Is the innovation performance of countries related to their internationalization?

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Executive summary

This report has been prepared for the European Commission project as a thematic paper of the European Innovation Scoreboard (EIS). It investigates the links between innovation performance, using the EIS Summary Innovation Index, and various indicators of internationalization.

The EIS measures and compares the innovation performance of countries on an annual basis using a synthetic composite indicator: the Summary Innovation Index (SII). The latter is based on 29 indicators addressing several dimension of a country's system of innovation. The EIS 2008 includes innovation indicators and trend analyses for the EU27 Member States as well as for Croatia, Turkey, Iceland, Norway and Switzerland (European Commission, 2009), and this is also the group of 32 countries that this report considers.

The aim of the research underlying this report is to test the association between innovation and internationalization. The extent to which a country's businesses, institutions and industries are linked with resources and capabilities located outside the country is likely to positively impact on the innovation performance of that country. Conversely, innovation-intensive firms and countries are more likely to be able to compete successfully in international locations. These propositions are rooted in theoretical analysis and are supported by empirical evidence for various countries.

The report starts by recalling some of the theoretical background as well as empirical evidence to the relationship between internationalization and innovation. It then presents the framework underlying the assessment of the relationship between innovation and internationalization. The innovation data is taken from the performance of the above 32 countries as in the SII. The contribution of this report is on the internationalization side and specifically in the following.

The research identifies three possible levels of internationalization relevant for innovation: the full aggregate level (A) in which internationalization variables are considered for the whole country and all industries; the level of technology-intensive industries (B) where internationalization of countries is considered with respect to these industries; and level (C) reported activities of firms in each country on the basis of data derived from two surveys – the Innobarometer survey (CI) and the Community Innovation Survey (CII). For each level several variables are considered. Specifically, level A includes the following variables: inward and outward FDI, imports and exports, mobility of employees and of students. Level B includes: inward and outward FDI for technology-intensive manufacturing sectors and for knowledge-intensive services, imports and exports of technology-intensive products, balance of payments debits and credits for knowledge-intensive services, and mobility of research students. Under level C of the analysis we include those questionnaire items in the Innobarometer and CIS surveys that have a bearing on the international embeddedness or focus of responding companies. Specifically, the following variables are taken from Innobarometer: proportion of companies that operated in international markets, outsourced activities to companies located abroad, invested into companies located abroad, cooperated with partners which were located abroad, recruited employees from other countries, carried out market-testing in foreign countries, considered international markets to be the lead markets. The following are derived from the Community Innovation Survey: proportion of enterprises that operated in international markets, proportion of foreign-owned enterprises, and proportions of enterprises reporting cooperation with partners abroad.

For each variable indicators of countries' scores are calculated applying a methodology similar to the one used for the SII, thus ensuring consistency between innovation and internationalization data. Summary Globalization Indices (SGI) are then calculated for each of the three levels: SGI/A, SGI/B, SGI/CI and SGI/CII (level C is split into two Indices based on CIS and Innobarometer data respectively).

The association between innovation and internationalization is tested by calculating correlation coefficients between SII and SGI/A, SGI/B, SGI/CI and SGI/CII. Coefficients for each single variable within each level and SII are also reported. Details of the data and methodology are discussed in sections 4 and 5. Further analysis was conducted on two sub-groups of countries, large and small, to check that the results were not purely a factor of size.

The results (for all countries and for the sub groups of large and small countries) show clear association between internationalization and innovation at all levels of analysis. The international variables that show association throughout the four levels are those related to outward foreign direct investment – and similar variable at the micro level – foreign students and foreign employees. The latter show the relevance of cross-border movements of skilled human resources for a positive, virtuous relationship between innovation and internationalization. Our results for imports, exports and for inward FDI are less clear and the possible reasons for this are discussed in 6.4.

This study is exploratory and its limitations are discussed in section seven. Time series or causality analysis is beyond the scope of this research and report. Nonetheless the results are robust enough to (a) warrant further deepening research; and (b) support the following conclusion. From the analysis of all the results together and from the underlying theoretical background we argue that there is causal interaction between internationalization and innovation and that this leads to a cumulative process in which the innovation and internationalization elements affect each other in a virtuous or vicious circle.

In policy terms we suggest that the relationship between innovation and internationalization points to the relevance of both for the performance of countries. The inter-relationship between the two suggests that public authorities should consider links between their innovation support to enterprises and support to internationalisation. The strong relationship between innovation performance and the cross-border movement of skilled people, suggests that innovation policy could usefully consider policies that support international mobility, training and secondments.

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1. Introduction

The research underlying this report is part of a European Commission project linking the innovation performance of countries as measured in the European Innovation Scoreboard (EIS) to a variety of economic and social elements. The present specific work links innovation to internationalization.

The EIS is an annual report managed by the European Commission – Directorate General Enterprises and Industry – carried out since 2001. The EIS measures and compares the innovation performance of countries using a synthetic composite indicator: the Summary Innovation Index (SII). The latter is based on 29 variables addressing several dimension of a country's system of innovation. The EIS 2008 includes innovation indicators and trend analyses for the EU27 Member States as well as for Croatia, Turkey, Iceland, Norway and Switzerland (European Commission, 2009), and this is also the group of 32 countries that this report considers. The boundaries of the research in terms of content, structure and number of countries included in the analysis are largely set by the EIS.

While considerable progress has been made to reveal cross-country patterns of innovation performance, not least made possible through the coordinated efforts by (European) governments to collect relevant data at a large scale through the Community Innovation Surveys (CISs), little progress has been made towards systematically capturing the global embeddedness of the innovation activities of countries.

The contribution of this paper resides in the following: (i) the identification of three levels of analysis for internationalization: all industries level (A), innovation-intensive industries (level B), self-reported firm behaviour level (C); (ii) the identification of sets of variables within each level; (iii) the transformation of variables into indicators following a procedure consistent with the data on SII; (iv) the calculation of Summary Globalisation Indicators (SGIs) for each level (A, B and C); and (v) the calculation of correlation coefficients between SII and the indicators of internationalization related to the three levels of analysis; (vi) the analysis of the results in the context of the background theories; and (vii) the drawing of some policy implications.

The data feeding into the analysis comes from national statistics and from surveys into firms/enterprises behaviour. The report provides a systematic analysis of patterns of association of international embeddedness with countries' innovation scores. At this stage, neither the project nor this report empirically tries to establish causality between innovation in European countries and their internationalization record. There are many factors affecting the innovation of countries; however, we cannot explore them within the scope of this report. The research leading to this report is intended to be exploratory and not definitive: the report will make recommendation as to the suitability and viability of further research in relation to the relevance of the results for policy implications.

There are limitations on drawing implications from correlations. The correlations: (a) could be spurious; and (b) even if not spurious they do not give us indications of the direction of causality. With regards to (a) we are inclined to rule it out and claim that the association between innovation and internationalization is well founded because there are plausible theoretical explanations for a causality link between these two economic elements. They will be explored in the next section as will the issue of direction of causality. Our claim is that, a priori, the international context of countries and their innovation performance are likely to be related.

The paper is structured in the following way. Section 2 provides the theoretical context against which the study is set. Section 3 develops the specific framework of this study. Sections 4 and 5 discuss respectively the data and the methodology. Section 6 presents the results and the last section summarizes and concludes.

2. Theoretical background

Innovation is the result of many factors operating at the macro, meso and micro levels. One element overarching all three levels of aggregation is internationalization. It has been claimed that companies that operate in many countries learn from different innovation contexts and are therefore able to benefit from them. The sources of learning and knowledge acquisition can be many. If a country is highly internationalised it is likely to have a higher innovation performance because: (i) its resources (labour, management etc.), its products and its institutions are exposed to alternative innovation contexts, and this allows firms and people to learn from different environments; and (ii) competition forces the firms to innovate.

The transmission mechanisms can be many and involve relationships between customers and sellers, principal and contractors, academic research networks, or employees working for the same institutions. In the case of transnational companies (TNCs) the transmission mechanisms are via the cross-countries internal networks of the company as well as via the contacts between each unit of the TNC (be it subsidiary or headquarter) and the local environment in which it operates.

The link between innovation and internationalization has a strong theoretical underpinning. The evolutionary theory of the firm (Nelson and Winter, 1982; Nelson and Rosenberg, 1993) has led to new developments in the theory of TNCs (Cantwell, 1989; Kogut and Zander, 1993) in which the behaviour and activities of TNCs are linked to innovation development and diffusion.

TNCs operate in foreign countries through several modalities ranging from foreign direct investment (FDI) to trade to licensing and from franchising to sub-contracting and to joint ventures. All modalities, in different ways, give rise to a variety of networks across countries. All these networks give scope for the acquisition of knowledge and innovation from diverse environments. The mechanisms through which the diffusion takes place can be via movements of tangible or intangible products, materials and assets or via the exchanges of human resources.

For any given country, both domestic and foreign TNCs with subsidiaries in it are part of networks which are internal to the company and which span several countries. Each company unit operating in a foreign country – whether affiliate, subsidiary or headquarter – has the opportunity to learn from the innovation context and system in the foreign country. The knowledge is absorbed by the unit and then transmitted – wholly or partially – to other parts of the company via its *internal networks* (Zahra, Ireland et al., 2000; Castellani and Zanfei, 2004; Frenz, Girardone et al., 2005; Castellani and Zanfei, 2006; Frenz and Ietto-Gillies, 2007)

Moreover, each company unit develops linkages with local businesses on innovation-related activities leading to *external networks* some of which are contractually formalized and others are more informal. There is therefore a *double network* contributing to knowledge and innovation acquisition and diffusion and thus to the capabilities of a specific country (Hedlund and Rolander, 1990;

Castellani and Zanfei, 2004; 2006). The extent of knowledge diffusion via internal and external networks may partly depend on the internal organizational structure of the company (Hedlund, 1986; Bartlett and Ghoshal, 1989; Gupta and Govindarajan, 1991; Gupta and Govindarajan, 2000).

Empirical support for the link between multinationality and innovation is in (Castellani and Zanfei, 2004; 2006; Frenz and Ietto-Gillies, 2007; Frenz and Ietto-Gillies, 2009). However, the direct activities of TNCs may be only one way in which companies, institutions, people and countries come in contact with the innovation context of other economies.

The evidence of diffusion of innovation via internal networks refers only to TNCs and not to other firms and actors within a country. However, the arguments and evidence about spillover effects into the local economy relate to the local and macro environments in which the units of the TNCs operate. Thus we have a possible impact of TNCs innovative activities on the local and macro environment.

Over and above the acquisition of innovation capabilities via the operations of TNCs, there is also acquisition via the operations of other actors. Trade – most, though not all of which, originates with TNCs – contributes to the acquisition of innovation capabilities by exposing domestic businesses to the needs of foreign clients or to their new products and processes. The international movements of highly skilled labour (Salt 1991 and 1997; OECD, 2002) – some internally to TNCs – are a key mechanism in knowledge and innovation transfer. Moreover, cross-border collaborations between companies, academic institutions and individual researchers contribute to innovation capabilities, so do international academic exchanges and trainings.

The combination of all these elements together facilitates the capture of the possible interaction between internationalization and innovation not only at the level of TNCs but also at the level of countries.

Most of the above discussion assumes that internationalization affects positively innovation. However, the causal link could go the other way round: firms and countries that are innovative are more likely to be able to conquer international markets and/or take up investment opportunities in foreign locations. The literature on the causal links between innovation and internationalization goes back many decades. Posner (1961) and Hufbauer (1966) linked trade performance to the technology gap between countries. Vernon (1966) extended the linkage to the impact of innovation on international production. The latest linkages are supported by more recent literature working within different theoretical frameworks (Cantwell 1989 and 1994; Cantwell and Sanna Randaccio 1993).

In reality there is likely to be an interactive process in which innovation and internationalization affect each other leading to cumulative effects.[1] A virtuous (or vicious) circle is likely to set in. Innovative firms are more successful in international business. This puts them into contact with alternative business cultures, innovation and technologies thus adding to their overall business knowledge. This in turn makes them more innovative and thus more able to compete internationally. Less innovative firms and countries may become locked into an opposite vicious circle.

[1] The problems of capturing the interactive process between innovation and internationalization elements (with respect specifically to R&D and exports) has been studied in Hughes (1986) and in Kleinknecht and Oostendorp (2002).

Our research is about association not causality and correlation coefficients in themselves do not give us guidance as to the possible direction of causality. We therefore keep an open mind as to the direction of causality between innovation and internationalization. However, the reader should bear in mind that, whatever the main direction of causation, a virtuous or vicious circle in innovation and internationalization is likely to be at work for innovative and non-innovative countries respectively.

3. The framework

There are several dimensions to the international context. We shall concentrate on the following: the level of aggregation, the modality of internationalization, and the intensity of innovation within the modality.

With respect to the level of aggregation we test variables at the macro/country level. Some of the raw data is available at the micro level (firms/enterprises), in particular data from two major European surveys: the Innobarometer and the Community Innovation Survey. We use this data at the aggregate level of the country as a whole.

The modalities of internationalization considered are inward and outward foreign direct investment (FDI), trade (both imports and exports), cross-border influx of skilled personnel and of students. The inclusion of both in- and outflows for FDI and trade respond to the assumption that firms learn from their contacts with other business units in foreign countries in any type of business contacts, be they as buyer or seller, recipient or initiator of cross-border investment and trade.

We want also to test whether the association between internationalization and innovation holds for two different levels of internationalization for the full aggregate level and for the level of technology intensive industries. In other words, does it matter – for the association between internationalization and innovation – that a country may be relatively low on the overall aggregate internationalization rank if it comes high on the internationalization ranking for innovation-intensive industries and vice versa? Should therefore countries that are keen to affect positively their innovation performance concentrate on the internationalization of their high technology industry or should their aim be to support their internationalization context in general?

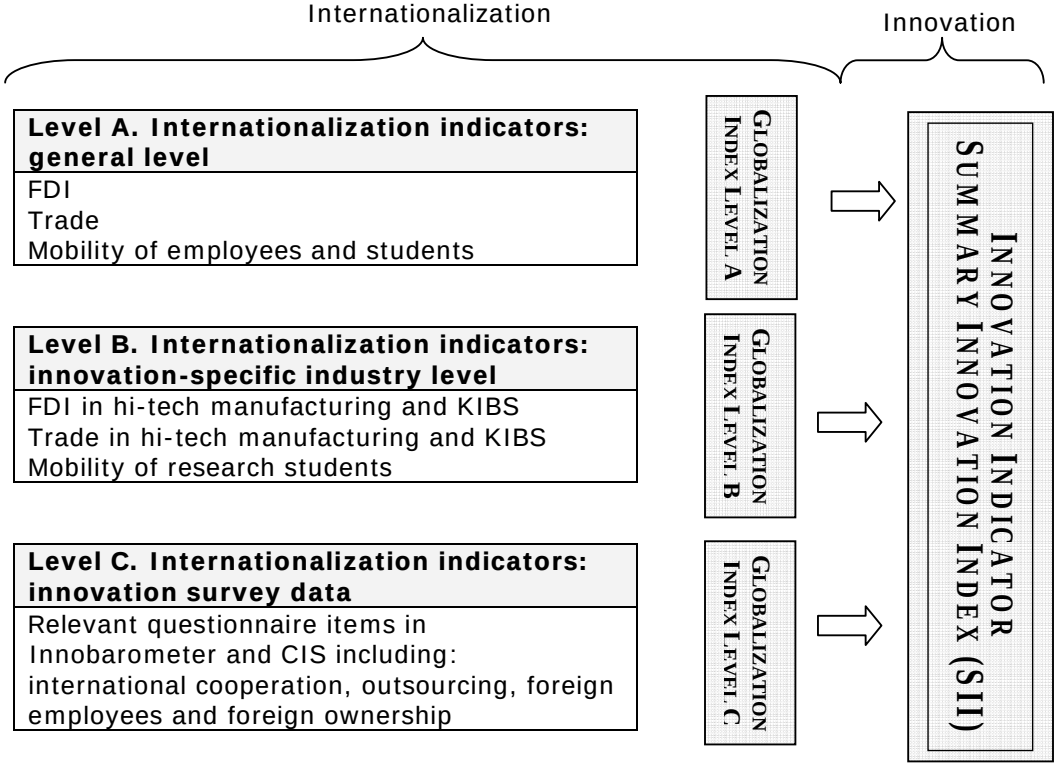
The internationalization framework we shall be working with is one which stresses the overall level of activities abroad or from abroad. Other dimensions of internationalization – such as the spatial dimension – will not be taken into account. For example the proximity of countries or the number of countries with which any one country has economic relationship. In other words we shall concentrate on what has been labelled as the 'intensity' dimension of internationalization rather than its 'extensity/spatial' dimension though the latter may be very important for the relationship internationalization-innovation (Ietto-Gillies 2010).

The plan for the research is therefore to assess the innovation performance of countries – as measured by the SII – against three sets of variables capturing the degree of internationalization. The latter is here interpreted to mean the degree to which the country is open to operations with all foreign countries considered together, independently of distance – spatial and/or cultural – or number.

The first set of country level variables is derived from general indicators of internationalization (e.g. FDI flows irrespectively of the industry); the second set

relates to indicators based on data derived from innovation-specific industries and resources; the third set refers to country level indicators based on firm level variables derived from the Innobarometer Survey and the Community Innovation Survey (CIS). The following box details the indicators in our three sets.

Box 1 Overview of the different level of internationalization indicators and innovation indicator



4. Data

In this section we discuss the data chosen for the innovation indicators and then those collected for the internationalization indicators. The methodology is discussed in the next section.

The countries considered in our analysis are those for which a specific set of data on innovation already exists: the European Innovation Scoreboard Summary Index (SII). Specifically, they are the EU27 countries plus Croatia, Turkey, Iceland, Norway and Switzerland. With respect to the time frame innovation scores relate to the years 2004 to 2008, while internationalization is measured from 1999 to 2007, with the exception of level C which is based on one cross-section of the relevant surveys. The Innobarometer data refers to the period 2006-08 and the CIS4 data to the period 2002-2004.

