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A proposal for developing new indicators on the internationalisation of R&D by matching micro-data from national R&D surveys

Claudio Cozza and Giulio Perani – ISTAT[*]

Aim of the paper

The paper provides methodological suggestions for the use of R&D survey data to measure R&D internationalisation. A well established empirical literature has pointed out the main issues about this phenomenon, both at enterprise and at country level of analysis, raising the need for improved statistics on this subject.

In order to fill this need by producing cross-country statistics, international efforts (including the ongoing OECD *R&D globalisation project*) are being undertaken by collecting, at a pilot level, macro and meso-data from different countries. We suggest that a further step might be taken by undertaking bilateral or multilateral matching of micro-data from national R&D surveys. We argue that R&D survey data may provide relevant evidence to address research issues discussed in current literature, such as the nature of existing relationships among different National Innovation Systems (NIS) or the motivations of R&D outsourcing/off-shoring strategies by Multinational Enterprises (MNEs).

1. Theoretical background

Economic literature is increasingly interested in the analysis of R&D internationalisation activities undertaken by business enterprises. Among scholars is widely diffused the perception that the R&D diffusion processes are highly hierarchical, mainly based on one-way transfer of knowledge generated in MNEs home countries. Since the late 1970s, some pioneering studies (Ronstadt, 1976; Lall, 1979; Mansfield, Teece and Romeo, 1979) have targeted R&D internationalisation as a key driver for economic growth. In those studies, R&D was still intended as a highly centralised activity; therefore, the MNE was seen as "a polyp with its brain in the home country and tentacles in the host countries" (Archibugi and Michie, 1995).

Lately, in the mid 1990s, some theoretical contributions have provided useful taxonomies to compare the different business strategies fostering the globalisation of R&D. We mainly refer to: Archibugi and Michie (1995), Dunning and Narula (1995) and Kuemmerle (1996, 1997). The first contribution argued that the so-called *globalisation of technology* is composed by three sub-phenomena: the global *exploitation* of technology, the global technology *collaboration* and the global *generation* of technology, the latter being referable "to a single actor only: the multinational corporation". This sentence is fully consistent with the figures on world 2002 R&D expenditure: 69% of world's business R&D was undertaken by "the 700 largest R&D spending firms of the world – of which at least 98% are Transnational Corporations" (UNCTAD, 2005).

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[*] ISTAT, Italian Statistical Institute, Division of Structural Economic Statistics, Via Tuscolana 1788, 00153 Rome (Italy). The views expressed in the paper are those of the authors and do not involve the responsibility of ISTAT.

Two other studies have provided a different taxonomy, distinguishing between two activities related to R&D Foreign Direct Investment (FDI): *asset exploiting* (Dunning and Narula, 1995) or *Home Base Exploiting* (HBE, Kuemmerle, 1996) on one side, *strategic asset augmenting* (Dunning and Narula, 1995) or *Home Base Augmenting* (HBA, Kuemmerle, 1996) on the other side. Respectively, "firms internationalise their R&D to improve the way in which existing assets are utilized" or "to improve existing assets or to acquire (and internalise) or create completely new technological assets through foreign-located R&D" (Narula and Zanfei, 2004).

Following those contributions, recent empirical studies have mainly investigated the following topics:
- at the enterprise (group) level:
    o the trade-off between Home and Host location advantages as a motivation for MNEs R&D FDI (Kuemmerle, 1999; Patel and Vega, 1999; Le Bas and Sierra, 2002);
    o the trade-off between Internationalisation and Diversification in MNEs (Le Bas and Patel, 2005);
- at the country level:
    o the impact of R&D internationalisation on countries' specialisation and diversification (Cantwell and Janne, 2000; Criscuolo et al., 2002);
    o a potential process of "hollowing out" of national capabilities because of R&D internationalisation (Criscuolo and Patel, 2003).

2. Current indicators on R&D internationalisation

These scientific contributions have largely shaped the demand, by analysts and policy-makers, for statistics and indicators measuring the globalisation processes. Most of their needs have been incorporated in the OECD's *Handbook on Economic Globalisation Indicators*, firstly released in 2005. Among several "globalisation issues" related to the relevant literature in the field, the *Handbook* focuses also on R&D internationalisation, having been largely influenced by questions emerged during the 2002 revision process of the *Frascati Manual*.

