Structural Change and Economic Dynamics 22 (2011) 227–237

Contents lists available at ScienceDirect

Structural Change and Economic Dynamics

journal homepage: www.elsevier.com/locate/sced

On indirect trade-related R&D spillovers: The "Average Propagation Length" of foreign R&D☆

Chiara Franco[a], Sandro Montresor[a,*], Giuseppe Vittucci Marzetti[b]

[a] Department of Economics, University of Bologna, Strada Maggiore 45, 40125 Bologna, Italy
[b] Department of Sociology ad Social Research, University of Milano-Bicocca, via Bicocca degli Arcimboldi 8, 20126 Milan, Italy

ARTICLE INFO

Article history:
Received July 2010
Received in revised form April 2011
Accepted April 2011
Available online 7 May 2011

JEL classification:
C23
F01
O30
O47

Keywords:
Average Propagation Length
International R&D spillovers
Total Factor Productivity

ABSTRACT

The paper estimates the impact on Total Factor Productivity of trade-related R&D spillovers by accounting for the economic distance between countries. The Average Propagation Length foreign R&D covers to reach a domestic country is used in building the foreign available R&D stock and to estimate its TFP impact vs. that of the domestic R&D stock. With respect to 20 OECD countries in the period 1995–2005, the impact on TFP of the available foreign R&D stock is greater than that of the domestic one. Results support the models that recognize indirect trade-related R&D spillovers and provide for them a more accurate interpretation.

1. Introduction

The role of international trade in conveying technology flows across countries has been both theoretically elaborated and empirically supported. A considerable number of papers on the so called "trade-related Research & Development (R&D) spillovers" has cumulated over the last twenty years (extensive surveys are Keller, 2004; van Pottelsberghe de la Potterie, 1997). A recent development of this research stream is the "indirect" nature of R&D spillovers via-trade. In brief, the idea that these spillovers can occur between two countries also *through* intermediate ones, even if they are not trading partners (Lumenga-Neso et al., 2005). A brief example, adapted from Lumenga-Neso et al. (2005, p. 1787), could help in clarifying the point. Suppose we have a simple World of just 3 countries: Belgium, the Netherlands and the US; and that while the Netherlands trade with both Belgium and the US, Belgium does it with the Netherlands only. In the standard R&D spillovers framework, that would entail the US technological knowledge

☆ The three authors contributed equally to the paper and share Sections 1 and 6. Still, Section 5 could be attributed to Chiara Franco; Section 2 to Sandro Montresor; Sections 3 and 4 to Giuseppe Vittucci Marzetti. The authors are grateful to the participants of the 2009 International Input–Output Conference (San Paulo, Brazil, 13–17 July 2009), of the 50° Riunione Scientifica Annuale della Società Italiana degli Economisti (SIE) (Rome, Italy, 22–24 October 2009), of the 2009 EAEPE conference (Amsterdam, The Netherlands, 6–8 November 2009) and to Erik Dietzenbacher, Francesco Lissoni, Bart Los and Markus Eberhardt, in particular, for their comments on earlier versions of this paper. The authors also thank two anonymous referees for their suggestions. All the three authors gratefully acknowledge financial support by the Autonomous Province of Trento, as the sponsor of the OPENLOC research project. Giuseppe Vittucci Marzetti also gratefully acknowledges the Autonomous Province of Trento for his post-doc scholarship (Grants 2006: FIC). Usual caveats apply.

* Corresponding author. Tel.: +39 051 2092651; fax: +39 051 2092670.
E-mail addresses: chiara.franco2@unibo.it (C. Franco), sandro.montresor@unibo.it (S. Montresor), giuseppe.vittucci@unimib.it (G. Vittucci Marzetti).

0954-349X/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.strueco.2011.04.003

diffuses through trade to the Netherlands only, *directly*. However, some of the US *produced* knowledge would reach Belgium too, *indirectly*, being *available* in the Netherlands.

This idea represents for us an important, although not yet fully recognized, development of the literature on the international diffusion of technology (e.g. Eaton and Kortum, 1999). Not only does such a diffusion depends on the "geographical" distance among countries, as the bulk of the literature retains (e.g. Keller, 2002). But it also depends on what we call the "economic" distance between them, in terms of "trade-rounds". This adds a further dimension to the manifold notion of "proximity" in economic studies (Boschma, 2005). Indeed, technology diffusion between two geographically close countries, could be weakened (or magnified) by the fact that they are distant (or close) economic partners.