4.1 Innovation data

The European Innovation Scoreboard Summary Index (SII) is compiled and published by European Commission – DG Enterprise and Industry on an annual basis and since 2001. Changes in the methodology applied to different waves of the EIS mean that comparable data on SII is available from 2004 onwards (European Commission, 2009). The SII is an aggregate index and is based on 29 individual variables (see Appendix I). It captures innovation performances of countries, such as the share of innovators in a country or the average turnover from innovations, but the EIS also covers wider framework conditions, such as finance and support for innovation, human resources and ICT infrastructures.

The 29 variables feeding into the European Innovation Scoreboard's SII are grouped – in the Innovation Scoreboard – into seven sub-categories human resources, finance and support, firm investment, linkages and entrepreneurship, throughputs, innovators and economic effects.

In this paper we test for associations of measures of internationalization and the SII; additionally, we test for associations with those variables out of the 29 variables feeding into SII which are direct inputs into innovation activities or direct outputs. Out of the 29 variables we selected those that are clear inputs or outputs as follows. Input variables: business R&D expenditures as a percentage of GDP, IT expenditures as a percentage of GDP, and (non-R&D) innovation related expenditures by firms as a percentage of GDP. Output variables: average new-to-market sales as a percentage of total sales, new-to-firm sales as a percentage of total sales, share of firms using patents, trademarks or registered designs. A detailed description of the methodology and variables feeding into the SII are available through the European Innovation Scoreboard (European Commission 2009).

4.2 Internationalization data

To assess the extent to which the internationalization of countries and their innovation performance are associated we first identify three levels at which we wanted to consider internationalization: level A, B and C as discussed in section 1. For each level several variables are considered as in Box 2. Specifically, level A includes the following variables: inward and outward FDI, imports and exports, mobility of employees and of students. Level B includes inward and outward FDI for innovation-intensive manufacturing sectors and for knowledge-intensive services, imports and exports of innovation-intensive products, balance of

payments debits and credits for knowledge-intensive services, and mobility of research students.[2]

Under level C of the analysis we include those questionnaire items in the Innobarometer and CIS surveys that have a bearing on the international embeddedness or focus of responding companies. Specifically, the following variables are taken from Innobarometer (CI): proportion of companies that operated in international markets, outsourced activities to companies located abroad, invested into companies located abroad, cooperated with partners which were located abroad, recruited employees from other countries, carried out market-testing in foreign countries, considered international markets to be the lead markets. The following are derived from the Community Innovation Survey (CII): proportion of enterprises that operated in international markets, proportion of foreign-owned enterprises and the proportion of enterprises reporting cooperation with partners abroad.

Box 2 Levels A to C internationalization indicators and data sources

Variables for levels A, B, C	Data source
A. Internationalization indicators: general level	
A.1 FDI	
Inward FDI flows for all industries as % of GDP	United Nations Conference on Trade and Development Database
Outward FDI for all industries as % of GDP	
A.2 Trade flows	
Imports as % of GDP	World Development Indicator produced by the World Bank
Exports as % of GDP	
A.3 Mobility of employees and students	
Foreign students in tertiary education as % total students in tertiary education	Education Statistics produced by the Organisation of Economic Cooperation and Development
Foreign employees as % of total employees	EU Labour Force Survey collected by Eurostat
Summary Globalisation Index at level A (SGI/A)	
B. Internationalization indicators: innovation-specific industry level	
B.1 FDI	
Inward FDI in high-tech manufacturing as % GDP	OECD (International Direct Investment Statistics)
Outward FDI in high-tech manufacturing as % GDP	
Inward FDI in knowledge intensive services as % GDP	OECD (Globalisation Statistics)
Outward FDI in KIBS as % total FDI	
B.2 Trade	
Imports of high-tech products as % of GDP	Eurostat (Science and Technology)
Exports of high-tech products as % of GPD	
Debits in knowledge intensive services as % of GDP	IMF Balance of Payments
Credits in knowledge intensive services as % of GDP	
B.3 Mobility of research students	
Foreign research students as % total research students	OECD (Education Statistics)
Summary Globalisation Index at level B (SGI/B)	

[2] Details of industries and products included in the variables for level B are in Appendix II.

C. Internationalization indicators: innovation survey data	
C.1 Enterprises operating in international markets as % of all companies	European Commission (Innobarometer)
C.2 Enterprises that outsource to companies located abroad as % of all companies	
C.3 Enterprises investing abroad as % of all companies	
C.4 Enterprises that engaging in international cooperation as % of all companies	
C.5 Enterprises that recruit employees from abroad as % of all companies	
C.6 Enterprises that engage in market-testing abroad as % of all companies	
C.7 Enterprises that consider lead markets to be abroad as % of all companies	
Summary Globalisation Index at level CI (SGI/CI)	
C.8 Enterprises that are foreign-owned as a % of all enterprises	Community Innovation Survey
C.9 Enterprises that operate in international markets as % of all enterprises	
C.10 Enterprises that cooperated with international partners as a % of all enterprises	
Summary Globalisation at Index level CII (SGI/CII)	

For levels A and B of the analysis, different data sources are used, including the United Nations Conference on Trade and Development for FDI data, the World Development Indicators produced by the World Bank for data on trade, the EU Labour Force Survey for the number of total and foreign employees and the Education Statistics from the Organisation of Economic Cooperation and Development for students and GDP. We collected the raw data from these different sources for the years 1999 up to 2007 – the latest available year.

For level C of the analysis the indicators are based on the latest available surveys of Innobarometer (European Commission 2009) and CIS4. Thus, with respect to level C, the data refers to one year only. This is because the relevant questions of the Innobarometer survey are only available for the latest – 2009 – survey.

5. Methodology

In this section we first discuss how the indicators and summary indices for levels A and B data are derived. This is followed by the discussion on level C.

When computing the individual indicators for levels A and B, we smooth the data by using five year moving averages. We cumulate both the nominators and denominators of the internationalization indicators over five years. For example, we sum the values for FDI inflows for 1999 up to 2003 and express the total over the five years as a percentage of GDP cumulated over the same period. Thus, between 1999 and 2007, there are five consecutive indicators, the first referring to the period 1999 to 2003 (our first time period T1) and the last to the period 2003 to 2007 (T5). This smoothing is done for two reasons. Firstly, because flow data – such as the data on FDI – is subject to some degree of volatility and this is flattened through the use of moving averages. Secondly, to capture in the indicators a cumulative process of learning by which a country's innovation performance is not only affected by the level of international embeddedness in the same or previous years, but depends on the cumulative impact of international linkages and learning over a period of time.

The six variables in A1 to A3 (Box 2 Section A) are expressed in relative terms, i.e. as a percentage of GDP, total number of employees or total number of students. The variables differ considerably in terms of their average values; for example trade expressed as a proportion of GDP typically takes values in the region of 0.5, while FDI expressed as a proportion of GDP takes values of around 0.05. Moreover, the variables differ across countries according to the size of the country and the structure of its economy. We normalized the variables and turn them into indicators that range from 0 to 1, partly to offset the problems of scale just mentioned but also to provide a reliable comparison between our indices and the SII we use to capture innovation. The latter uses the same method to compute indicators of SII. The normalisation was done as follows:

$$G_{it} = \frac{G_{it} \quad \min G_t}{\max G_t \quad \min G_t} \qquad (1)$$

with i denoting the 32 countries and t the five time periods.

When computing the indicator, the raw data (variables) are inspected and adjusted for outliers using the inter-quartile range (IQR). IQR is equal to the distance between the first and third quartiles (or between the 75^{th} and 25^{th} percentiles): IQR=Q3-Q1, where this distance spans the middle 50% of the data. Outliers are identified as follows: negative outliers are values < Q1 –3×IQR, while positive outliers > Q3 + 3×IQR. Outliers are not included in determining the maximum and minimum scores in the normalisation process. For outliers where the value of the relative score is above the maximum score or below the minimum score the re-scaled score is set to 1 and 0 respectively.

From the six indicators (related to the six variables included in A1-A3), we compute a summary index SGI/A as average of the six indicators. For some countries not all of the six variables – and thus indicators – are available. In such cases the average is calculated over the available indicators. A similar procedure is followed for level B for which we start from nine variables (see Box 2 section 4).

The SGI/A and SGI/B and their underlying indicators of internationalization are linked with a time lag of one year to the SII; the SGI/A and B based on 1999 to

2003 data are associated with the SII for the year 2004, the SGIs based on 2000 to 2004 data to SII for 2005 and so forth up to SII for 2008. The rationale for the lag is that international embeddedness in the earlier time period feeds into the innovation performance of a country in the later period. In the case of level C the SGI/C is available for the reference period of the surveys (2006 onwards in the case of the Innobarometer and 2002-2004 in the case of CIS) and the indicators are correlated with the latest SII (2008).

Turning now to level C of the analysis, the Innobarometer survey used in this paper was conducted by the European Commission in April 2009. This is the first wave of the Innobarometer survey which contained a range of questions specifically aimed at measuring internationalization. Questionnaires were completed by enterprises in 29 European countries, with a total of 5,234 observations, with each of the 29 countries achieving a sample size of 200 with the exceptions of Norway and Switzerland for which there are 100 observations, and Cyprus, Luxembourg and Malta for which there are 70 observations. The survey contains seven questionnaire items which relate to aspects of international embeddedness of firms' activities since 2006 as listed in Box 2 under CI. All items provide binary data indicating whether or not the company engaged in the relevant international activities.

For the purpose of this paper we first compute the proportion of companies which, for example, operated in international markets (compared with all companies that responded to the Innobarometer). We then follow the same data transformation to derive at seven indicators ranging from 0 to 1 (see Equation 1 above). Finally, we derive a level CI globalisation index which is the simple average of the seven indicators. The reference period for the Innobarometer indicators is 2006 to 2008, and EIS is based on 2006 and 2007 data.

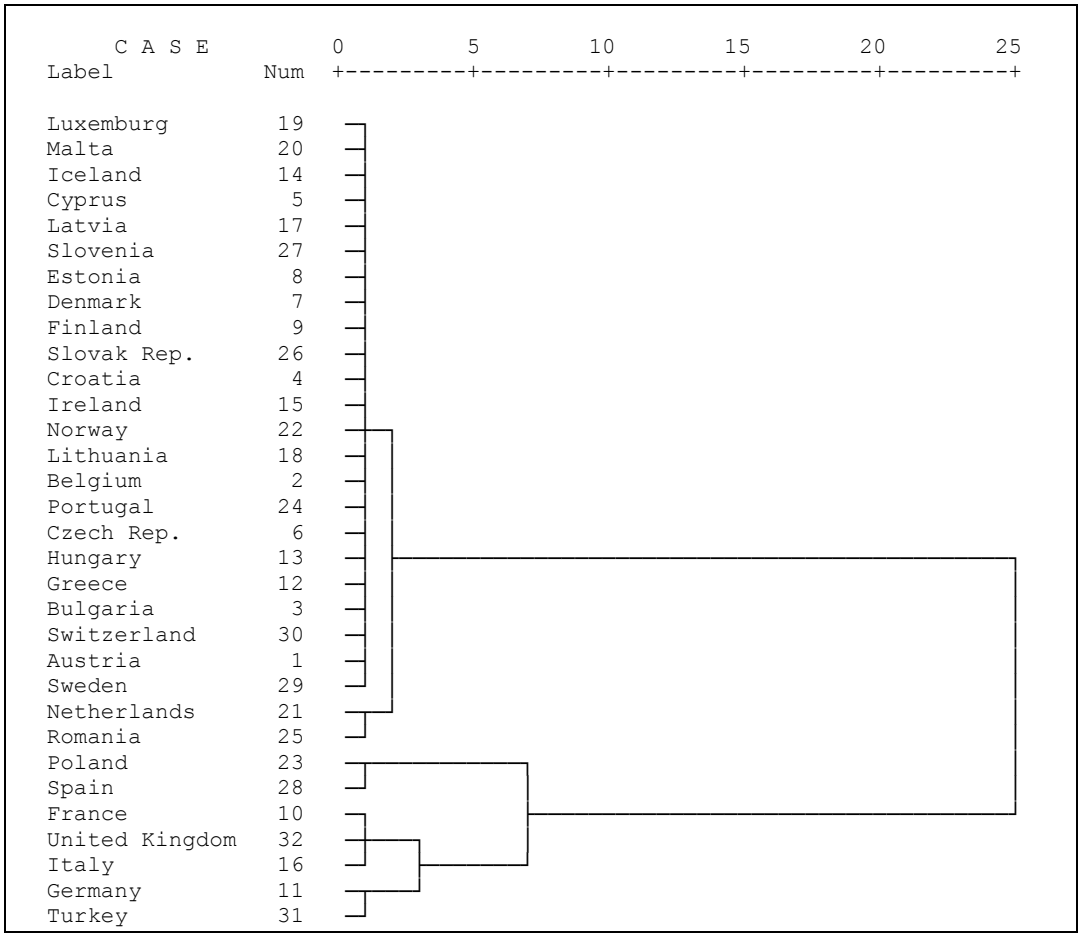
Additionally to the Innobarometer indicators, we use the fourth European CIS, conducted by the individual member states and compiled by Eurostat for 27 countries (while Switzerland and the UK conduct CISs, they do not deposit the data in the Eurostat database). As for the Innobarometer, the unit of analysis is the enterprise, which is the smallest independent reporting unit which may be part of a much larger company group, and is often located in a single site, but can comprise more than one site. The reference period is 2002-2004. While one of the variables used – enterprise operates in international markets – is also captured by the Innobarometer survey (with respect to the company rather than the enterprise), the other variable – foreign-ownership, is not. Moreover, the number of observations that the EU CIS are based on a much larger – just under 70,000 – compared with the Innobarometer survey, so the results for international markets act as a robustness check for the Innobarometer results.

At each level of analysis the correlation coefficients between SII, SII-inputs and SII-output variables, and the internationalization indicators are calculated for the following: (i) the single indicators that compose each sets at the three levels (A, B and C); (ii) single sub-periods; (iii) the pooled data for all the periods; and (iv) the aggregate Summary Globalization Index (SGI) for each specific level. The correlation coefficients are partial correlations controlling for the population size of countries. These partial correlations do not differ substantially from the zero-order correlations – which we computed but do not present – in terms of their size and significance.

In order to further account for heterogeneity across countries – over and above the control for population size in the correlations and normalization process of the indicators – the countries are grouped into small and large countries – and the

level A correlations are computed for both small and large countries separately.[3] The grouping is informed by hierarchical cluster analysis based on between group linkages. The variables feeding into the cluster analysis are GDP and population of the 32 countries. Box 3 is provides the dendrogram of the clustering process.

Box 3 Dendrogram based on a hierarchical clustering of countries



The first cluster contains 27 'small' economies listed as the first countries in Box 3. The results for the 27 countries are juxtaposed against the seven 'larger' economies –Poland, Spain, France, the UK, Italy, Germany and Turkey – listed at the bottom of Box 3.

[3] The two sub-sets of countries are not considered at levels B and C because of fewer observations at these levels and because the analysis at level A did not provide an indication of very different results across the two subsets.

6. Results

Box 4 guides the reader through section 6 by providing information on the relevant sub-sections in which the results in relation to the variables and indices across all levels discussed above can be found.

Box 4 Guide to the results based on correlations across variables and indices at levels A, B and C

<table>
<tr><th>Level A</th><th>Level B</th><th>Level C</th></tr>
<tr><td>Section 6.2
Correlations of 6 variables from A1 to A3 and SGI/A with SII</td><td>Section 6.5
Correlations SGI/B with SII, SII inputs and outputs</td><td rowspan="2">Section 6.7
Correlations of 7 variables from CI and SGI/CI (Innobarometer) and 3 variables from CII and SGI/CII (CIS) with SII, SII inputs and outputs</td></tr>
<tr><td>Section 6.3
Correlations of 6 variables from A1 to A3 and SGI/A with SII inputs and outputs</td><td>Section 6.6
Correlations of 9 variables from B1 to B3 with SII, SII inputs and outputs</td></tr>
<tr><td>Section 6.4
Correlations of 6 variables from A1 to A3 and SGI/A small versus large countries</td><td></td><td></td></tr>
</table>

Note: For details of the variables A1 to A3, B1 to B3 and CI and CII see Box 2.

6.1 Countries' internationalization scores

This section provides the descriptive statistics on the internationalization scores. Tables 1, 2, 3 exhibit the indicators for each of the variables in levels A, B, CI and CII respectively. Indicators are given for each of the variables within the relevant level and for the summary indicators of each level in the last column in bold. The corresponding values for the variables from which the indicators are derived are in Appendix II.

Across the 3 tables the results for the relevant Summary Globalization Indicators (SGI/A, SGI/B, SGI/CI and SGI/CII) show that, on the whole, the small countries are the most internationalized. Moreover, Tables 1 and 2 show Turkey, Greece and Italy to be the least internationalized countries. However, the least internationalized countries according to indicators based on firms'/enterprises' assessment from the two surveys are Germany, Bulgaria and Hungary from Innobarometer; Latvia, Romania and Poland from CIS4. Therefore the sets of level A, B and level C data do not give fully consistent results.

Level A and B data differ from level C data in the sense that A and B refer to the volume of flows across borders. These may originate with a few or many companies/enterprises. Level C does not provide information on the volume of flows, but the number of companies/enterprises that report international activities. This could suggest, for example, in the case of Greece that a comparatively lower volume of FDI to GDP and/or trade to GDP is distributed across a comparatively higher proportion of firms.

With respect to level A and B data, these are computed for 32 countries; at level CI data is available for 29 countries (the 32 countries minus Turkey, Iceland and Croatia) and at level CII for 27 countries (the 29 countries minus Switzerland and the UK).

