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Project co-ordinator name, Title and Organisation: Alfonso Gambardella, Prof., Bocconi University, Italy

Tel: + 39 02 5836 3712

Fax: +39 02 5836 3791

E-mail: alfonso.gambardella@unibocconi.it

Project website address: http://www.innost.unibocconi.it

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1. Executive summary

InnoS&T developed and collected novel and systematic science and technology indicators covering Europe, Japan and the United States through extensive surveys of patent inventors and the creation of indicators based on citations to science in patents. The project also developed empirical models and policy analyses using these indicators in the following research topics: the economic use of patents; science-industry links and innovation performance; gender, education and mobility of inventors; and the economic value of patents.

As far as the creation of innovative indicators is concerned we carried out the following activities:

- PatVal-EU II, PatVal-US and PatVal-JP surveys interviewing inventors of EPO patents with priority dates in 2003-2005 in 20 European countries, US, Japan and Israel. We received 22,533 responses by the inventors in all surveyed countries, corresponding to a corrected response rate of 20%.
- construction and matching to the survey data of a large set of complementary indicators at the level of patents, inventors, companies, regions, technologies.
- creation of an extensive dataset of indicators of industry-science linkages based on the creation and validation of an algorithm for extracting more than eleven millions of scientific non patent references contained in worldwide patents for all OECD countries in the 1990-2005 period.

This report shows empirical evidence and results obtained from the analyses of the S&T indicators created in this project. It also discusses the policy implications and wider impact deriving from the results of our analysis and our main dissemination activities.

In particular InnoS&T produced the following empirical and impact analyses in four topics:

1. Study of the extent and determinants of four different **uses of patents**: commercial use of patents, patent sale, patent licensing and use of patents for the creation of new firms. We also look at unused patents, for blocking reasons or sleeping patents.
2. Creation of country profiles over time in terms of **science-technology linkage** indicators and analysis of the impact of our indicators of scientific intensity of technology on innovation dynamics and performance at three levels: patents, firms and (national) innovation systems.
3. Analysis of the differences in wages and productivity between female and male inventors and development of a comprehensive study on the **gender gap** issue, taking into account factors such as the characteristics of the individuals (age, education, ability), their productivity and working hours, the social setting in which they live (family, children), their mobility and role within the organization.
4. Study of determinants and impact of the **value of patents** by focusing on (i) the inventive step of the patent and (ii) the social value of the information disclosure associated with patents.

2. Project context and main objectives

The InnoS&T project aimed at

1) developing and collecting novel, systematic and more adequate science and technology indicators, and
2) developing empirical models that can contribute to improve policies on four key areas: (i) economic use of the patents; (ii) science-industry linkages and innovation performance; (iii) Gender, education and mobility of inventors; (iv) The economic value of patents.

The idea of this project arise from the need to answer some key questions in science, technology and innovation: which factors determine the rate of commercialisation of inventions? How did science contribute to technological progress? Are differences in technological performance between countries related to the science intensity of technology? How can policy support the production of valuable inventions and their commercial exploitation? How can they contribute to remove impediments in the markets for technology?

These questions arise from some facts. First, the number of patented inventions exploded in the last three decades. However, a large portion of inventions is not used by their applicants. There are several explanations for the limited commercial use of inventions. Some inventions may not reach the market because their applicants do not possess the complementary assets to produce and commercialise them. Another reason may be the small value of many inventions. Recent evidence has shown that the distribution of the value of patents is skewed. Moreover, there is concern about the fact that firms patent for strategic reasons like blocking rivals' investments in related inventions. However, the assessment of these patterns is not straightforward, while they are relevant for competition policy.

Another important concern is to understand the extent to which science influences technological progress. The answer to this question has profound implications on public policy, notably on the decision to provide public funding to (public) research institutions but also on the appropriateness of fostering or stimulating industry-science linkages. Previous academic work revealed the importance of basic science for economic growth and the presence of externalities stemming from (local) academic research on private R&D and patenting. Interactions between private firms and knowledge actors have increased over the last decade and are today manifesting themselves in multiple ways: university-industry collaboration and contracting, industry financing of university research, university spin-offs and licensing activity, mobility of university researchers.

While researchers, practitioners and policy makers stress the importance of interactions between scientific activities, technological development and innovation processes, relevant indicators of knowledge creation and diffusion that cover the interfaces between science, technology and innovation are still lacking. The increasing availability of large datasets on patents, publications, and references, are offering considerable potential for the development of more sophisticated indicators that span science and technology realms.

To contribute to the above issues, the first part of the project was devoted to the construction of new indicators. Precisely, we carried out the following two activities:

1) implementation of three new survey data collections, PatVal-EU II, PatVal-US and PatVal-JP, which build on the PatVal-EU survey conducted in 2003-2005 by team members of this project (see Giuri et al. 2007 for details). The new surveys interview inventors of EPO patents with priority dates in 2003-2005 in 20 European countries (Germany, France, Great Britain, Italy, Netherlands, Switzerland, Sweden, Finland, Belgium, Austria, Denmark, Spain, Norway, Ireland, Greece, Slovenia, Hungary, Czech Republic, Poland, and Luxembourg), US, Japan and Israel.

2) creation of indicators for industry-science links based on patent citations to science for all OECD countries, over time, across industries, by firms, by universities and by firms to universities and public research institutions. These indicators cover all OECD countries and the 1990-2005 period.

In addition to the two main activities of generation of new indicators, we also collected relevant complementary indicators on patents (citations, oppositions etc.), publications, individual inventors, companies, public research institutions and universities, regions, sectors. These indicators are mainly drawn by existing datasets, but needed several important steps for the matching with the survey data, including cleaning of company names, consolidation of subsidiary to parent companies etc.

The production of new datasets and indicators allowed us to reach the following goals.

First, by submitting a novel survey questionnaire including several under explored key issues about invention processes and the exploitation of patents, we produced a large datasets of indicators which allow direct comparisons between Europe, US and Japan. Such information is currently lacking in the literature, and our inventor survey methodology was uniquely suited to generate the information.

Second, the collection of complementary indicators, in addition to the indicators resulting from the survey, allows us to take into account simultaneously a mix of key factors that may have important impacts on policies.

Finally, indicators and methods that take adequately into account the linkages between science, technology and industry are currently not available, especially for such a broad coverage of countries and years. Moreover, these indicators have been externally validated in this project by using specific questions included in the survey questionnaire and other external information.

The second part of the project developed empirical models and policy analyses using innovative indicators. We identified four research topics in which new indicators and empirical models can address relevant policy issues:

1. The economic use of patents: commercial use of the patent, patent licensing and sale, creation of new firms from patents, unused patents and strategic patenting.
2. Science-industry linkages and innovation performance at three levels of analysis: countries, institutions and inventions.
3. Gender, education, mobility and productivity of inventors.
4. The economic value of patents: social and monetary value of patents, inventive steps of patented inventions.

We believed that the indicators and the empirical analyses of this project represent an important step forward with respect to the current state of the art of indicators and evidence.

In particular our indicators contribute to fill the following gaps.

First, there are no available indicators on the following issues: the extent of strategic patenting; the impediments to licensing, the actual decision of cross-licensing a patent; the characteristics of the founders, the owners; the social setting of inventors (family, children), the geographical extension of mobility (national vs. international), their role and position in the organization in which they are employed.

Second, some indicators (i.e. extent of licensing, of unused patents, of new firms from patents, of female inventors, NPR) were currently available only for some European countries. Some information is available for the US and Japan but the methods for collecting information are different, data cover different periods and therefore a reliable comparison between indicators in different countries is not possible.

Third, the construction of Science & Technology indicators based on patent and non-patent references in patent documents required the development of new algorithms to extract this information from the patent files and validate them in the web of knowledge. This is an extremely intense IT-based task carried out in this project and that considerably improved the reliability and accessibility of such indicators.

The other important advancement achieved in this project is the development of appropriate and effective empirical methods that enable to assess simultaneously the impact of a variety of factors on key economic phenomena (i.e. the use of patents; the role of gender inventive activities). This is possible because we developed a broad set of survey-based, industry-science link and complementary indicators at different levels of analysis: the patent, the link with the scientific environment, the applicant of the patent (i.e. SMEs, large firms, Universities), the inventor (age, sex, education, family characteristics), the technology area of the patent, the geographic location of the invention and the characteristics of the country/region.

3. Main S & T results/foregrounds

This section reports some of the main results obtained in this project.

It will summarise:

- Results from the activities of creation of novel S&T indicators:
  - Patval-EU II, Patval-US and Patval-JP surveys
  - S-T linkage indicators
  - Complementary indicators
- Results from empirical analyses conducted by using the indicators produced in this project in the following topics:
  - The economic use of patents
  - Science-industry linkages and innovation performance
  - Gender, education and mobility of inventors
  - The economic value of patents.

3.1 S&T indicators

3.1.1 Patval-EU II, Patval-US and Patval-JP surveys

The InnoS&T project aimed at collecting data on a number of issues relating to invention processes and their determinants, inventor biographies and motivation, patent value, commercialization and related issues.

InnoS&T follows in many regards the example of the PatVal-EU project (see Giuri et al. 2007). It differs from PatVal-EU by being global in scope and by being more focused as regards the research questions. Inventors in Europe, the USA and Japan are contacted and surveyed, using a harmonized questionnaire across all surveyed regions. In particular, the following countries are taken into account:

- Europe - 20 EPC member countries (AT, BE, CH, CZ, DE, DK, ES, FI, FR, GB, GR, HU, IE, IL, IT, LU, NL, NO, PL, SE, SI), and Israel
- Japan
- USA.

In order to have a reserve for cases in which address information may be deficient, we sampled 133,411 patents. The main data source used to draw the sample for the InnoS&T survey is the EPASYS database as of 04/2008. Information on technological fields is supplemented from the PATSTAT database as of 04/2008. The sample was drawn at the level of patent applications with priority dates between 2003 and 2005. After sampling the patents, one inventor listed on the patent document was chosen at random. 2003 was used as a lower bound of the priority years to avoid too much overlap with two inventor surveys recently conducted in the US and Japan (which used priority years between 1995 and 2003). 2005 was chosen as an upper bound, since PCT filings only enter the regional phase 30 months following the priority date. Choosing patent applications with later priority years would have led to biases due to “missing” PCT filings.

The implementation of the survey, described in the following, was supported by TNS Infratest, which is part of the TNS Group, one of the world’s largest custom market research companies.

Before starting the full scale survey, we conducted three pre-tests: (1) to test the final version of the questionnaire and to test the whole procedure of conducting the survey, (2) to test the response rates given the inventors are provided with paper questionnaires instead of a letter containing a link leading to an online questionnaire, and (3) to ask the inventors about reasons for not responding or about their experience with the questionnaire.

For the full scale survey inventors received a letter asking them to fill out an online questionnaire on a website that they can access through an ID and a password, generated for the specific inventor by the market research company. Reminder letters have been sent after a couple of months from the first letter in Europe. In the US and Japan we sent two reminder postcards.

