. One important issue is whether the reliance on the United States Patents and Trademarks Office (USPTO) data might bias the results, through a potential 'home effect'. Indeed, new entrants generally lack resources to apply for patents abroad. The significance of the bias could be assessed through the use of EPO (European Patent Office) or JPO (Japanese Patent Office) data. Third, the number of forward patent citations and the lag to the first citation are two major indicators included in the empirical analysis. It would be of particular interest to separate self from non-self patent citations, to test whether the speed of innovation and its quality are determined mainly 'internally' to the firm or 'externally' as a result of strong inter-firm knowledge spillovers.

A Firm's Patenting Behaviour Strongly Depends on its Innovation Strategy (Chapter 9)

In Chapter 9, Carine Peeters and Bruno van Pottelsberghe investigate several factors that determine the patenting behaviour of firms. The theoretical model the authors rely on suggests that the patenting behaviour of firms is influenced by three types of factors: firm and sector specific variables, characteristics of the innovation strategy, and barriers to innovation and to the use of the patent system.

A central issue in the study is to assess the role played by different types of innovation strategies. Four main dimensions of an innovation strategy are taken into account. The first one differentiates R&D active from non-R&D active firms. The second one relates to the kind of R&D activities undertaken and, more particularly, the relative importance of basic and applied research on the one hand and development work on the other hand. The third one reflects the propensity of firms to enter into research partnerships with business and scientific institutions. The last dimension accounts for the orientation of the innovation strategy towards the development of new products, new processes, or both.

The database used in the empirical study is built through a survey of 148 firms operating in Belgium in 2001. The patent behaviour of these firms is proxied by two variables reflecting the existence and size of their patent portfolio. Four main findings should be highlighted:

- First, even though it sharply reduces the significance of traditional firm and sector specific variables, introducing characteristics of the

innovation strategy pursued by firms improves the general quality of the model.

- Second, entering into research partnerships with scientific institutions or competitors has a strong positive effect of the patenting behaviour of firms. This stresses that collaborative research induces a need for strong intellectual property protection.
- The importance of science-based research in determining the patenting behaviour of firms is witnessed by the positive and significant coefficient of both the share of basic and applied research in the total R&D budget, and the propensity to collaborate with universities, research institutes and public labs.
- A complex innovation strategy targeting high levels of both product and process innovation is associated with patent portfolios of intermediate size. Product innovators have the largest patent portfolios and process innovators the smallest, not significantly different from non-innovators.

This study opens the way to several avenues for further research. First, the empirical analysis could be improved by taking into account the quality of the patent portfolio (with the number of forward citations) along with the quantity of active patents. It would also be worthwhile validating the results using larger databases of firms, ideally in different countries or regions. Finally, as suggested by the authors, being able to differentiate patent portfolios as mere indicator of innovation performance from patent portfolios as strategic tools to leverage in technological negotiations or to use in building strong technological positions vis-à-vis competitors, would constitute a quantum leap in the current state of research on patenting behaviour.

Technological Opportunity Attracts More Venture Capital (Chapter 10)

Despite the wide recognition of venture capital funds as key players in the national innovation system, there are important differences across countries in the relative amounts of VC. It is, for instance, relatively high in the US and Canada but very low in Japan.

The central hypothesis tested by Astrid Romain and Bruno van Pottelsberghe is that, besides the determinants previously tested in the literature, two broad sets of factors unheard of in the existing empirical research might also contribute to explain heterogeneity of VC intensity across countries. These factors relate to the entrepreneurial environment

and to technological opportunity – intellectual property rights in particular. A theoretical model that takes into account the factors that affect the demand and supply of VC is developed. These factors include the growth of GDP, short-term and long-term interest rates, several indicators of technological opportunity (business R&D expenditures growth rate, level of business R&D capital stock, and number of triadic patents), and indicators of entrepreneurial environment.

The model is tested using a panel dataset composed of 16 countries over an 11 year period. Empirical results can be summarized as follows:

- Interest rates have a significant impact on VC intensity. Whereas short-term and long-term interest rates influence positively the relative level of VC via a strong demand-side effect, the difference between long-term and short-term interest rates has the opposite impact, revealing a stronger supply-side effect.
- VC is pro-cyclical. It follows an evolution similar to the GDP growth rate. In periods of high growth, the flow of venture capital outperforms the GDP growth rate, and vice versa.
- Indicators of technological opportunity, such as the available stock of knowledge and the number of high value patents (triadic patents), positively influence a country's investment in VC.
- The positive effect of the stock of knowledge is strongly reinforced in countries with a very high rate of entrepreneurship.

One important policy implication that emerges from these results is that in order to stimulate VC activity in a country, demand-side factors have to be taken into account. The most important factors affecting the demand of VC are the stock of knowledge, the innovative output proxied by the number of highly valued (triadic) patents, and the interest rates. The level of entrepreneurship does play an important role as well.

This empirical study of the determinants of venture capital could be improved in several ways that constitute interesting avenues for future research. A first and simple upgrade would be to reiterate similar estimates over a longer time-span that would go beyond the year 2000. Indeed, after the turn of the century a significant drop has occurred in the level of VC in most industrialized countries. It would be interesting to test the robustness of the results in this respect. Another improvement would be to include data on IPOs and stock market performance, as they reflect the effectiveness of capital markets.

This introductory chapter has highlighted that, besides significantly contributing to the current stream of research, the ten chapters of this

book open fascinating avenues for future research in the field of the economics and management of innovation and intellectual property, at the individual, firm, sector and country level, in various regions of the world, and with implications for policy-makers, business practitioners, research scholars and educators.

The research question of whether and how intellectual property ultimately fosters innovation and economic growth is definitely far from being obsolete. Through their contributions to this book, professors and research scholars from leading institutions throughout the world have pushed one step farther the frontiers of our understanding of this issue. It is our greatest hope that, as it has been for us as editors, this book will prove a valuable and inspiring experience to the readers and a fruitful source of ideas for research scholars.

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Notes: f = figure; n = note; t = table; **bold** = extended discussion or heading emphasized in main text.