A SURVEY OF INNOVATION SURVEYS: TAKING STOCK OF A GROWING LITERATURE[1]

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[1] VERY PRELIMINARY. NOT TO BE CIRCULATED. COMMENTS MOST WELCOME.

1. **History of innovation surveys**

In the late 1980s, under the auspices of the Organization of Economic Co-operation and Development (OECD), scholars and statisticians interested in the measurement of innovation elaborated the Oslo manual (OECD, 1992), which has since undergone two revisions (OECD, 1996 and 2005). A new type of survey, the innovation survey, was worked out. In the EU countries, a common core questionnaire was agreed upon and surveys were launched under the acronym of CIS (Community Innovation Surveys). Similar surveys were run in many other countries, including non-OECD and developing countries. In total, over 50 countries have carried out at least one innovation survey.[2]

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). Multiple rounds of innovation surveys exist also in most of the other countries. Some 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 has a yearly survey and the Netherlands have a biannual survey), some conduct additional innovation surveys that are specific to certain sectors (such as the Canadian survey on services or on the construction industry) or to certain aspects of innovation (such as the French surveys on intellectual property rights and the one on organizational changes).

A number of more or less similar surveys were conducted earlier. Probably the first one was conducted by the Science and Policy Research Unit (SPRU) of the University of Sussex combining information from firms and from a panel of experts on specific innovations. The Ifo Institute for Economic Research at the University of Munich has been conducting a yearly innovation survey since 1982 in Germany. The Ministry of Industry in Spain has conducted the firm-level survey ESEE (Encuesta Sobre Estrategias Empresariales) with questions on innovation for about ten years. Besides innovation surveys, there exist literature based innovation indicators such as the commercialized innovation data set (by 4-digit SIC) collected from technology, engineering and trade journals at the US Small Business Administration.[3] [4]

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[2] While CIS-1 covered only 13 countries, CIS-4 has been implemented in all 27 EU countries (check). 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), 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.

[3] See for example Robson, Townsend and Pavitt (1988), and Geroski, Van Reenen and Walters (1997) for analyses based on the SPRU innovation data; Lachemaier and Rottman (2006) for an examination of the ifo innovation data, Huergo and Jaumandreu (2004) and Gonzalez, Jaumandreu and Pazo (2005) for analyses using the ESEE data. See Acs and Audretsch (1988) for an analysis based on the Small Business Administration data. A similar data set has been set up in the Netherlands (see Dolfsma and van der Panne, 2007).

2. Contents and structure of innovation surveys

The Oslo manual grew out of a concern to capture: a) a wider range of innovation activities than R&D expenditures, such as the acquisition of patents and licenses, product design, personnel training, trial production, and market analysis; b) indicators of innovation output other than patents and bibliometrics, such as the introduction of new products and processes, organizational changes and marketing innovations, the percentage of sales due to new products, the percentage of sales due to products new to the industry, and the share of products at various stages of the product life-cycle; and c) information about the way innovation proceeds, such as the sources of knowledge, the reasons for innovating, the perceived obstacles to innovation, the perceived strength of various appropriability mechanisms, and the partners of research cooperation.

The innovation surveys assemble data on innovators and non-innovators, where "innovators" are defined as enterprises that have over the last three years introduced a new product or a new process, have tried, or are still in the process of doing so, where "new" is defined as substantially improved and completely new, and where a distinction is made between products new to the firm (but not necessarily new to the market) and products new to the firm and to the market. In these surveys, firms are asked to give information about the inputs, the outputs and the behavioral and organizational dimensions of their innovative activities. Some of these data are quantitative, some are dichotomous (yes/no responses), and some are polychotomous, categorically ordered data, measured on a Likert scale. Table 1 presents a schematic overview of the main typical contents of the innovation surveys, the structure of the questionnaire and the nature of the data.[5]

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[4] For a more detailed account of the history of innovation surveys, see UNU-INTECH (2004) and Debresson (1996, pp. 8-10).

[5] While the core CIS questionnaire is the same in all countries, almost every country has its own peculiarities, be it additional questions, differences in the sequence of the questions or slightly different formulations of the same questions. For more details about the differences in the content of the CIS questionnaire over time, see Arundel and Bordoy (2005).