By November 1, 2011 we received 22,533 responses by the inventors in all surveyed countries,

corresponding to a corrected response rate of 20%.

We finally obtained a large set of indicators on:

- Inventors’ education, age, gender, social setting, employment, mobility, inventions and scientific publications;
- Inventions process: employer (size, age, R&D organization), formal and informal collaborations, sources of knowledge, timing, resources
- Inventors’ motivations and rewards: compensation, non monetary rewards
- Use and value of patents: use of patent for commercial applications, sale, licensing, cross-licensing, foundation of new company, motivations for patenting, inventive step

3.1.2 S-T linkage indicators

We developed S-T linkage indicators in the following areas:

1. *The presence of universities as patent applicants*

University applicants have been identified in an exhaustive manner. Existing sector allocation methodologies - that allow distinguishing patent assignees by organizational type - have been refined and extended for university applicants. This sector allocation was used for mapping the presence of universities in the technological landscape across OECD countries (using EPO application data, covering the period 1978-2009).

Within a next step, all university names have been harmonized, resulting in detailed and precise statistics on the level of universities. Data were extracted for EPO and USPTO patent documents; covering the time period from 1990 to 2007.

2. Forward patent citation rates of university owned patents

The methodology developed to identify university owned patents has been used as well to identify citations within patent documents towards university owned patents (so called Patent References, or Patent Literature).

3. Scientific non patent references

Major efforts have been devoted to identify exhaustively scientific references within patent documents. For the first time, all non-patent references (NPR's) from the PATSTAT database (October 2009) have been categorized as scientific (Yes/No). In order to arrive at such an exhaustive classification, two complementary approaches have been deployed. On the one hand, classification rules have been distilled, based on exact matching procedures and keywords. On the other hand, supervised machine learning algorithms have been designed to classify all references. Both, complementary, methods allow to classify all NPR's (> 11 Mio.) in an exhaustive manner with an accuracy level of 95%.

3.1.3 Complementary indicators

We developed a set of complementary indicators at the following levels of analysis: patents, inventors, companies, regions, technologies. These indicators have been created by using existing data sources. Most of these indicators have been matched to the Patval survey data obtained in this project through the application of matching algorithms and intensive manual data check and cleaning. We finally obtained the following indicators:

Patent level: backward and forward citations classified by category, oppositions, claims, shared priorities, divisional applications, procedural characteristics such as the application path (PCT vs. Euro-direct), request for accelerated examination and search (Source of data: PATSTAT and EPASYS databases).

Inventor level: number of patents, citations, the size of the inventor team (Source of data: PATSTAT).

Company level (at the level of the applicant and of its parent): type of applicant (i.e. business company, university, etc.), geographical origin, number of patents, patent stock, citations, technological diversification, R&D intensity, age, sales, employees, sector, and other balance sheet data (Sources of data: Amadeus, Orbis, Osiris, Compustat, OECD STAN, PATSTAT).

Regional level (at the NUTS2 and NUTS3 level): GDP, population, area, number of patents by technological class, number of patents by organization type, citation counts by organization type, share of new business patentees, technological specialization of the region (Sources of data Eurostat Regio, PATSTAT).

Technology level (at the level of IPC3, IPC4 and OST30): yearly number of patents, number of applicants, degree of concentration of applicants, number of young patenting firms (Sources of data PATSTAT).

3.2 Empirical results in the four themes

This section shows some empirical evidence and results obtained from the analyses of the S&T indicators created in this project. We illustrate the main findings in the four themes of our project by providing some descriptive statistics on the main indicators in each theme and a summary of the results obtained in the empirical estimations of our project[1]. Full results of our empirical analyses are reported in deliverable 7.3 of this project.

3.2.1 The economic use of patents

The issue of patent use is crucial since patent value depends on the ability to exploit the underlying invention to develop useful process and product innovations. However, most patents do not generate any substantial value to their owners. Many patents are also not used or are used for purely strategic reasons (e.g. blocking patents and cross-licensing) rather than being used to protect valuable innovations.

Our project created a set of novel indicators and empirical studies on four different uses of patents: commercial use of patents, patent sale, patent licensing and use of patents for the creation of new firms. We also look at unused patents, for blocking reasons or sleeping patents.

Our indicators contribute to cover important shortcomings with respect to the availability of data on different patent uses and the literature on these topics. In particular our novel contributions are the following:

- We developed indicators on four different potential uses of patents which are not currently available with such a large geographical coverage and after 2000.
- We created new indicators on patent sale, which are very relevant since the literature on this phenomenon is practically inexistent, as well as empirical evidence. Most theoretical and empirical studies investigated the extent and functioning of technology markets by looking at patent licensing. With our survey and empirical analysis we provide an important contribution to this issue, since patent sale accounts for an important share of markets for technology.
- Our indicators also measure, for the four different uses, if patents the owners are willing to use their patents, but patents are not yet used at the time of the survey. Evidence for "Willing to be used" patents is not currently available for different type of uses and with a large coverage. The significant share of patents that the owners are willing to use raises the question as to how the use of patents can be intensified and how the market for technology in different countries can be expanded.
- We identify unused patents, that is patents that are neither commercially used by the organization neither they are sold, licensed or used to found a new firm. This is an important issue for innovation and IPR policies because it raises the question as to whether the costs of patenting are proportional to

[1] The empirical analyses of these report using the PatVal-EU II, PatVal-US and PatVal-JP datasets use unweighted responses.

the benefits accruing to innovators and the society. Moreover, a significant share of patents are not used but could be used because the owner is willing to use. This also raises the issue of policies that reduce the barriers to a more intensive use of patented technologies.

Table 1 illustrates the share of different patent uses, of willing to be uses patents and unused patents by country. By looking at the total results we observe that:

- On average 53.05% of patented inventions are used commercially, i.e., in a product, service or in a manufacturing process, while 21.48% of patents are not used commercially. For about one fourth of patents the patent owners are still investigating the possibility of using the patent commercially.
- 5.47% of patents are sold to independent owners, while for 5.61% owners are willing to sell their patents.
- About 8% of patents are licensed and another 8% are willing to be licensed.
- 4.57 % of patents have been used to found a new company (in 64% of cases by the inventor or a co-inventor), while in 2.91 % of cases the foundation of a new company is planned.

A first look at the data also shows an important distinction between two categories of unused patents:

- Blocking patents (26.53% of cases), which are taken to block other patents (i.e., avoiding that others patent similar inventions, complements or substitutes);
- Sleeping patents (16.04 %), which are not used for reasons unrelated to block other patents.

There are substantial differences across countries in the use of patents. The countries using patents most are small countries with intense patent activity - Austria, Switzerland, Ireland, and Denmark – and Italy.

Table 1 also illustrates the share of patent sale and licensing by country. Small countries with intense technology activity (Norway, Sweden, Finland, Denmark, Netherlands, Ireland) have a higher propensity to sell and/or license. Also some emerging economies (Greece and Slovenia) are more active as patent sellers than the average. Emerging countries with a high propensity to license are the Czech Republic, Hungary and Poland. This may be due to difficulties of firms based in these economies to have access to key complementary assets. Among large countries, patent sale is around 10 % and patent licensing about 14% of patents in Great Britain and the United States, where it is likely that markets for technology are more developed. The share of patents for which sale and licensing is planned is also larger in these countries.

Patents in emerging countries like Czech Rep., Poland, Hungary and Greece are also more likely to be used to found a new firm (this may reflect the lack of large domestic companies). In small countries like Ireland and Norway the rate of new firm formation is also quite high. Entrepreneurship seems to be lively also in the US and Great Britain while the creation of new firms is much smaller in Japan (only 1.15%) where also the share of patent licensing and sale is evidently smaller than the average.

Table 1 finally shows that European Nordic countries like Denmark, Sweden and Norway have a percentage of use above the average while France, Belgium and Luxemburg are among the countries with a rate of use below the average along with Japan. These countries (with the exception of Belgium) are also among those with a share of blocking patents above the average. Eastern European countries show a quite high variance in the share of unused patents, with Czech Republic showing the lowest share, well below the sample average, and Hungary the highest share. Finally, Ireland and France are the countries with the highest share of sleeping patents.

Table 2 illustrates patent uses and unused patents by type and size of the organization.

Universities and PROs have a lower commercial use than business enterprises (29% of patent use for PRO against 55% for firms). Table 2 also shows that patent sale and licensing is larger in Universities and PROs, while it decreases with firm size. Small firms (below 100 employees) have a higher propensity to both sell and license their patents compared with larger, older firms. The lack of complementary assets and severe financial constraints spur small startups to sale their patents to generate cash flow.

Patents held by small firms (<99 empl.), universities and PROs are also more likely to be used to start a new firm compared with patents of large private enterprises.

As expected, firms have a higher share of used patents compared with universities and public research institutions (PRI). The higher share of blocking patents among firms shown is also in line with the importance of strategic patenting for the business sector as compared with the academic and scientific sector. Instead, the relatively large share of sleeping patents held by PRI points out the difficulties of these institutions to bring patented inventions to the market and the limited resources usually dedicated to the economic exploitation of innovations.

Patents are mostly used by small to medium-sized firms and are less used by very small firms (<10 employees) and large firms (>499 employees) probably for different reasons. Very small firms may not be able to use commercially the invention because they lack complementary assets like manufacturing and marketing assets. By contrast very large firms may build large patent portfolios for strategic reasons (i.e. blocking patents, prevention from infringement suits, etc.), but they are not willing to use all those patents. Moreover, the cost of patenting may be higher for SMEs, who are thus more likely to patent in order to use their inventions.

The final columns of Table 2 further confirm these findings. We find that the share of unused patents increases with firm size, ranging from less than 30 % in SMEs (less than 250 employees) to over 50% in very large firms (over 5,000 employees). The blocking-to-sleeping ratio also varies with firm size by pointing to the relatively larger importance of strategic patenting in large firms.

We carried out econometric estimations of the main factors affecting the probability of commercial use, sale, licensing and creation of new firms. We also study the factors affecting the probability of non-use and examine the differences between unused blocking and sleeping patents.

For this multivariate analyses we used novel indicators about: characteristics of the organization where the inventor was employed like the size and the presence of complementary assets for the economic exploitation of the invention; characteristics of the invention process like the scenario leading to the patented invention, the collaboration with external actors, the competitive environment; characteristics of the patented invention, like technological field, priority year, country of inventor, status of the patent. We also use complementary indicators at the patent level drawn from EPO-Epasys dataset like the number of citations received by the patent.

In the following we summarize our main findings on the most relevant factors affecting the different uses of patents.

