International R&D Sourcing and Knowledge Spillover: Evidence from OECD Patent Owners*

Sophia Chen† Estelle Dauchy‡

April 2015

Keywords: R&D Spillover, Patent, R&D tax incentives, Firm productivity
JEL: O3, H25, E22

Abstract

The effect of knowledge spillover for resident companies from international R&D activities has been scarcely studied because of data limitations and because knowledge spillover is traditionally viewed as being generated from inward foreign investment. This paper is the first to evaluate empirically international knowledge spillovers from outward R&D in OECD countries. Our estimations also offer a new way to measure a country's position in a network of international knowledge influence links, based on inward and outward, bilateral and multilateral knowledge spillovers. We deal with the potential endogeneity issue of the innovation location decision in various ways, using several instruments including pre-sample patent applications—directly or indirectly owned—and R&D tax incentives. We find that foreign spillover effects are positive and significant overall. There is a large variation between countries.

*We thank Alexey Khazanov and Alexander Tonis for great research assistance. The views expressed in this paper are those of the authors and do not necessarily represent those of the IMF.

†ychen2@imf.org. Research Department, International Monetary Fund, Washington, D.C., USA

‡edauchy@nes.ru. New Economic School, Moscow, Russian Federation

1 Introduction

Most countries acknowledge that innovation is key to sustainable long-term growth. The Great Recession has reinforced existing trends in OECD countries towards an increased support to innovation. While most OECD countries still suffer from slow growth and significant fiscal constraints, they remain committed to invest resources in R&D activities, including direct public spending and support for business R&D. The most prevalent type of tax incentives for business R&D has been to reduce the cost of R&D spending. Such incentives widely vary across countries and include R&D tax credits, accelerated depreciation of capitalized R&D or physical assets used in research, additional expensing of R&D or current assets used in research [Guellec and Wunsch-Vincent, 2009].[1]

One important justification for policy support to private R&D spending is the social return it generates from spillovers across businesses.[2] In order to evaluate the effects of R&D policy, it is essential to understand the eco-

[1]Since 2000, income-based tax incentives have also emerged in several countries as a way to encourage domestic investment and ownership of innovative assets and mitigate tax-induced distortions such as profit shifting [Evers and Spengel., 2013, 2014]. For example, since 2000 twelve countries including eleven OECD countries have adopted intellectual property box regimes.

[2]Economists generally agree that public support to R&D is justified because privately financed R&D investment is likely to be too low and not optimally allocated across innovative assets: R&D investors fail to account for backward—to other producers,—and forward—to consumers—knowledge spillovers [Grossman and Helpman, 1993, Romer, 1990]. R&D investors also fail to internalize losses they impose on previous innovators and social costs of duplicated research, suggesting that privately financed R&D investment may also be too large or not optimally targeted [Aghion and Howitt, 1992, Jones and Williams, 2000].

nomic impact of knowledge spillovers.[3] Despite the large body of research on innovation and knowledge spillovers, an important question remains largely unanswered, namely, can knowledge spillover occurs through corporate R&D investment of firms in foreign countries?[4] If so how does it compare to spillover effects from domestic R&D activities? This paper fills this gap by providing a comprehensive evaluation of inbound and outbound, bilateral and multilateral, cross-border knowledge spillovers from R&D activities among OECD countries.

Our paper is closest to Griffith et al. [2006]. They estimate the domestic spillover effects generated by British firms that directly invest in R&D in the United States and find that it is significant and large. Their finding supports the view that conducting R&D activities abroad (i.e., "technology sourcing") is an important method of gaining access to foreign knowledge. Our approach differs from Griffith et al. [2006] in important ways. First, while they investigate a unilateral spillover effect, namely the domestic spillover effect in the

[3]Wieser [2005] reviewed several studies that estimate the private and social impact of R&D performed by firms, and finds that although the private returns are large (between 7 and 69 percent in terms of productivity growth), the social returns of R&D (including private returns and spillovers) are much larger, up to two to three times the size of the private returns (see Swensson [2008] for a detailed review of the literature on the impact of R&D on growth). There is also evidence that the spillover effects vary across sectors, and may be larger between industries than within industries [Swensson, 2008].

