# Innovation surveys and innovation policy

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## 1 Presenting the innovation surveys

In the late 1980s scholars of technological change were concerned about measuring more aspects of innovation than the mere information contained in the R&D surveys. They sat down under the auspices of the Organization of Economic Co-operation and Development (OECD) and wrote the so-called Oslo manual, which set out the guidelines for a new type of survey, the innovation survey (OECD, 1992).[1] In the EU countries under the coordination of Eurostat, the statistical office of the European Union, a common core questionnaire was agreed upon and surveys were launched under the acronym of CIS (Community Innovation Surveys). These surveys have been repeated every four years. Up to now there exist four waves of CIS (CIS 1 for 1990-1992, CIS 2 for 1994-1996, CIS 3 for 1998-2000, and CIS 4 for 2002-2004).[2] [3]Similar surveys have been conducted in other countries, including emerging, transition and developing countries. In total, over 50 countries have carried out at least one innovation survey.[4]

The innovation surveys provide us with three broad groups of measures: innovation inputs, innovation outputs, and modalities of innovation. The innovation inputs encompass besides R&D, other expenditures related to innovation such as acquisitions of patents and licenses, product design, training of personnel, trial production, and market analysis. Four types of innovation outputs are distinguished in the latest version of CIS, namely the introduction of new products (which can be new to the firm or new to the market), the introduction of new processes, organizational changes and marketing innovations. Whereas patents and bibliometrics measure the technical, scientific, inventive side of innovation, the innovation output measures contained in the innovation surveys measure the development, the implementation, and the market introduction of new ideas, namely they measure the introduction on the market of new products or services and the introduction of new ways of organizing production and distribution. The modalities of innovation are the sources of information that lead to an innovation, the effects or innovation or the reasons for innovating, the perceived obstacles to innovation, the perceived strength of various appropriability mechanisms, and the cooperation in research and innovation.

The innovation surveys serve two purposes. First and foremost, they are used by policy makers to monitor innovation and benchmark innovation performance. Their second utility is to provide statistical data to researchers in the economics of technological change in order to determine the reasons for innovating and the effects of innovation on economic performance. We shall discuss these two aspects with some illustrations of the usefulness of these data and a discussion of some of their limitations.

## 2 Direct use of innovation surveys for innovation policy

The main use that has been made of the innovation surveys is for the purpose of monitoring and benchmarking the innovation performance in different countries. Some data from the CIS surveys have been included in the European Innovation Scoreboard (EIS) and in the construction of innovation indexes such as the Global Summary Innovation Index (see Sajeva et al., 2005 and Arundel et al., 2007). The EIS 2006 included from the innovation surveys the percentage of enterprises receiving government support for innovation as an indicator of knowledge creation, the percentage of SMEs with innovative activities, the percentage of SMEs cooperating with others, the ratio of innovation expenditures over total sales, and the percentage of SMEs with organizational innovation as indicators of entrepreneurship, and the share in total turnover of new-to-firm or new-to-market products as indicators of innovation output. Innovation indexes are used by policymakers to check whether there is an innovation gap between the European Union (EU) member states and some other parts of the world, a convergence in innovation between old and new member states of the EU, and the improvement in innovation performance on the way towards achieving the Lisbon Strategy.

Let us illustrate the utility of these indexes for policy makers by giving some examples. The Global Summary Innovation Index 2005 showed that the EU with an index value of 0.5 was laggind behind the average innovation performance of countries like Singapore, Israel, the Republic of Korea, Canada, Japan and the US. Comparing that same index over time reveals that there has been a process of convergence in innovation performance since the launching of the Lisbon agenda, with old member states like France and Germany showing a decline in their index and many of the new member states improving their performance while being in the catching-up phase. The gap in innovation performance of the EU could be due to a lack in innovation activities, a deficiency in turning innovation inputs into innovation outputs, or a different sectoral composition knowing that innovation intensities vary across sectors.

It is interesting for policy makers to be able to compare their country’s relative performance on a certain number of individual indicators like R&D, success in product innovations, importance of collaborations, etc. A country may fare comparatively well in comparison to others in its R&D expenditures in percentage of GDP but come up with a lower share of new products. This may suggest that the incentives for R&D are there but that a problem may exist in converting R&D into sales of innovative products. Or you can have a country where many enterprises declare receiving some kind of government support and yet few MNEs innovate. Since government support for innovation often goes to MNEs, such a situation calls at least for a reconsideration of the effectiveness of those measures of support. A simple confrontation of some descriptive statistics drawn from the innovation surveys can help refuting some hypotheses or identifying possible cases of government failure, although policy makers should be aware that proximate causes may not reveal the ultimate explanations and that pairwise correlations may hide the mutual dependence on third factors. We shall get back to this point in the next section.