Commercial use of the patent

- Firm size: Organizations between 20 and 249 employees are more likely to use their patents compared with smaller firms but larger organizations do not have a higher propensity to use commercially their patents. Very large firms (5,000 employees and more) are less likely to use commercially their patents.
- Complementary assets: commercial use is more likely when the organization possesses internal assets for the economic and technical success of the invention. We also find that frequent communication with other departments – a measure of the importance of complementary assets, affects positively the commercial use of patents.
- Creative process: inventions that are not the target achievement of a R&D project are less likely to be used commercially.
- Collaboration with external actors: Collaboration with customers or product users and suppliers is useful for the commercial use of the invention. On the contrary, collaboration with universities and PRO are negatively correlated with commercial use, suggesting that these institutions are likely sources of more abstract, less ready-to-use knowledge.
- Economic value: it positively affects commercial use.

Patent sale

- Firm size and complementary assets overall have a negative impact on the probability of sale.
- Collaboration with competitors, universities and private research institutions is positively associated with patent sale. However, the largest effect is generated by collaboration with competitors which suggests that patent sale is probably part of a broader alliance with competitors.

- Organic chemicals, pharmaceuticals and, to a lesser extent, telecommunications are the technical fields where patent sale is most likely to occur.
- Patent sale is not significantly correlated with patent value.

Patent licensing

- The likelihood of licensing out a patent decreases with size.
- Firms that possess either complementary resources to a technical success or the resources to turn the invention into an economically valuable innovation are more likely to license. This may appear at odds with the idea that complementary assets reduce the incentive to license out. However, this finding suggests that the control of only part of complementary assets needed to develop and exploit an innovation spurs the search for partners that possess these complementary assets.
- The creative process leading to the patented invention overall is not correlated with the decision to license with the exception of inventions resulting from the normal job of inventors whose main activity is not R&D. A possible explanation for this result is that these inventors are likely to produce ideas that are either of limited value or far from the core business of the organization.
- Collaboration with customers, other firms and universities during the inventive process is important to explain licensing and the magnitude of some of these effects is substantial.
- Patent value is positively correlated with licensing.

Startups

- The likelihood of using the patent to start a new firm decreases with the size of patent owner.
- The availability of technical and nontechnical assets required to develop and exploit the invented patent has a strong negative impact on the probability of startup.
- The creative process leading to the patented invention has some effect on the decision to start a new firm, especially if the invention is the result of the normal job of inventors, which is not inventing, that is further developed in a R&D project or the result of pure inspiration/creativity.
- The decision to use the patent to start up a new firm is positively correlated with collaboration with competitors, universities and other research institutions. This suggests that the learning opportunities offered by these external sources of knowledge are relatively not valuable or more difficult to exploit by the parent organization compared with a new organization probably entirely focused on these opportunities. From a different perspective, this finding shows that exposition to a rich set of external sources of knowledge and professional contacts may help skilled inventors to use a valuable patent to start up a new firm.

Unused patents

- Large firms have a larger probability of not using a patent than smaller firms. This probably reflects the larger size of patent portfolios and, sometimes, the use of patents for purely strategic reasons.
- The availability of complementary assets reduces the probability of nonuse.
- Inventions that are not the target achievement of a R&D project in general are more likely to remain unused.
- The existence of competitors for the same patent has no effect while aggressive competition negatively affects nonuse. This is in line with other findings in our estimations showing that intense technological (and market) competition spurs a more intensive use of innovations, either by direct commercial exploitation or licensing out.
- Patents in semiconductors, organic chemicals, and biotechnology are more likely to remain unused.
- There is a negative effect of patent value on nonuse.

Blocking and sleeping patents

- The probability of both blocking and sleeping patents increases with firm size, with a difference. While, blocking patents are more frequent in both medium and large firms compared with smaller firms, sleeping patents are more frequent only in large firms (more than 500 employees).
- The availability of complementary resources to a technical success has an opposite effect on sleeping and blocking patents. These resources are positively associated with blocking patents because they are useful to enforce the protection of the invention particularly in patent litigation or licensing deals.
- Competition has also an opposite effects on sleeping and blocking patents. As expected, the presence of competitors for the patent has a positive effect on the blocking strategy. Competition spurs firms to rely on blocking patents to prevent being blocked by others patents or to preempt entry in downstream markets. Instead, the negative impact of competition on sleeping patents may reveal an efficiency effect of competition on the use of patents.

Country	Used patents	Willing to use	Sold patents	Willing to sale	Licensed patents	Willing to license	Start-up founded	Willing to found	Unused patents	Unused patents *blocking*	Unused patents *sleeping*
AT	66.81	20.43	4.37	1.75	7.01	5.61	2.81	2.41	32.24	16.94	15.30
BE	52.12	25.87	3.36	3.78	8.12	6.41	3.32	5.17	45.41	26.02	19.39
CH	60.04	23.64	4.76	4.55	8.89	6.00	5.68	3.04	35.82	20.10	15.72
CZ	58.06	27.42	9.84	13.11	12.28	12.28	10.77	3.08	31.11	24.44	6.67
DE	55.77	26.21	3.84	2.63	6.50	4.74	2.67	1.83	40.95	22.06	18.89
DK	59.68	26.61	10.08	2.33	5.17	8.62	5.37	2.68	34.65	18.81	15.84
ES	48.82	31.76	3.80	13.29	9.68	12.90	18.44	5.59	41.91	25.00	16.91
FI	53.15	30.77	10.07	5.76	13.45	14.29	4.29	2.45	33.66	12.87	20.79
FR	35.59	30.40	2.87	3.63	5.88	5.63	3.31	3.61	58.60	36.56	22.04
GB	52.20	28.04	10.79	8.39	13.67	16.48	9.38	4.53	39.31	22.89	16.41
GR	51.85	37.04	12.50	33.33	4.35	34.78	24.14	24.14	30.00	10.00	20.00
HU	50.85	20.34	8.33	18.75	14.89	17.02	14.04	3.51	53.13	34.38	18.75
IE	60.81	29.73	8.82	17.65	20.31	20.31	11.84	13.16	36.36	12.73	23.64
IL	47.00	25.00	12.79	11.63	12.16	10.81	14.00	7.00	46.15	32.31	13.85
IT	61.30	21.58	5.02	7.34	9.14	9.24	6.20	4.62	35.88	23.88	12.00
JP	50.22	24.39	3.13	6.70	4.43	9.43	1.15	0.76	48.71	35.86	12.85
LU	34.15	21.95	0.00	5.00	5.00	2.50	2.33	0.00	66.67	41.67	25.00
NL	53.79	28.97	7.06	6.81	13.43	9.45	8.24	4.77	36.89	20.17	16.71
NO	57.84	27.45	15.53	6.80	9.00	15.00	13.46	8.65	36.67	24.44	12.22
PL	58.82	21.57	6.67	15.56	9.52	21.43	12.50	8.93	39.39	24.24	15.15
SE	52.38	30.77	8.68	6.42	7.47	10.37	8.55	2.96	38.42	25.12	13.30
SI	55.56	29.63	11.76	9.80	4.26	6.38	1.85	11.11	45.00	30.00	15.00
US	54.48	22.88	9.39	6.88	13.72	10.84	6.67	3.70	37.55	23.53	14.03
Total	**53.05**	**25.47**	**5.47**	**5.61**	**8.19**	**8.45**	**4.57**	**2.91**	**42.56**	**26.53**	**16.04**
N	14757	14757	14302	14302	13525	13525	15706	15706	11585	11585	11585

Table 1. Uses of patents by country

	Used patents	Willing to use	Sold patents	Willing to sale	Licensed patents	Willing to license	Start-up founded	Willing to found	Unused patents	Unused patents blocking	Unused patents sleeping
Firm	55.33	23.50	4.99	4.45	6.55	6.75	3.23	1.94	41.67	27.13	14.53
PRI	29.61	45.58	9.93	15.56	23.40	21.50	14.42	10.38	53.64	16.81	36.83
Other	46.56	31.15	7.73	10.34	13.13	16.41	9.86	7.81	44.65	27.82	16.83
Total	**53.10**	**25.42**	**5.48**	**5.54**	**8.09**	**8.35**	**4.38**	**2.86**	**42.60**	**26.53**	**16.06**
N	14658	14658	14204	14204	13419	13419	15593	15593	11506	11506	11506
1-9 empl	55.07	30.02	14.65	16.27	19.17	22.22	27.01	12.43	28.47	14.70	13.77
10-19 empl	61.14	23.27	10.26	12.82	16.26	17.34	11.11	8.21	29.81	20.51	9.29
20-49 empl	63.21	19.65	13.00	6.26	15.44	7.72	7.74	4.86	29.88	16.33	13.55
50-99 empl	64.84	18.41	9.93	5.85	9.18	7.30	4.98	2.41	27.15	15.23	11.92
100-249 empl	65.02	19.03	5.49	3.37	7.40	6.48	4.07	3.01	30.92	19.14	11.77
250-499 empl	60.12	22.11	3.57	3.68	5.78	6.23	2.37	1.19	37.88	24.37	13.51
500-999 empl	56.05	23.55	3.09	3.19	6.88	5.72	2.10	1.40	41.10	27.48	13.63
1000-4999 empl	52.38	24.86	3.93	5.11	6.00	7.64	2.24	1.70	44.16	26.95	17.21
5000+ empl	47.08	27.91	3.71	3.87	6.09	6.26	1.22	1.38	51.16	32.87	18.29
Total	**53.19**	**25.32**	**5.48**	**5.50**	**8.14**	**8.27**	**4.40**	**2.80**	**42.51**	**26.49**	**16.02**
N	14626	14626	14168	14168	13380	13380	15556	15556	11486	11486	11486

Table 2 Uses of patents by type and size of organization.

3.2.2 Science-industry linkages and innovation performance

By using the Science-industry linkage indicators created in this project we carried out several empirical analyses.

Country profiles

First, the developed set of indicators using scientific non patent references allow to assess (national) innovation systems over time in terms of Science-Technology indicators. We created OECD country profiles, covering the period 1978-2007 including the following indicators (see Table 3 as an example for Germany and United States from 2003 to 2007):

- number of patents
- science intensity of technology: number of patents with Scientific Non-Patent References (SNPRs), number of SNPRs, SNPR intensity (all patents), SNPR intensity (only patents with SNPRs), university SNPR intensity
- technological orientation of scientific organizations: number of university patents, share of university patents, patent citation rate.

Appl year	# pats	# pats with SNPRs	# SNPRs	SNPR intensity (all pats)	SNPR intensity (only pats with SNPRs)	# university pats	% university pats	university SNPR intensity
Germany								
2003	35721	5129	14648	0.41	2.86	219	0.61	2.35
2004	34460	4736	13733	0.40	2.90	247	0.72	2.17
2005	33699	4701	15138	0.45	3.22	294	0.87	3.06
2006	31360	4419	12836	0.41	2.90	366	1.17	2.68
2007	25974	3582	11124	0.43	3.11	353	1.36	3.08
United States								
2003	45413	10522	36791	0.81	3.50	1558	3.43	3.51
2004	43504	9780	33500	0.77	3.43	1388	3.19	3.24
2005	42538	9095	29293	0.69	3.22	1490	3.50	2.69
2006	41407	8035	23769	0.57	2.96	1591	3.84	2.36
2007	32582	5957	16418	0.50	2.76	1279	3.93	1.78

Table 3

Validation and Impact

All indicators have been validated and assessed in terms of impact. Validation efforts include the assessment of 'congruent' validity on the level of firms, patent documents and national innovation systems. Moreover, patent examiners and experts have been involved in validating and interpreting the derived indicators. In terms of impact, analyses have been performed on the same three levels - patents, firms and

(national) innovation systems. On all levels, our findings reveal the relevancy of incorporating the derived indicators when modelling and analysing innovation dynamics and performance.
In particular our main findings at the three levels of analysis are the following.