As a result, some areas which were neglected in the past are now covered by statistical production: R&D expenditure flows to/from abroad and R&D activities performed by foreign-controlled affiliates, on the inward side, and by affiliates abroad of domestic MNEs, on the outward side.

In particular, the *Handbook on Economic Globalisation* recommends the production, at country level, of the following indicators on the MNEs R&D activities:

- R&D expenditure by foreign-controlled affiliates, absolute value and share of total business R&D expenditure (*Inward R&D – expenditure*);
- Number of researchers in foreign-controlled affiliates, absolute value and share of total researchers (*Inward R&D – employees*);
- Share of business R&D expenditure financed from abroad (*R&D Inflows*);
- R&D expenditure by affiliates abroad as a share of domestic R&D expenditure in the compiling country (*Outward R&D*).

The ability of countries to comply with these recommendations and regularly producing these indicators is largely influenced by the methodology adopted in carrying out their business R&D surveys. For instance, the Italian R&D survey, having adopted a census approach rather than a sample one, is assumed to be particularly effective in individuating the amount of R&D performed by affiliates of foreign-controlled MNEs (*Inward R&D*).

3. The prospects for international collaboration in R&D statistics

The growing need for statistics on the economic globalisation can be seen as a major challenge for national and international statistical systems. A comprehensive set of statistical indicators on the economic globalisation processes is now available from the OECD[1]. It includes indicators on international trade and FDI, as well as data on the activities of foreign affiliates (also their S&T activities) in several countries. The European context is less developed and is mostly related – in addition to the traditional trade and FDI statistics - with the development of a set of foreign affiliates statistics, including both economic and R&D data (FATS domain).

Further developments of statistical activities by international agencies in the field of globalisation could take place along two distinct lines of action:

- fostering the flow of foreign affiliates data from member countries;
- developing new data collection exercises at international level.

Although OECD and Eurostat are both trying to collect more detailed evidence on financial and economic flows among countries, the latter may take some advantage in the near future because of the forthcoming implementation of a specific European legislation on statistics on foreign affiliates activities, as well as of its future potential role of data producer through a survey on European multinational enterprises. A survey on MNEs – mainly if carried out at international (European) level – will offer several advantages in comparison with the collection of data from member countries. Phenomena like the intra-firm trade and the setting-up of international R&D networks within large multinational groups can be extensively surveyed only with a supranational exercise.

On the other hand, the implementation of a Europe-wide survey may be affected by serious methodological and technical problems ranging from the correct identification of the statistical units, to the management of non-responses or to the need of reducing other potential non-sampling errors. Shortly, it could be an expensive effort with a low probability to be very successful.

Thus, it is not surprisingly that OECD and Eurostat are still largely relying on data collected at national level. As to the specific R&D domain, the OECD *R&D globalisation project* provides a very good example about potentialities and limits of a systematic collection of national statistics on the R&D performed by foreign affiliates and by foreign affiliates of nationally-based MNEs.

On the one hand, an international project exploiting the information collected through the national business R&D surveys, could open the way to an intensive use of information – including meso and micro-data – usually neglected because of:
- the need of protecting data confidentiality,
- the lack of demand from national users,
- poor methodological guidelines and definitions,
- problems with the comparability with other countries' data.

In fact, the OECD project is attracting a large interest on both the policy and the research sides mainly because it provides a strong methodological base to compare for the first time data on R&D internationalisation from different countries.

On the other hand, what it is still critical with this approach are the obstacles to access confidential data. This is a main shortcoming for the OECD project, since some inconsistencies between data from different countries (and sometimes from different statistical or administrative data sources in the same country) can be addressed only checking the original micro-data or, at least, data with a restricted access for confidentiality concerns.

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[1] OECD Economic Globalisation Indicators 2005.

After the presentation of some preliminary finding of their *R&D globalisation project*[2], the OECD researchers responsible for it have addressed to national data producers some key questions about the future of the project:

- *What are the difficulties in identifying foreign-controlled affiliates and in measuring data concerning affiliates performing R&D abroad? Can exchange of practices, and perhaps bilateral exchange of otherwise confidential information, help in improving the coverage of this population?*

- *Can the sources of discrepancies between the Outward and Inward R&D data be identified? Can they be reconciled? What is the feasibility of using such bilateral and mirror information to improve the measurement of Outward R&D statistics?*

What is behind these questions is a possible development of the project towards a different structure allowing for a more flexible data collection approach, including data exchange activities not necessarily involving an international organisation but focusing on bilateral or multilateral data sharing among participant countries.