Table 1 Level A indicators and SGI/A by country

Country	*Inward FDI*	*Outward FDI*	*Imports*	*Exports*	*Foreign students*	*Foreign empl.*	***SGI/A Value***	***Rank***
Austria	0.16	0.28	0.36	0.44	0.75	0.43	**0.40**	**10**
Belgium	0.60	0.73	0.90	0.94	0.58	0.33	**0.68**	**3**
Bulgaria	0.92	0.01	0.71	0.53	.	0.01	**0.43**	**9**
Croatia	0.45	0.08	0.51	0.39	.	.	**0.36**	**13**
Cyprus	0.64	0.36	.	.	.	.	**0.50**	**7**
Czech Rep.	0.53	0.04	0.69	0.69	0.22	0.04	**0.37**	**12**
Denmark	0.30	0.32	0.28	0.39	0.42	0.13	**0.31**	**17**
Estonia	0.76	0.29	0.94	0.82	0.06	0.92	**0.70**	**2**
Finland	0.23	0.29	0.13	0.29	0.12	0.05	**0.19**	**26**
France	0.21	0.47	0.02	0.07	0.33	0.23	**0.22**	**24**
Germany	0.13	0.16	0.14	0.24	0.58	0.38	**0.27**	**21**
Greece	0.01	0.06	0.12	0.00	0.04	0.26	**0.08**	**31**
Hungary	0.37	0.14	0.71	0.68	0.16	0.02	**0.35**	**16**
Iceland	0.53	0.82	0.26	0.19	0.20	0.13	**0.36**	**13**
Ireland	0.44	0.62	0.81	1.00	0.16	0.23	**0.45**	**8**
Italy	0.05	0.14	0.01	0.07	0.08	0.26	**0.09**	**30**
Latvia	0.29	0.05	0.52	0.33	.	0.04	**0.26**	**22**
Lithuania	0.25	0.06	0.58	0.48	.	0.03	**0.28**	**19**
Luxemburg	0.72	0.94	1.00	1.00	0.66	1.00	**0.91**	**1**
Malta	0.81	0.21	1.00	0.93	.	0.13	**0.66**	**5**
Netherlands	0.51	0.95	0.58	0.69	0.21	0.15	**0.52**	**6**
Norway	0.09	0.33	0.06	0.33	0.23	0.16	**0.20**	**25**
Poland	0.25	0.05	0.18	0.18	0.00	0.00	**0.12**	**29**
Portugal	0.23	0.31	0.20	0.11	0.13	0.11	**0.18**	**27**
Romania	0.38	0.00	0.29	0.19	.	0.00	**0.18**	**27**
Slovak Rep.	0.63	0.02	0.89	0.81	0.04	0.00	**0.40**	**10**
Slovenia	0.16	0.13	0.55	0.55	.	0.01	**0.28**	**19**
Spain	0.26	0.50	0.09	0.08	0.12	0.35	**0.23**	**23**
Sweden	0.39	0.62	0.22	0.36	0.40	0.19	**0.36**	**13**
Switzerland	0.24	0.83	0.23	0.33	1.00	0.95	**0.67**	**4**
Turkey	0.05	0.02	0.00	0.02	0.03	.	**0.03**	**32**
UK	0.28	0.48	0.08	0.07	0.74	0.23	**0.31**	**17**

Note 1 The indicators range from 0 (lowest) to 1 (highest) and are computed on the basis of equation 1 on page 12. The values of the variables from which the indicators are calculated are presented in Appendix III.
Note 2 Where there are missing values, i.e. a lower number of indicators, the SGI/A is the average of the indicators for which we have information.
Note 3 In terms of time, the indicators are computed as averages across a five-year period (e.g. 1999-2003, 2000-2004, etc.). The values in this table are the averages of our indicators which refer to different time periods starting with 1999-2003 and ending with 2003-2007.

We have computed correlation coefficients (Table 4) between the four SGI which we use in our analyses to see what relationship there may be between our various measures of internationalization and innovation. The findings confirm the discussion above. They show high correlation between SGI/A and SGI/B; this is not surprising since most variables in level B are a subset of those in level A. There is also a high and significant correlation between SGI/CI and SGI/CII though not between SGI/CI and SGI/A or SGI/B.

The final column in Table 1 provides the ranking of countries based on SGI/A. SGI/A is a summary index combining information on FDI flows, trade and movement of employees and students. It combines inflow and outflow measures, and it is normalized by GDP or a similar denominator. Based on this summary index, small economies tend to score/rank higher on internationalization, in part driven by inflow measures, more so than outflows. There may be limitations to the extent to which groups of countries are comparable with respect to modalities of internationalization. We have taken this point up in the level A results for which we cluster countries based on GDP and population size and then explores the associations between internationalization and innovation separately.

With respect to internationalization in innovation-specific sectors in Table 2 (high-tech products, knowledge intensive services, and research students) the ranking of countries remains largely similar to the overall degree of internationalization (see Tables 1 and 2). Both Finland and France exhibit a higher internationalization in innovation-specific sectors compared with their overall international embeddedness. Table 2 data and thus SGI/B is influenced by missing values because for a number of countries information on FDI within industries was not available. As a result SGI/B, which is the average based on all available information, is comparatively more driven by information on trade, and this is likely to influence our results[4].

[4] We computed the correlations excluding countries for which more than half variables were missing. The results were not much different from the ones in which all the countries are included as presented here.

Table 2 Level B indicators and SGI/B by country

Country	*Inward FDI hi-tech products*	*Outward FDI in hi-tech products*	*Inward FDI in knowledge intensive services*	*Outward FDI in knowledge intensive services*	*Imports of high-tech products*	*Exports of high-tech products*	*Debits in knowledge intensive services*	*Credits in knowledge intensive services*	*Foreign students in research*	***SGI/B***	
										Value	***Rank***
Austria	0.18	0.08	0.17	0.42	0.33	0.26	0.25	0.59	0.42	**0.30**	**13**
Belgium	0.55	0.52	0.92	0.93	0.43	0.30	0.01	0.72	0.80	**0.58**	**4**
Bulgaria	.	.	.	.	0.21	0.04	0.90	0.22	.	**0.34**	**10**
Croatia	.	.	.	.	0.14	0.06	0.27	0.66	.	**0.28**	**14**
Cyprus	.	.	.	.	0.14	.	0.77	0.40	.	**0.44**	**8**
Czech Rep.	0.18	0.10	0.07	0.11	0.62	0.33	0.18	0.39	0.15	**0.24**	**17**
Denmark	0.13	0.13	0.29	0.22	0.19	0.21	.	.	0.46	**0.23**	**19**
Estonia					0.65	0.27	0.26	0.34	0.06	**0.32**	**11**
Finland	0.13		0.04	0.11	0.21	0.33	0.59	0.72	0.14	**0.28**	**14**
France	0.19	0.23	0.25	0.50	0.22	0.22	0.00	0.00	0.84	**0.27**	**16**
Germany	0.15	0.07	0.26	0.11	0.22	0.23	0.00	0.00	.	**0.13**	**27**
Greece	0.13	0.09	0.02	0.11	0.02	0.01	0.05	0.25	0.02	**0.08**	**31**
Hungary	0.24	0.14	0.39	0.43	0.89	0.57	0.50	0.97	0.15	**0.48**	**7**
Iceland	0.30	0.94	0.15	0.64	0.11	0.02	0.26	0.08	0.25	**0.31**	**12**
Ireland	0.92	.	.	0.45	0.92	1.00	1.00	1.00	.	**0.88**	**1**
Italy	0.15	0.17	.	.	0.03	0.06	0.05	0.16	0.04	**0.09**	**30**
Latvia	.	.	.	.	0.16	0.03	0.22	0.28	.	**0.17**	**24**
Lithuania	.	.	.	.	0.20	0.05	0.08	0.15	.	**0.12**	**28**
Luxemburg	.	0.14	0.38	1.00	0.93	0.70	1.00	1.00	.	**0.74**	**3**
Malta	.	.	.	.	1.00	1.00	0.43	0.56	.	**0.75**	**2**
Netherlands	0.26	0.83	0.10	0.29	0.82	0.57	0.66	0.90	.	**0.56**	**5**
Norway	.	.	0.10	0.25	0.03	0.04	0.23	0.38	0.41	**0.21**	**21**
Poland	0.20	0.08	0.05	0.13	0.11	0.02	0.05	0.41	0.05	**0.12**	**28**
Portugal	.	.	.	.	0.13	0.06	0.06	0.31	0.16	**0.14**	**26**
Romania	.	.	.	.	0.17	0.04	0.15	0.27	.	**0.16**	**25**
Slovak Rep.	0.27	0.07	0.03	0.12	0.46	0.13	0.24	0.52	0.00	**0.20**	**22**
Slovenia	.	.	.	.	0.21	0.11	0.22	0.57	0.10	**0.24**	**17**
Spain	0.15		0.09	0.11	0.04	0.04	0.25	0.40	0.36	**0.18**	**23**
Sweden	0.01	0.84	0.02	0.19	0.19	0.23	0.94	0.70	0.41	**0.39**	**9**
Switzerland	.	.	.	.	0.32	0.34	.	.	1.00	**0.55**	**6**
Turkey	0.15	0.07	0.00		0.00	0.00	0.00	0.06	0.03	**0.04**	**32**
UK	0.20	0.32	0.04	0.14	0.21	0.21	0.00	0.00	0.84	**0.22**	**20**

See notes under Table 1.

Table 3 Level C indicators, SGI/CI and SGI/CII by country

	Innobarometer data							*CIS4 data*			***SGI/CI***		***SGI/CII***	
Country	*Int. markets*	*Out-sourcing*	*Invest in firms abroad*	*Int. co-operation*	*Foreign empl.*	*Market-testing abroad*	*Int. lead markets*	*Foreign-owned*	*Int. markets*	*Int. co-operation*		***Value*** ***Rank***		***Value*** ***Rank***
Austria	0.53	0.25	0.70	0.39	0.51	0.64	0.78	.	.	0.11	**0.54**	**8**	**0.11**	**24**
Belgium	0.43	0.71	1.00	0.67	0.50	0.89	0.21	0.64	0.75	0.29	**0.63**	**3**	**0.56**	**6**
Bulgaria	0.38	0.13	0.08	0.15	0.11	0.00	0.42	0.09	0.31	0.05	**0.18**	**28**	**0.15**	**23**
Cyprus	0.00	0.28	0.20	0.16	0.85	0.26	0.59	0.13	0.54	0.16	**0.34**	**21**	**0.28**	**18**
Czech Rep.	0.63	0.38	0.74	0.30	0.44	0.52	0.26	0.35	0.14	0.19	**0.47**	**13**	**0.22**	**20**
Denmark	0.61	0.49	0.57	0.69	0.39	0.60	0.51	0.60	1.00	0.31	**0.55**	**7**	**0.64**	**3**
Estonia	0.51	0.38	0.19	0.95	0.13	0.59	1.00	0.34	0.81	0.27	**0.53**	**10**	**0.47**	**8**
Finland	0.43	0.46	0.33	0.86	0.32	0.40	0.46	0.33	.	.	**0.47**	**13**	**0.33**	**14**
France	0.44	0.42	0.24	0.28	0.25	0.26	0.57	0.27	0.69	0.03	**0.35**	**20**	**0.33**	**15**
Germany	0.11	0.00	0.13	0.00	0.15	0.11	0.00	0.16	0.63	0.08	**0.07**	**29**	**0.29**	**16**
Greece	0.55	0.43	0.40	0.46	0.33	0.59	0.94	0.09	0.68	1.00	**0.53**	**10**	**0.59**	**4**
Hungary	0.28	0.05	0.08	0.31	0.03	0.13	0.59	0.27	0.49	0.08	**0.21**	**27**	**0.28**	**17**
Ireland	0.30	0.44	0.23	0.37	1.00	0.39	0.38	.	.	0.19	**0.44**	**16**	**0.19**	**22**
Italy	0.47	0.19	0.48	0.16	0.15	0.32	0.84	0.09	0.63	0.00	**0.37**	**19**	**0.24**	**19**
Latvia	0.37	0.55	0.00	0.26	0.00	0.24	0.21	0.00	0.00	0.08	**0.23**	**26**	**0.03**	**27**
Lithuania	0.41	1.00	0.51	0.98	0.18	0.54	0.82	0.21	0.65	0.46	**0.63**	**3**	**0.44**	**9**
Luxemburg	1.00	0.56	0.82	0.52	0.81	0.44	0.47	0.98	0.91	0.84	**0.66**	**1**	**0.91**	**2**
Malta	0.27	0.27	0.19	0.11	0.63	0.19	0.18	0.21	0.11	0.84	**0.26**	**23**	**0.38**	**10**
Netherlands	0.59	0.51	0.83	0.70	0.53	0.69	0.46	0.37	0.67	0.00	**0.61**	**6**	**0.35**	**12**
Norway	0.40	0.53	0.94	0.58	0.76	0.53	0.05	0.37	0.54	0.51	**0.54**	**8**	**0.47**	**7**
Poland	0.49	0.20	0.09	0.46	0.13	0.25	0.15	.	.	0.03	**0.25**	**24**	**0.03**	**26**
Portugal	0.41	0.42	0.59	0.32	0.33	0.61	0.50	0.16	0.72	0.20	**0.45**	**15**	**0.36**	**11**
Romania	0.40	0.18	0.07	0.35	0.05	0.40	0.32	0.09	0.11	0.08	**0.25**	**24**	**0.09**	**25**
Slovak Rep	0.42	0.52	0.47	0.46	0.18	0.58	0.30	0.37	0.29	.	**0.42**	**17**	**0.33**	**13**
Slovenia	0.86	0.35	0.55	0.62	0.61	1.00	0.57	.	.	0.93	**0.65**	**2**	**0.93**	**1**
Spain	0.21	0.40	0.49	0.15	0.53	0.45	0.42	0.13	0.51	0.03	**0.38**	**18**	**0.22**	**21**
Sweden	0.33	0.43	0.79	1.00	0.61	0.65	0.60	1.00	0.66	0.05	**0.63**	**3**	**0.57**	**5**
Switzerland	0.43	0.23	0.57	0.40	0.92	0.50	0.37	.	.	.	**0.49**	**12**	**.**	**.**
UK	0.21	0.28	0.27	0.32	0.52	0.24	0.47	.	.	.	**0.33**	**22**	**.**	**.**

Indicators are derived from Innobarometer and CIS4 data, and represent proportions of firms with a specific activity, e.g. operating in international markets, in each of the countries.

Table 4 Correlations between the four internationalization indicators

		SGI/A	*SGI/B*	*SGI/CI*	*SGI/CII*
SGI/A	Correlation	1			
	p-value	.			
	N	32			
SGI/B	Correlation	0.80***	1		
	p-value	0.00	.		
	N	32	32		
SGI/CI	Correlation	0.29	0.19	1	
	p-value	0.12	0.32	.	
	N	29	29	29	
SGI/CII	Correlation	0.34	0.2	0.69***	1
	p-value	0.07	0.3	0.00	.
	N	28	28	27	28

Significance level: * p<0.10; ** p<0.05; *** p<0.01

6.2 Level A correlations between internationalization and innovation (SII)

Table 5 provides the correlation coefficients between the six internationalization indicators of level A, SGI/A and the Summary Innovation Index (SII) across the five different time periods, as well as for the pooled dataset.

The associations between SII and SGI/A across the five periods range between 0.31 and 0.41, with the pooled data suggesting a correlation of 0.35. All these coefficients between SGI/A and SII are significant as are the coefficients between SII and the following individual indicators: outward FDI, foreign students and foreign employees.

The overall results for level A suggest a positive association between a country's innovation score and its openness to foreign tertiary education students as well as to qualified foreign personnel. The strong association between SII and outward FDI points to two possible explanations: (i) the innovative firms and countries are the ones that compete successfully in taking up investment opportunities abroad; or (ii) the linkages with foreign investment and foreign subsidiaries allow the firms to learn from other business cultures and this affects positively the innovation score of their home country. The causality linkage could go in either direction..

The strong results for foreign students and foreign employees point to the following. Skilled foreign human resources bring knowledge into the host country with positive effects on innovation. Conversely, innovative countries attract skilled foreign human resources. We shall comment on the results for inward FDI and imports and exports later after the level B results are presented.