Patent level

The analysis conducted on the level of patent documents clearly reveals a positive, significant, relationship between the amount of scientific non patent references and the number of received citations of the patent document. In addition, patents held by universities receive significantly more citations (from other patents). A similar pattern is observed for patents which are cited by the scientific literature. The only 'scientific' variable which does not coincide with more citations relates to the presence of an equivalent document as scientific article. Overall, these findings clearly indicate that the presence of 'science' in technological activities results in patents which receive significantly more citations.
As such, our results not only provide evidence for the validity of our indicators, as we documented in other deliverables of this project. The observations in terms of impact at the same time underscore their relevancy for examining 'drivers' of technological (and innovative) performance.

Firm level

When examining the innovative performance effects of science-technology interactions at the firm level by means of CIS data, we only observe a clear, positive effect of collaboration with academic partners on the introduction of new products. Co-patenting (with Academia) does not yield positive effects; this should however not come as a surprise, given the low levels of incidence for this variable. In none of the models, Scientific NPR's become significant, suggesting that – at the firm level – the science intensity of technology does not coincide with innovation performance. However, the data used within this analysis might not warrant such a conclusion, as the amount of explained variance of all models is very limited.
These results are nevertheless very much in line with the work by Cassiman, Veugelers and Zuniga (2008; 2010) and indicate that we should look at a more micro-level for effects of industry-science links on innovative performance. Our results in this report do confirm the importance of university collaborations for innovation performance in a more recent time frame and suggest that scientific-non-patent references per se do not explain much of the innovation performance at the firm level without a clearer understanding about how the science intensity interacts with collaboration efforts of the firm with universities and research centers. In conclusion, future work on the importance of industry-science links on innovation performance will need to pay careful attention to the intertemporal link of science based technological outcomes and their eventual appearance in the innovation output measures typically used in this line of research.

Country level

Using national level indicators of science-technology relatedness, we evaluate whether, within national innovation systems, the occurrence of science-technology relatedness indeed imply an innovation advantage, as measured by a country's technological performance (within different technology domains). The analyses show a clear national-level impact of science-technology relatedness on technological productivity and on specialization. Taking into account time trends, country effects and field-specificity (as well as their interaction), it is revealed that a higher science-intensity of the national patent portfolio is positively related to subsequent technological performance on a country level. This suggests that a closer relatedness between technology development and scientific knowledge can leverage national-level technological productivity and also specialization. The other indicator of science-technology relatedness – university patents per capita – considers the extent to which universities actively contribute to national technology development. The results show that national innovation systems can indeed benefit from such an active contribution, as it positively affects technological productivity and specialization.

3.2.3 Gender, education and mobility of inventors

This part of the report explores differences in wages and productivity between female and male inventors. Though there is a vast literature on the gender gap issue, a comprehensive study taking into account factors such as the characteristics of the individuals (age, education, ability), their productivity and working hours, the social setting in which they live (family, children), their mobility and role within the organization, does not exist, mainly because of a lack of information at a large scale. The unique and novel data provided by the InnoS&T offers an opportunity to explore these issues. Our findings, which could be interesting both from a scientific and policy-making point of view, reveal that there is a gender-wage gap: after controlling for several sources of heterogeneity, female inventors, married and with young children, earn lower wages than male inventors. This gap, however, does not correspond to worse inventive performance in terms of the technological importance of the inventions produced, and is not explained by different effort, education, ability, productivity, experience, type of employer and role in the organization, all factors that we control for. One potential explanation that is consistent with our data is that women with partner and young children exert less effort in negotiating their salary. This is because attention to children and the income of the partner reduce the marginal utility of their own income, and thus any costly effort that may be necessary to raise it. In short, these women appear to behave consistently with Babcock & Laschever's (2003) idea that "women don't ask."

Table 4 provides demographic information as well as family related characteristics of the inventors separated by countries. In particular, the average age of the inventors amounts to 44.3 years. Whereas inventors from Japan are on average youngest (39.6 years), inventors from the US are on average oldest (48.4 years).

The share of female inventors (on average 5%) is highest in Israel (12%) and Poland (11%) and lowest in Austria (2%). Whereas in the Czech Republic 90% (maximum) of the inventors are married this is only the case for 72% in Poland (minimum). The inventors who answered our questionnaire have on average 1.5 children. The number of children varies between 1.15 in Japan (1.17 in Italy) and 2.07 in Israel. Finally, Table 4 provides information about the mobility of the inventors. 29% of the inventors in our sample changed their employer at least once during the 5 years prior to making the invention underlying our survey. The highest share of mobile inventors is observed in Ireland and Israel (47% each) the lowest share of mobile inventors is observed in France and Slovenia (22% each). Japan only exhibits a mobility rate of 14%. The reason for this low mobility rate is a special type of intra-firm or intra-network mobility, called secondment, i.e. employees are lent to subsidiaries, suppliers or otherwise related companies and return to their original employer, afterwards.

Country	average age	share of	share of	mean number of	share of
AT	42.92	0.02	0.84	1.53	0.31
BE	42.59	0.05	0.88	1.76	0.26
CH	46.19	0.04	0.82	1.52	0.36
CZ	45.36	0.06	0.90	1.77	0.39
DE	44.68	0.03	0.86	1.47	0.28
DK	43.11	0.07	0.87	1.66	0.53
ES	44.22	0.08	0.78	1.37	0.22
FI	42.37	0.05	0.85	1.36	0.46
FR	43.72	0.07	0.87	1.63	0.22
GB	46.61	0.05	0.85	1.57	0.41
GR	45.57	0.07	0.76	1.62	0.26
HU	47.26	0.06	0.77	1.57	0.31
IE	40.67	0.06	0.75	1.37	0.47
IL	46.61	0.12	0.89	2.07	0.47
IT	44.63	0.06	0.77	1.17	0.26
JP	39.55	0.03	0.74	1.15	0.14
LU	45.23	0.05	0.82	1.45	0.23
NL	44.98	0.03	0.87	1.66	0.33
NO	46.61	0.06	0.89	1.97	0.40
PL	44.34	0.11	0.72	1.47	0.37
SE	45.07	0.06	0.85	1.63	0.40
SI	41.50	0.09	0.81	1.52	0.22
US	48.43	0.06	0.87	1.74	0.45
Total	**44.25**	**0.05**	**0.83**	**1.47**	**0.29**

Table 4: Demographic and family related characteristics of the inventors by country

Figure 1 shows the reasons for moving. The largest share of inventors changed their employer because of an attractive job offer from a new employer. The second largest group contains those that moved because of advancement.

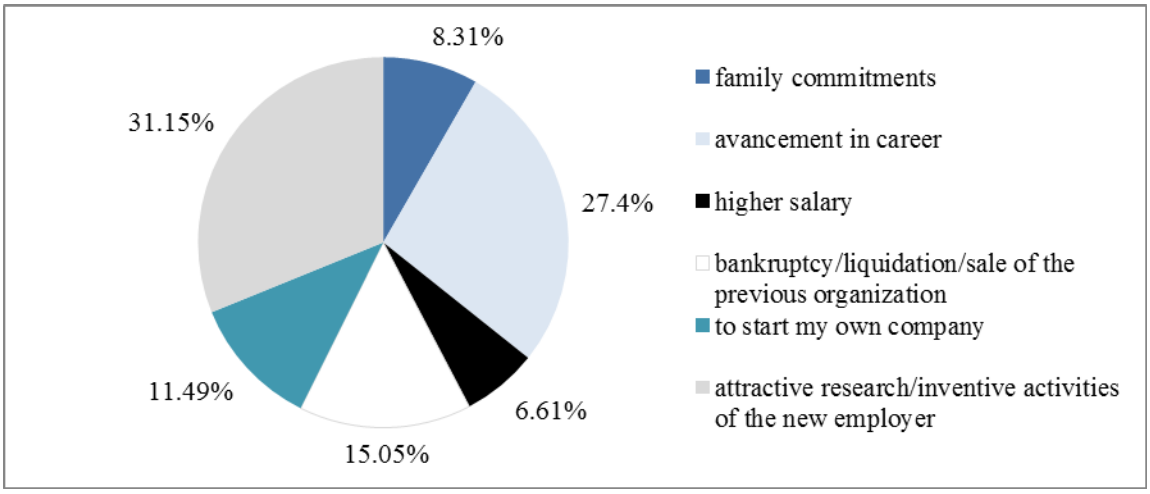

Figure 1: Reasons for moving (N = 4,526)

Figure 2 displays the wage distribution of men and women. Results show that women seem to earn less than men. Whereas the lowest three wage categories account for 59% of the female inventors, only 25% of the male inventors fall into the three lowest categories.

Table 5 provides more information about the differences in wage between men and women by providing wages by level of education. It is not surprising that the level of education is generally positively related to wage. Again, this table shows that women earn less. Considering the highest wage category (≥ 100,000 €), the wage gap between men and women is highest for inventors who earned a PhD.

Table 6 indicates that mobile inventors earn more than non-mobile inventors. Interestingly, the increase in wage due to mobility seems to be stronger for female compared to male inventors.