Table 1. Content and structure of the innovation surveys*

I. General information

Independent or part of a group?
Domestic or foreign group?
Country of location
Main industry affiliation
Nb of employees (level and growth)
Turnover (level and growth)
Exports (level and growth)
Mother, daughter or sister enterprise (CIS 1)
Significant changes in turnover (CIS 2 and 3)
Newly established (CIS 2 and 3)
Merger affected turnover for more than 10% (CIS 2 and 3)
Closure affected turnover for more than 10% (CIS 2 and 3)
Most significant market: national or international, nearby or distant (CIS 3)
Gross investment in tangible goods (CIS 3)
Number of employees with higher education, female, expected increase (CIS 3)

II. Innovator (yes/no)

Introduced new to the firm product in the last 3 years?
Is yes: share of innovative sales
Who developed the new products ? (CIS 2 onward)
Introduced new to the market product in the last 3 years?
Is yes: share of innovative sales
Introduced new process in the last 3 years?
Unfinished or abandoned innovative project?

III. Categorical data for innovators

Sources of information for innovation
Objectives of innovation (CIS 1 and 2)
Effects of innovation (CIS 3 and 4)
Means of transferring technology (CIS 1)
Effectiveness of appropriation mechanisms (CIS 1)

IV. Dichotomous data for innovators

R&D
R&D continuously
R&D cooperation with partners
Government support for innovation from various sources (CIS 3 and 4)
Applied for a patent? (CIS 2)

V. Continuous data for innovators

R&D expenditures (intra- & extramural)
R&D personnel (CIS 2 and 3)
Innovation expenditures (+ sub-items)
Estimated share of products in different phases of life-cycle (CIS 1)
Share of innovative products new to enterprise
Share of products new to market

VI. Data on all firms (innovators or not)

Factors hampering innovations (after a filtering question from CIS 2 on)
Applied for a patent? (CIS 3 and 4)
Possession of valid patents (CIS 3)
If yes: number of valid patents
share of patent protected sales
Use of any other IP protection methods? (CIS3 and 4)
Organizational changes? (CIS 3 and 4)
Importance of organizational changes (CIS 4)
Marketing innovations (CIS 4)

* if no indications are given, the items appear in all innovation surveys

3. Characteristics of the data contained in the innovation surveys

Qualitative variables Most of the data from the innovation surveys are qualitative, i.e. discrete: dichotomous (binary), ordered categorical (such as on a five-point Likert scale) or unordered categorical (e.g. product versus process innovation). Needless to say, qualitative data are less precise and noisier. Appropriate econometric techniques have been developed to handle these kinds of data: probit, logit, ordered probit or multinomial logit.

Censored variables Some variables are censored, i.e. collected only for a subset of the firms in the entire population. Those are, for instance, the variables related to innovation expenditures and innovation output. Only "innovators" as defined above, have to answer the questions in categories II to V. It may well be, for instance, that non-innovators perform R&D, but unfortunately those data are not recorded. It should therefore be clear that we have little information regarding non-innovators. The censoring should be corrected for to avoid inconsistent estimates. Tobit and Heckman selection models due the trick, although in some contexts a zero share of innovative sales or a zero R&D expenditure figure are deliberate choices and not values obtained from a censoring.

Subjective data Not only the qualitative but also some of the quantitative variables are subjective. One of the most interesting variables, the share in total sales due to innovative products, has values that are rounded up (10%, 15%, 20%, …), suggesting that perhaps it should be treated as a categorical variable and that we should not make too much out of its continuous variations. What exactly is defined as a new or improved product is not always clear, certainly not to the respondent. There are some examples given in the Oslo manual, but those are not always reproduced in the questionnaires. The distinction between new to the firm and new to the industry is also subject to a great deal of subjective appreciation.

Endogeneity The share in total sales is measured in the last year of a three year period, referring to products introduced in the last three years. Explanatory variables should be dated before that unless they are clearly exogenous with respect to innovation. Variables like R&D, exports, employment are measured in the same year as the share of innovative sales and can therefore hardly be considered as exogenous to innovation, certainly not for explaining the occurrence of innovation over the three year period. Many of the variables in the innovation surveys are actually jointly dependent on third factors or interacting with other. This is a major problem that not many studies so far have even tried to tackle.