Table 5 Level A results – correlations between six internationalization indicators, SGI/A and SII

Innovation index		*SII 2004*	*SII 2005*	*SII 2006*	*SII 2007*	*SII 2008*	***SII pooled***
Internationalization indicators and index		1999-2003	2000-2004	2001-2005	2002-2006	2003-2007	**1999-2007**
SGI/A	Correlation	0.41**	0.37**	0.31*	0.31*	0.35**	**0.35*** **
	p-value	0.02	0.04	0.09	0.09	0.05	**0.00**
	N	32	32	32	32	32	**160**
Inward FDI flows	Correlation	0.21	0.02	-0.16	-0.21	-0.25	**-0.10**
	p-value	0.27	0.90	0.39	0.25	0.18	**0.22**
	N	32	32	32	32	32	**160**
Outward FDI flows	Correlation	0.77***	0.70***	0.57***	0.57***	0.64***	**0.64*** **
	p-value	0.00	0.00	0.00	0.00	0.00	**0.00**
	N	32	32	32	32	32	**160**
Imports	Correlation	-0.09	-0.12	-0.13	-0.17	-0.15	**-0.13**
	p-value	0.65	0.54	0.50	0.39	0.45	**0.13**
	N	31	31	31	29	29	**151**
Exports	Correlation	0.14	0.12	0.12	0.06	0.08	**0.11**
	p-value	0.46	0.51	0.52	0.76	0.70	**0.17**
	N	31	31	31	29	29	**151**
Foreign students	Correlation	0.74***	0.75***	0.75***	0.71***	0.67***	**0.72*** **
	p-value	0.00	0.00	0.00	0.00	0.00	**0.00**
	N	23	23	22	22	24	**115**
Foreign employees	Correlation	0.41**	0.48***	0.51***	0.50***	0.52***	**0.49*** **
	p-value	0.05	0.01	0.01	0.01	0.01	**0.00**
	N	24	27	29	28	28	**136**

All correlations control for the natural log of the population size of each country. These partial correlations do not differ significantly from the zero-order correlations.
Significance level: * p<0.10; ** p<0.05; *** p<0.01

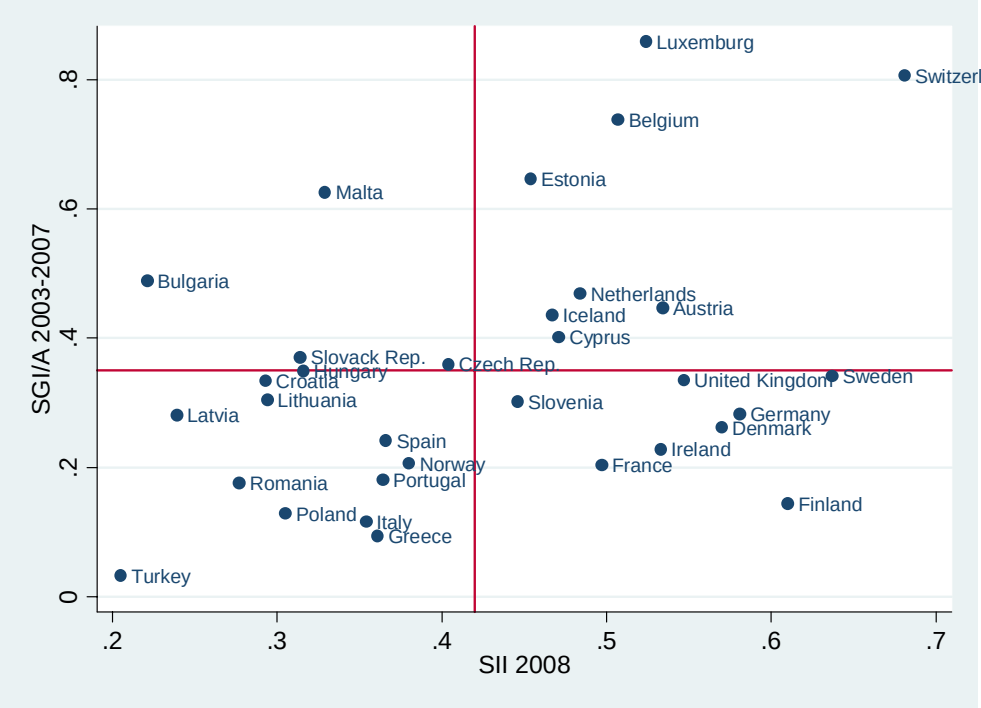
We also computed the correlations between SGI/A and SII without the time lag and the smoothing of data, thus correlating SII2004 with SGI/A based on 2004 data and so on. Fewer data pairs are available for these correlations, specifically with respect to the internationalization variables, because the years for which we have internationalization and innovation data are 2004, 2005, 2006 and 2007. The results of the correlations based on 2004 to 2007 data with no time lag are highly similar with the coefficient. For example, the pooled correlation coefficient is r=0.33 (p<0.01) compared with r=0.35 from the table above.[5]

The results in Table 5 are visually confirmed by the scatter plots of countries' innovation and internationalization scores presented in Graphs 1, 2, 3 and 4 respectively for SG1/A, and the significant indicators which are outward FDI, foreign students and foreign employees.

In Graphs 2, 3, and 4 we see small changes compared to Graph 1. Specifically UK and Germany move up to quadrant I from quadrant IV on the three main indicators (outward FDI, foreign students and foreign employees).

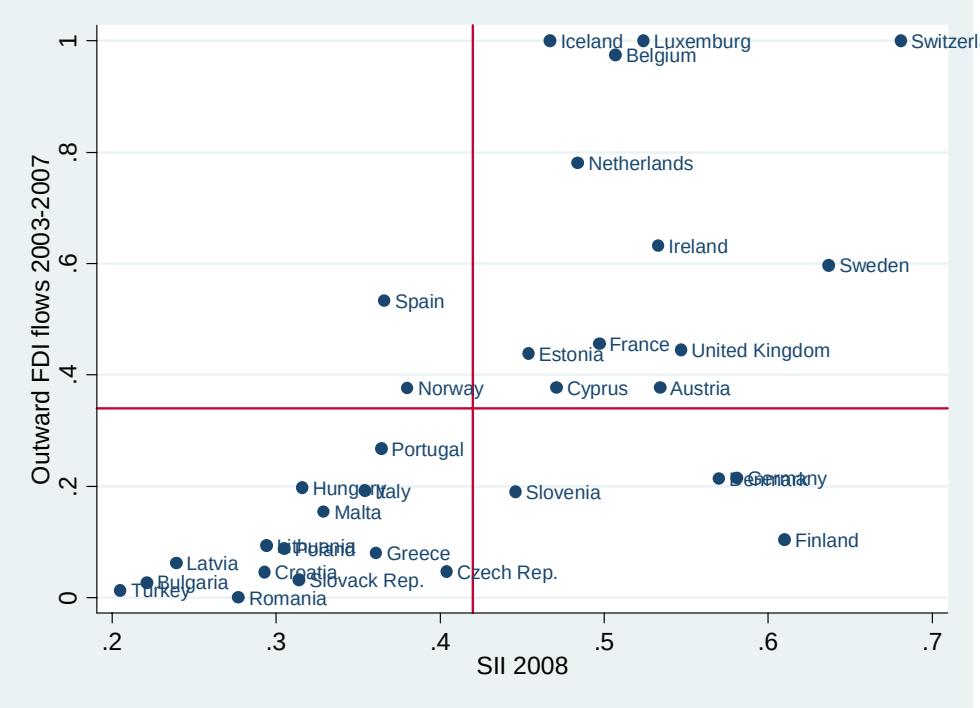
[5] Further details of the results are not reported here.

Graph 1 Scatterplot between SGI/A and SII 2008, Level A, 32 countries



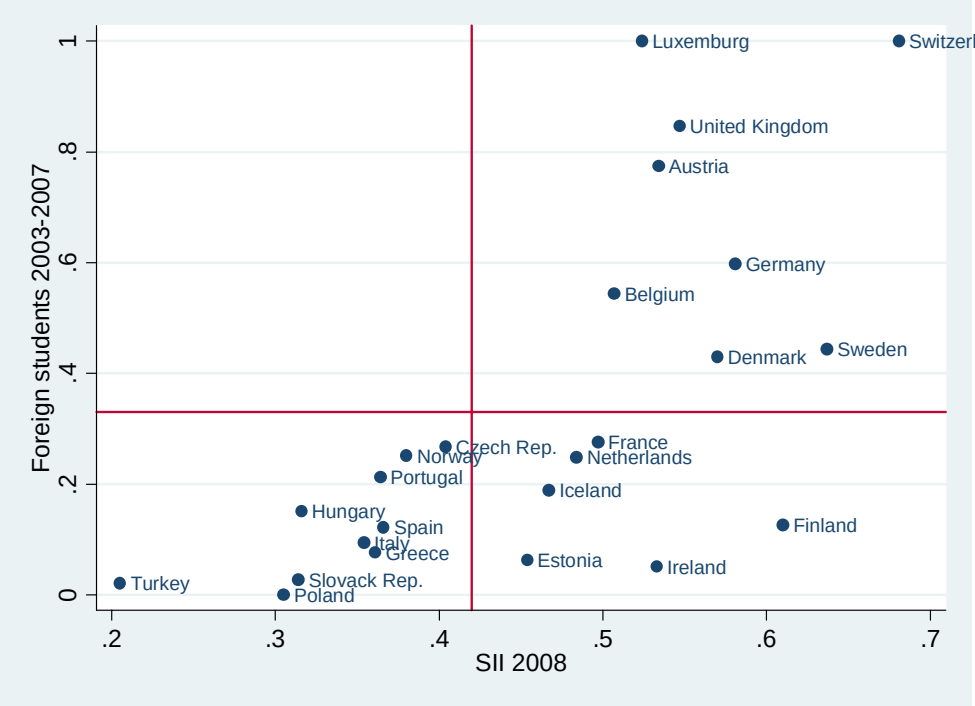
Notes: the pairs of scores are based on the latest available SII and SGI/A. Axes cross at average values.

Graph 2 Scatterplot between outward FDI and SII 2008, Level A, 32 countries



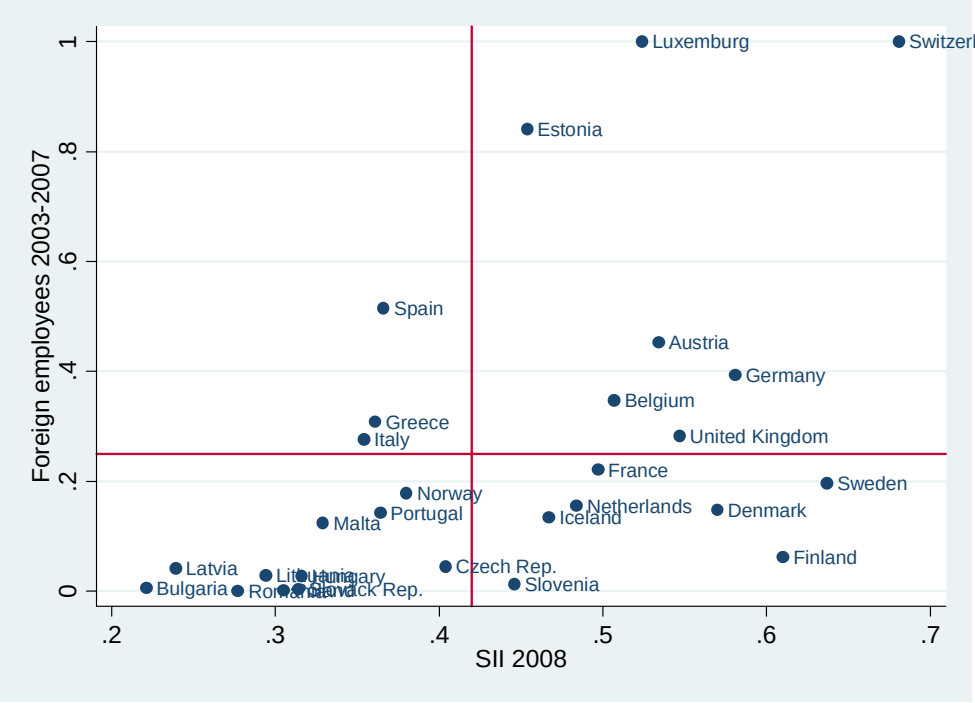
Notes: as per Graph 1.

Graph 3 Scatterplot between the share of foreign students 2003-2007 and SII 2008, Level A, 32 countries



Notes: as per Graph 1.

Graph 4 Scatterplot between the share of foreign employees 2003-2007 and SII 2008, Level A, 32 countries



Notes: as per Graph 1.

As discussed in section 5 the SII is calculated using 29 variables some related to inputs some to outputs some to infrastructure as indicated in Appendix I. This aggregate measure (SII) is the one we use in Table 5 and in most of our calculations.

6.3 Level A correlations between internationalization and innovation inputs and outputs

We wanted to test also the association with a more homogeneous subsets of the variables included in the SII. In Tables 6 and 7 we present correlation coefficients with these two subsets of the SII: subset SII-input relates to innovation inputs only and subset SII-ouput relates to innovation outputs only. We selected the variable representing inputs and outputs from the list in Appendix I. The innovation inputs variables are business R&D expenditures, IT expenditures, and (non-R&D) innovation related expenditures by firms. Output variables are average new-to-market sales, new-to-firm sales, share of firms using patents, trademarks or registered designs.

Table 6 Level A results – correlations between six internationalization indicators, SGI/A and SII-input variables

Innovation index		*SII-input 2004*	*SII-input 2005*	*SII-input 2006*	*SII-input 2007*	*SII-input 2008*	***SII-input pooled***
Internationalization indicators and index		1999-2003	2000-2004	2001-2005	2002-2006	2003-2007	**1999-2007**
SGI/A	Correlation	0.58***	0.48**	0.45**	0.53***	0.56***	**0.52*** **
	p-value	0.01	0.03	0.04	0.01	0.01	**0.00**
	N	32	32	32	32	32	**160**
Inward FDI flows	Correlation	0.39*	0.06	0.03	0.06	0.09	**0.11**
	p-value	0.08	0.80	0.91	0.81	0.69	**0.25**
	N	32	32	32	32	32	**160**
Outward FDI flows	Correlation	0.51**	0.45**	0.40*	0.38*	0.42*	**0.43*** **
	p-value	0.02	0.04	0.07	0.09	0.06	**0.00**
	N	32	32	32	32	32	**160**
Imports	Correlation	0.03	0.04	0.05	0.19	0.23	**0.11**
	p-value	0.88	0.86	0.83	0.43	0.34	**0.28**
	N	31	31	31	29	29	**151**
Exports	Correlation	0.19	0.20	0.22	0.37	0.40*	**0.27*** **
	p-value	0.42	0.39	0.35	0.12	0.09	**0.01**
	N	31	31	31	29	29	**151**
Foreign students	Correlation	0.76***	0.79***	0.80***	0.68***	0.66***	**0.73*** **
	p-value	0.00	0.00	0.00	0.00	0.00	**0.00**
	N	23	23	22	22	24	**115**
Foreign employees	Correlation	0.53**	0.54***	0.53***	0.49**	0.44*	**0.50*** **
	p-value	0.02	0.01	0.01	0.03	0.06	**0.00**
	N	24	27	29	28	28	**136**

SII Inputs are business R&D expenditure, IT expenditures and other (non-R&D) innovation related expenditures. All correlations control for the natural log of the population size of each country. These partial correlations do not differ significantly from the zero-order correlations.
Significance level: * p<0.10; ** p<0.05; *** p<0.01

The results in Table 6 show higher correlation coefficients between SII-input and SGI/A (between 0.48 and 0.58) compared with what we had obtained for the correlation between SII and SGI/A (Table 5). Moreover, in Table 5 the indicator related to exports considering all countries is not significant, but is now positively and significantly associated with SII-inputs suggesting that all those countries

whose firms export more also spend more on innovation related activities and are thus able to compete in international markets and locations.

Additional graphs for all the significant correlations for levels B, CI and CII are in Appendix IV. Table 7 reports the results of correlations with SII-outputs.

Table 7 Level A results. Correlations between six internationalization indicators, SGI/A and SII-output variables

Innovation index		*SII-output 2004*	*SII-output 2005*	*SII-output 2006*	*SII-output 2007*	*SII-output 2008*	***SII-output pooled***
Internationalization indicators and index		1999-2003	2000-2004	2001-2005	2002-2006	2003-2007	**1999-2007**
SGI/A	Correlation	0.37**	0.37**	0.34*	0.38**	0.43**	**0.37*** **
	p-value	0.04	0.04	0.06	0.04	0.02	**0.00**
	N	32	32	32	32	32	**160**
Inward FDI flows	Correlation	0.15	0.04	-0.03	-0.07	-0.20	**-0.05**
	p-value	0.44	0.83	0.88	0.72	0.29	**0.56**
	N	32	32	32	32	32	**160**
Outward FDI flows	Correlation	0.70***	0.65***	0.54***	0.53***	0.62***	**0.60*** **
	p-value	0.00	0.00	0.00	0.00	0.00	**0.00**
	N	32	32	32	32	32	**160**
Imports	Correlation	-0.03	-0.07	-0.07	-0.10	-0.07	**-0.06**
	p-value	0.88	0.71	0.71	0.62	0.71	**0.43**
	N	31	31	31	29	29	**151**
Exports	Correlation	0.17	0.14	0.14	0.12	0.13	**0.15***
	p-value	0.36	0.45	0.45	0.54	0.51	**0.07**
	N	31	31	31	29	29	**151**
Foreign students	Correlation	0.59***	0.67***	0.65***	0.71***	0.73***	**0.67*** **
	p-value	0.00	0.00	0.00	0.00	0.00	**0.00**
	N	23	23	22	22	24	**115**
Foreign employees	Correlation	0.43**	0.49***	0.53***	0.55***	0.61***	**0.52*** **
	p-value	0.04	0.01	0.00	0.00	0.00	**0.00**
	N	24	27	29	28	28	**136**

SII Output variables are sales from new-to-market and new-to-firm products (goods and services), share of firms using patents, trademarks, or registered designs. All correlations control for the natural log of the population size of each country. These partial correlations do not differ significantly from the zero-order correlations. Significance level: * p<0.10; ** p<0.05; *** p<0.01

The results are similar to those reported in Table 6 for SII-inputs. However, while exports, in the pooled results, remain significant (p<0.10), the coefficients are smaller. Imports are negatively correlated throughout and the strongest associations arise with foreign students, outward FDI and foreign employees. These results are similar to those in Table 5 when we considered all elements of innovation in the SII. The negative results for imports point to the fact that the association between innovation and internationalization might be due to a type (i) relationship (see above), i.e. that innovative firms and countries compete successfully abroad as well as in home markets.

6.4 Level A correlations between internationalization and innovation – small versus large countries

Tables 8 to 10 explore the relationship between internationalization at level A and innovation for all countries, as well as for the two clusters – small versus large countries.

Table 8 Level A results small versus large countries. Correlations between six internationalization indicators, SGI/A and SII

Innovation index		*SII pooled*	*SII pooled*	*SII pooled*
Internationalization indicators and index		All countries 1999-2007	Small countries 1999-2007	Large countries 1999-2007
SGI/A	Correlation	0.35***	0.30***	0.67***
	p-value	0.00	0.00	0.00
	N	160	125	35
Inward FDI flows	Correlation	-0.10	-0.07**	-0.23
	p-value	0.22	-0.02	0.18
	N	160	125	35
Outward FDI flows	Correlation	0.64***	0.60***	0.93***
	p-value	0.00	0.00	0.00
	N	160	125	35
Imports	Correlation	-0.13	-0.08**	-0.52***
	p-value	0.13	-0.03	0.00
	N	151	118	33
Exports	Correlation	0.11	0.17*	-0.32*
	p-value	0.17	0.06	0.08
	N	151	118	33
Foreign students	Correlation	0.72***	0.68***	0.92***
	p-value	0.00	0.00	0.00
	N	115	90	25
Foreign employees	Correlation	0.49***	0.37***	0.93***
	p-value	0.00	0.00	0.00
	N	136	108	28

All correlations control for the natural log of the population size of each country. These partial correlations do not differ significantly from the zero-order correlations.
Significance level: * p<0.10; ** p<0.05; *** p<0.01

The final two columns of Table 8 explore the relationship for two distinct clusters of countries separately – for small and for large countries – while the first column provides the results based on all countries as presented in Table 5. In summary, the results discussed previously are reconfirmed by the associations based on the two clusters – small vs. large countries – with foreign students, foreign employees and inwards FDI having the strongest positive association with innovation performance.