Aggregating these various indicators into a global innovation indicator, with specific weights and arbitrary choices of which indicators to include and which ones to exclude, is however more debatable. The choice of indicators entering the construction of an index is often based on the availability of data. The EIS 2002 was based on 17 indicators, the EIS 2006 on 26 indicators. At each new wave of CIS additional questions are asked to include new dimensions of innovation (like questions on knowledge management in CIS3 or marketing innovations in CIS4). Some components might be highly correlated giving undue weight to certain dimensions. The interaction among indicators, precisely the idea behind the notion of complementarity or optimal policy mix, is largely ignored. It is even more difficult to aggregate qualitative data unless there is an underlying latent variable model or a constructed latent variable from a factor or principal component analysis (see Hollenstein, 1996). Moreover it is heroic to make international comparisons when the questionnaires differ in their content, the order of the questions and their formulations, and when the sampling of the respondents differs across countries. In countries with mandatory surveys, there may be an endogenous selection of respondents that have a tendency to respond in a certain way. The 2005 Canadian Survey of Innovation, in contrast to the CIS surveys, does not ask for quantitative information on output and labor from which labor productivity could be measured. Instead firms are asked to give an ordered categorical evaluation of the perceived effect of innovation on productivity growth.

The composite innovation indices can be useful in so far as they indicate how an economy performs compared to other economies and how this relative position varies over time. They do not, however, indicate which policies to put in place to overcome possible deficiencies (for a further discussion of some of these points, see Arundel and Hollanders, 2008). For a careful analysis of causality needs to be done, followed by a reflection of the direct and indirect effects of possible policy measures including an evaluation of past policies to determine their effectiveness.

To improve the quality of the data and the ensuing policy analysis, we recommend the following points. First, as much as possible the survey questionnaires and the sampling procedure should be identical across countries. If this is not possible, information about the sampling should be provided in order to correct for possible biases when comparing performances across countries. Second, some of the questions asked should remain stable across waves so that a trend analysis can be performed. For example, between CIS2 and CIS3 the objectives of innovation were replaced by the impacts of innovation, making it impossible to continue examining the role of innovation objectives on innovation behavior. More specifically, we recommend the questionnaire to be split into three parts: a) the core permanent part, as stable over time as possible and as identical as possible across countries; b) a specific harmonized part, varying from one survey to another to analyse specific aspects, but strictly harmonized across countries; c) an optional part in response to country specific interests. Third, it would be useful to have more information about non-innovators, be it only to correct for possible selection biases when conducting an analysis on innovators.[5] Fourth, if at all possible, try to follow a core group of firms over time by making sure that they are part of successive samples. Fifth, it might be a good idea to make experiments about the sensitivity of the survey responses to the order in which questions are asked and the functional role of the respondents within an enterprise.

In summary, the innovation surveys have increased our information about the way innovation occurs, the reasons for innovating, the obstacles in the process of innovating, the sources of knowledge, the cooperation in innovation, the importance of intellectual property rights and the different ways of innovating. By coordinating as much as possible the contents of the questionnaire, not just within the European Union but also in other OECD and non-OECD countries, it becomes possible to compare to some extent the innovation performances in different parts of the world. The survey questionnaires could be improved in constructing them in a more scientific way, learning from past experience in order to avoid repeating mistakes and having in mind the kind of information and economic analysis that is intended to be performed with these data.

## 3. Use of innovation surveys to increase our understanding of innovation

The innovation surveys have also been used by researchers to examine all sorts of aspects of innovation, ranging from the analysis of determinants (of innovation activities, innovation outputs, collaborations, obstacles, sources of information), to complementarities (between these same set of variables), to their mutual interrelations and effects on various measures of performance (exports, productivity, employment).