4. The rationale for data exchange in the EU context

In a context of increasing integration of statistical data production at international level, as it is the case for the European Union, the pivotal role of a "central" statistical agency has to be supported by a close co-operation among all the actors active in the field. Obviously, the extent the institutions involved in the process will be willing to co-operate is quite various. For instance, some projects could be managed jointly by two or more national statistical agencies[3], while only an international (or supranational) methodological coordination might be acceptable for key data collection exercises.

In general, it seems that the European Statistical System (ESS) – the network of institutions producing official statistics in the European Union – is going to become a key producer of statistics at global level. This system is currently evolving from being only a forum managing data transmission from EU member states to the European Commission[4] (namely Eurostat), to a network of national data producers co-operating on improving coverage and quality of European statistics[5]. Increasingly sharing common rules and procedures, ESS could evolve towards an effective "statistical system" at continental level, allowing also for the exchange of best practices, methodologies and even statistical data not only along a vertical path (from national producers to Eurostat), but also along horizontal links on the basis of bilateral or multi-lateral agreement among EU member states.

It has to be stressed that most of the European national institutions producing official statistics are not yet ready to contribute to such an effort. Even though the access to statistical data (including micro-data and metadata) is widely allowed in European countries, it can still be requested in most countries only for research purposes. As a consequence, access to micro-data for improving the quality of statistical production in another country could be hardly undertaken in the current institutional context. Nevertheless, to transform the ESS from a network of totally separate

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[2] "Note on R&D internationalisation: a pilot exercise undertaken by the NESTI Task Force", paper presented by Alessandra Colecchia at the 2006 NESTI Meeting in Berlin (29-31 May 2006), DSTI/EAS/STP/NESTI(2006)22.
[3] As it is the case for several EU funded Framework Program's research projects.
[4] Following the framework EC Regulation n.322/1997, several EU Regulation have been approved in order to give a normative background to the Eurostat data collection activities.
[5] The experience with the adoption of statistical tools like the *European Self-Assessment Checklist for Survey Managers* and the *Eurostat Standard Quality Report*, as well as with the implementation of the *European Statistics Code of Practice* is an indicator of the evolution of the ESS towards a more integrated methodological and institutional structure.

institutions into a community of producers committed to provide the European Union with high quality official statistics, a certain degree of co-operation in statistical production should be achieved.

In this respect, the Italian National Statistical System (SISTAN) could be proposed as a model for designing a statistical system at European scale. Within SISTAN – which is bringing together all producers of official statistics in Italy, ranging from ISTAT to the regional and local statistical agencies – a close co-ordination of the statistical production has been implemented in order to avoid duplications in data production and to reduce the burden for respondents. A key part of this strategy is the provision for circulating statistical macro- and micro-data among the institutions belonging to SISTAN. In fact, the collective adoption of a "deontological code" for public statisticians has made possible for every statistician operating within the system to have access, either for research or statistical production purposes, to all data available in the system.

A similar "deontological code" or "code of conduct" for European statisticians might be a useful tool for opening the way to the exchange of data and information among the ESS institutions. In this perspective, it is worth mentioning that an important development has already taken place in 2005 with the approval of the *European Statistics Code of Practice*[6], On the other hand, since cultural changes need long time to become effective, some statistical domains – primarily, the statistics on R&D internationalisation – could serve as experimental areas where some procedures could be tested and evaluated. As an example, the main advantages of such an evolution for R&D statistics could include:
- Improving the quality of R&D statistics by comparing different methods and approaches in order to develop some "best practices" to be spread throughout the EU; some quality aspects would be mostly affected:
    o international comparability;
    o statistical coverage;
    o coherence with other information sources.
- Providing the EU with a new statistical infrastructure distributed among member countries which would not add burden on Eurostat while producing relevant statistics at European level;
- Developing a set of new indicators aimed at filling the gap between the current statistical production on international flows of R&D and the increasing request for new indicators.