The correlation coefficients for the seven large economies are larger, which means that the variability in the pairs of scores is lower, while the variation among the small countries is higher. This is to be expected because we are examining seven countries over time and the variation within countries over time are low. Imports and exports have a negative association with SII for large countries. But, exports have a positive association with innovation for the small countries.

Table 9 Level A results small versus large countries. Correlations between six internationalization indicators, SGI/A and SII-input variables

Innovation index		*SII-input pooled*	*SII-input pooled*	*SII-input pooled*
Internationalization indicators and index		All countries 1999-2007	Small countries 1999-2007	Large countries 1999-2007
SGI/A	Correlation	0.52***	0.42***	0.83***
	p-value	0.00	0.00	0.00
	N	160	125	30
Inward FDI flows	Correlation	0.11	0.06	0.18
	p-value	0.25	0.6	0.34
	N	160	80	30
Outward FDI flows	Correlation	0.43***	0.30***	0.91***
	p-value	0.00	0.01	0.00
	N	160	80	30
Imports	Correlation	0.11	0.08	-0.32*
	p-value	0.28	0.46	0.10
	N	151	78	28
Exports	Correlation	0.27***	0.31***	-0.31
	p-value	0.01	0.01	0.12
	N	151	78	28
Foreign students	Correlation	0.73***	0.36***	0.97***
	p-value	0.00	0.00	0.00
	N	115	62	25
Foreign employees	Correlation	0.50***	0.36***	0.98***
	p-value	0.00	0.00	0.00
	N	136	76	28

SII Inputs are business R&D expenditure, IT expenditures and other (non-R&D) innovation related expenditures. All correlations control for the natural log of the population size of each country. These partial correlations do not differ significantly from the zero-order correlations.
Significance level: * p<0.10; ** p<0.05; *** p<0.01

As previously in Table 8, exploring correlations with SII-inputs finds similar patterns for all countries, small and large countries. Exports are now positively and significantly associated with SII-inputs for all countries, small countries, but not the seven large countries.

Table 10 Level A results small versus large countries. Correlations between six internationalization indicators, SGI/A and SII-output variables

Innovation index		*SII-output pooled*	*SII-output pooled*	*SII-output pooled*
Internationalization indicators and index		All countries 1999-2007	Small countries 1999-2007	Large countries 1999-2007
SGI/A	Correlation	0.37***	0.37***	0.52***
	p-value	0.00	0.00	0.00
	N	160	125	30
Inward FDI flows	Correlation	-0.05	0.00	-0.31*
	p-value	0.56	0.97	0.08
	N	160	125	35
Outward FDI flows	Correlation	0.60***	0.57***	0.76***
	p-value	0.00	0.00	0.00
	N	160	125	35
Imports	Correlation	-0.06	0.02	-0.61***
	p-value	0.43	0.82	0.00
	N	151	118	33
Exports	Correlation	0.15*	0.25***	-0.57***
	p-value	0.07	0.01	0.00
	N	151	118	33
Foreign students	Correlation	0.67***	0.70***	0.86***
	p-value	0.00	0.00	0.00
	N	115	90	25
Foreign employees	Correlation	0.52***	0.43***	0.87***
	p-value	0.00	0.00	0.00
	N	136	108	28

SII Output variables are sales from new-to-market and new-to-firm products (goods and services), share of firms using patents, trademarks, or registered designs. All correlations control for the natural log of the population size of each country. These partial correlations do not differ significantly from the zero-order correlations. Significance level: * p<0.10; ** p<0.05; *** p<0.01

Table 10 reports correlations with SII-outputs. With respect to the correlations based on small countries vs all countries, the coefficients are highly similar. With respect to the correlations based on large countries caution needs to be exercised. Into the SII-output measure feed two variables which are taken from the CIS. Because CIS is not collected annually, the relevant values feeding into SII-output are imputed. This, taken together with the fact that there are only seven countries in the cluster 'large countries', means that the variability in the data is low. This is an artefact of the data. In turn the correlation coefficients are all very significant. These results need to be treated with caution.

6.5 Level B correlations between internationalization and innovation, including innovation inputs and outputs

Table 11 gives the results of the SGI/B over time. This analysis (change in correlations over time) is not broken down into the individual indicators, due to the missing values in FDI at the industry level in some of the countries. Correlations for the nine individual indicators at level B are presented in Table 12 and are based on the pooled data.

Table 11 Level B results. Correlations between SGI/B and SII, SII-inputs variables and SII-output variables

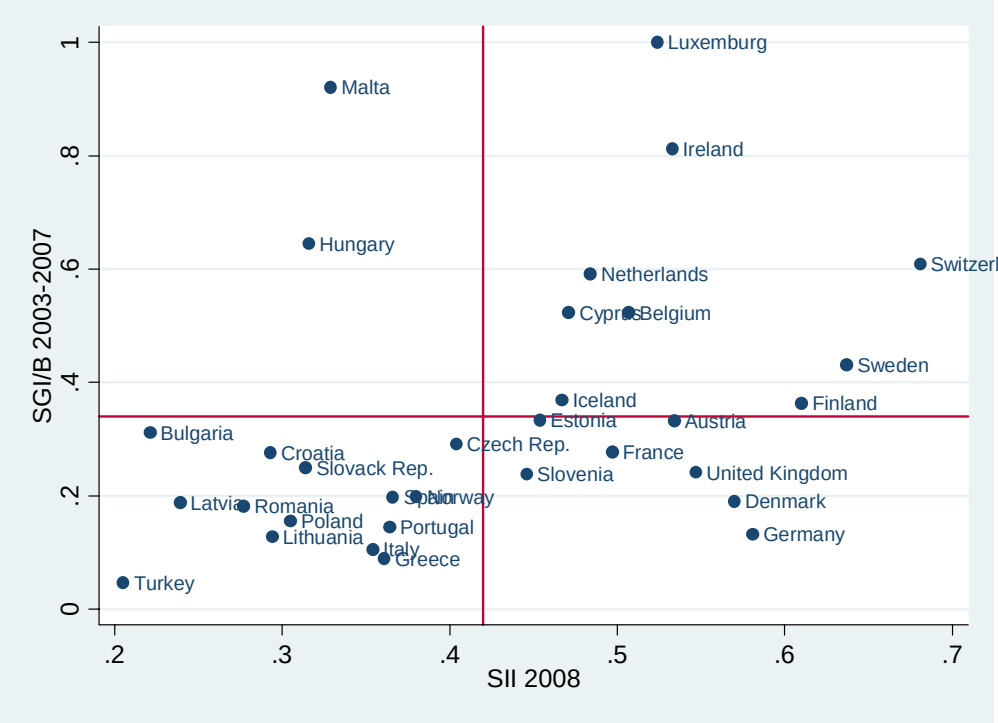
Innovation index		*SII 2004*	*SII 2005*	*SII 2006*	*SII 2007*	*SII 2008*	***SII pooled***
		1999-2003	2000-2004	2001-2005	2002-2006	2003-2007	**1999-2007**
SGI/B	Correlation	0.43***	0.38**	0.33*	0.32*	0.35**	**0.37*** **
	p-value	0.01	0.04	0.07	0.08	0.05	**0.00**
	N	32	32	32	32	32	**160**
		SII-input 2004	*SII-input 2005*	*SII-input 2006*	*SII-input 2007*	*SII-input 2008*	***SII-input pooled***
SGI/B	Correlation	0.27	0.25	0.25	0.27	0.29	**0.27*** **
	p-value	0.23	0.28	0.26	0.24	0.20	**0.01**
	N	22	22	22	22	22	**110**
		SII-output 2004	*SII-output 2005*	*SII-output 2006*	*SII-output 2007*	*SII-output 2008*	***SII-output pooled***
SGI/B	Correlation	0.41**	0.33*	0.29	0.37**	0.47***	**0.38*** **
	p-value	0.02	0.07	0.11	0.04	0.01	**0.00**
	N	32	32	32	32	32	

All correlations control for the natural log of the population size of each country. These partial correlations do not differ significantly from the zero-order correlations.
Significance level: * p<0.10; ** p<0.05; *** p<0.01

On the whole, the correlation coefficients computed at level B are not higher compared with the level A analysis. This seems to indicate that internationalization *per se* and not necessarily with respect to high technology and knowledge intensive industries/products impacts on countries' innovation performance. We might have expected to see stronger associations with the innovation scoreboard at level B. However, correlations do not describe size effects but are measures of covariation which express the closeness of pairs of scores around either a positive or negative straight line. The slope of the straight line – the size effect – is not reflected in the correlation coefficient, but would require different estimations.

Graph 5 gives the scatterplot for SGI/B and SII.

Graph 5 Scatterplot between SGI/B 2003-2007 and SII 2008, Level B, 32 countries



Notes: the pairs of scores are based on the latest available SII and SGI/B. Axes cross at average values.

The position of countries is similar to the one we found for SGI/A. The fact that missing value on FDI and research students, but not on trade occur, means that SGI/B is biased towards trade patterns, and the comparison between coefficients at level A (general level) and level B (innovation-specific level) have to be treated with caution. As we saw previously, trade with respect to level A showed little, and in the case of imports negative associations with countries' innovation performance.

6.6 Level B correlations between nine indicators of internationalization and innovation, including innovation inputs and outputs

Table 12 provides the breakdown into nine indicators of internationalization and SII. On the whole, the results for level B reinforce those for level A: innovation and internationalization appear to be correlated at both overall level and at the level of innovation-intensive industries.

Looking at the results for both level A and B together, there are two sets of variables we have not yet commented on: inward FDI and the trade variables. In all these cases the results are more uncertain than for outward FDI and for the variables related to the mobility of human resources.

As regards inward FDI the relationship between this variable and innovation is not straightforward. The existence of FDI into a country may be a sign that foreign TNCs are more competitive than domestic firms partly by being more innovative than the domestic firms. This is, indeed, how we interpret the strong results we get for correlations with outward FDI. However, there is also some evidence that, in the case of specific countries such as the UK, foreign TNCs may be attracted to

invest in countries with a strong innovation environment (Driffield and Love, 2003). The uncertainty of the results for inward FDI may be the outcome of these conflicting forces at work. The true situation may require country by country studies.

Table 12 Level B results. Correlations between nine internationalization indicators and SII, SII-inputs and SII-output, pooled data

Innovation index		*SII pooled*	*SII-input pooled*	*SII-output pooled*
Internationalization indicators and index				
Inward FDI in high-tech manufacturing	Correlation	0.09	-0.20*	-0.06
	p-value	0.41	0.10	0.59
	N	93	68	93
Outward FDI high-tech manufacturing	Correlation	0.42***	0.46***	0.26**
	p-value	0.00	0.00	0.02
	N	80	60	80
Inward FDI in knowledge intensive services	Correlation	0.20*	0.13	0.23**
	p-value	0.06	0.32	0.04
	N	86	61	86
Outward FDI in knowledge intensive services	Correlation	0.15	0.05	0.18*
	p-value	0.19	0.68	0.10
	N	82	61	82
Imports of high-tech products	Correlation	0.17**	0.20**	0.23***
	p-value	0.03	0.03	0.00
	N	156	110	156
Exports of high-tech products	Correlation	0.35***	0.26***	0.43***
	p-value	0.00	0.01	0.00
	N	155	110	155
Debits in knowledge intensive services	Correlation	0.25***	0.14	0.21***
	p-value	0.00	0.15	0.01
	N	147	100	147
Credits in knowledge intensive services	Correlation	0.27***	0.14	0.25***
	p-value	0.00	0.16	0.00
	N	150	100	150
Foreign research students	Correlation	0.68***	0.52***	0.57***
	p-value	0.00	0.00	0.00
	N	91	67	91

All correlations control for the natural log of the population size of each country. With respect to the nine indicators at level B the analyses are done on the pooled data only because of partial missing values affecting some of the indicators (specifically those related to. FDI).
Significance level: * p<0.10; ** p<0.05; *** p<0.01

With respect to imports and exports, the most significant results are obtained at the level B of analysis. There is significance for the correlation of these variables with the total SII as well as with the subsets related to inputs and outputs (Table 12). All the coefficients are positive. There may be an indication here that countries with a strong innovation base are also the ones that have large volumes of imports of high technology products and this is likely to impact positively on the innovation performance and thus on their exports performance of high technology products[6] as well as on the need to import further high-tech products in a cumulative virtuous process. Similar - though less strong – patterns are exhibited by the variables on Debits and Credits in knowledge-intensive services.

[6] The products imported and exported may or may not belong to the same industrial category. The vast literature on intra-industry trade starting with Grubel and Lloyd (1975) is summarized in Grimwade (2000).

6.7 Level C correlations between internationalization and innovation

Finally, in Table 13 we present the results at level C. Indicators are based on the international activities as perceived or assessed by enterprises responding to the Innobarometer or CIS4 surveys. We analyse separately indicators related to these two surveys under CI and CII respectively.

Table 13 Level C results. Correlations between seven internationalization indicators, SGI/C and SII2008

Innovation index		*SII 2008*	*SII-input 2008*	*SII-output 2008*
Internationalization indicators and index Innobarometer				
SGI/CI	Correlation	0.39**	0.15	0.27
	p-value	0.04	0.51	0.17
	N	29	29	29
Company operated in international markets	Correlation	0.05	0.04	0.17
	p-value	0.79	0.86	0.38
	N	29	29	29
Outsourced activities to companies located abroad	Correlation	0.00	-0.13	-0.11
	p-value	0.99	0.58	0.57
	N	29	29	29
Investment into companies located abroad	Correlation	0.38**	0.17	0.43**
	p-value	0.05	0.47	0.02
	N	29	29	29
Cooperated with partners which were located abroad	Correlation	0.30	0.34	-0.01
	p-value	0.12	0.13	0.94
	N	29	29	29
Recruited employees from other countries	Correlation	0.57***	0.18	0.55***
	p-value	0.00	0.43	0.00
	N	29	29	29
Market-testing in foreign countries	Correlation	0.28	0.18	0.15
	p-value	0.15	0.43	0.46
	N	29	29	29
Company considered international markets as lead markets	Correlation	0.05	-0.14	-0.09
	p-value	0.81	0.55	0.66
	N	29	29	29
Internationalization indicators and index CIS4				
SGI/CII	Correlation	0.67***	0.62***	0.50**
	p-value	0.00	0.01	0.02
	N	22	22	22
Enterprise is foreign owned	Correlation	0.62***	0.72***	0.52**
	p-value	0.00	0.00	0.02
	N	23	23	23
Enterprise operates in international markets	Correlation	0.67***	0.28	0.41*
	p-value	0.00	0.32	0.02
	N	22	18	22
Involved in international cooperation	Correlation	-0.02	-0.26	0.16
	p-value	0.92	0.27	0.44
	N	26	20	26

Correlations are based on 29 countries included in the Innobarometer; and 27 countries for which the Eurostat CIS4 data is available. All correlations control for the natural log of the population size of each country. These partial correlations do not differ significantly from the zero-order correlations.
Significance level: * p<0.10; ** p<0.05; *** p<0.01

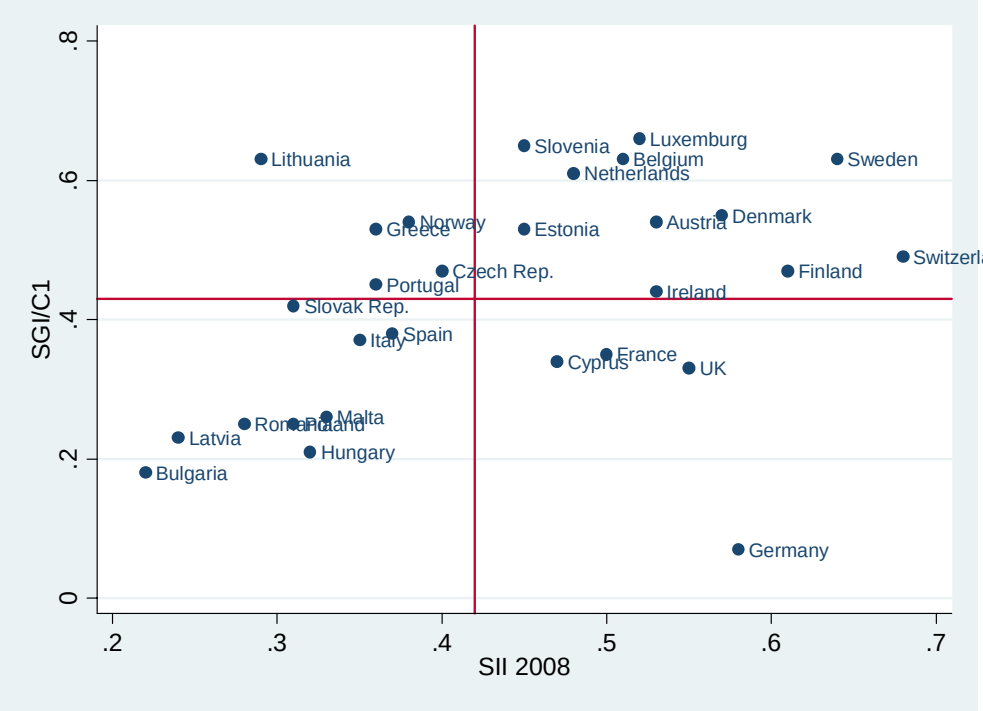
The summary index SGI/CI and SII2008 have a correlation of 0.39, similar to the correlation coefficients for SGI/A; however, SGI/CI is not associated with SII-inputs or outputs. The strongest associations with the innovation score among the

individual indicators at level C are found with the share of companies recruiting employees from other countries. This finding is similar to the level A indicator on share of foreign employees. The next strongest correlation is with investment abroad. Part of this investment is likely to take the form of outward FDI, which under level A was positive and significant. The next two indicators in terms of strength of association are cooperation and market-testing abroad, neither of which are significant, while the remaining three indicators are close to zero.