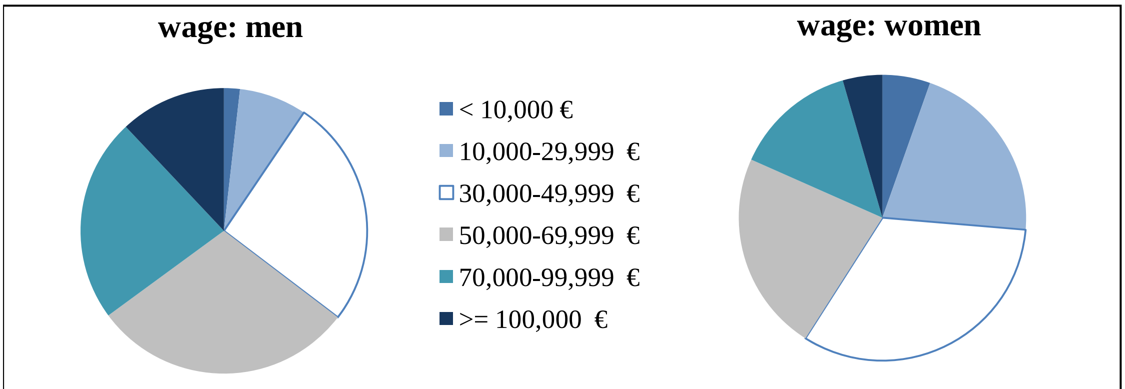

Figure 2: Wage by gender (N = 14,076)

wage_group	secondary school or lower		high school diploma		bachelor		master		PhD		post-doc		total	
	men	women	men	women	men	women	men	women	men	women	men	women	men	women
< 10,000 €	4.95	14.29	3.37	10.00	1.60	5.78	1.77	7.74	0.98	2.43	1.57	7.41	1.79	5.42
10,000-29,999 €	19.96	28.57	15.16	40.00	7.50	26.59	6.22	21.94	3.81	14.57	9.09	14.81	7.57	21.05
30,000-49,999 €	32.60	57.14	34.71	30.00	25.29	34.10	31.03	32.90	17.47	31.58	12.54	22.22	25.74	32.66
50,000-69,999 €	26.56	0.00	23.93	6.67	33.32	22.54	28.71	22.58	27.38	27.13	23.51	7.41	29.40	22.45
70,000-99,999 €	11.36	0.00	14.41	3.33	23.14	9.83	22.16	14.19	30.38	17.81	25.08	22.22	23.35	13.93
≥ 100,000 €	4.58	0.00	8.42	10.00	9.16	1.16	10.12	0.65	19.98	6.48	28.21	25.93	12.14	4.49

Table 5: Wage categories by level of education and gender (N = 13,805)

wage_group	non-mobile		mobile	
	men	women	men	women
< 10,000 €	1.54	5.92	2.34	3.90
10,000-29,999 €	7.92	22.78	6.76	17.56
30,000-49,999 €	27.06	34.62	23.38	29.27
50,000-69,999 €	30.01	21.41	28.44	25.37
70,000-99,999 €	22.28	12.30	25.21	16.10
≥ 100,000 €	11.19	2.96	13.87	7.80

Table 6: Wage categories by mobility and gender (N = 13,927)

Figure 3 reveals that the largest group of inventors in our sample (66%) is male, married and has children. The second largest group represents men, who are married (or live with a person) but do not have children.

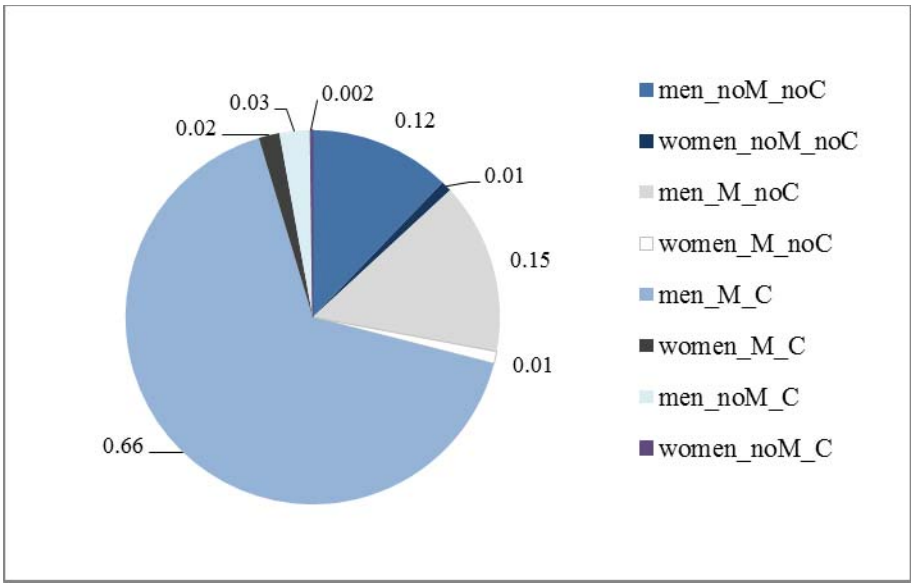

Figure 3: Gender, family status and children (N = 12,443)

[men_noM_noC = men/not married/no children; women_noM_noC = women/not married/no children; men_M_noC = men/married/no children; women_M_noC = women/married/no children; men_M_C = men/married/children; women_M_C= women/married/children; men_noM_C = men/not married/children; women_noM_C = women/not married/ children].
Note: being married also includes situations in which inventors live with a partner.

Figure 4 presents information about the distribution of work and leisure time of female and male inventors. Results indicate that men on average think more often about their work during their leisure time than women and are also more risk loving (variables on the use of leisure time vary between 0 and 5, where 5 is for activities undertaken very often by the inventors during leisure time). Women more often use child care and spend their leisure time with their family.

Productivity is measured as the number of patents per inventor divided by the years the respondents have experience in making inventions. We also employed a corrected productivity measure which is computed as the number of patents divided by experience but, for each child, one is subtracted from the denominator (i.e. the years of inventive activity). Both productivity measures reveal a larger average value for male inventors.

Figure 5 provides more detailed information about the use of child care and time commitment for different groups of inventors. Results show that female inventors make more use of child care service than male inventors when they have (young) children. At the same time, however, when back home from work, they spend more of their leisure time with their families compared to men, especially when children are younger than 12.

Figure 5 is consistent with the idea that married women with young children might have a lower reservation price: in many instances they are not the primary source of household income and, in the division of labor between partners, they have a much heavier presence in the house, taking care of the family.

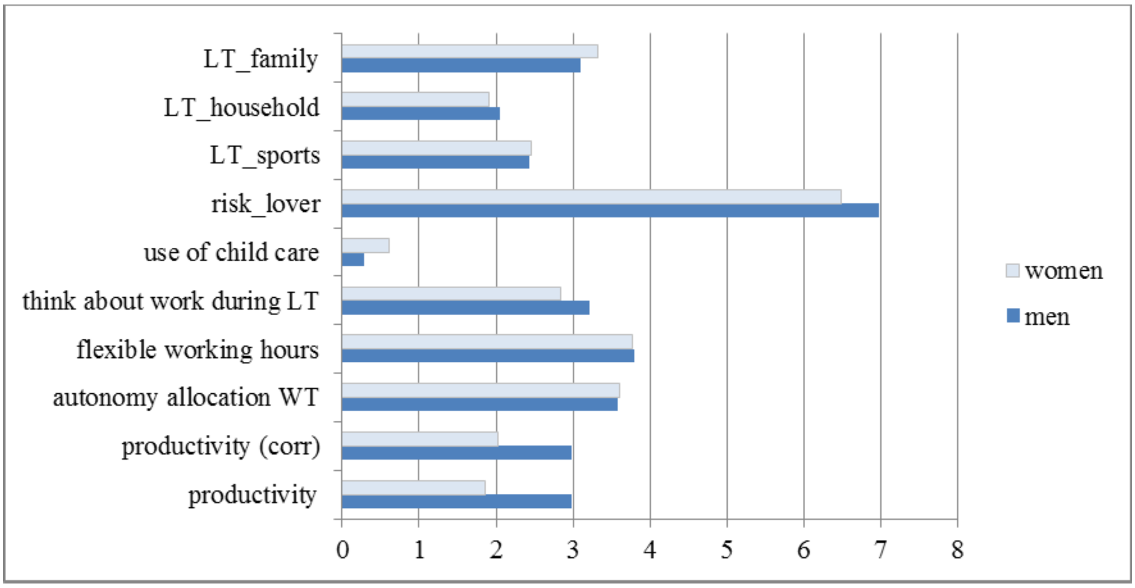

Figure 4: Time commitment by gender (LT = leisure time / WT = work time)

[* LT_family / LT_household / LT_sports: 0 = never, 5 = very often; N_{family} = 11,868 / $N_{household}$ = 11,814 / N_{sport} = 11,195 // risk_lover: min=1, max = 11; N = 12,194 // child care: 1 = yes, 0 = no; N = 8,524 // think about work during LT: 0 = never, 5 = very often, N = 11,845 / flexible working hours / allocation WT: 0 = no autonomy, 5 = very high autonomy; $N_{flexible}$ = 11,956 / $N_{allocation}$ = 11,794 // productivity: N = 12,188 / productivity (corr): N = 12,181]

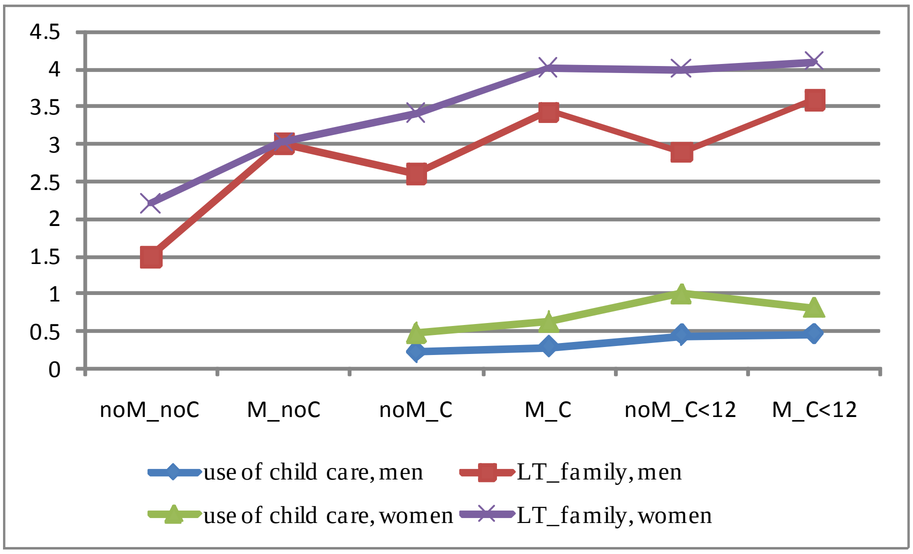

Figure 5: LT spent with family and use of child care services by gender and by family status (N = 11,075 for LT_family; N=7,973 for use of child care service)

Table 7 provides information about the perceived risk-taking behavior of the inventors. Generally, men seem to be more willing to take risk than women.

willingness to take risks	(N = 16,376) Share of men	Share of women
completely risk-averse	1.14	2.13
2	1.58	3.86
3	5.67	8.64
4	10.44	10.11
5	7.18	7.98
6	15.29	16.62
7	11.09	11.97
8	19.21	18.35
9	15.9	9.97
10	4.72	3.72
completely risk-loving	7.77	6.65
Total		

Table 7: Willingness to take risk by gender

[*wage_groups: 1= < 10,000 € / 2 = 10,000-29,999 € / 3 = 30,000-49,999 € / 4 = 50,000-69,999 € / 5 = 70,000- 99,999 € / 6 = ≥ 100,000 €]

Overall, our exploratory study and additional multivariate regression models provides first indication that a gender-wage gap does exist, and it is not totally explained by differences in the number of working hours between genders, or by different productivity levels, or other observable factors. Moreover, it is particularly large and statistically significant when female inventors have young children and are married.