In this framework, the quality issue is of paramount importance. The trend towards an increase in the number and complexity of statistical indicators requested by European policy-makers needs a higher level of coordination between the producers of official statistics in Europe. This is particularly evident in the R&D domain where the general recommendations provided by the Frascati Manual for harmonising the statistical production on R&D in the OECD countries are turning to be insufficient to assure an adequate level of coherence among the R&D statistics from the 25 EU member countries. Even though a "European Frascati Manual" may not be really needed, the adoption, also in the R&D domain, of tools like the *European Self-Assessment Checklist for Survey Managers* and the *Eurostat Standard Quality Report* for statistical survey shows a new attitude towards accountability and comparability in official statistics which should be primarily based on the harmonisation of statistical methodologies.

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[6] Commission Recommendation of 25 May 2005 on the independence, integrity and accountability of the National and Community Statistical Authorities (COM-2005/217).

5. The ISTAT R&D internationalisation project

Since January 2006, ISTAT has been undertaking a national project aimed at improving its ability to produce relevant indicators on the internationalisation of the Italian R&D system. In this perspective, ISTAT has also contributed to the OEC*D R&D globalisation project* producing pilot statistics on foreign affiliates R&D (expenditure and personnel), as well as collecting preliminary estimates on outward FATS R&D expenditure and personnel.

As part of the project, data collected by the OECD *R&D globalisation project* and data published by the European Commission in the DG RTD's *EU Industrial R&D Investment Scoreboard* have been compared with micro-data from the ISTAT R&D survey. Inconsistencies and errors have been reported in order to improve both the international data collection activities and the national statistical processes.

With the aim of complementing this analysis, as well as to test the coverage of the preliminary estimates on the internationalisation of the Italian R&D system, ISTAT has contacted the institutions responsible for R&D statistics in some OECD countries in order to assess the chances for sharing quantitative and qualitative information on bilateral flows of R&D.

Some collaborations have been undertaken – on a purely experimental basis – with Stiftungsbetreuung im Stifterverband for Germany, the Office fédéral de la statistique for Switzerland, the Office for National Statistics for the UK and the Federal Office SPP "Politique scientifique" for Belgium. The identification of proper procedures for collaboration is currently undergoing with the U.S. National Science Foundation and the Ministère de la recherché of France.

Several activities have been carried out to check the interest by other countries of implementing:
- exchange of meta-data on the national R&D surveys, including information not regularly reported to the OECD's *Sources and Methods* database;
- exchange of macro-data not regularly published by the surveying institutions;
- exchange of information on macro-data not published for confidentiality concerns;
- exchange of information on micro-data to be used for specific analyses.

As a result, a general interest in exploring the opportunities for sharing such information can be reported. In some cases, the definition of specific bilateral agreements will be pursued in order to establish a permanent co-operation between R&D statistics producers.

After the completion of the data collection process, the Italian project will proceed through four main activities:
- assessment of the level of consistency between Italian business R&D data and similar data produced in other countries;
- development of procedures for checking Italian data against foreign data, as well as for integrating the Italian data with information from other countries;
- production of indicators at enterprise (group) level;
- production of indicators at country level.

As to the first issue, it has to be stressed that comparability problems will be the main obstacle to a full implementation of the project. Some preliminary comparisons of data show that even minor divergences in data collection methodologies can seriously affect the joint use of data from different statistical surveys. The most serious problems experienced in the Italian project include: different frequency of statistical surveys, differences in the definition of the population, discrepancies between data produced with census vs. sample methods.

Data checking, to be helpful in order to improve the statistical production in another country, has to be undertaken at micro-level. As a consequence, only data from countries which will accept to share some information on enterprises and groups of enterprises will be used for improving the Italian

statistical production. In addition to data provided by partner countries, data available at international level (including, for instance, data from the *EU Industrial R&D Investment Scoreboard*) will be used as complementary information on R&D activities undertaken by large MNEs active in Italy or in some partner countries.

