ABSTRACT

Title: Identification of embodied interindustry R&D spillovers across EU countries: a novel approach based on input-output structures

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Abstract:
This paper has a twofold purpose: firstly, we propose a new, relatively easy procedure to estimate flows of R&D spillovers between industries and countries. The procedure proposed here bases on the parameter-free radiation model presented in Simini et al. (2012) and the concept of interindustry technological proximity presented in Los (1997). While the radiation model was originally applied to predict patterns of human mobility (such as migration or commuting flows), it has been later applied to estimate economic flows, as in the production of the EUREGIO multi-regional input-output table for the NUTS2 regions of the EU. In the same spirit, we present a modification of this procedure to be applied to the estimation of the R&D activities embodied in goods and services. Secondly, we show by means of an empirical application how the method can be used to derive these flows for a given cluster of industries. Our case of study refers to the EU countries and we make use of the input-output flows available in the WIOD dataset, together with indicators of investment and stock of R&D activities as reported in the EUKLEMS database.

The basic ideas of the research presented here lies in two interrelated concepts, in no particular order. The first one is a measure of inter-industry technological distance *a la* Jaffe (1986), who introduced the concept of a ‘potential spillover pool’. This consists of all knowledge that cannot be appropriated by the firms that have generated this knowledge. The public knowledge in the pool is accessible to every firm in the economy. However, not all knowledge is relevant to every firm. For instance, recent insights concerning the air streams around aircraft wings is likely to have no impact on the R&D efforts of a wooden furniture manufacturing firm, while a producer of trucks may think of new opportunities to lower their drag. The more similar two firms’

technological activities are, the more they may benefit from each other's public knowledge. As in Coe et al. (1997), given the nature of the (macro) data analyzed, this measured has been modified (as in Los, 1997) to capture interindustry instead of interfirm knowledge spillovers. The structure present in an input-output table enables a straightforward application of such an idea, since a column of an input coefficient matrix derived from an input-output table is a strongly simplified representation of the corresponding industry's technology, giving the amounts of the various inputs needed to produce one value unit of that industry's output. Therefore, similarity measures of two industries' production technologies can be derived from such columns.

The second relevant concept, interrelated with the previously described indicator of inter-industry technological distance, is the application of the radiation model to predict inter-industry R&D flows. We present an adaptation of this model as an alternative to other methods to estimate these technological flows. Radiation models that have been recently purposed to describe human mobility patterns (see Simini et al., 2012; and the extensions presented in Liang et al., 2013; Ren et al., 2014; Yang et al., 2014; or Kang et al., 2015). These models belong to the type that use the concept of intervening opportunities as a measure of the transaction frictions that define C_{ij}. In these models (see Stouffer, 1960; Wills, 1986; or Guldmann, 1999) C_{ij} is determined by the number of opportunities encountered between locations i and j, which are related -but not necessarily equal- to the physical distance or the travel time between them. Radiation models can be framed within this approach, since the measure of impedance S_{ij} between locations i and j is defined as the sum of masses (opportunities) P_k located within a circle centered on i with radius equal to the physical distance -or the travel time- to j. In other words, $S_{ij} = \sum_{k \neq i,j} P_k$ can be interpreted as the sum of opportunities in all the alternative destinations to j that could be reached from i at equal or less physical distance -or time-. Note that the mass and position of the other neighbor locations to i and j play a role in determining the value of S_{ij}. As a consequence, oppositely to the general convention on gravity-type models where T_{ij} is assumed to be equal to T_{ji}, S_{ij} is not necessarily equal to S_{ji} in heterogeneous spaces.

The basic formulation of this model predicts the flux from i to j as:

$$M_{ij} = \rho_i \frac{P_i P_j}{[P_i + S_{ij}][P_i + P_j + S_{ij}]}$$

Where M_{ij} is the flux from location i to location j and ρ_i is an observable scaling parameter measuring the total number of fluxes departing from i. Recent literature has evaluated the capacities of this model for fitting and predicting human mobility patterns, finding not unanimous results: while some authors find that the radiation approach outperforms gravity-based models for explaining migration or road trips (Ren et al. 2014; Simini et al. 2012), others conclude that some form of a gravity law is superior regarding the prediction of commuting flows, specially for short distance trips (Lenormand, Bassolas, and Ramasco 2016). The research presented in this paper modifies these concepts related to human mobility to the specific field of inter-industry relations.

Finally, the empirical application of our analysis requires of an appropriate database with the structure of an input-output matrix. For this purpose, we use the EU-KLEMS database combined with the World Input Output Data (WIOD) tables for the EU.[1]

[1] Details on the database can be found in Timmer et al. (2015).

WIOD is a time-series of national and inter-country input–output tables that are connected with each other by bilateral international trade flows. The available time series in the most recent release of WIOD contains data for the time span 2000-2014, including all the EU-27 countries (plus United Kingdom) and most of the relevant economies out of the EU (such as the US, Japan or Brazil). It provides a comprehensive summary of all transactions in the global economy between industries and final users across countries with a sectoral breakdown into 56 industries.

Our analysis will base on a multiregional (multi-country) input-output (MRIO) framework that is comprised of *C* spatial units, where each country comprises of *N* sectors identically defined across them. The MRIO analysis framework begins with the following accounting balance of monetary flows $x_j = \sum_i z_{ij} + lc_j + w_j + m_j$, where **x** is the output matrix formed of M vectors $\mathbf{x}^s$ (*n x 1*) that represent the gross outputs of country *s*. Matrix **y** is formed of M vectors $\mathbf{y}^{sr}$ (*n x 1*), that denotes the final demand of country *r* for products from country *s*. Block matrix **Z** contains diagonal matrices $\mathbf{Z}^{rr}$ (*n* x *n*) that indicate the intermediate input flows among industries within the same country and off-diagonal matrices $\mathbf{Z}^{sr}$ (*n* x *n*) whose elements z_{ij}^{sr} (*i, j=1,…,n*) represent the value of sales by industry *i* in the country *s* to industry *j* in other country *r*. The structure of the available WIOD database allows to be consistently assembled with the sectoral estimates of R&D stocks and R&D investment at industry level in EUKLEMS, which allows for applying the proposed methodology for the estimation of R&D flows.

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