The correlations between the indicators derived from CIS4 and SII (presented under the CII section of Table 13) are somewhat larger which might be the case because some of the variables feeding into the SII index are derived from different sections of CIS and, therefore, are derived from the same enterprises. Foreign-ownership is positively and significantly associated with SII, and the innovation indicators restricted to direct innovation inputs and outputs. The CIS does not have information on whether the surveyed enterprise is part of a domestic TNC with investment abroad. Thus a variable related to outward FDI which was considered under A, B and CI are not available within CII. Nonetheless, looking at the results across CI and CII (specifically those for indicators: 'Investment into companies located abroad' from CI and 'Enterprise is foreign owned' from CII) we can observe the following. Countries whose firms/enterprises are part of a TNC – be it domestically or foreign owned – appear to have stronger association with innovation. This result is consistent with other studies in which multinationality was found to affect innovation positively independently of whether the TNC is a foreign or domestic company (Frenz and Ietto-Gillies, 2007 and 2009; Castellani and Zanfei 2004) for the reasons explained in section 2. Fairly significant are also the results for 'Enterprise operates in international markets' but not for the indicator 'Enterprise is involved in cooperation with partners abroad'. The latter result is consistent with those obtained in Frenz and Ietto-Gillies (2009). It may be due to issues of appropriability of knowledge relevant for innovation, and to the exchange of knowledge, specifically tacit elements of knowledge, across borders but outside the company environment.

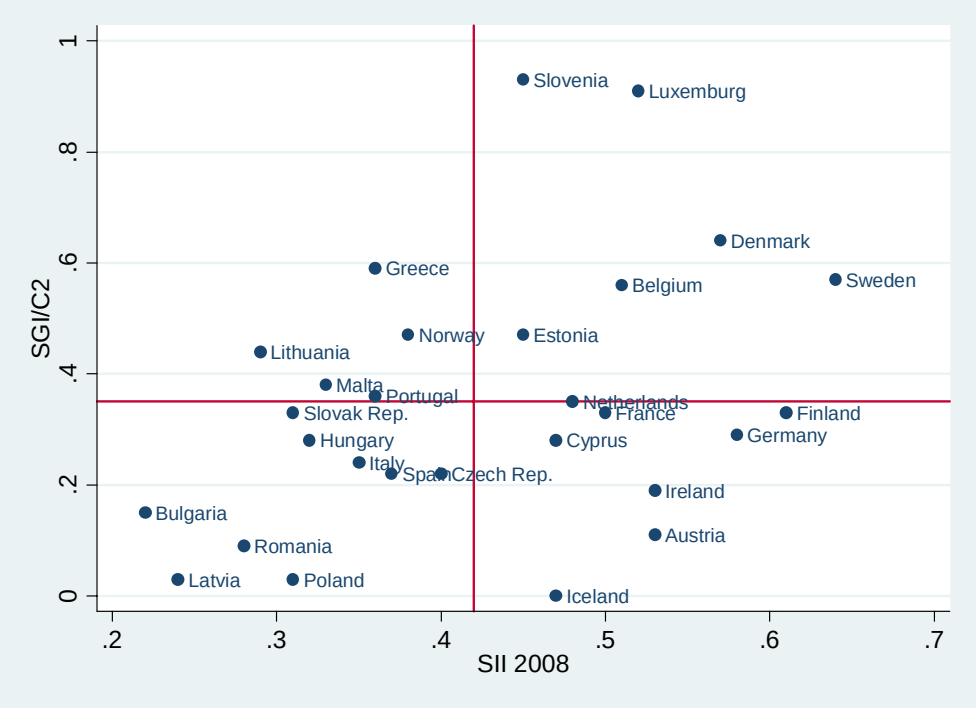
The scatterplots for CI and CII produced in the following Graphs 6 and 7 confirm the position of small countries into quadrant I.

Graph 6 Scatterplot between SGI/CI 2003-2007 and SII 2008, Level CI 29 countries



Notes: the pairs of scores are based on the latest available SII and SGI/C. Axes cross at average values.

Graph 7 Scatterplot between SGI/CII and SII 2008, Level C 28 countries



Notes: the pairs of scores are based on the latest available SII and SGI/C. Axes cross at average values.

7. Summary and conclusions

The exploratory report aims to test the association between internationalization and innovation for the countries for which the EIS innovation scores are available. It starts by recalling some of the theoretical background as well as empirical evidence to the relationship between internationalization and innovation. It then presents the framework underlying the assessment of the relationship between innovation and internationalization. The contribution of this report is on the internationalization side and specifically in the following.

The research identifies three possible levels of internationalization relevant for innovation: the full aggregate level (A) in which internationalization variables are considered for the whole country and all industries; the level of technology-intensive industries (B) where internationalization of countries is considered with respect to these sectors; and (C) reported activities of firms in each country on the basis of data derived from two surveys – the Innobarometer survey and the Community Innovation Survey. For each level several variables are considered. Specifically, level A includes the following variables: inward and outward FDI, imports and exports, mobility of employees and of students. Level B includes inward and outward FDI for technology-intensive manufacturing sectors and for knowledge-intensive services, imports and exports of technology-intensive products, balance of payments debits and credits for knowledge-intensive services and mobility of research students. Under level C of the analysis we include those questionnaire items in the Innobarometer and CIS surveys that have a bearing on the international embeddedness or focus of responding companies. Specifically, the following variables are taken from Innobarometer: proportion of companies that operated in international markets, outsourced activities to companies located abroad, invested into companies located abroad, cooperated with partners which were located abroad, recruited employees from other countries, carried out market-testing in foreign countries, considered international markets to be the lead markets. The following are derived from the Community Innovation Survey: proportion of enterprises that operated in international markets, proportion of foreign-owned enterprises and proportion of enterprises reporting cooperation with partners abroad.

For each variable indicators of countries' scores are calculated applying a methodology similar to the one used for the SII thus ensuring consistency between innovation and internationalization data. Summary Globalization Indices (SGI) are then calculated for each of the three levels: SGI/A, SGI/B, SGI/CI and SGI/CII.

The association between innovation and internationalization is tested by calculating correlation coefficients between SII and SGI/A, SGI/B, SGI/CI and SGI/CII while controlling for the populations of countries. Coefficients for each single variable within each level and SII are also reported. At levels A and B correlations were calculated also for two subsets of SII related to innovation inputs and outputs. Moreover, for Level A only further correlations were calculated for two subsets of countries: small and larger ones.

The theoretical explanations coupled with results from other studies support our view that the correlations are not spurious. However, it is not possible from correlation coefficients to draw strong inference on the direction of causation. Causality could go from innovation to internationalization or vice versa. If a country is highly internationalised it is likely to have a higher innovation performance because (i) its resources (labour, management etc.), its products and its institutions are exposed to alternative innovation contexts, and this allows firms and people to learn from different environments; and (ii) competition forces

the firms to innovate. However, the causal link could go the other way. Firms and countries that are innovative are more likely to be able to penetrate international markets and/or take up investment opportunities in foreign locations.

In reality a virtuous (or vicious) circle is likely to set in. Innovative firms are more successful in international business. This puts them into contact with alternative business cultures and technologies, thus adding to their overall business knowledge. This in turn makes them more innovative and thus more able to compete internationally. Less innovative firms and countries may become locked into an opposite vicious circle.

The results show association between internationalization and innovation at all levels of analysis. The international variables that show clear association throughout the three levels are those related to outward foreign direct investment and similar indicators of firm behaviour, foreign students and foreign employees. The strong association obtained for the latter two variables indicate the relevance of movement of skilled human resources in relation to innovation. These results point to the relevance of internationalization for innovation possibly via learning mechanisms.

Our results for imports, exports and for inward FDI are more uncertain. Regarding trade the results are, however, all positive and significant for Level B internationalization. We interpret this to show evidence of the following. Innovative countries import high-tech products; this supports their innovation performance and helps them to compete abroad via the exportation of high-tech products (which are not necessarily part of the same industrial category as the imports).

As regards inward FDI the uncertain correlations may be the results of underlying country-specific patterns. Penetration by foreign TNCs via inward FDI could be a sign of low innovative performance in the host country. However, it could also be an indication that foreign companies are attracted by the advanced innovative context of the host country. It is not possible to draw inference at the aggregate level; country specific studies may be needed here.

There are clear limitations in a study of this nature. In terms of data they range from: the composition of the EIS itself to the timescale set by the availability of the EIS as well as of the two surveys (CIS and Innobarometer). At the theoretical level there are also limitations and specifically: (i) the inability to take into account alternative dimensions to internationalization and specifically the spatial/extensity dimension (as highlighted in section 3); (ii) possible tensions between indicators based on firm responses and those on flows of FDI, trade and human capital; (iii) inability to capture the possible interaction in the direction of causality.

Nonetheless even within the boundaries of this exploratory research some definite conclusions are possible based on the empirical results as well as on the underlying theoretical framework.

- The persistence of significant results for outward FDI and for the variables related to mobility of human resources points to the relevance of internationalization for innovation.
- The overall results point to interactive effects between innovation and internationalization with possible cumulative virtuous or vicious effects.
- The results are robust and interesting enough to warrant further work on the linkages between innovation and internationalization particularly in view of policy implications.

In policy terms we suggest that the relationship between innovation and internationalization points to the relevance of both for the performance of countries. Economies caught in a less than virtuous circle of causation should be helped to get out by a combination of investment in innovation in order to help their companies compete internationally. In terms of our results protectionist measures hampering the movements of skilled labour would have a negative impact on innovation. In the current global financial crisis this reinforces calls for resisting a possible retrenchment into protectionism and away from international activities and from the movements of international human resources. Such a retrenchment would diminish the scope for knowledge acquisition and thus for innovation.

Recent works (Bogliaccino and Pianta, 2009) stress the relevance of demand for innovation performance. It is possible to speculate that low levels of demand and particularly investment brought about by the recession will lead to lower levels of innovation. If this is combined with declines in internationalization activities – brought about by possible retrenchment due to the recession – then one can see a vicious circle setting in.

References

Bartlett, C. A., Ghoshal, S., 1989. *Managing Across Borders: The Transnational Solution*, Harvard Business School Press, Boston, MA.

Bagliaccino, F. and Pianta, M. 2009, Innovation performances in Europe: a long term perspective (mimeo), Consiglio Nazionale delle Ricerche: Roma.

Cantwell, J. A., 1989, *Technological Innovation and Multinational Corporations,* Blackwell, Oxford

Cantwell, J. A., 1994, The relationship between international trade and international production', in D. greenway and L. A. Winters (eds), *Surveys in International Trade,* Oxford: Basil Blackwell.

Cantwell, J. and F. Sanna Randaccio, 1993, 'Multinationality and firm growth', *Weltwirtschaftliches Archiv*, 129 (2): 275-99.

Castellani, D., Zanfei, A., 2004. Choosing international linkage strategies in the electronic industry: the role of multinational experience. *Journal of Economic Behavior and Organization,* 53 (4), 447–475.

Castellani, D., Zanfei, A., 2006. *Multinational Firms, Innovation and Productivity.* Edward Elgar, Cheltenham.

Driffield, N., Love, J. H. 2003. FDI, technology sourcing and reverse spillovers. *The Manchester School*, 71 (6): 659-672.

European Commission 2009. *European Innovation Scoreboard 2008. Comparative analysis of innovation performance.* Brussels, European Commission, DG Enterprise.

European Commission 2009. *Innobarometer 2009*. Brussels, DG Enterprise and Industry.

Frenz, M., Girardone, C., Ietto-Gillies, G., 2005. Multinationality matters in innovation. The case of the UK financial services, *Industry and Innovation* 12 (1): 65-92.

Frenz, M., Ietto-Gillies, G., 2007. Does multinationality affect the propensity to innovate? An analysis of the third UK Community Innovation Survey, *International Review of Applied Economics,* 21 (1): 99–117.

Frenz, M., Ietto-Gillies, G., 2009. The impact on innovation performance of different sources of knowledge: Evidence from the UK Community Innovation Survey. *Research Policy*, 38 (7): 1,125-1,135.

Grimwade, N. 2000. *International Trade: New Patterns of Trade, Production and Investment.* London: Routledge, 2nd edition.

Grubel, H.G. and Lloyd, P. J. 1975. *Intra-Industry Trade.* London: Macmillan.

Gupta, A. K., Govindarajan, V., 1991. Knowledge flows and the structure of control within multinational corporations, *Academy of Management Review,* 16 (4): 768–792.

Gupta, A. K., Govindarajan, V., 2000. Knowledge flows within multinational corporations, *Strategic Management Journal,* 21 (4): 473–496.

Hedlund, G., 1986. The hypermodern MNC – a heterarchy? *Human Resource Management*, 25 (1): 9–35.

Hedlund, G., Rolander, D. 1990. Action in heterarchies: new approaches to managing the MNC, in *Managing the Global Firm* by C. A. Bartlett, Y. Doz, G. Hedlund (eds), Routledge; London.

Hufbauer, G. C. 1966. *Synthetic Materials and the Theory of International Trade.* London: Duckworth.

Hughes, K 1986. Exports and innovation: A simultaneous model, *European Economic Review* 30 (2): 383-399.

Ietto-Gillies, G., 2010. Conceptual issues behind the assessment of the degree of internationalization, *Transnational Corporations,* (forthcoming).

International Monetary Fund, 1993. *Balance of Payments Manual*. Fifth edition.

Kleinknecht, A., Oostendorp, R. 2002. R&D and export performance: taking account of simultaneity, in A. Kleinknecht, Mohnen P. (eds.), *Innovation and firm performance*, London: Palgrave, pp. 310-320.

Kogut, B., Zander, U., 1993. Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies* 24 (4): 625–645.

Nelson, R., Rosenberg, N. 1993. *Technical Innovation and National Systems. National Innovation Systems: A Comparative Analysis*. R. Nelson. Oxford University Press, Oxford.

Nelson, R., Winter, S., 1982. *An Evolutionary Theory of Economic Change*. Harvard University Press, Cambridge, MA.

Posner, M. V. 1961. International trade and technical change. *Oxford Economic Papers,* 13: 323-341.

Vernon, R. 1966. International investment and international trade in the product cycle. *Quarterly Journal of Economics,* 80: 190-207.

Zahra, S. A., Ireland, R. D., Hitt, M. A., 2000. International expansion by new venture firms: international diversity, mode of market entry, technological learning and performance. Academy of Management Journal 43 (5): 925–950.

Appendix I: Description of the 29 indicators feeding into the European Innovation Scoreboard

ENABLERS
Human resources
1.1.1 S&E and SSH graduates per 1000 population aged 20-29 (first stage of tertiary education)
1.1.2 S&E and SSH doctorate graduates per 1000 population aged 25-34 (second stage of tertiary education)
1.1.3 Population with tertiary education per 100 population aged 25-64
1.1.4 Participation in life-long learning per 100 population aged 25-64
1.1.5 Youth education attainment level
Finance and support
1.2.1 Public R&D expenditures (% of GDP)
1.2.2 Venture capital (% of GDP) EVCA
1.2.3 Private credit (relative to GDP)
1.2.4 Broadband access by firms (% of firms)
FIRM ACTIVITIES
Firm investments
2.1.1 Business R&D expenditures (% of GDP)
2.1.2 IT expenditures (% of GDP) EITO
2.1.3 Non-R&D innovation expenditures (% of turnover)
Linkages & entrepreneurship
2.2.1 SMEs innovating in-house (% of SMEs)
2.2.2 Innovative SMEs collaborating with others (% of SMEs)
2.2.3 Firm renewal (SME entries plus exits) (% of SMEs)
2.2.4 Public-private co-publications per million population
Throughputs
2.3.1 EPO patents per million population
2.3.2 Community trademarks per million population OHIM
2.3.3 Community designs per million population OHIM
2.3.4 Technology Balance of Payments flows (% of GDP)
OUTPUTS
Innovators
3.1.1 SMEs introducing product or process innovations (% of SMEs)
3.1.2 SMEs introducing marketing or organisational innovations (% of SMEs)
3.1.3 Resource efficiency innovators, unweighted average of:
• Share of innovators where innovation has significantly reduced labour costs (% of firms)
• Share of innovators where innovation has significantly reduced the use of materials and energy (% of firms)
Economic effects
3.2.1 Employment in medium-high & high-tech manufacturing (% of workforce)
3.2.2 Employment in knowledge-intensive services (% of workforce)
3.2.3 Medium and high-tech manufacturing exports (% of total exports)
3.2.4 Knowledge-intensive services exports (% of total services exports)
3.2.5 New-to-market sales (% of turnover)
3.2.6 New-to-firm sales (% of turnover)

Source: European Commission (2009)

Appendix II: Level B indicators are based on the following innovation-specific industry or product groups

B.1 FDI

Based on industries available from the OECD's International Direct investment Statistics we selected the following sectors:

- Technology intensive manufacturing selected are: 2400 – chemical products; 3000 – office machinery and computers; 3200 – radio, television, communication equipments. Other sectors have not been included due to a lack of data

- Knowledge intensive services are: 7200 – computer activities; 7300 – research and development services; 7400 – other business services

B.2 Trade

Based on products available from Eurostat (Science and Technology - High-tech industry and knowledge-intensive services) we derived trade in the following high-tech products:

- Chemicals, computer-office machines, electrical machinery, electronics-telecommunications, non-electrical machinery, pharmacy, scientific instruments

With respect to trade in services we selected the following positions (credits and debits) from the IMF's Balance of Payments (IMF, 1993)

- "259. Computer and information services covers computer data and news-related service transactions between residents and non-residents. Included are data bases, such as development, storage, and on-line time series; data processing—including tabulation, provision of processing services on a time-share or specific (hourly) basis, and management of facilities of others on a continuing basis; hardware consultancy; software implementation—including design, development, and programming of customized systems; maintenance and repair of computers and peripheral equipment; news agency services—including provision of news, photographs, and feature articles to the media; and direct, non-bulk subscriptions to newspapers and periodicals."

- "260. Royalties and license fees covers the exchange of payments and receipts between residents and non-residents for the authorized use of intangible, non-produced, nonfinancial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, franchises, etc.) and with the use, through licensing agreements, of produced originals or prototypes (such as manuscripts and films). Inclusion of this item under services, rather than under income, is in accordance with the SNA treatment of such items as payments for production of services for intermediate consumption or receipts from sales of output used as intermediate inputs."