One of the most ambitious aims of the project is the development of some methods to define specific "profiles" of MNEs involved in R&D in Italy, with reference to their R&D strategies at global level. The literature on MNEs is very helpful in this respect. For instance, the systematic collection of data, at MNE level, on international and intra-group flows of R&D expenditure (complemented with data on the economic results of these groups) could shed light on the trade off between "Home Base Exploiting" and "Home Base Augmenting" R&D strategies. Moreover, collecting information on a large number of MNEs and their global R&D strategies would probably be the best approach for monitoring the rapidly changing trends of delocalisation/off-shoring of R&D assets at international level. On the other hand, serious methodological problems for developing such data collection exercises have not yet properly addressed. Even basic definitions and recommendations from the OECD *Handbook on Economic Globalisation Indicators* - which provides the more advanced results of the international process of harmonisation in this field - have to be regarded as still "experimental" both for having been implemented only recently and for being quite difficult to adopt in some national contexts. A serious problem to mention is linked with the definition of "unit of ultimate control" of a foreign-controlled affiliate by the Handbook[7]. In practice, defining the "home country" of a foreign affiliate as the home country of its "unit of ultimate control" (which could be even just an individual or a pure financial holding), there is a high risk that this "home country" will not be the place where strategic decisions are actually taken. As an example, if an Italian enterprise belongs to a UK-based MNE whose majority share is owned by an individual resident in Switzerland, the Handbook recommends to consider it as a "Swiss" enterprise even though economic and technological strategies which will affect its activities will be probably defined in the UK. Further work in this field will have to be carried out to sort out from this kind of methodological inconsistencies.

6. A proposal for developing new indicators on the internationalisation of R&D

The task of defining a set of indicators on the internationalisation of R&D at country level can be based on a more consolidated experience than the development of indicators on MNEs strategies. In the framework of the ISTAT project, several indicators are currently being tested (see Table 1). Some of the indicators are already produced and used at international level following the OECD recommendations.

Besides testing the feasibility of producing them, the ISTAT project is going to develop a consistent framework where these indicators could provide an overall assessment of the degree of internationalisation of a national R&D system in terms of "propensity" to invest in R&D abroad, "permeability" to foreign R&D investments and ability to "penetrate" in selected R&D systems abroad. Finally, some specific indicators will be aimed at measuring the degree of "integration" between two national R&D systems.

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[7] "An investor (company or individual) is considered to be the *investor of ultimate control* of an investment if it is at the head of a chain of companies and directly or indirectly controls all the enterprises in the chain without itself being controlled by any other company or individual". It might be thought that a firm's parent ought to be the company of ultimate control. While this might seem obvious in theory, it can in practice not be the case because of the difficulty of obtaining all the necessary information. (OECD, 2004, p.104).

Table 1. Indicators on the internationalisation of R&D	
International R&D Propensity	a. Overall Propensity (O Pro)*
	b. Country Propensity (C Pro)*
	c. Sector/Country Propensity (SC Pro)
International R&D Permeability	a. Overall Permeability (O Per)*
	b. Sectoral Permeability (S Per)
	c. Country Permeability (C Per)
	d. Sector/Country Permeability (SC Per)
International R&D Penetration	a. Simple Country Penetration (SC Pen)
	b. Relative Country Penetration (RC Pen)
International R&D Integration	a. Bilateral Integration (B Int)
	b. Sectoral Bilateral Integration (SB Int)
* Indicators recommended by the OECD *Handbook on Economic Globalisation*	

Some of the indicators considered in the ISTAT project have been calculated – even though for testing purposes only - and the results are presented in Table 2.

Indicators on *Overall propensity* (OPro) and *Overall permeability* (OPer)[8] are quite straightforward and are already available in the OECD databases (at least for countries estimating the R&D expenditure by foreign affiliates in the country and by home-controlled foreign affiliates abroad). While no partner countries have produced data for calculating OPro to compare with Italy, OPer has been produced for five countries showing quite different national attitudes towards foreign R&D investments.

On the "propensity" side some additional information is provided on the relative interest of Italian MNEs to invest in a country rather than in another one (*Country propensity* CPro)[9]. Data for four European partner countries show that Italian MNEs could be interested to perform R&D more in Germany than in other countries. To detail this indicator at sectoral level the availability of micro-data from one or more foreign country would be needed. The feasibility of calculating this indicator will be tested in the future.

On the "permeability" side, the level of acceptability in Italy of R&D investments from other countries is measured (*Country permeability* CPer)[10]. German R&D investments seem slightly more acceptable than others for the Italian R&D system.