Errors in variable The share in innovative sales due to new products is a relative measure. It can vary for whatever determines the denominator, i.e. total sales. For instance it can depend on the business cycle, markup pricing, whether new products substitute for old products, etc. Paradoxically, the share of total sales due to new products may rise when firms experience diminished sales. Startups are expected to have very high figures, since all of their products are by definition new. The duration of a product's life-cycle can also influence the measured share of innovative sales and therefore it should also depend on the sector of activity: coming up with new products is part of the whole business in electronics, whereas in the wood industry we expect more process than product innovations. The other interesting quantitative variable from the innovation surveys, the innovation expenditures, are, apart from R&D that firms are used to reporting, of low quality, often unanswered, because firms do not systematically keep track of these data.

4. What have we learned from the innovation surveys that we did not know before?

4.1 Understanding innovation

The innovation surveys have allowed us to reexamine the determinants of innovation on the input side, i.e. in terms of R&D or other innovation expenditures, and to examine whether the same effects hold for the output side, i.e. the propensity to innovate and the intensity of innovation as measured by the share in total sales due to innovative products. Although the results are never completely verified for all countries, all industries, all definitions of innovation, and all models, by and large the following results stand out.

Confirmed is the importance of important variables like **size** and **market concentration** that are traditionally associated with the Schumpeter hypothesis. Probably these two variables enter in a nonlinear fashion, following a quadratic or even a cubic function. Acs and Audretsch (   ) find that the number of literature-based innovations has a cubic relationship with firm size, first increasing, then decreasing, and then again increasing with firm size. At least for large firms the authors conclude that R&D is subject to decreasing marginal returns. Acs and Audretsch (1988) find that the number of innovations in the U.S. decreases with the degree of industry concentration. Blundell et al. (1999) find the same with UK innovation count data. They also 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. Many studies have found that the probability to innovate increases with firm size but that the intensity of innovation is unaffected or even decreases with firm size.

Unfortunately few countries (like France) include in their questionnaire explicit questions on the **demand pull** and **technology push** hypotheses following the traditions of Schmookler and Schumpeter respectively. Proxies have sometimes been constructed for these two variables from the questions on the objectives and the sources of information for innovation. Demand pull often turns out with a significant positive coefficient; technology push is also positive but less often significant.

R&D, and especially the fact of performing R&D on a continuous basis, is found to have a positive effect on innovation output.[6]

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

Pavitt (1984) has, on the basis of some 2000 significant innovations in Britain, classified firms into **industry groups** that are often used in empirical studies to control for industry-specific effects. He proposes to classify firms into supplier dominated firms, production intensive (subdivided into scale intensive and specialized suppliers), and science. His taxonomy is based on the sources of technology, the requirement of users, and the possibilities for appropriation. As a simple alternative to Pavitt's industry groupings, standard industrial 2-digit industry classes are used as control variables for industry effects. The OECD has proposed a four-way classification into high-technology, medium-technology (sometimes subdivided into medium-high and medium-low) and low-technology on the basis of the R&D intensity (with respect to value added or sales). Hollenstein (1996) and Baldwin and Gellatly (2000) object to this unidimensional classification of industries and propose a classification based on principal components analysis accounting for a number of innovation characteristics. Raymond et al. (2006) propose an econometric approach to industry classification based on a statistically accepted hypothesis of homogeneity of a model of innovation behavior for firms that belong to the same group. Applying their approach to the Dutch innovation data and to the homogeneity in innovation determinants they pretty much confirm the OECD classification with the exception of the wood industry. It may very well be that each country has a different classification pattern.

Mairesse and Mohnen (2002) propose an accounting framework to compare innovation performance across regions, industries or countries, similar to 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. A few results stand out: first, the unexplained residual, i.e. the measure of our ignorance in matters of innovation, is very high; second, we are better able to "explain" innovation in high-tech than in low-tech sectors; third, the magnitude of the residual is not unrelated to the response rate of the survey.

A phenomenon that has been widely tested on the innovation survey data is the one of complementarity, in the sense that adopting a package of strategies yields better results than the sum of their individual effects. In other words, the whole is more than the sum of its parts. This notion has been applied to various choices related to innovation:

- 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).
- internal and external technology sourcing (Cassiman and Veugelers, 2002; Fernández-Bagüés, 2002; Belderbos, Carree and Lokshin, 2005)
- different types of cooperation strategies (Lokshin, Belderbos, Carree, ????)
- internal skills and cooperations (Leiponen, 2003)

The results are rather mixed and heavily dependent on the appropriate correction for unobserved heterogeneity. Even after controlling for it, Leiponen (2003) concludes that internal skills are a prerequisite for successful collaborations, confirming the absorptive capacity hypothesis.