To illustrate the kind of econometric analysis that has been performed with the innovation survey data, we distinguish four kinds of studies: a) a reexamination of the relationship between R&D and productivity, b) testing the existence of complementarities, c) evaluating the effectiveness of government interventions, and d) exploring the dynamics of innovation. We present some selected examples of these studies and summarize some of the results obtained.[6]

### 3.1 R&D-innovation output-productivity relationship

The R&D-productivity relationship has been revisited using the additional information on the outputs and the modalities of innovation contained in the innovation surveys. With these data we can go a step further towards estimating a richer, more structural, and more informative model of the link between R&D and productivity. Crépon, Duguet and Mairesse (1998) (CDM) proposed and estimated such a model composed of three equations: first, an equation explaining the amount of R&D; second, an innovation output equation where R&D appears as an input (CDM had two alternative measures of innovation output: the number of patents and categorical data on the share of innovative sales), and, finally, a productivity equation, in which innovation output appears as an explanatory variable. The CDM model has been estimated for a number of countries individually - France, Germany, the Netherlands, Scandinavia, Estonia, Russia, Chili, the UK, China, Italy, Spain, Portugal … and the list keeps growing. It has also been run with the same specification to compare the performance in four countries: France, Germany, Spain and the UK (see Griffith et al., 1996). A larger project, which is presently being coordinated by the OECD (the NESTI/WPIA Innovation Microdata project), does the same cross-country comparison but on a much larger set of countries.

As Kremp et al. (2006) report, the results on the magnitude of the rates of return to R&D found in the early studies of the 80s and 90s are confirmed by the CDM model, as long as proper account is taken of selectivity and endogeneity in R&D and innovation output. The estimates are also robust to various measures of product innovation, in particular qualitative and quantitative measures, and new-to-firm versus new-to-market innovations. It is, however, true that innovation output statistics are noisier than R&D statistics (in part perhaps because they are subjective measures) and need to be instrumented to correct for errors in variable. On French data, process innovations yield higher returns than product innovations, but this is not always the case in other countries as reported in the international comparison study of Griffith et al. (1996). Indeed, we expect process innovation to affect directly the average cost of production, whereas product innovations can displace existing products and therefore have mixed effects on total sales and take more time to show up in the productivity statistics.

Among the determinants of innovation, these are some of the regular findings. In most studies size explains the propensity to innovate, but does affect or even decrease the intensity of innovation, as measured for instance by the share in total sales due to the sales of new or improved products. Few countries (France is an exception) include in their questionnaire explicit questions regarding the demand pull and technology push hypotheses, respectively attributed to Schmookler and Schumpeter. Otherwise, proxies have been constructed for these two variables using information on the objectives and the sources of information for innovation. Both show up with a positive marginal effect but demand pull is more often significant than technology push. The strongest explanation of innovation output, that indirectly feeds into productivity, is the R&D effort, especially the fact of performing R&D on a continuous basis. Blundell et al. (1999) find that the dominant firms innovate more not because they have cash on hand to finance the innovation but because they have more to lose than newcomers by not innovating. Indeed, incumbents risk losing their monopoly position by not innovating.[7]

Although the innovation survey data reveal a lot of interesting information on the links between innovation inputs, output and productivity, our understanding of the innovation process is still far from perfect. Mairesse and Mohnen (2002) propose an accounting framework to compare innovation performance across regions, industries or countries, similar to the growth accounting for productivity decomposition. By linearly approximating the innovation performance function around a reference region, industry or country, it is possible to attribute cross-sectional differences in performance (innovation propensity or innovation intensity) to differences in its determinants. The unexplained residual, i.e. the measure of our ignorance in matters of innovation, is very high, especially in low-tech sectors. The magnitude of the residual may not be unrelated to the voluntary/mandatory nature of the survey, calling for closer attention to the sampling issue, as mentioned earlier.

## 3.2 Complementarities

Many studies have tested the phenomenon of complementarity between different innovation strategies using the data from the innovation surveys. There is complementarity between innovation strategies when two strategies tends to be adopted together rather than in isolation because their joint adoption leads to better results. Some studies have tested the occurrence of joint adoption, others have tested whether indeed joint adoption leads to higher performance. This issue has been investigated for various aspects of innovation: a) different types of innovation, e.g. product and process innovation (Cabagnols and Le Bas, 2002; Martínez-Ros and Labeaga, 2002; Lokshin, 2002; Miravete and Pernías, 2006); b) internal and external technology sourcing (Cassiman and Veugelers, 2006; Belderbos, Carree and Lokshin, 2005; Catozzella and

Vivarelli, 2007); c) different types of cooperation strategies (Belderbos, Carree, Lokshin, 2006); and d) internal skills and cooperations (Leiponen, 2003).

There are signs of complementarity in all these dimensions. Firms tend to innovate in both products and processes, to produce their own knowledge while acquiring knowledge from outside the enterprise, therefore they need to build up their own capacity to be able to absorb outside knowledge, and they tend to cooperate with different partners at the same time. There is not always full complementarity when more than two strategies are involved, i.e. complementarity across all strategies. Firms may, for instance, collaborate with some partners and not with others. Another result that is often encountered in this literature is the importance of controlling for unobserved heterogeneity. Miravete and Pernías (2006) have clearly shown that not accounting for unobserved heterogeneity can lead to false conclusions as to a possible complementarity (supermodularity) in innovation strategies, because the unobserved heterogeneity can be falsely attributed to observed innovation strategies.