This is consistent with the idea of female inventors having lower bargaining power or a lower reservation price compared to men when they have family commitments. The use of leisure time that they mostly spend with their families (in general, and more than married men with children) provides some support to our interpretation that female inventors might accept jobs without negotiating too much about their wages, and then being able to dedicate more attention to family commitments. This can well be the result of ages of history of division of roles between males and females in the household, whereby females (even if they work) take care of the family, while males are more concerned about being the primary source of the household income.

3.2.4 The economic value of patents

In this project we studied the economic value of patents. This is an important issue for several reasons. First and foremost, the process by which innovations translate into economic value is not fully understood. In particular, we do not know much about the factors that affect the economic value of the “inventions” – i.e., before the innovations are fully developed and commercialized. We know that the size and quality of several downstream assets provide an important contribution to the value created during the development, production and commercialization stages. However, a better understanding of the earlier stages is critical as well. For example, the rise of markets for technology, or the growing importance of ideas for future innovations and new products, suggest that firms increasingly want to assess the value of the inventions before they are developed. Within firms, the growing attention to the performance of R&D labs calls for a better understanding of the economic value of their outcomes, and the mechanisms that produce such values.

Earlier research based on the PatVal-EU1 data addressed the question of what determines the economic value of patents. In most industries patented inventions need to be developed, produced or commercialized, and thus, they are typical outcomes of the upstream part of the research process. Not all the inventions are patented. However, not only do patents cover a relevant share of invention output, they are also an important asset of the firm. Moreover, in markets for technology, patents are either the object of the transaction, or an important component of it. At the same time, companies use patents strategically to strengthen protection. The analysis in our earlier research encompassed this point as well, and it studied the determinants of the value of patents whether they contribute to value as genuine inventions, or as tools for protecting them.

Specifically, in our earlier study we provided a better understanding of some mechanisms that produce valuable patents, and we estimated them empirically. We focused on the determinants of the economic value of a portfolio of related patents. This is a novel perspective because the patent literature typically looks at patents in isolation, while the relevant technology is, on many occasions, covered by more than one patent. This is because firms want to better protect the technology, or because they develop variants. Note that here we do not mean “equivalent” patents, or patent “families”, as they are called. Equivalent patents regard the same invention patented in different patent offices around the world. Instead we mean different inventions that are related to each other – e.g., complementary, substitutes, or simply flowing from the same project and technically related in some way. The main question that we asked stemmed naturally from this perspective. The value of a portfolio of patents can increase either because the number of inventions increases or because of increases in the value of the individual inventions. We then studied the extent to which the value of the portfolio is determined by the former or by the latter, and the factors that affect the “extensive” vs. “intensive” margin.

Our empirical results highlighted the importance of the extensive margin. We found that the value of patent portfolios increases largely because of the number of related patented inventions than because of increases in the average value of the portfolio. Interestingly, we found that both the man-months invested in the invention project, and the skills of the inventors raise the number of inventions produced more than the value of the individual inventions. In sum, a major contribution of this study is that the process by which firms create value from inventions depends to a significant extent on the breadth of the portfolio.

Against this background we used the PatVal-EU2 to focus on other dimensions of value. In particular, we focused on: a) the determinants of the inventive step; and b) on the social value of patent disclosure. We discuss both analyses below.

Determinants of the inventive step

As far as the inventive step is concerned, there has been considerable concern among policy-makers, academic observers and patent practitioners about recent developments in patent systems. While it is uncontroversial that patent offices have seen a strong increase in patent filings and are currently suffering from immense backlogs, it is less clear and sometimes hotly debated what the exact reasons for this development are and if in its course, more and more “trivial” patents have been filed.

We have then sought to cast new light on a number of questions related to the “inventive step” in patented inventions. Along with other questions, in the PatVal-EU2 survey, we asked the inventors to provide a subjective assessment of the invention’s inventive step. To the best of our knowledge, this is the first time that inventive step information has been collected in a large-scale survey.

There is a large legal literature regarding the virtues and weaknesses of the EPO’s “problem and solution approach” which provides the backdrop of any discussion of inventive activity and non-obviousness. Since its early days, the Technical Boards of Appeal at the EPO have refined this approach, and most of the modern discussions on the patentability of new subject matter such as software or business methods have employed elements of this fundamental debate. Moreover, the “problem and solution approach” is fundamental for the resolution of other issues, such as unity of invention and the enabling nature of descriptions included in patent applications. Yet, this discussion has rarely been connected with economic issues. Nor are the legal arguments – to the best of my knowledge: ever – associated with empirical research that could verify or refute implicit assumptions made in the debate. Our study of the inventive step makes a first attempt to do so, and it develops a set of hypotheses relating external determinants to the expected invented step of an invention. These theoretical expectations are then confronted with data from a large-scale survey which has yielded a large and rich dataset well-suited for disentangling some of the thorny issues at hand.

Patent applications are based on inventions which may differ considerably w.r.t. their inventive step. We developed a conceptual model based on a two-step process by which inventions are first generated within a given setting, and then screened for application. Both steps are likely to impact the inventive step of inventions for which applications are ultimately filed. We first turn to the inventive step of the initial set of inventions, and then to the selection of inventions into the pool of patent applications. We summarize the hypotheses of our paper below. All these hypotheses have been corroborated by our data.

<u>Inventor and invention process level determinants</u>. Our earlier PatVal-EU1 paper showed that the importance of inventions depends crucially on inputs, such as the talent and education of inventors, the number of inventors and the financial resources deployed in the invention process. *Hence, we find that the inventive step in inventions is positively related to the following determinants: i) the educational attainment of contributing inventors, ii) the resources (person months) deployed, iii) and the size of the inventor team.* Obviously, ii) and iii) are immediately related so that it may be difficult to separate these determinants empirically.

Out of the initial pool of inventions available, applicants will select those inventions that deliver a sufficiently high benefit-cost ratio, given their own financial constraints in handling the expenses of filing, examination and prospective renewal and the potential to reap rewards from a patent, including monetary and strategic benefits. We discuss these in turn.

<u>Organization type</u>. Commercial organization will typically have more experience in patenting, maintain larger portfolios and stronger commercialization activities than non-private organization such as hospitals, universities and other types of public institutions. We therefore expect that private organizations will file applications for inventions the marginal inventive step of which will be smaller than in the case of other types of organizations. *Inventive step of inventions filed by commercial organizations are lower than inventive step in filings of other types of organizations.*

<u>Organization size</u>. Numerous studies have shown that the patent filing propensity of large organization exceeds that of smaller ones. As patent portfolios increase, the marginal value of an additional filing increases for strategic reasons, and filing an application may make sense for a large organization even in

cases where this step is not profitable for smaller ones. *Thus, with increasing firm size, average inventive step declines.*

The relationship between these antecedents and the observed measures of inventive step are the first empirical contribution of our analysis. The second one is a study of potential consequences. For the purpose of this exploration, we argue that inventive step will at some point be determined by the underlying invention. While patent attorneys and their clients may seek to amplify the contribution to the state of the art in their negotiations with the examiner, these efforts will nonetheless not disturb in a systematic manner the relationship between the given inventive step and its implications. We specify our theoretical expectations again in the form of a number of hypotheses, which are also corroborated by our data.

<u>Patent use</u>. Our PatVal-EU2 survey data allow us to identify the ultimate purpose of a given patent. *We expect that patents with low inventive step will mostly serve strategic purposes, i.e. are not used for protecting own innovations, but as bargaining chips and for blocking other parties.* In these cases firms may use the implicit threat of possibly enforcing an intellectual property right.

<u>Claims</u>. Patent filings with high inventive step may yield high monetary value. The promise of high value will lead patent attorneys to exert more effort in crafting and designing an application than in the case of an invention with low inventive step. High inventive step should therefore lead to a relatively large number of claims in the application. Claims are therefore reflective of value, but not causal.

<u>Patent family</u>. A similar comment applies to the size of the patent family. If the inventive step is high, then the applicant may seek patent protection in many countries in order to exploit the commercial potential of the invention.

<u>Patent value</u>. Our survey data also allow us to explore the relationship between inventive step and patent value *directly*. We argue here that monetary patent value as elicited in our survey should be positively impacted by the inventive step of an invention.

Social value of patent disclosure

Finally, we studied the social value of the information disclosure associated with patents. Many scholars and courts see patent disclosure as an important objective of patent systems. Towards this objective, patents are required to provide “full disclosure” in most national and regional patent systems. Moreover, in Europe, the suggestion of “insufficient disclosure” is a frequently used and successful attack in opposition proceedings. At the same time, a number of legal scholars claim that the system is not working well in the US, and this is due for systematic reasons, *inter alia:* a) disclosure would be important for inventions that are hard to reverse-engineer – but those are often protected by secrecy; b) patents are opaque, hard to read and to extract information from – other sources of technical information are easier to use and more suited for search; c) there may be legal risks in the US in using patents as a source of information.

The current empirical evidence in this debate is extremely thin. Most legal analysis is based on single cases and court statements. Economic studies have produced rather “soft” evidence so far and rely on assessments of managers who may not be deeply involved in the invention processes. In our PatVal-EU2 analysis we have taken a different approach: we have asked the inventors for quantitative data. The question that we asked is – is patent disclosure a contributor to welfare or just an overrated story?

To operationalize and measure the effects of disclosure, we measured the cost reduction due to knowledge of the patent literature at the level of patent applications (not inventors) within the context of an inventor survey.

Our findings can be summarized as follows. First, we find that the time saving in the invention process due to disclosure effects appear to be relatively small, but with some heterogeneity across technical fields (the range of median responses is 2.7 hours in telecommunication to 99.8 hours in organic chemicals). Second, there is a high (non-trivial) correlation between appropriation and disclosure effects. In areas in which important inventions are patented, inventors read patents and learn from them. To turn this around, a (counter-factual) limitation of patent rights to areas like pharmaceuticals and chemicals is unlikely to cause cost increases for follow-up inventions.

Our results open some relevant questions. The little evidence in favor of the positive disclosure suggests that learning from past patents is a highly overrated story, at least as regards the facts. Normatively speaking, this raises the question whether we want to strengthen disclosure, and particularly whether there should be more stringent requirements on disclosure.

4. Potential impact and dissemination

The indicators and the empirical methods and models developed in this project represent an important step forward with respect to the current state of the art of indicators and methods. The large variety of Science and Technology indicators covering many different aspects of the invention process at different levels of analysis and with a large geographical coverage (20 European countries, USA, Japan and Israel), and the employment of rigorous methodologies allow to address relevant issues for which adequate indicators did not exist.

In this project we completed the creation of these large sets of indicators and developed empirical models and policy implications in the four topics of our project. However the potential application of our indicators is still very extensive, since we will be able to address other relevant issues in S&T like the social and economic impact of different forms of strategic patenting, the organization of the invention process in different types and size of organizations, the individual motivations to S&T activities, etc. Moreover, in addition to the country level results obtained in this project, we may specifically address issues related to the competitiveness of Europe, with respect to US and Japan, and of different European countries and areas, also by focusing on key sectors and technologies that are important for fostering growth and employment.