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 and Portugal. It has also been run with the same specification on four countries: France, Germany, Spain and the UK. 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 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). We expect process innovation to affect directly the average cost of production, whereas product innovations can displace existing products and possibly have mixed effects on total sales.

Another hypothesis that has been tested with the innovation survey data is the persistence of innovation. Does innovation breed more innovation? 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, 2000). With innovation data, Duguet and Monjon (2001) find a strong persistence in innovation, and Cefis (1996) 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 (2005) finds persistence in innovation activities. Raymond et al. (2006) do not find persistence in innovation output, but well in innovation inputs.

4.2 Innovation policy

The innovation surveys contain some information, alas only in dichotomous form, about getting **government support for innovation**. It allows though to check whether government support for innovation has a positive effect on performance and whether public and private funding for innovation are substitutes or complement to each other: 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. 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.[7] [8]

Just as complementarity has been examined between various innovation strategies for individual firms, it has also been examined between various innovation policies for governments. 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.

5. Technical difficulties and pitfalls

When comparing the empirical evidence on why and how much firms innovate, it is important to check the adopted definition of innovation. The exact definition of innovation may vary across studies. The Oslo Manual (OECD, 2005) distinguishes four

[7] 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.

[8] See Arundel et al. (2007) for a summary of the findings regarding government support for innovation in various innovation surveys.

types of innovations: product innovations (new goods or services or significant improvements in existing ones), process innovations (changes in production or delivery methods), organizational innovations (changes in business practises, in workplace organizations or in the firm's external relations) and marketing innovations (changes in product design, packaging, placement, promotion or pricing). An innovative firm can be defined as one that has successfully introduced one of these types of innovations in the period under consideration, but it could also be enlarged to firms that have not yet introduced the innovation, but have unsuccessfully tried or are still in the process of implementing the innovation. Product innovations have moreover been distinguished by their degree of novelty (new to the firm, region-first, country-first, or world-first). As an alternative, being innovative could be measured on the input side by the fact of having pursued innovation activities, such as R&D, acquisition of external knowledge, training for new products and processes and their market introduction.

Some researchers have tried to explain why a firm is innovative or not, i.e. by explaining a dichotomous measure of innovation (pertaining to a particular type of innovation output or innovation activity, or to the occurrence of any of them). Others have, instead of, or in addition to, the preceding, investigated the factors that explain the intensity of innovation, i.e. the number of innovations or share of total sales due to innovative products, which could be considered as the weighted sum of innovations, with weights equal to the share in total sales accounted for by the respective product or service innovations. In a way, the share of innovative sales amounts to weighing each innovation by its degree of success in total turnover. The innovation count or weighted sum of innovations has sometimes been restricted to patented products.

The R&D figures contained in the innovation surveys are not always consistent with the R&D data declared in the R&D surveys. It may well be that the respondents have a tendency to declare in the innovation surveys informal R&D or R&D expenditures that are not strictly defined as such according to the Frascati manual. Certain countries do not collect R&D data in their innovation surveys (e.g. Canada, or France for CIS 1); others send their R&D survey questionnaires only to hard-core R&D performers (e.g. the Netherlands). The innovation expenditures data are not well defined and hence of poor quality (see below).

The list of explanatory variables that can be introduced to explain innovation depends heavily on the variables included in the innovation surveys that are available for all firms and those that are available for innovators only. Most studies have no access to other data that can be merged with the innovation surveys. In that case, as mentioned elsewhere in the text, the number of explanatory variables available to explain the propensity to innovate as rather restricted. Somewhat more variable are available to explain the intensity of innovation, but the correction for a possible selection bias must rely on the few variables available to explain the propensity to innovate.

It is important to control for unobserved heterogeneity. For instance, when examining whether several innovation strategies like product, process and organizational innovations are complementary, Miravete and Pernías (2006) and Fernández-Bagüés (2002) 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.

