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Measuring Internationalization of RDI in small countries

Submitted to the new theme “Design and use of indicators for small countries & regions”

The study focuses on measuring and monitoring integration of small national innovation systems into the global innovation system using input, output and linkage measures. Indicators for monitoring the strengths and weaknesses of small countries are presented. The analysis covers private and public research, development and innovation activities in European countries with less than 2.5 million inhabitants¹. Internationalization takes different forms in research and development (R&D) activities. Internationalization in this context is understood as a way to broaden knowledge, skill and expertise base, gain access to capital and investments, equipment, and an opportunity to benefit of knowledge and technology spillovers. Certainly, access to complementary resource pools generates competitive advantage in all countries, but due to much more limited national supply of all R&D factors, internationalization plays a vital role in small economies.

Some small countries have set up policies supporting internationalization of research. Often the policies are related to inward and outward mobility of researchers. Apart from visiting researchers and foreign R&D personnel, internationalization is also about cooperation across borders. This is attested by co-publications, co-patents and co-inventions. In private R&D, co-operation and knowledge transfers may take place between domestic and foreign enterprises which may be based in the small country or abroad. At the economy level, internationalization contains e.g. R&D investments by foreign-owned enterprises. From policy perspective these are highly important as they contribute to the country's business enterprise R&D statistics (BERD) which usually builds up the majority in GERD.

The data used for publications come from the Web of Science, patents from Patstat and data on private R&D from the Community Innovation Survey (CIS). The Eurostat website doesn't provide a breakdown by ownership status for most countries, thus calculation of indicators on private R&D required accessing the non-anonymised firm-level data at the Eurostat Microdata Safe Center in Luxembourg.

Internationalization in Publications

As one indicator for internationalization of research the co-publications with foreign co-author as a share of all publications is used. In comparison to large or medium size countries, the small countries show a high level of internationalization; the smallest countries being most involved in international collaboration (Luxembourg, Iceland, Malta and Cyprus).

In Luxembourg, depending on the field of science altogether 70-90% of all publications have a foreign co-author, in Iceland and Cyprus the share is 70%, whereas in Estonia, Latvia, Malta and Slovenia the share is 40-55%. In the level, the small countries aren't lagging behind their larger counterparts, but some of them are worryingly diverting from the international trend. Despite the overall increase in international co-publications, their share in Cyprus, Estonia, and Latvia seems to be decreasing in 2001-08.

¹ This work was conducted in the FP7-funded ERA-PRISM project (www.eraprism.eu) aiming at addressing the need to develop more effective R&I policies for small EU member states, the countries include Cyprus, Estonia, Latvia, Luxembourg, Malta and Slovenia, outside the EU Iceland.

The data allows for a breakdown of co-publications by the country of affiliation of the foreign co-author). In Malta the origin of co-authors' institution is more highly concentrated to one country than in any other small country. Due to historical reasons the co-publications of Maltese and UK labs are most common. The Cypriot researchers co-publish most often with institutions located in Greece, US and UK. In Estonia, most frequently the joint publications are written together with the Swedes or Finns. Especially, in the 2000's it hasn't been uncommon for the Estonians to receive their graduate/post-graduate degrees in Sweden or Finland which are located within geographical proximity and Finland also within linguistic proximity. In Latvia the most common institutions affiliations of the international co-authors are Germany, Russia, US and Sweden. In Luxembourg, the co-authored publications are typically joint works with labs from the neighboring countries. Reason might be related to the fact that the majority of the Luxembourg-based researchers come from the neighboring countries and they have kept or established close ties with their compatriot researchers. Slovenia is one of the three small countries in which the US is the most common origin of co-authors' institution; the second most common origin is Germany and third Italy. In Iceland, the order is US, Sweden and UK. The Icelandic researchers often have studied in those countries from which their co-authors originate; besides the above listed these include Denmark and Norway. Icelandic people are driven to those countries by geographical and linguistic proximity. Overall, there seems to be at least two different patterns to leading to international co-publications: Firstly, sending young people to study at foreign universities, since by their return they have developed extensive networks to be deployed in home countries. Secondly, hiring foreign researchers with existing networks in their home countries will bring similar benefits. United States is regarded as the super power in science, which makes the US-based researchers coveted collaborators. Among the small countries, Cyprus, Iceland and Slovenia have a significant share of all their co-publications with the US institutions. Even among the European countries Cyprus and Slovenia show top performance at the European level. As a general rule, small countries collaborate preferentially with other EU countries. Their level of collaboration with US is lower than in larger EU countries. In small countries, the roles of geographical proximity, historical heritage & language proximity are probably more pronounced.