## 3.3 Innovation policy

The innovation surveys contain qualitative information about whether firms receive government support for innovation. This information may be sufficient to check whether government support for innovation has a positive effect on performance (R&D, innovation output, or productivity) and whether public and private funding for innovation are substitutes or complements to each other. In other words, does government support for innovation lead to a partial substitution of private funding for public funding or does it actually lead to more innovation than the amount of public funding involved? This can be done either by examining the effect of the presence of government support on innovation, by modeling at the same time the determinants of government support, or, as it is mostly done, by comparing the difference in innovation performance between matched pairs of supported and non-supported firms. For this evaluation of government support to lead to sensible results, enough observations must be available either to identify the determinants of government support for innovation, or to find good matches among the non-supported firms for all the firms that receive government support. Most studies conclude that government R&D support leads to additional private R&D, innovation expenditures or innovation outputs and not to crowding-out of private R&D by public R&D support.[8] [9]

Just as complementarity has been examined between various innovation strategies, it has also been examined between various innovation policies. The obstacles to innovation can be regarded as mirror images of failures in innovation policy. If an obstacle is perceived to be high by a respondent, it means that somewhere there is a deficiency in innovation policy. Although it may not be possible to pinpoint exactly which government policy should be acted upon to remove the perceived obstacle, especially as different policies may play out differently in different industries, an analysis of complementarity of the obstacles nevertheless shows whether one or more policies should be adopted simultaneously to improve innovation. In other words, should there be a policy mix or not? If two obstacles are complements, they reinforce each other. Removing one will attenuate the other one. There might be less of a reason to remove both at the same time. If two obstacles are substitutes, however, the presence of one obstacle relieves the pressure from the other one. In that case removing one obstacle will exacerbate the other one. Both should be removed jointly. Mohnen and Röller (2005) conclude that when it comes to turn non-innovators into innovators, it is important to remove a bunch of obstacles at the same time: easing access to finance, making more skilled labor available, or allowing for more collaboration. Governments should adopt a mix of policies, for instance easing access to finance and allowing firms to cooperate with other firms and technological institutions, or increasing the amount of skilled personnel and reducing the regulatory burden. When it comes to increasing the amount of innovation, one or the other policy will do.

### 3.4 Dynamics of innovation

Another hypothesis that has been tested with the innovation survey data is the persistence of innovation. Does innovation breed more innovation? Such an analysis has not yet been done for many countries because it requires the existence of multiple observations per firm across successive waves of innovation surveys, with a sufficient amount of overlap of sampling across successive waves. The underlying models are dynamic precisely because the interest lies in testing whether firms tend to innovate conditional on past innovation. Clearly these studies will become more frequent in the future as the time-series dimension of the data increases.

A couple of studies based on patent data had concluded that there was no persistence in patenting (Geroski, van Reenen and Walters, 1997; Malerba and Orsenigo, 1999; Le Bas, Cabagnols and Gay, 2003). With innovation data, Duguet and Monjon (2001) find a strong persistence in innovation, and Cefis (2003) finds that persistence in innovation is characteristic of major innovators. As mentioned by Duguet and Monjon (2001), persistence is more difficult to obtain with patent data because it requires innovation plus being the first to innovate. Peters (2008) finds persistence in innovation activities. Raymond et al. (2007) find persistence in innovation output, both in the appearance of new products and/or processes and the eventual share in total sales due to new products, in enterprises that belong to the high tech category.

## 4. Conclusion

Fifteen years ago countries started conducting innovation surveys. These surveys are structured and administered in a possibly comparable way in more and more countries. These surveys collect data on innovation inputs, innovation outputs and innovation modalities. International comparisons are still hampered by differences in coverage and wording of the questionnaires and intertemporal comparisons by additions and deletions of questions in successive waves of those surveys. Despite these hurdles, the information retrieved from these surveys allows governments to better monitor and benchmark the innovation performance of their economies.