Appendix III: Variables from which the indicators at levels A to C are computed

Table III.1 Variables behind level A indicator (see Table 1). Average values 1999-2007

Country	Inward FDI (%GDP)	Outward FDI (%GDP)	Import (%GDP)	Export (%GDP)	Foreign Students (% total students in tertiary education)	Foreign employees (% total employees)
Austria	0.03	0.03	0.46	0.50	0.13	0.09
Belgium	0.08	0.08	0.80	0.83	0.10	0.07
Bulgaria	0.12	0.00	0.68	0.56	.	0.00
Croatia	0.06	0.01	0.56	0.47	.	.
Cyprus	0.08	0.04	.	.	.	0.12
Czech Rep.	0.07	0.00	0.67	0.67	0.04	0.01
Denmark	0.04	0.04	0.42	0.47	0.08	0.03
Estonia	0.10	0.03	0.82	0.75	0.02	0.20
Finland	0.03	0.03	0.32	0.41	0.02	0.01
France	0.03	0.05	0.26	0.26	0.06	0.05
Germany	0.02	0.02	0.33	0.37	0.11	0.08
Greece	0.01	0.01	0.32	0.22	0.01	0.06
Hungary	0.05	0.02	0.68	0.66	0.03	0.01
Iceland	0.08	0.18	0.41	0.34	0.04	0.03
Ireland	0.07	0.07	0.74	0.90	0.03	0.05
Italy	0.01	0.02	0.25	0.26	0.02	0.06
Latvia	0.04	0.01	0.57	0.43	.	0.01
Lithuania	0.04	0.01	0.60	0.53	.	0.01
Luxemburg	0.12	0.19	1.26	1.47	0.12	0.44
Malta	0.11	0.02	0.86	0.83	.	0.03
Netherlands	0.06	0.10	0.60	0.67	0.04	0.03
Norway	0.02	0.04	0.28	0.43	0.04	0.03
Poland	0.04	0.01	0.36	0.33	0.00	0.00
Portugal	0.03	0.03	0.37	0.29	0.03	0.03
Romania	0.05	0.00	0.42	0.34	.	0.00
Slovak R	0.08	0.00	0.79	0.75	0.01	0.00
Slovenia	0.02	0.01	0.58	0.57	.	0.00
Spain	0.03	0.05	0.30	0.27	0.02	0.08
Sweden	0.05	0.07	0.38	0.45	0.07	0.04
Switzerland	0.03	0.09	0.38	0.44	0.18	0.20
Turkey	0.01	0.00	0.25	0.23	0.01	.
UK	0.04	0.05	0.29	0.26	0.13	0.05

Own calculations based on the data sources as per Box 2 Section A.

Table III.2 Variables behind level B indicator (see Table 2). Average values 1999-2007

Country	Inward FDI hi-tech products (%GDP)	Outward FDI in hi-tech products (%GDP)	Inward FDI in knowledge intensive services (%GDP)	Outward FDI in knowledge intensive services (%GDP)	Imports of high-tech products (%GDP)	Exports of high-tech products (%GDP)	Credits in knowledge intensive services (%GDP)	Debits in knowledge intensive services (%GDP)	Foreign research students (% total research students)
Austria	0.001	0.000	0.010	0.016	0.05	0.05	0.004	-0.007	0.18
Belgium	0.009	0.004	0.054	0.040	0.06	0.06	0.000	-0.008	0.32
Bulgaria	.	.	.	.	0.04	0.01	0.014	-0.003	.
Croatia	.	.	.	.	0.03	0.01	0.004	-0.008	.
Cyprus	.	.	.	.	0.04	0.00	0.012	-0.005	.
Czech Rep.	0.002	0.000	0.004	0.000	0.08	0.06	0.003	-0.005	0.07
Denmark	0.000	0.001	0.015	0.004	0.04	0.04	.	.	0.19
Estonia	.	.	.	.	0.08	0.05	0.004	-0.004	0.03
Finland	0.000	.	0.002	0.000	0.04	0.06	0.009	-0.008	0.07
France	0.002	0.002	0.015	0.020	0.04	0.04	0.000	0.000	0.36
Germany	0.001	0.000	0.014	0.000	0.04	0.04	0.000	0.000	.
Greece	0.000	0.000	0.001	0.000	0.02	0.00	0.001	-0.003	0.02
Hungary	0.004	0.001	0.028	0.018	0.11	0.11	0.008	-0.011	0.07
Iceland	0.005	0.031	0.009	0.053	0.03	0.01	0.004	-0.001	0.11
Ireland	0.035	.	.	0.014	0.12	0.19	0.094	-0.099	.
Italy	0.001	0.001	.	.	0.02	0.01	0.001	-0.002	0.03
Latvia	.	.	.	.	0.03	0.01	0.004	-0.003	.
Lithuania	.	.	.	.	0.04	0.01	0.001	-0.002	.
Luxemburg	-0.004	0.000	-0.026	0.004	0.13	0.13	0.045	-0.020	.
Malta	.	.	.	.	0.22	0.24	0.007	-0.007	.
Netherlands	0.004	0.008	0.005	0.010	0.10	0.11	0.011	-0.010	.
Norway	.	.	0.006	0.002	0.02	0.01	0.004	-0.004	0.17
Poland	0.002	0.000	0.003	0.001	0.03	0.01	0.001	-0.005	0.03
Portugal	.	.	.	.	0.03	0.01	0.001	-0.004	0.07
Romania	.	.	.	.	0.04	0.01	0.002	-0.003	.
Slovak R.	0.003	0.000	0.002	0.001	0.06	0.02	0.004	-0.006	0.01
Slovenia	.	.	.	.	0.04	0.02	0.003	-0.007	0.05
Spain	0.000	.	0.004	0.005	0.02	0.01	0.004	-0.005	0.16
Sweden	-0.004	0.008	0.001	0.004	0.04	0.04	0.015	-0.008	0.17
Switzerland	.	.	.	.	0.05	0.06	.	.	0.40
Turkey	0.000	0.000	0.000	.	0.02	0.00	0.000	-0.001	0.03
UK	0.002	0.003	0.002	0.002	0.04	0.04	0.000	0.000	0.34

Own calculations based on the data sources as per Box 2 Section B.

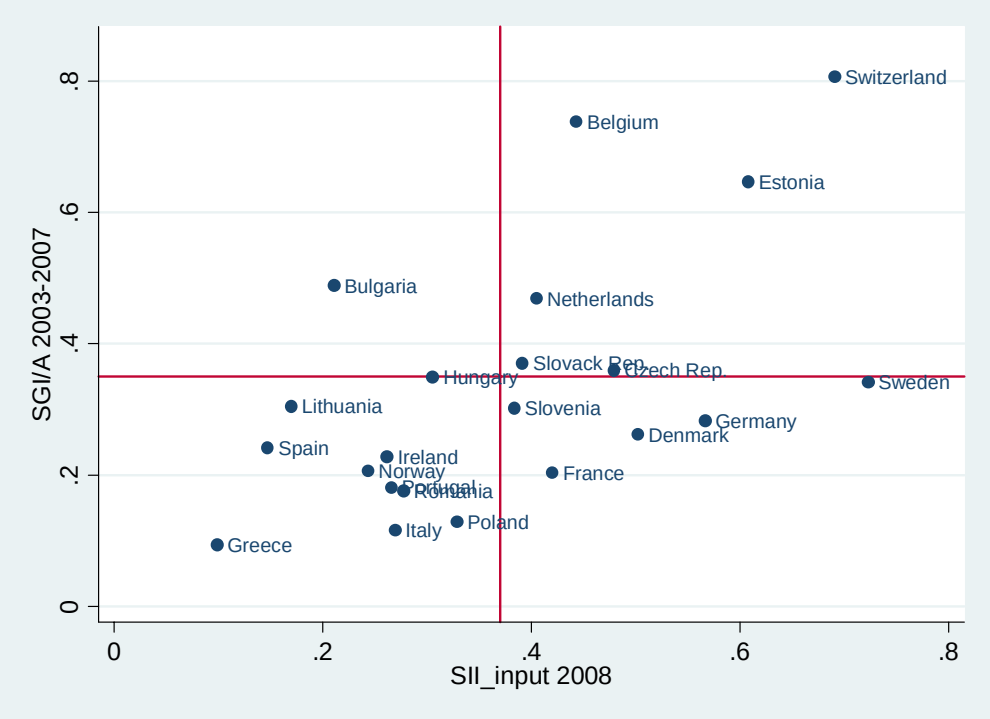
Table III.3 Variables behind level C indicator (see Table 3). Average values 1999-2007

	Level CI – Innobarometer							Level CII - CIS4		
Country	Operate in international markets	Outsourcing	Investment in firms located abroad	International cooperation	Foreign employees	Market-testing abroad	International lead markets	Head office abroad	International markets	International cooperation
Austria	0.53	0.15	0.18	0.29	0.33	0.28	0.24	.	.	0.07
Belgium	0.49	0.28	0.25	0.40	0.32	0.36	0.14	0.24	0.27	0.18
Bulgaria	0.46	0.11	0.05	0.20	0.14	0.10	0.18	0.04	0.11	0.03
Cyprus	0.29	0.16	0.08	0.20	0.48	0.17	0.20	0.05	0.19	0.10
Czech Rep.	0.58	0.18	0.19	0.26	0.29	0.25	0.15	0.13	0.05	0.12
Denmark	0.57	0.22	0.16	0.41	0.27	0.27	0.19	0.23	0.35	0.19
Estonia	0.52	0.19	0.07	0.51	0.15	0.27	0.27	0.13	0.29	0.17
Finland	0.49	0.21	0.10	0.48	0.24	0.21	0.18	0.13	.	.
France	0.49	0.20	0.09	0.25	0.20	0.17	0.20	0.10	0.24	0.02
Germany	0.34	0.07	0.06	0.14	0.16	0.13	0.10	0.06	0.22	0.05
Greece	0.54	0.20	0.12	0.32	0.24	0.27	0.26	0.03	0.24	0.62
Hungary	0.42	0.09	0.05	0.26	0.10	0.14	0.20	0.10	0.17	0.05
Ireland	0.43	0.20	0.08	0.28	0.55	0.21	0.17	.	.	0.12
Italy	0.51	0.13	0.14	0.20	0.15	0.19	0.25	.	.	0.00
Latvia	0.46	0.24	0.03	0.24	0.09	0.17	0.14	0.04	0.22	0.05
Lithuania	0.48	0.37	0.14	0.53	0.17	0.26	0.24	0.00	0.00	0.29
Luxemburg	0.75	0.24	0.21	0.34	0.46	0.23	0.18	0.08	0.23	0.52
Malta	0.41	0.15	0.08	0.18	0.38	0.15	0.13	0.37	0.32	0.53
Netherlands	0.56	0.22	0.21	0.42	0.33	0.30	0.18	0.08	0.04	0.00
Norway	0.47	0.23	0.23	0.37	0.44	0.25	0.11	0.14	0.24	0.32
Poland	0.52	0.13	0.05	0.32	0.15	0.17	0.13	0.14	0.19	0.02
Portugal	0.48	0.20	0.16	0.26	0.24	0.28	0.19	.	.	0.13
Romania	0.47	0.12	0.05	0.28	0.11	0.22	0.16	0.06	0.25	0.05
Slovak R.	0.48	0.23	0.13	0.32	0.17	0.27	0.15	0.03	0.04	.
Slovenia	0.68	0.18	0.15	0.38	0.37	0.39	0.20	0.14	0.10	0.58
Spain	0.39	0.19	0.14	0.20	0.33	0.23	0.17	.	.	0.02
Sweden	0.44	0.20	0.20	0.53	0.37	0.29	0.21	0.05	0.18	0.03
Switzerland	0.49	0.14	0.15	0.30	0.51	0.24	0.17	0.38	0.23	.
UK	0.39	0.16	0.09	0.26	0.33	0.17	0.18	.	.	.

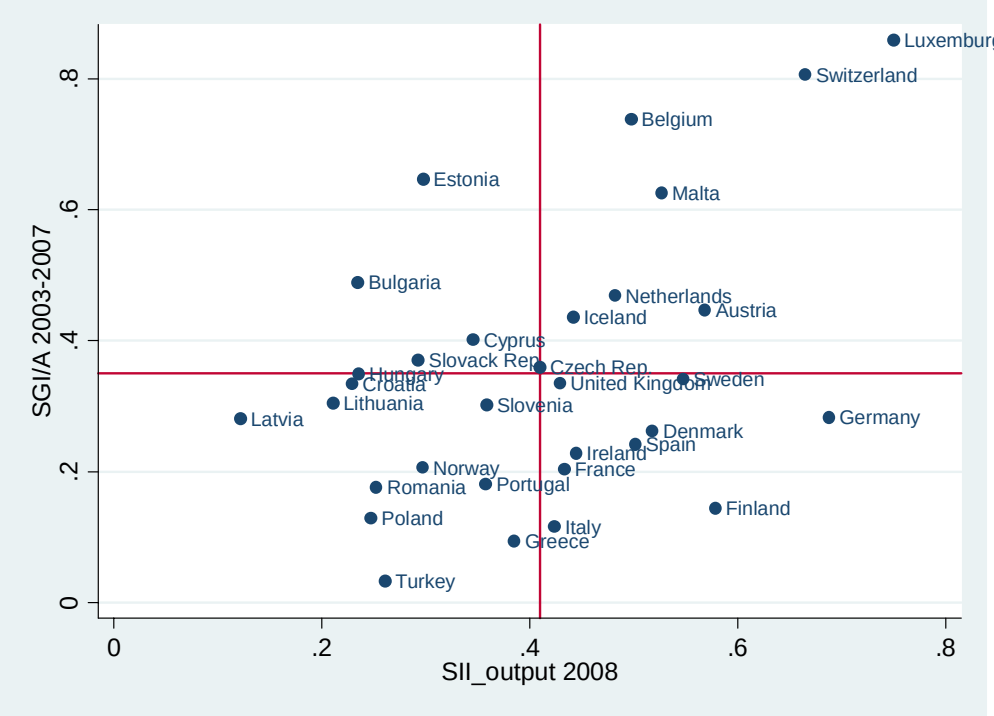
Own calculations based Innobarometer and CIS4.

Appendix IV: Additional scatterplots of innovation and internationalization scores

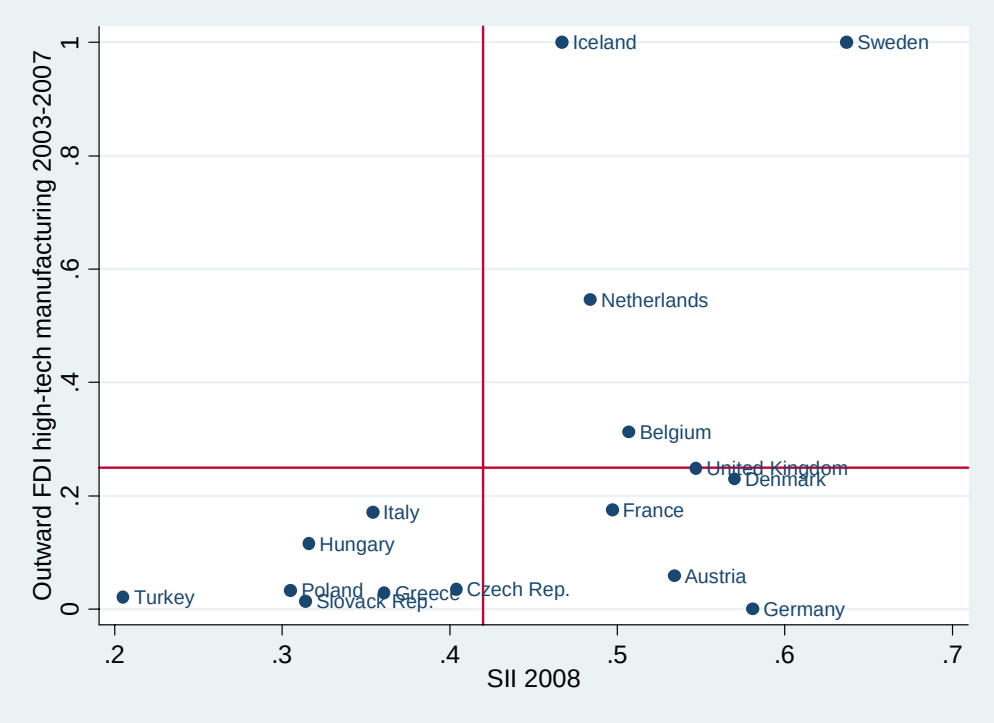
Graph IV.1 Scatterplot between SGI/A 2003-2007 and SII-input 2008, 22 countries



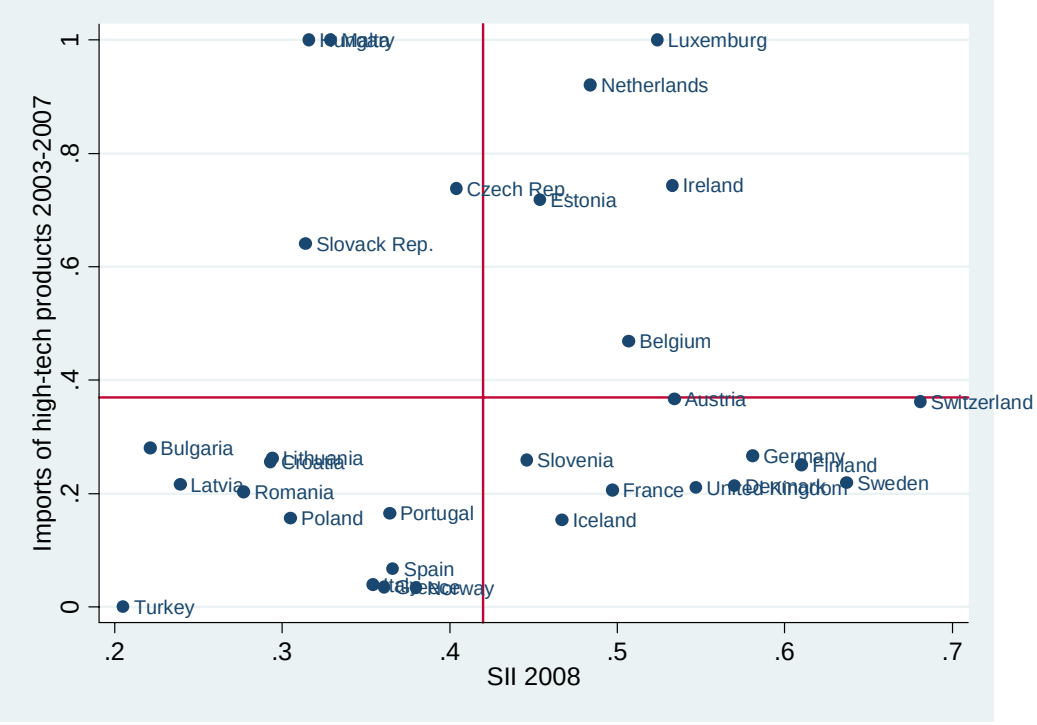
Graph IV.2 Scatterplot between SGI/A 2003-2007 and SII-output 2008, 32 countries