Our dissemination activities conducted during this project aimed at communicating the activities and main results of this project. Dissemination activities will further continue over the next years through the presentation of results to various audiences and the publications of scientific articles and policy reports and documents in various contexts.

The following sections discuss the policy implications deriving from the result of our analysis in four topics and our main dissemination activities. One of the four topics, gender of inventions, allows to contribute to awareness and wider societal impact.

4.1 Impact and policy implications

4.1.1 The economic use of patents

Our analysis bears several policy implications which are primarily centred on the reasons for the quite large share of unused patents and the potential barriers to a more efficient use of patented technology.

We found that larger firms are less likely to use their patents as compared with smaller firms. Many large firms own many unused patents, a large share of which being shelved for blocking reasons. Why are these patent not used more intensively, for example by licensing, sale, or voluntary spinoff? Clearly, blocking patents are not used for strategic reasons and therefore they produce some private benefit to the patentee although they may reveal an anticompetitive behaviour and represent a waste of resources for the society.

Our analysis shows that patents in semiconductors, organic chemicals and biotechnology are more likely to remain unused compared with other technologies. This is in line with the cumulativeness of technical change, interdependence and high risk of infringement and holdup. These conditions favor the accumulation of blocking patents.

Even if technological markets (sale and licensing) were more efficient, the owners of large patent portfolios in industries like semiconductors and biotechnology would probably continue to stack a lot of blocking patents as they are threatened by the risk of holdup and blocking patents can be used as a bargaining chip in infringement suits or cross-licensing. Patent policies that limit the scope and enforceability of patents may reduce IP fragmentation and blocking patents. However, these policies would also impact upon other patents, including unused patents that are not necessarily taken for strategic, anticompetitive reasons. In some countries like the UK patent law allows for compulsory licensing in case the owner does not use a potentially useful patent. In other countries like the US compulsory licensing is under discussion. But the assumption that unused patents are a proof of anticompetitive behavior is arguable.

As a matter of fact, our analysis shows that a significant share of unused patents (about 38%) are sleeping patents, i.e. they are unused for reasons different than blocking. However, this raises the question as to why these patents are sleeping if not for strategic reasons. According to scholars (Weeds, 1999), sleeping patents may protect an early stage invention whose development and commercialization require further irreversible investments that the owners could undertake if technological or market conditions become more favorable. These patents then have an option value that compulsory licensing would destroy with negative consequences for the ex- ante private incentives to invest in multi-stage research projects. Policies like compulsory licensing then require a careful ex-ante identification of purely blocking patents to avoid negative consequences for non-blocking patents.

To stimulate more intense exploitation of sleeping patents that protect early stage inventions there exist alternatives to compulsory licensing such as deferred examination of patents which consists in delaying the request for patent examination after the application. Examination deferral is allowed only in few countries, like Japan, Germany and the UK, where the examination is initiated only upon request by the applicant and a request for examination can be filed up to a given deadline (3 to 5 years) from the date of application. In other patent systems (including the USPTO and EPO) patent examination is automatically started after the application. A revision of this system is under discussion in the US since deferred examination could reduce the growing granting lag due to the difficulty of processing the large number of applications received by patent offices. Introducing a patent deferral option into the EPO system could increase the set of option available to firms that delay the use of patents for nonstrategic reasons and could have positive effects on innovation.

However, not all sleeping patents are delayed to learn about technological and market conditions before deciding whether to incur further irreversible development costs. Some of them are probably not used because the owner has already decided not to exercise the option to use or has not managed to use them for instance for the difficulty to find a licensee or an acquirer.

Our analysis shows that patented inventions that result from the collaboration with universities and low value patents are less likely to be used. These are probably patents based on scientific knowledge which requires quite a long time and significant additional investment to produce useful innovations. For these inventions then compulsory licensing policies should not be applied, although one may ask whether inventions based on basic research should not be patented at all.

We also find that patents resulting from the collaboration with customers/users are more likely to be used. This also raises doubts about the usefulness of patents based on abstract knowledge and then distant from real applications. The probability that a patent is unused is also high for inventions arising as an expected or unexpected byproduct of R&D projects, inventions made by inventors whose main activity is not inventing and inventions resulting from pure inspiration or creativity. It is unlikely that these inventions are patented to block other patents. Unused patents have also a low value according the inventor's perception. Uncertainty about the value or limited fit with the firm core technology and business then explain why these patents are not used.

Policies oriented to improve the efficiency of the technology market, for instance policies that favor the take-off of online marketplaces, should favor a more intense use of these patents. Acquirers or licensees with a comparative advantage in the use of these technologies may be more able to extract value from them. Policies favoring technology trade should identify the technologies, the type of patent owner and patent characteristics that are associated with significant misallocation of patent rights. IP policies could complement market-building policies. The rising patent protection that occurred since the 1980s has favored the reallocation of patent rights, specialization and the formation of a market for technology (Serrano, 2008). However, too large patent scope and low barriers to patents increase the probability of overlapping IPR and induce blocking patenting. The role of IP policies is then complex and should be more closely coordinated with competition policies.

To better understand the obstacles to patent use we calculated the probability of using a patent conditional on the willingness to use it. We find that large firms (5000 employees and more) are less likely to use their patents commercially even when they are willing to do. This reflects the size and complexity of patent portfolios of very large firms which make it difficult to assess the value and potential applications of any single patent. Moreover, patents arising from collaboration with universities and PROs are less likely to be used commercially even if the firm is willing to use them. The same occurs to patents in semiconductors, organic chemicals and biotechnology. Finally, inventions resulting from the normal job of inventors, which is not inventing, and inventions generated by pure creativity/inspiration are less likely to be used commercially even if the owners is willing to use them.

We did not find significant differences between actual and potential use in the case of licensing, selling and start a new firm. The only exception is represented by the conditional probability of licensing that is lower when inventions result from the normal job of inventors (not inventing) and pure creativity/inspiration. These results overall suggest that the conditions that favor or hamper licensing, sale and startup are largely anticipated by the patent owner when she decides whether to use the patent. This does not contradict the fact that there are barriers to a more efficient use of technology that public policy can remove by improving the efficiency of markets for technology or creating more favorable conditions to the startup of new technology-based firms. With respect to the use of patents to found new firms in particular, we should note the contribution of technology-based startups to economic growth.

Future research will investigate if internal commercial use and various types of external use are complements or substitutes. We will also include other relevant factors in our empirical analysis at the level of the firm like the size of the patent portfolio, the R&D intensity, data about the ownership and other accounting and financial data.

We will also deepen our analysis of entrepreneurship by looking at the characteristics of the inventors who are also founders of spin-offs from patents.

Finally, we will extend our analysis of unused patents by looking at other strategic reasons for patenting like cross-licensing, and prevention from infringement suits.

4.1.2 Science-industry linkages and innovation performance

The notion 'innovation systems' stresses the importance of interactions between different types of actors for understanding the dynamics behind innovative performance and economic growth. Industry-Science interactions are considered as pivotal in this respect.

One of the objectives of the InnoS&T project relates to the development of indicators that reflect such interactions, including an assessment of their validity and their relevance for studying innovative dynamics. The indicators considered in this project pertain to (1) university involvement in technology development (the presence of universities as patent applicants), (2) the impact of university-generated technology on consecutive technology development efforts (measured by forward patent citation rates of university owned patents), and (3) the presence of scientific non-patent references within patent documents. The validity of these indicators has been examined at the level of inventions (patent documents), firms and national innovation systems (countries). The analyses conducted within the InnoS&T project reveal that these indicators are not only signaling the occurrence of science-technology interactions; our findings also demonstrate a positive relationship with patent value (measured by forward citations) and technological performance (firm and country level). Hence, the developed indicators can be considered both valid and relevant.

The indicators pertaining to (1) the contribution of universities in technology development through academic patenting and forward citations to academic patents, as well as (2) the science-intensity of patents can become recurrent indicators, instrumental for measuring and assessing the contribution of science to technology development on the level of national or regional innovation systems and/or on the level of specific organizations (HEI and/or firms).

While some of the indicators developed within the framework of InnoS&T focus on university-owned patents (i.e. patents for which the university acts as assignee / applicant), several scholars have pointed out that a considerable portion of patents which imply academic inventors are not assigned to the university but to another organization – notably a firm. A comprehensive view on academic patenting activities hence would include these university-invented patents as well. As such, assignee/applicant-based indicators should be complemented with indicators reflecting academic inventorship. Methods for accomplishing the identification of these university-invented patents on a large scale have not been part of the InnoS&T project, but are currently being undertaken within the APE-INV project[2].

The country profiles (in terms of ST interactions) that have been developed in the framework of the InnoS&T project reveal considerable differences between national innovation systems. This is in line with previous studies which reveal heterogeneity in terms of science-technology interactions (Debackere & Veugelers, 2005; Van Looy et al., 2011). So while the relevance of science and scientific actors for technology development is widely recognized, the actual participation of science and scientific actors in technological developments – and the role enacted by universities –varies considerably between countries. The indicators developed within the framework of this project allow to further investigating antecedents as well as consequences of this observed heterogeneity (e.g. the role of legislation and regulations[3]).

The impact analyses that were performed in the framework of the InnoS&T project demonstrate that science intensity and the involvement of universities in technology development (measured by indicators on academic patenting) leverage technological performance (patents per capita) and specialization. If developing technology in the vicinity of science makes sense, then so do policy measures and initiatives that stimulate science-technology exchanges, e.g. through forums involving business and scientific partners, research consortia, collaborative projects, etc.

The knowledge base on which firms can build when developing technologies may be sourced locally as well as globally (for a systematic exploration of cross-country knowledge flows between universities and firms, measured by patent citations: see Veugelers et al., 2011). To the extent that local knowledge is more easily

[2] See http://www.esf-ape-inv.eu/index.php

[3] For an illustration of the effect of different legislations: see Van Looy et al. (2011)

absorbed, policies could be envisaged that complement the stimulation of science-technology interaction with initiatives that strengthen the local (national) science-base.

The results of the national-level impact analyses also reveal positive effects when scientific institutes become themselves actively involved in technological development (cf. the revealed positive relation between university patent activity and technological performance and specialization). Therefore, policies aimed at stimulating academic entrepreneurship (by providing the right mix of incentives for universities to become / stay involved in patenting) seem appropriate. The relevance of such regulations and policies has already been recognized in the past (Cohen and Noll, 1994). These include support schemes for cooperation between business and academia and measures that regulate intellectual property rights, such as the Bayh-Dole Act and the Stevenson-Wydler Act in the U.S. (Nelson 2001, Mowery et al, 2004, Branscomb et al. 1999; Clark, 1998; Van Looy et al., 2003). Several countries, also in Europe, have adopted similar support schemes and regulatory frameworks (OECD, 2003). Such policies would not only enhance technological productivity, but our findings showed that they also support technological specialization (and that they may hence be deployed as instruments for steering specialization profiles). Appropriate levels and patterns of specialization remain issues which are currently being studied and which are high on the agenda of national and regional policy makers[4].

