METHODS OF INDIRECT ESTIMATION OF THE INNOVATIVE DEVELOPMENT INTENSITY

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Abstract

This paper outlines the methods that can be used to estimate the intensity of the indirect innovations. Two approaches are presented: a) estimation based on technological flows matrix; b) Leontief approach, based on the "input-output" table.

1 Introduction

In the context of economic globalization, technology is the key to economic growth and competitiveness in business. Companies under the conditions of intensive development are more innovative, win new markets, use the available resources more efficient, can offer employees a higher reward. High-tech industries expand most in the area of international trade and their dynamics can improve the performance of other sectors. In order to analyze the impact of the technology to other industrial processes and build special international classification criteria it is important to be able to identify those sectors and products that contribute most.

2 Assessment based on technological matrix flow

The input-output database splits the transaction flows between industries by domestic and imported flows. In addition, components of gross fixed capital are distinguished by the originating industry and are available separately for domestic and imported flows. Based on these accounts, an input-output model to measure the total innovative development intensity can be described in the following way: The innovation flows, embodied in domestic intermediate product purchased by industry j from industry i, can be obtained via:

\[ RII_{ij}^d = \frac{X_{ij}^d}{X_i} \]

\[ R_i = X_{ij}^d R_i X_i \]

where \( X_{ij}^d \) represents the quantity of output of industry i purchased by industry j, \( X_i \) the total sales of industry i, and \( R_i \) is the own own innovative cost of industry i. \( \frac{R_i}{X_i} \) is the innovation intensity for sector i per unit of gross output of sector i.
Although it is very important to take lags of innovations into account (on average 2-3 years in previous work) and to develop better indicators for the products technological content (e.g. estimation of innovative stock), for now only the current innovative costs have been used to estimate the embodied innovative flows for the particular year. Nevertheless, the inclusion of these omitted parts will be considered in the near future. Innovations embodied in the purchased domestic fixed assets, similar to the innovation embodied in the capital equipment purchases by industry j from industry i, RINV dij, can be shown as:

\[ RINV^d_{ij} = INV^d_{ij} R_i X_i, \]

where \( INV_{ij} \) - the sales of capital good from industry i to industry j in a particular year, \( R_i X_i \) - on innovative cost per unit cost of production sector i;

For a particular country the innovation embodied in imported intermediate inputs i purchased by industry j, will be calculated by using:

\[ RII^m_{ij} = X^m_{ij} \left( \sum_k \alpha_{ik} \frac{R_{ik} X_{ik}}{X_{ik}} \right), \]

where \( X^m_{ij} \) - the demand for the imported intermediate input of product i by the industry j and \( \alpha_{ik} \) - the import share of the country k. This indicator can be also split by the country of origin of the innovation d) Innovation embodied in the purchased imported investments goods. In a similar way, innovations, embodied in the imported fixed assets purchased by the industry j from abroad can be calculated by:

\[ RINV^m_{ij} = INV^m_{ij} \left( \sum_k \alpha_{ik} \frac{R_{ik} X_{ik}}{X_{ik}} \right). \]

Finally, the total innovative gains of the industry j can be obtained by summing up these indirect innovative embodiments across all sectors, plus own innovative expenditures of the industry j itself:

\[ RT_j = R_j + \sum_i RII^d_{ij} + \sum_i RII^m_{ij} + \sum_i RINV^d_{ij} + \sum_i RINV^m_{ij}. \]

In the above equation, the diagonal elements of each matrix are eliminated in order to avoid the double counting of own innovations and innovations of other industries. The first term of this equation shows the amount of the direct innovations, and the other three terms describe the indirect innovations embodied in the industry j-s purchase of either intermediate products or fixed assets purchased domestically and from abroad. The intensity version of these indicators, i.e. innovation embodiment per output, can be simply calculated by dividing each term of the above equation by the industry’s output Xj. Other indicators such as the ratios of direct/indirect innovations or domestic/imported innovations have also been calculated.
**Leontief inverse approach**

The balance equations of gross output in an open static input-output system for domestic flows can be written as:

\[ X = A^d X + S^d I + F^d + E, \]

where \( X \) - the vector of gross outputs, \( A^d \) - the matrix of domestic input-output coefficients, \( S^d \) - the share matrix of private business investment, \( S^d_{ij} = I^d_{ij} / I_j \), \( I^d \) - the vector of total private business investment by sector of origin, \( F^d \) - final demand vectors of domestic output and imports exclusive of investment expenditures and \( E \) is exports vector. Investment costs are treated as exogenous in equations. From domestic balance equations, we obtain:

\[ X = (I - A^d)^{-1} S^d I + F^d + E \]

Defining the sectoral direct RD intensity as:

\[ r_i = \frac{R_i}{X_i}, i = 1, 2, ..m. \]

The vector of domestic total innovation embodiment, \( T^d \), can be defined by multiplying the diagonal matrix of industry innovation coefficients in the equation and obtaining:

\[ T^d = \hat{r} \left( I - A^d \right) \left[ S^d I + F^d + E \right]. \]

This equation shows that the total domestic innovations embodiment can be connected to each component of the domestic final demand and export. Based on this equation, the total domestic innovations embodiment per unit of final demand for industry \( j \) can be defined as the \( j \) column sum of the above coefficients matrix:

\[ r_{fj} = \sum_{i=1}^{n} r_i b_{ij}, j = 1, 2, ..n, \]

where \( b_{ij} \) are the elements of inverse \( B = \left( I - A^d \right)^{-1} \).

The calculation of total innovations embodiments in purchased intermediate goods for industry \( j \) is slightly different from the above equation, because it is based on final demand and not on the industry’s output. In other words, it shows how much innovation is embodied into one unit of final demand for output \( j \), not how much innovation is embodied in output \( j \). The industry’s innovations embodiment addresses the latter question. Innovation embodied in purchased domestic capital goods for industry \( j \):

\[ r_{inv}^d_j = \sum_{i=1}^{n} r_i \left( \sum_{k=1}^{n} b_{ik} S^d_{kj} \right). \]
Innovation, embodied in purchased imported intermediate inputs for industry j (k-indicates country):

\[ rii_j^m = \sum_{i=1}^{n} \alpha_{ij}^m \sum_{k=1}^{n} (\alpha_{ik}r_{jk}^d) . \]

Innovation, embodied in purchased imported capital goods for industry j (k indicates country):

\[ rinv_j^m = \sum_{i=1}^{n} \beta_{ij}^m \sum_{k=1}^{n} (\alpha_{ik}tinv_{ik}^d) . \]

*Total innovation Embodiment for industry j*

\[ rt_j = r_j + rii_j^d + rinv_j^d + rii_j^m + rinv_j^m . \]

The first term describes the line, and the following four - indirect innovative component for industry j.

3 Findings

These approaches to the evaluation of the industry innovations can extend the intensity concept definition, from taking into account only the level of innovation and characteristic of the industry (the ratio of innovations costs), to validating also the innovative technology embodied in the intermediate goods and fixed assets purchased by the industry.

References


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