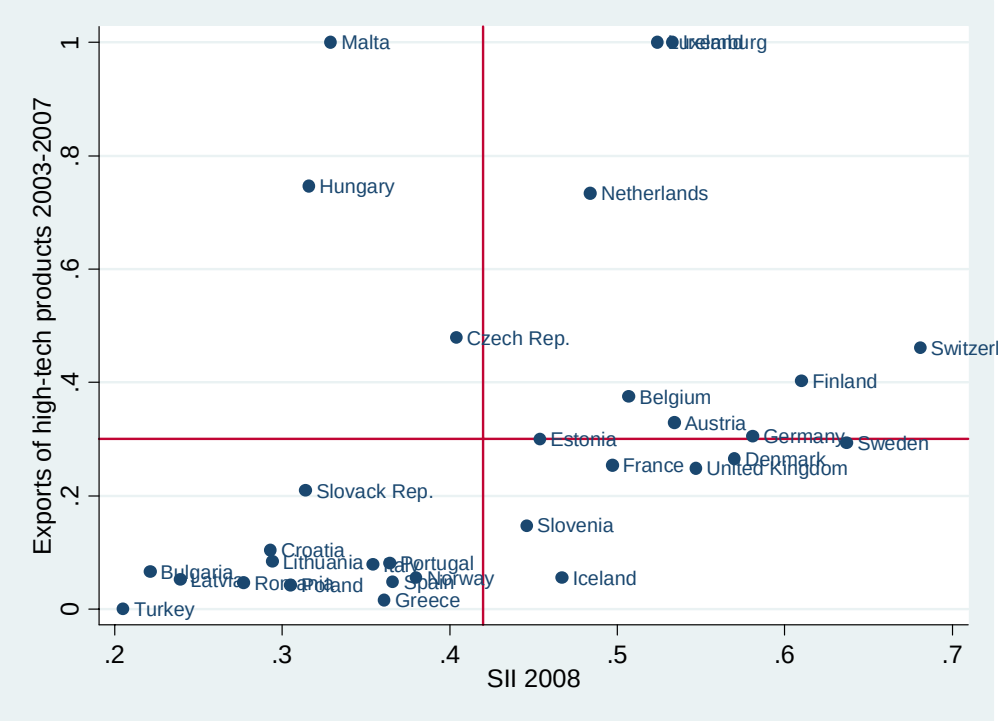
Graph IV.3 Scatterplot between Outward hi-tech FDI 2003-2007 and SII 2008, 16 countries



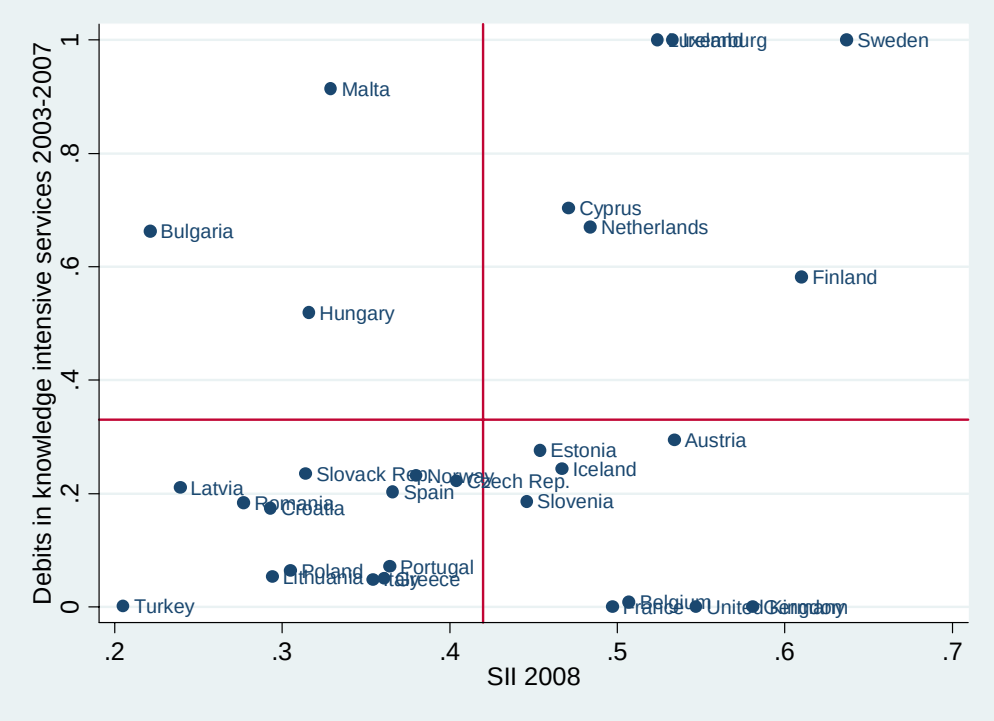
Graph IV.4 Scatterplot between hi-tech import 2003-2007 and SII 2008, 32 countries



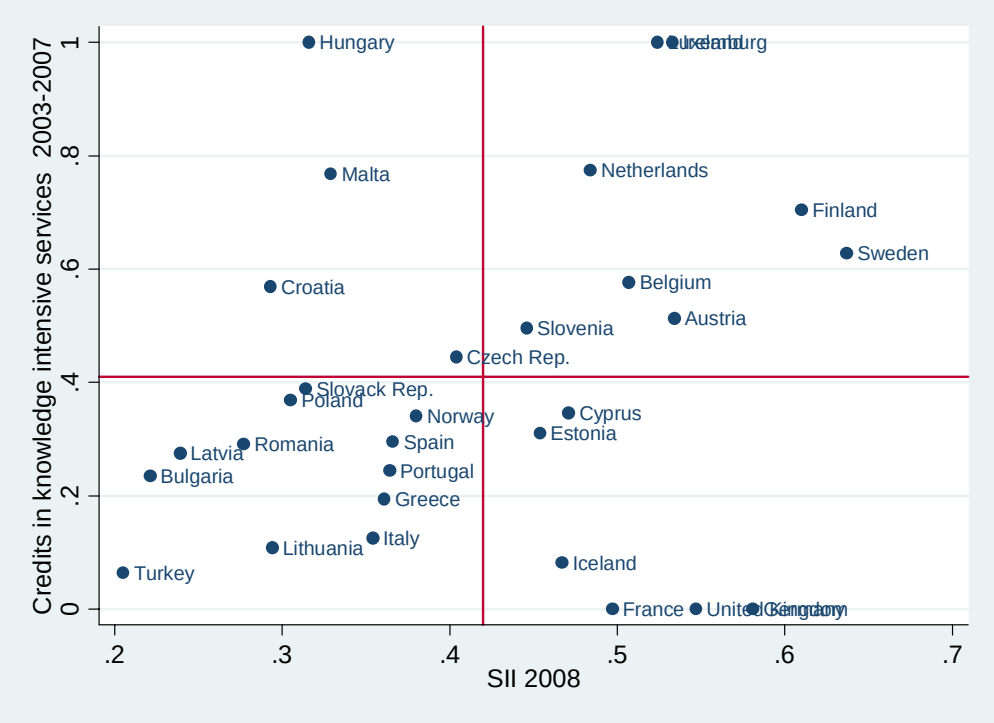
Graph IV.5 Scatterplot between hi-tech export 2003-2007 and SII 2008, 32 countries



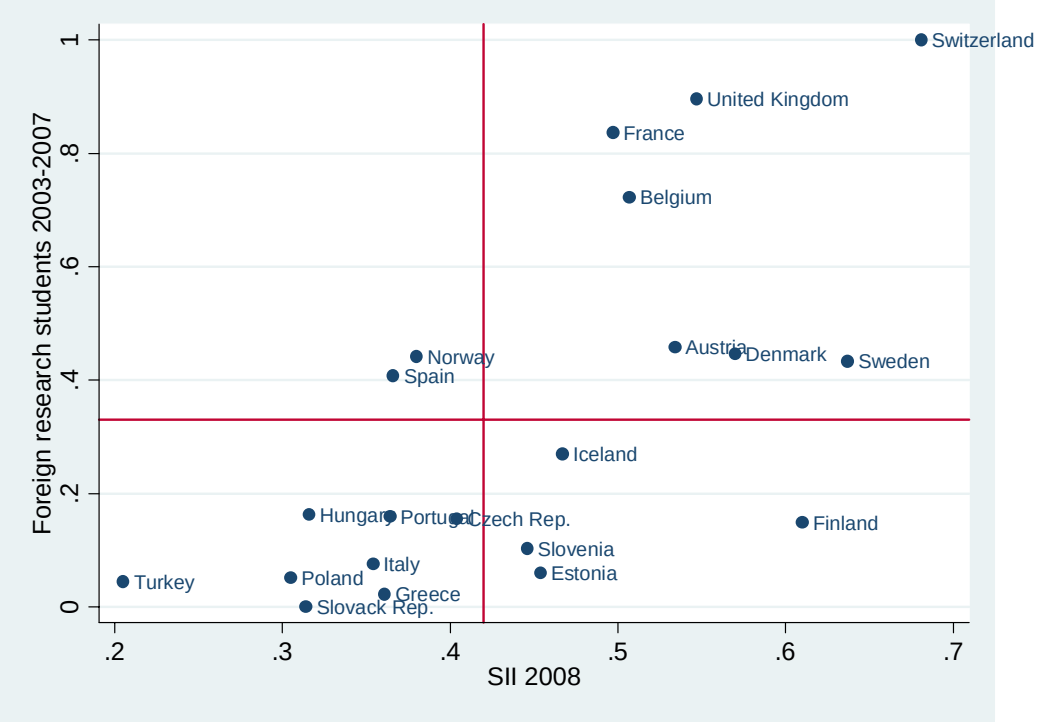
Graph IV.6 Scatterplot between debits in knowledge-intensive services 2003-2007 and SII 2008, 30 countries



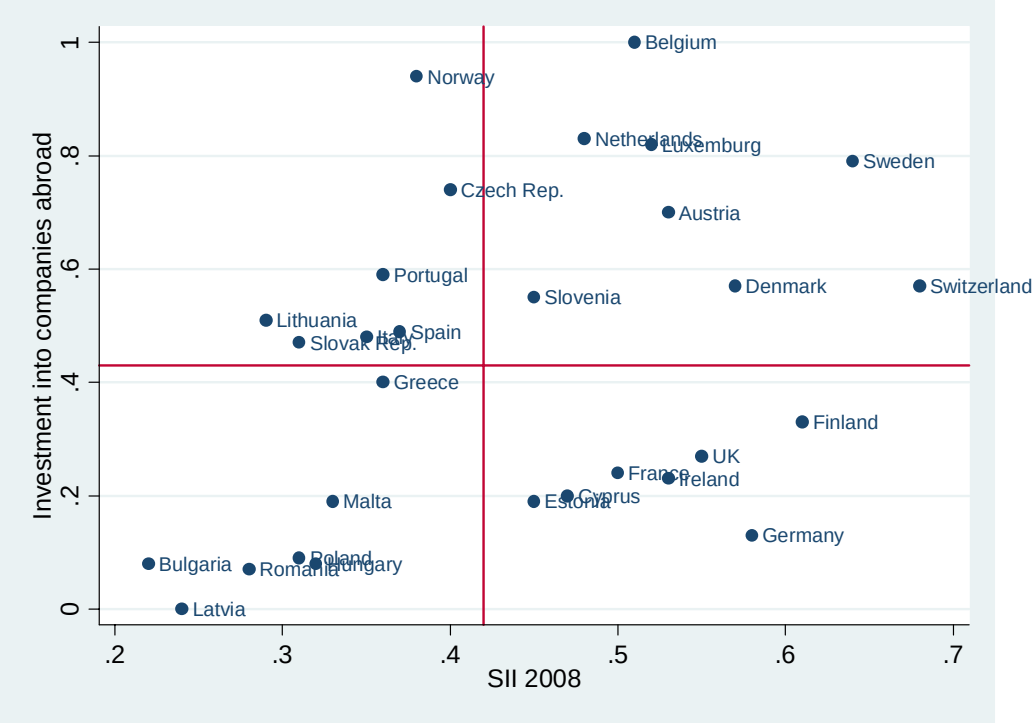
Graph IV.7 Scatterplot between credits in knowledge-intensive services 2003-2007 and SII 2008, 30 countries



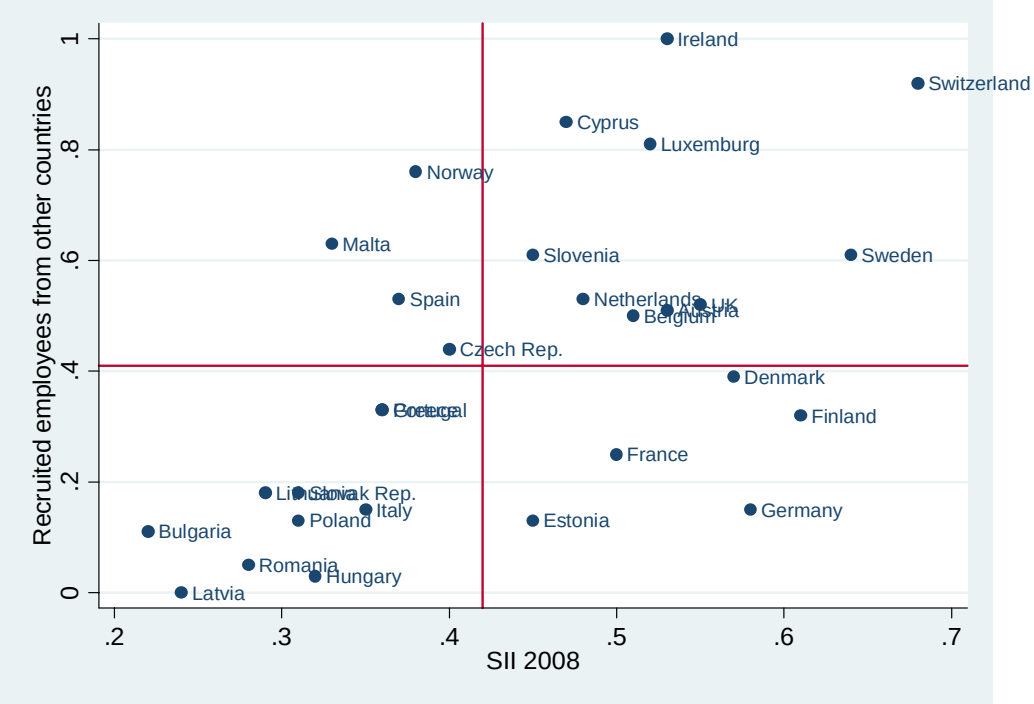
Graph IV.8 Scatterplot between foreign research students 2003-2007 and SII 2008, 23 countries



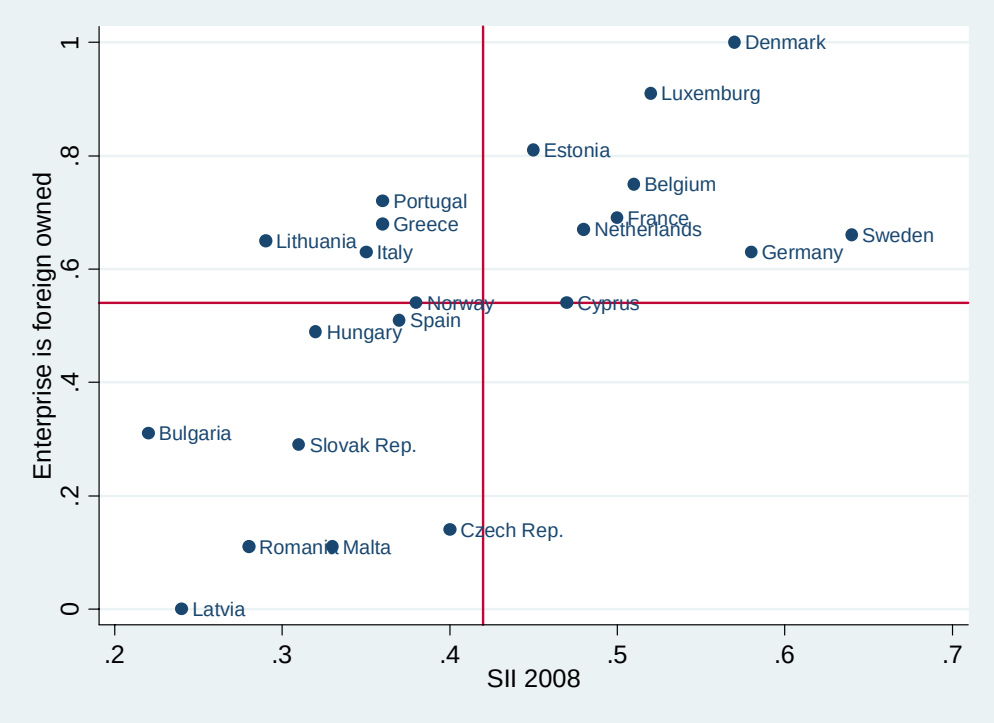
Graph IV.9 Scatterplot between investments into companies abroad and SII 2008, 29 countries



Graph IV.10 Scatterplot between foreign employment and SII 2008, 29 countries



Graph IV.11 Scatterplot between enterprises foreign owned and SII 2008, 27 countries



Graph IV.12 Scatterplot between enterprises operating abroad and SII 2008, 27 countries