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[8] : The *Overall propensity* is calculated as the rate of R&D activities owned by domestic firms abroad on total domestic business R&D activities.

$$O \Pr o = \frac{\text{Outward R \& D}}{\text{Domestic R \& D}}$$

The *Overall permeability* is calculated as the rate of domestic R&D activities owned by foreign parent companies on total domestic business R&D activities.

$$OPer = \frac{\text{Inward R \& D}}{\text{Domestic R \& D}}$$

[9] The *Country propensity* is calculated as the rate of R&D activities owned by domestic firms in country X on total R&D activities owned by domestic firms abroad.

$$C \Pr o = \frac{\text{R \& D in country X}}{\text{Outward R \& D}}$$

[10] The *Country permeability* is calculated as the rate of domestic R&D activities owned by parent companies resident in country X on total domestic business R&D activities.

$$CPer = \frac{\text{Inward R \& D from country X}}{\text{Domestic R \& D}}$$

Table 2. Selected indicators on Italian R&D internationalisation, year 2003		
Indicator	*Country*	*Value*
Overall Propensity Outward R&D / Domestic R&D	**Italy**	**0,028**
Country Propensity R&D in country X / Outward R&D	**Italy** to Belgium to Germany to Switzerland to UK	 0,006 0,197 0,074 0,052
Sector/Country Propensity R&D in sector Y of country X / R&D in sector Y abroad		*needs multilateral matching*
Overall Permeability Inward R&D / Domestic R&D	**Italy** Belgium Germany UK US	**0,321** 0,571 0,252 0,450 0,145
Sectoral Permeability Inward R&D in sector Y / Total R&D in sector Y	**Italy** NACE 17 (Textile industry) NACE 24 (Chemical industry)	 0,154 0,589
Country Permeability Inward R&D from country X / Domestic R&D	**Italy** from Belgium from France from Germany from the UK **Sweden** from Belgium from Germany from the UK	 0,011 0,025 0,034 0,027 0,001 0,006 0,181
Sector/Country Permeability Inward R&D in sector Y from country X / Total R&D in sector Y	**Italy** Nace 17 from Germany Nace 24 from Germany	 0 0,024
Simple Country Penetration Inward R&D from country X / Inward R&D	**Italy** from Belgium from France from Germany from the UK **Sweden** from Belgium from Germany from the UK	 0,036 0,077 0,105 0,086 0,002 0,012 0,399
Relative Country Penetration Inward R&D from country X / Inward R&D from the top investor country	**Italy** from the Netherlands from the US from Germany	 1 0,523 0,277
Bilateral Integration	Italy-Germany Italy-UK Italy-Sweden UK-Sweden UK-US	0,039 0,012 0,003 0,013 0,377
Sectoral Bilateral Integration	Italy-Germany: Nace 24 Italy-Germany: Nace 29, Machinery	0,012 0,067

A similar indicator has been developed at sector level (*Sector permeability* SPer)[11] confirming that the chemical industry (including the pharmaceutical industry) in Italy is much more open to foreign R&D investments than the textile industry. A more complex indicator combining sectoral and country "permeability" (*Sector/country permeability* SCPer)[12] has been calculated, though only with reference to Germany as investor country and the textile and chemical industries as sectors. It seems that in Italy the chemical industry would be more attractive for German enterprises than the textile industry.

Assuming that a "competition" would exist among countries to enter into foreign national R&D systems - similarly to what happens in the global trade market - the degree of "penetration" of enterprises from country X to country Y will provide a measure of competitive success. ISTAT is currently testing two indicators: (*Simple country penetration* SCPen) and (*Relative country penetration* RCPen)[13]. While SCPen shows that Germany is more successful than UK or France to invest in the Italian R&D system (as it is the UK, compared to Germany, with regard to the Swedish R&D system), RCPen provides the additional information that the Netherlands, as top investor country in the Italian R&D system, is outperforming the US by a factor of two, and Germany by a factor of five, as to the ability to invest on R&D in Italy.

The final group of indicators under testing for the ISTAT project are focusing on bilateral integration of national R&D systems. Two main indicators have been developed comparing, respectively, the integration between countries in general (*Bilateral integration* BInt)[14] and the integration between countries at sectoral level (*Sectoral bilateral integration* SBInt)[15]. These are key indicators in a project mainly aimed at stimulating the bilateral co-operation in R&D statistical

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[11] The *Sectoral permeability* is calculated as the rate of domestic R&D activities in sector Y owned by foreign parent companies on total domestic R&D activities in sector Y.

$$SPer = \frac{\text{Inward R \& D in sector Y}}{\text{Total R \& D in sector Y}}$$

[12] The *Sector/Country permeability* is calculated as the rate of domestic R&D activities in sector Y owned by parent companies resident in country X on total domestic R&D activities in sector Y.

$$SCPer = \frac{\text{Inward R \& D in sector Y from country X}}{\text{Total R \& D in sector Y}}$$