Another measure applied is the affinity index which is defined as the observed bilateral joint publications divided by expected/potential bilateral joint publications. The results show expected country pairs with high affinity: Cyprus and Greece; Slovenia and Croatia; Latvia and Lithuania; Estonia and Finland. A bit lower affinity is noted in the following pairs: Iceland and Norway; Iceland and Denmark; Luxembourg and Belgium.

Internationalization in Patent Applications and Joint Inventions

There are clear differences in co-patenting and co-inventing behaviors. Overall, listing two or more inventors in a patent application is more common than having at least two persons/institutions applying for a patent. It seems that the small countries can be divided into two groups regards the frequency of co-inventions. In Cyprus, Luxembourg and Malta less than 55% of patent applications to the European Patent Office were based co-inventions, whereas in other countries the figures exceeded 65%. Co-applications and co-inventions were more common in Latvia and Estonia than in other small countries.

In Cyprus, joint inventions with the US citizens are most common but co-patenting is equally common with Chinese and Dutch. In Luxembourg co-inventions are typically developed with residents of the neighbouring countries or US residents. Co-applications for patents are submitted most often with US citizens or Germans, whereas the joint inventions are most often developed with Germans. Latvians invent together with Swedes, German and Britons, but submit co-applications for patent with Finns, Dutch or Russians. In Slovenia co-inventions are created mostly with Germans and to a lesser extent with Austrian and US citizens, however, joint patent applications are submitted with Germans. In Estonia, the co-inventions are most

common with Germans, but there is no country of origin overriding the others in co-applications. In Iceland co-inventing is most common with the US citizens, and Israel residents, whereas co-patenting typically occurs with Americans.

Internationalization of Business R&D

The aim is to see how common the most direct forms of internationalization in the small countries are. In addition, some measures on the differences between domestic and resident foreign enterprises will be presented. Benefits of internationalization for enterprises are often linked to opportunities to broaden knowledge and skill pool, have access to new or other type of technology, equipment, and other resources (capital, funding). More indirect effects come in the form of spillovers, knowledge and technology transfers. At national level internationalization means e.g. inward and outward investments in R&D, rotation in the pool of enterprises engaged in R&D and mobility of highly-skilled labor force. At the firm-level, potential forms of internationalization include e.g. relocated and outsourced R&D activities, R&D cooperation with resident and non-resident foreign companies/research organizations/universities, recruitment of R&D staff from abroad and acquisition of knowledge/intellectual property from abroad. For a domestic enterprise operating in a small innovation system access to the knowledge creation system of a multi-national enterprise plays a significant role since that system may easily be larger than the domestic innovation system. This cooperation may take place either through cooperation with the resident foreign enterprises or enterprises located abroad.

A reason for the importance of the presence of and cooperation with foreign-owned enterprises in the small countries stems from the fact that the foreign enterprises have higher propensity to be innovative than the domestic ones. There is even an increase in the gap between the innovativeness of domestic and foreign firms in Luxembourg and Latvia in 2000-06. Furthermore, difference in innovation propensity between domestic and foreign enterprises is largest in Malta, Iceland and Latvia.

Intra-mural investments in R&D by foreign enterprises shouldn't be neglected either, although their level and trend vary a lot between countries. In 2006 in Luxembourg and Malta the foreign owned enterprises accounted for the majority of intramural R&D investments; in Estonia and Cyprus the shares were almost equal. In Iceland, Latvia and Slovenia the contribution by foreign enterprises was less than 13%. There are three observations in time available for Estonia, Luxembourg and Latvia showing that in the two first mentioned the shares have significantly increased in 2000-06, but in Latvia there is a slight decrease.

Border crossing knowledge flows are addressed using data on cooperation practices. Foreign enterprises' cooperation with domestic partners is taken as an indication of their embeddedness in the national innovation system. Cooperation with foreign partners by domestic firms is connected to their knowledge absorption skills and the width and depth of their networks. It seems that it is more common for foreign enterprises to cooperate with domestic partners than for domestic enterprises to cooperate with foreign partners. This observation holds true for all other countries except for Luxembourg where the domestic enterprises are more likely to cooperate with foreign partners than foreign enterprises to cooperate with domestic partners. Overall, the share of foreign firms cooperating with any type of Luxembourgish partners is relatively low. In other words, they seem to be searching for their place in the national innovation system.

The results so far suggest that in internationalization of research all the small countries are doing well or very well, but their performance in internationalization of private R&D is very diverse.