As reported in Kremp et al. (2006), the returns to R&D from the CDM model estimated on French data are significant only when innovation output measures are instrumented to make them less noisy. Moreover the difference in magnitude between instrumented and non-instrumented variables suggests that the source of the bias is due to errors in variable rather than to simultaneity between innovation and productivity. Besides endogeneity, it is important to correct for selectivity. This is usually done by specifying a threshold latent variable above which innovation occurs. To some extent innovations, especially new-to-market innovations are not completely under the firm's control, but depend on the market's acceptance of these new products or the workers' acceptance of a new production method or organizational innovation. Our rational models of selection and decision making fall short to take these uncertainties into account.

A distinction has to be made between spurious and true persistence of innovation. As reported in Raymond et al. (2006), the persistence parameter, i.e. the lagged innovation indicator, was significant when the individual effect or the endogeneity of the initial condition was not taken into account. To determine whether there is true persistence it is thus necessary to model correctly the individual effect and the endogeneity of the initial condition.

The recipients of innovation support are likely to have some characteristics that distinguish them from the other firms. The proper way to estimate the effect of government support is therefore to treat it as an endogenous variable. It may also be that some firms are not always recipients of government support during the sample period, which can lead to downward biased estimates. It is thus also important to account for selectivity.

6. How to progress?

- Merge innovation survey data with other data

  In order to explain the choice of innovating or not, or to correct for selectivity in explaining the intensity of innovation, little can be done with the innovation survey data alone, because few variables are collected for all firms (including non-innovators) in the CIS innovation surveys. It would be recommendable that data from the innovation surveys could be complemented and merged with census data, accounting data, or data from other surveys in order to increase the explanatory power of the models, to improve the correction for selectivity, to provide more instruments to correct for endogeneity or measurement errors, and to avoid a bias due to missing variables.

- Create longitudinal datasets

  If a panel of firms could be constructed, that was followed over a number of years, it would be possible to correct for firm-specific effects, individual unobserved heterogeneity, and to get better estimates that could help devise more effective policy interventions. A major difficulty of course is that firms change shape over time by mergers, acquisitions and rationalizations. To what extent is firm A, which still bears the same name 10 years later, still comparable in its activities and strategies with firm A today? It would help the econometrician if the same firms could be followed over time, rather than wave by wave different samples of firms.

- Harmonize surveys across countries

  Although there might be some country specific issues worth investigating and collecting data for (e.g. regional aspects of innovation or the importance of FDI in developing countries), it would be advisable for the purpose of cross-sectional comparability to have the same basic questions asked, in the same way, with the same definitions, and in the same order in different countries. It would also be advisable that the sampling rule was the same in all countries and that the response rates were similar or at least that we could correct for differences in response rates.

- Ease access to data

  Access to the innovation survey data, in the same way as access to other individual firm data, can be problematic for researchers who are not somehow connected to the public sector. At stake is the issue of data confidentiality, which statistical offices indeed have to guarantee, and the use of the data for analytical purposes, in particular academic research, to increase our understanding of innovation. Improvements has been made by granting secure remote access to the raw data or by providing micro-aggregated or otherwise noise-contaminated data that hide the firms' identity. These methods should be generalised in a uniform way to allow researchers to access data from various countries and do international comparisons.

- Collect data on groups and especially on multinationals

  It may be argued that innovation possibilities, constraints and objectives are determined at the group level. If this is so, then the group should be the appropriate level of analysis. In particular, a great deal of R&D and innovation output occurs in groups of multinational firms, but innovation surveys only record data from activities performed and performances achieved domestically. If R&D and innovation are planned on a global scale, which is quite likely for multinational firms, limiting the analysis to domestic data is likely to lead to biased results and conclusions. A concerted effort by statistical agencies should be made to collect data from the same multinationals in different countries.

- Need for more studies on panel data

  Most studies are based on cross-sectional data from a single innovation survey. Partly because of difficulties of comparability mentioned earlier, international comparisons are still limited. It would be interesting to exploit panel data to study the dynamics of innovation, i.e. the time lags in the determinants and the effects, and to control for individual unobserved heterogeneity.

- Pay more attention to endogeneity

  Most variables in the innovation surveys are codetermined and jointly influenced by other variables. Few studies take the joint causality and dependence on third effects explicitly into account, partly because of the lack of long time series and partly because of the lack of other variables than those collected in the innovation surveys. The danger is to base policy measures on alledged causalities that are nothing more than mere correlations.

- Explore the links between innovation management and innovation performance

- Little work has been done about the dynamics of innovation

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