[13] The *Simple country penetration* is calculated as the rate of R&D activities owned by parent companies resident in country X on total Inward R&D activities. Therefore it represents the geographical distribution of Inward Investment.

$$SCPen = \frac{\text{Inward R \& D from country X}}{\text{Inward R \& D}}$$

The *Relative country penetration* is calculated as the rate of R&D activities owned by parent companies resident in country X on R&D activities owned by parent companies resident in the top investor country.

$$RCPen = \frac{\text{Inward R \& D from country X}}{\text{Inward R \& D from the top investor country}}$$

[14] The *Bilateral integration* ratio is calculated as the rate of the reciprocal R&D activities in countries A and B, weighted by their total foreign R&D investment, on the sum of the reciprocal R&D activities in countries A and B, weighted by the sum of their total foreign R&D investment.

$$BInt = \frac{\dfrac{\text{A in B}}{\text{Inward B}} * \dfrac{\text{B in A}}{\text{Inward A}}}{\dfrac{\text{A in B} + \text{B in A}}{\text{Inward B} + \text{Inward A}}}$$

[15] The *Sectoral bilateral integration* ratio is calculated as the Bilateral Integration, with regards to specific sectors of activity for both countries A and B.

$$SBInt = \frac{\dfrac{\text{A in Yb}}{\text{Inward Yb}} * \dfrac{\text{B in Ya}}{\text{Inward Ya}}}{\dfrac{\text{A in Yb} + \text{B in Ya}}{\text{Inward Yb} + \text{Inward Ya}}}$$

production. Data already available from the OECD allow for producing the basic bilateral indicator for several couples of countries. Some interesting evidence is emerging from this indicator: the Italian R&D system is more "integrated" with the German system than with the British one; the R&D systems of the US and the UK are very highly integrated; Sweden performs quite low in R&D integration with Italy and even with the UK. A larger availability of data – namely, a sectoral breakdown of foreign affiliates R&D expenditure data – would make possible to produce more detailed indicators on bilateral sectoral integration. Evidence from Italy and Germany shows a higher degree of R&D integration in the machinery sector than in the chemical sector. This outcome is, obviously, independent from the relevance of the German R&D investments for the chemical R&D in Italy, drawing the attention of the users more on the high level of reciprocal investments in a specific field of R&D, than on the level of "penetration" of a national R&D system into another.

Only preliminary samples of the activities carried out by ISTAT in developing and testing indicators on the internationalisation of R&D have been presented above. More evidence could be collected and analysed in relation to the future availability of additional R&D data from partner countries.

7. Conclusions

The growing demand for indicators on the internationalisation of R&D activities should lead to a better exploitation of the results of business R&D surveys in order to produce indicators at both country and enterprise level.

Several difficulties have to be still addressed before R&D surveys would become a major source of data for statistics on internationalisation. It has also to be stressed that the integration of several administrative and statistical sources will have to be planned moving towards a "statistical system" producing data on the internationalisation of R&D.

On the other hand, the ISTAT *R&D internationalisation project* can be seen as a pilot experience to test the results of an intensive use of R&D survey data. The ISTAT exercise has moved from the basic assumption that if national R&D data will be shared (on either a bilateral, or multilateral context) among producers, the options for improving the statistical production in the field of R&D internationalisation will increase dramatically.

First results of the exercise have provided encouraging evidence that there is room for bilateral agreements on micro or macro-data sharing between countries to complement data collection exercises at OECD or Eurostat level. The evolution of the European Statistical System towards a more harmonised and coherent community of producers of statistics may also provide a good environment for testing such bilateral co-operation on R&D statistics.

As to the future prospects for this activity, the need for a full integration with statistical activities on economic globalisation have to be pointed out. Problems like the definition of an effective criterium to identify a MNE or the development of methods to improve the coverage of foreign affiliates have to be addressed at a more general level than just the R&D statistics domain (even though the needs of R&D statistics have to be taken into account in addressing them).

In general, the efforts to stress the current procedures adopted in official statistics in order to develop new methods for matching and combining enterprise-level data to improve the statistical production in selected critical fields (while preventing public dissemination of sensible data, of course) will be one of the main challenges statistical agencies will face in future years. Not less important is that these efforts will be made effective only promoting a closer co-operation between national and international data producers on the one hand, as well as producers and users on the other hand.

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