The aim of the paper is to provide a measurement of this economic distance between countries, and to evaluate its impact on the international diffusion of R&D through trade. In order to do that, we refer to the input–output idea of *Average Propagation Length* (APL) (Dietzenbacher et al., 2005) – of a final demand or value added shock – and we extend it from its original, domestic intersectoral setting to an inter-country, aggregate one. More precisely, a country-by-country APL matrix is built up by drawing on their bilateral imports. Such a matrix is then used to weigh the domestic R&D expenditures which become *available* abroad and to obtain a more accurate measurement of the relative stock. Finally, the impact on Total Factor Productivity (TFP) of this available R&D stock is estimated for 20 OECD countries over the decade 1995–2005, and compared with that of the R&D stock produced by them domestically and by their direct partners only.

The paper is organized as follows. Section 2 reviews the literature on trade-related R&D spillovers and distinguishes direct from indirect foreign R&D spillovers. Section 3 re-frames the notion of "indirect" R&D spillovers and defines the inter-country APL as a measurement of the economic distance between countries. Section 4 discusses the econometric model and its empirical specification. Section 5 presents the econometric results. Section 6 concludes and illustrates some future research lines.

2. Trade-related R&D spillovers: direct vs. indirect

Trade-related R&D spillovers are technology flows which diffuse across countries through their import-export relationships. For this reason they are retained an "embodied" kind of flows. In brief, by investing in R&D, exporting firms introduce in traded commodities ameliorations and improvements, which are "embodied" in them and make the related knowledge circulate across countries. What is more, the exporting firms are unable to fully charge the importing firms for this incorporated knowledge, thus allowing them for a "rent R&D spillover" (Griliches, 1979, 1992).

Trade-related R&D spillovers are inherently diverse from those occurring through Foreign Direct Investments (FDI) (van Pottelsberghe de la Potterie and Lichtenberg, 2001). By making R&D investments abroad, Multi-National Corporations (MNC) create new technological knowledge which partially spillovers on the firms of the host-country. This occurs even in the absence of an underlying market transaction between MNC and local firms (as different from a simple interaction): that is, in a "disembodied" way. The fact that knowledge is non fully appropriable is enough to have "pure knowledge" spillovers.[1]

International R&D spillovers have been investigated also with respect to other disembodied flows. Following the method proposed by Jaffe (1986), pure knowledge spillovers have been mapped by looking at the technological similarity between sectors, as captured by cross-patent citations in technology-flow matrices (e.g. Verspagen, 1997). Patent citations have been also used to investigate the role of geographic distance in driving the impact on TFP of domestic vs. international spillovers (e.g. Jaffe et al., 1993), controlling for the absorptive capacity of the recipient country (Mancusi, 2008), the origin of R&D funding (Guellec and van Pottelsberghe de la Potterie, 2004), and other characteristics of the institutional set-up. Recently, increasing attention has being devoted to the role of information technology in international R&D spillovers and productivity growth (Tang and Koveos (2008), for example, use international telephone traffic as means of disembodied R&D flows). A survey of the massive literature on the topic is out of this paper's reach (for a review see Saggi, 2002). However, overall it seems to us that, at least in the OECD area, bilateral trade is still an important channel for international R&D spillovers, especially vs. FDI, whose impact is instead relatively small (Zhu and Jeon, 2007, p. 955). Accordingly, trade-related R&D spillovers deserve more careful investigation (Bitzer and Geishecker, 2006), a research stream along which this paper places.

Once identified as an important channel of international technology diffusion, trade is also a potential driver of economic growth (e.g. Jacob and Los, 2007). In particular, it enables innovation to flow across countries, for example via the increase in the number and quality of intermediate inputs (Grossman and Helpman, 1991; Peri, 2005). Accordingly, the foreign R&D stock of a country can be expected to impact on its TFP as well as its domestic one.

The issue then becomes an empirical one, in which an accurate index of the foreign trade-related R&D capital stock (hereafter foreign R&D stock) has to be worked out. This is a research question which Coe and Helpman (1995) (CH hereafter) for first addressed by suggesting to equate the foreign R&D stock of a certain country to the

[1] One might just think of those spillovers which pass through "demonstration effects" of the new technology by the MNC to the local firms, or through the "employment effects" related to the local workforce training and mobility. Different is instead the case of those spillovers which pass through the vertical (both backward and forward) and horizontal linkages MNC have with the domestic suppliers-clients and competitors, respectively. In the presence of an underlying market transaction, the disembodied flows actually combine with embodied, rent ones. A certain combination can be traced also with respect to trade, where disembodied spillovers can add to embodied ones by considering that international trade can simply "expose" the foreign knowledge to the importing country (van Pottelsberghe de la Potterie and Lichtenberg, 2001) Still, unlike trade-based, FDI-based R&D spillovers should be considered for us disembodied flows (e.g. Kim and Lee, 2004), rather than embodied ones, as some authors claim (e.g. Tang and Koveos, 2008).