The innovation surveys have also been widely used by researchers interested in estimating the determinants, interrelationships and effects of these various innovation indicators. Among the many topics investigated, we have selected four on which some tentative conclusions seem to emerge. R&D is found to have an effect on the appearance of new products and processes. The rates of return on R&D estimated previously by linking directly R&D and productivity are confirmed even when innovation output is added to the models. There are signs of complementarity between different types of innovation and ways to obtain knowledge for innovating, but more work needs to be done especially with panel data to find out whether this complementarity is spurious or robust to the presence of unobserved heterogeneity. Evaluations of government support for innovation on the basis of data from the innovation surveys points to some additionality. Finally as panel data become available it becomes possible to investigate the dynamics of innovation. Contrary to many previous studies using patent data as innovation output measure, those based on the introduction of new products and processes as innovation output indicators reveal signs of innovation persistence.

In order to improve the availability and usefulness of the innovation surveys both as a guide to policy makers and a tool of analysis for researchers and science and technology we recommend a continued harmonization of the survey questionnaires across countries, the development of a core set of questions which do not change over time, the development of the possibility of merging these data with other firm data, and the improved access of these data to individual researchers.

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[1] The Oslo manual has since undergone two revisions (OECD, 1996 and 2005).

[2] Some European countries had initiated their own surveys prior to CIS 1 (such as France, Germany, Italy, the Netherlands, Norway and Sweden). A few countries conduct their surveys more frequently than every 4 years (Germany, for instance, has a yearly survey, and the Netherlands conduct their surveys on a biannual basis). Some countries conduct innovation surveys that are specific to certain sectors (such as the 1996 Survey of Innovation in Service Industries and a survey on the construction industry in Canada) or to certain aspects of innovation (such as the French surveys on intellectual property rights, organizational changes, and the financing of innovation).

[3] In parallel, similar surveys were conducted, some even predating the innovation surveys. Probably the first one was conducted by the Science and Policy Research Unit (SPRU) at the University of Sussex. It collected information on specific innovations from firms and from a panel of experts (see, for example, Robson, Townsend and Pavitt (1988) and Geroski, Van Reenen and Walters (1997) for analyses based on the SPRU dataset). The Ifo Institute for Economic Research at the University of Munich has been conducting a yearly innovation survey in Germany since 1982 (see Lachenmaier and Rottman (2006) for a study on the ifo data). The Ministry of Industry in Spain has conducted for about ten years the firm-level survey ESEE (Encuesta Sobre Estrategias Empresariales) containing questions on innovation (see Huergo and Jaumandreu (2004) and González, Jaumandreu and Pazó (2005)). Besides innovation surveys, there exist literature-based innovation indicators such as the commercialized innovation data set collected from technology, engineering and trade journals at the US Small Business Administration (see Acs and Audretsch (1988)). In Italy, the investment firm Mediocredito Centrale has conducted a number of waves of the survey *Indagine sulle Imprese Manifatturiere*, in which firms are asked about their R&D and the incidence of product and process innovations.

[4] While CIS-1 covered only 13 countries, CIS-4 has been implemented in all 25 EU Member States, as well as in Iceland, Norway, Bulgaria and Romania.. Innovation surveys exist also in Canada, Mexico (North-America), Australia, New Zealand (Oceania), Norway, Switzerland, Russia, Turkey (other European countries), Argentina, Brazil, Chile, Colombia, Peru, Uruguay, Venezuela (South-America), China, Japan, Malaysia, Singapore, South Korea, Taiwan, Thailand (Asia), Tunisia and South Africa (Africa). The United States is one of the major countries with no innovation survey, although the U.S.

National Science Foundation conducted a pilot innovation survey in 1985. Innovation surveys are being conducted in India and planned to be implemented in various African countries within the NEPAD initiative.

[5] About non-innovators all we know is their turnover, export and number of employees, in levels and growth rates, the main industry they belong to, and their potential affiliation to a group.

[6] We have selected the studies that we know best, which are often those in which we were ourselves involved. A more exhaustive and complete survey is presently underway, which also goes more in depth into the econometric difficulties of handling correctly the innovation survey data.

[7] For a synoptic table comparing the results on the determinants of innovation from different studies, see Raymond et al. (2006).

[8] It is, however, only a partial picture of the justification for government intervention in private innovation. Spillovers are not taken into account. Spillovers can be positive if sequential innovation builds on past innovation or if innovation in one sector spurs innovation in another sector. But spillovers could also be negative if innovation puts pressure on the wages of researchers and thereby crowds out other research initiatives. We know nothing about the administration costs of government programs. Moreover, most of these studies do not evaluate the productivity of the additionally induced innovation efforts. It could be that only marginally productive or valuable research projects are stimulated by public incentives.

[9] See Arundel et al. (2008) for a summary of the findings regarding government support for innovation in various innovation surveys.