4.1.3 Awareness and wider societal implications: "Gender of inventors"

In our project we analyzed the role of gender in the invention process. The direct implication of female inventors accepting lower wages then men resulting from our study – conditional on observable characteristics and role within the organizations – is that firms can extract some surplus from relying on cheaper women workforce compared to what they pay male peers. Probably, a first step in the direction of reducing the gender gap is to make female inventors aware of the fact that a gender gap exists, and that they might use some of their bargaining power (if any) in their salary formation. Other possible mechanisms might help to reduce the gap. These should work to improve the work-family balance between men and women. An example in this direction is to implement a policy of compulsory "paternity leaves" for fathers as soon as a new baby is born. This would allow fathers to learn immediately how to take care of the kids, and how to share child-care with their partners. This could also reduce the close "exclusive" link that mothers and children establish soon after children are born, and could increase the probability that mothers eventually decentralize to others (including fathers) children necessities and make them more enthusiastic about their job even soon after a baby is born. The possibility to have a long-term (e.g. a year)

[4] Cf. the emergence of project activities in the area of Smart Specialization (see Foray et al., 2009)

part-time leave for fathers (rather than mothers) in order to be the primary care giver also goes in the direction of equally sharing family and work duties between genders.

So far not considered in more detail have been country-specific differences between gender-wage gaps as well as the distribution of labor within families. In particularly, inventors from Italy and Japan are characterized by the lowest average number of children. Additionally, results showed that inventors in the US, in Luxembourg, in Switzerland and in Germany earn higher salaries compared to the other countries, with inventors in the Czech Republic, Poland and Hungary being at the bottom of the income distribution. Hence it would be interesting to see whether higher salaries lead to higher gender-wage gaps or whether the gender-wage gap diminishes in higher wage countries. What would also be very interesting is to have a closer look at country-specific policies adopted to foster women's participation in the labor market. Maybe some of these regulations could be transferred to other countries that, so far, lack these programs.

Finally, it has to be mentioned that the share of female inventors is generally very low. In our sample, the share of female inventors on average amounts to 5% and is highest in Israel (12%) and Poland (11%) and lowest in Austria (2%). Hence, a start point for policy makers (especially in countries where the share of female inventors is particularly low) could be to design and implement programs that increase the number of female inventors. An area which could be addressed to increase the share of female inventors is the education system, i.e. the share of women to pick up natural sciences as a subject at university should be increased.

4.1.4 The economic value of patents

Our study of the value of patents has some relevant policy implications.

Fist, our study on the value of patent portfolio suggests that firms create value largely by increasing the number of patented inventions as opposed to the value of the individual invention. In terms of policy, this suggests that it is important to devise ways to distinguish whether the number of patents produced respond to the logic of creating fences or strategic patenting, as opposed to genuine inventions stemming for instance from a common body of knowledge or general-purpose technologies. By discouraging the former, one may give up valuable portfolios of inventions associated to the latter processes, and vice versa. Thus, policy tools should encourage patent breadth based on genuine innovations and discourage those that aim largely at creating strategic defenses.

Second, we have shown that the inventive step is most likely associated to non-commercial organizations, smaller firms, and valuable patents. By contrast, it is negatively correlated with strategic behavior and appropriability. In terms of policy this means that by looking at the extent of the inventive step one obtains a good correlate of the unobserved future value. Thus, policies aims at encouraging the inventive steps, and the organizations that tend to produce a more sizable inventive step, are likely to favor the invention economic value as well.

Third, our empirical analysis has shown that the disclosure of information associated with the patent system is less pronounced than expected. This makes the social value of patents potentially less important. This is a serious concern because the social disclosure associated with patents is often intended as the social benefit that offsets the social cost due to the private appropriability of the invention. This raises policy questions about how to raise the social disclosure associated with patents or to encourage different social benefits of patents that can balance the social costs of appropriability.

4.1.5 Expected impact from future studies

The indicators developed in our project have a great potential for the development of studies in this field in addition to the studies developed within InnoS&T. Further studies will have both a scientific and policy orientation. We have the opportunity to study original issues based on novel questions included in our surveys covering important gaps in the literature of economics and management of innovation (among the others, the origins and organizational environment of the inventions, team vs. individual work, communication among different departments in business organizations).

From a policy perspective, we will identify the impact of: policies supporting SMEs or promoting the development of intermediaries in the markets for technologies on the extent of economic use of patents; geographical agglomeration of S&T on knowledge spillovers and entrepreneurship; decisions to provide public funding to (public) research institutions or to foster industry-science linkages on the production of valuable inventions and firms' performances; policies in New Member States vs. other European countries.

4.2 Dissemination

The InnoS&T project dissemination activity focused on presenting and diffusing information about the project's activities, methods, indicators and final results. Since the construction of indicators was an intensive activity completed in the final stage of the project, the main purpose of dissemination activities was to make the broad public and academics aware of the methodology and indicators, while the diffusion of results started in the final stage of the project and is expected to continue intensively over the next years.

We use several means for disseminating information and results of this project.

First, indicators and empirical models resulting from InnoS&T are mainly used for the publication of reports and scientific papers in leading journals. There are plans for publishing scientific articles in a special issue of a leading journal in the field devoted to the InnoS&T project, like it was done with the Patval-EU I project, obtaining high impact and diffusion on the scientific community.

The project produced a website, available at the following address: http://www.innost.unibocconi.it. The website included a public as well as a private intranet section, only available for project members. As far as the former is concerned the contents were addressed to provide contacts information on the project's consortium, on the inventors' survey, on events and public deliverables.

The website will be renovated in its graphical implementation and stay available also after the project's end as an open window on the achievements, publications, conferences, working papers carried out by using indicators developed within the InnoS&T project.

InnoS&T partners often presents the project's results in several national and international events (from academic, to managerial and policy-oriented workshops and conferences), and participates to policy debates and other events or seminars in various relevant institutions.

Within our project we organized a final conference in Munich (15-16 February 2011) at European Patent Office, which also provided a financial support to the event through the participation of the European Policy for Intellectual Property Association (EPIP). The event involved people from the European Commission, European Patent Office, WIPO, national patent offices, OECD, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS), and scholars from several universities. The agenda included the participation of project's partners as well as invited speakers, experts in the field, from US, Japan and Europe, whose presentations are available on the project website.

A descriptive leaflet was also created to provide a general description of the project. Moreover, InnoS&T project was included in the annual 2011 "International Innovation" review published and extensively diffused by Research Media to many different interested audiences (available at http://www.research-europe.com/magazine/EUROFOCUS/2011-5/pageflip.html).

Within this project we created a dataset of audiences that we use for disseminating results of our projects (like reports) or relevant events like the InnoS&T final conference.

The project results will also be diffused through research networks participated by the team members within the various specific actions for networking and dissemination of research results or within other research projects and collaborations with scholars on related fields. As a matter of fact, we are launching new projects and activities which will focus on the use of the indicators to produce additional empirical models and policy analyses or analytical outputs.

Some project's outcomes are also intended for inventors, business companies, universities. We plan to send the reports or the links to the project website including the reports to a variety of audiences, also according to the new projects that we will participate (e.g. policy institutions, inventors and companies participating to the survey, universities, national and international patent offices, IP intermediaries). For this purpose we will prepare executive summaries or reports on specific topics (i.e. gender, innovative S&T

indicators in New Member States, licensing of inventions) tailored for specific audiences. They will also include the link to the full reports and the empirical studies available on the project website.

Individual partners will also diffuse results related to their own country or regions through other means. For example, the partners may diffuse papers or parts of the overall reports that focus on their country or regions to local policy makers, managers or administrators.

References

Babcock L., Laschever S. 2003. Women Don't Ask, Princeton, NJ: Princeton University Press.

Branscomb, L.M., Kodama, F., & Florida, R. 1999. Industrializing Knowledge: University-Industry Linkages in Japan and the United States. London, MIT Press.

Cassiman, B., Veugelers, R. and M.P. Zuniga. 2008. "In Search of Performance Effects of (in)Direct Industry – Science Links," Industrial and Corporate Change, 17(4), p. 611-646.

Cassiman, B., Veugelers, R. and M.P. Zuniga. 2010. "Diversity of Science Linkages: A Survey of Innovation Performance Effects and Some Evidence from Flemish Firms," Economics, 4: 2010-33. http://dx.doi.org/10.5018/economics-ejournal.ja.2010-33.

Clark, B.R. 1998. Creating Entrepreneurial Universities: Organizational Pathways of Transformation. Oxford, Elsevier Science for IAU Issues in Higher Education.

Cohen, L.R., & Noll, R.G. 1994. Privatising public research. Scientific American 271: 72-77.

Debackere, K., & Veugelers, R. 2005. The role of academic technology transfer organizations in improving industry science links. Research Policy 34, No.3: 321–342.

Giuri, P., Mariani, M., Brusoni, S., Crespi, G., Francoz, D., Gambardella, A., Garcia-Fontes, W., Geuna, A., Gonzales, R., Harhoff, D., Hoisl, K., Lebas, C., Luzzi, A., Magazzini, L., Nesta, L., Nomaler, O., Palomeras, N., Patel, P., Romanelli, M., Verspagen, B., 2007. Inventors and Invention Processes in Europe. Results from the PatVal-EU survey. *Research Policy* 36, 1107-1127.

Mowery, D.C., Nelson R.R., Sampat B.N., & Ziedonis A. 2004. Ivory Tower and Industrial Innovation: University-Industry Technology Transfer before and after the Bayh-Dole Act. Stanford University Press.

Nelson, R. 2001. Observations on the post-Bayh-Dole rise of patenting at American universities. Journal of Technology Transfer 26, No. 1–2: 13.

OECD. 2003. Turning science into business. Patenting and licensing at public research organizations. OECD Publications, Paris.

Serrano, C. (2008), The dynamics of the transfer and renewal of patents, NBER Working Paper 13938

Van Looy, B., Debackere, K. and Andries, P. (2003). Policies to stimulate regional innovation capabilities via university-industry collaboration. R&D Management 33: 209-229.

Van Looy, B., Du Plessis, M., Callaert, J., Meyer, M., & Debackere, K. 2011. The impact of legislative framework conditions on the technological performance of European Universities: An empirical assessment. Paper presented at the 13th ISSI Conference 2011, Durban, South-Africa.

Veugelers, R., Callaert, J., Song, X., & Van Looy, B. (2011), "The participation of entrepreneurial universities in technology development: Do creation and use coincide? An empirical investigation on the level of national innovation systems." Paper prepared for the Special issue in Economics of Innovation and New Technology on Academic Entrepreneurship and Economic Competitiveness – Under Review.

Weeds, H. (1999). Sleeping patents and compulsory licensing: an options analysis, Warwick Research Papers #577, Warwick University, Coventry.