[4][Aghion and Howitt, 1992, Griliches, 1992, Jones and Williams, 1998, 2000] show how to estimate social rates of return under endogenous innovation. Using growth accounting in a neoclassical framework, Griliches [1973] calculates total factor productivity growth and show that the coefficient in a regression of TFP on R&D intensity (measured by the R&D/GDP ratio) provides an estimate of the social return to R&D. Jones and Williams [1998, 2000] Their results suggest that the large social returns reported in the empirical literature [Griliches, 1992] are lower bounds, and that net social gains of private R&D are relatively high.

UK of outbound and inbound innovative investment with respect to the US, we estimate the complete network of bilateral spillover links between OECD countries. To do this, we use a rich database on companies and patents in OECD countries obtained from ORBIS and evaluate the average spillover effects from 2008 to 2011.[5] Second, we also aim to improve the identification strategy by using a wider set of instruments for the proxy used to identify the location decision of innovative assets. The standard model of the firm is such that a firms' location decisions directly affect foreign spillover effects in firms' production function. We use current patent weights as a proxy for domestic and foreign activities, as in Griffith et al. [2006], but with two important differences. The first difference is that our patent weight is not based on a *partial* multinational group (i.e. two countries only), but the group of all OECD (or worldwide) subsidiaries with the same global parent. The second important difference is that we divide this contemporary patent weight in two parts—direct and indirect. *Direct* patent ownership includes patents directly filed by a publicly traded global parent, either domestically or in other countries. *Indirect* patent ownership includes patents filed by domestic or foreign subsidiaries owned by the same publicly traded global parent. To the extent, for instance, that parents have more decision and monitoring power over directly filed patents than over patents indirectly owned by their subsidiaries, we may expect that domestic spillover effects of these two types of outward

[5]Although we estimate the spillover effect for every year from 2008 to 2011, our preferred approach is to use an average effect to limit the extent of measurement error and diffuse the effect of potential remaining outliers.

innovative investments differ. We test this hypothesis in various ways (e.g., by grouping foreign countries along location characteristics), in addition to calculating a total foreign effect. Also, although our list of subsidiaries only includes firms majority owned by a parent, subsidiaries are simultaneously partially owned by other global parents, in which case one may expect indirect spillover effects to be more diffuse than direct spillover effects.[6] Third, as in Griffith et al. [2006], we use past patent weights—observed from 1976 up to 10 years before the contemporary measure—as instruments for current location weights, the main difference being that, as for contemporary patent weights, we divide pre-sample patent weights into direct and indirect weights and use patents filed by the group in all OECD countries (or worldwide) to calculate these weights. Last, but not least, we construct another instrument for location weights: we collect detailed countries' tax law information since 1998 to calculate the total cost of R&D in each OECD countries and 20 industries.[7] Although this instrument is based on tax policy, hence more likely to be exogenous contemporarily, we use past values of the cost of R&D, averaged over 5 years from 1998 to 2002.[8]

We find strong evidence for a positive effect of international knowledge

[6]Orbis defines majority ownership as being directly or indirectly owned by a global parent by an ownership share of 50 percent or more.

[7]Tax law information involved a significant amount of data collection related to tax parameters in all OECD countries since 1998, including R&D tax credits, accelerated depreciation of R&D-related physical assets, extra expensing of current R&D spending and specific incentives for R&D employees, and top corporate tax rates. This information was gathered from various sources including Ernst & Young, Deloitte, and the OECD.

[8]We believe that using an average measure of the cost of R&D based on past tax law is less likely to suffer from the potential endogeneity of *tax system picking*.

spillovers. Our findings suggest that *domestic* spillover effects of foreign-based R&D spending are often larger that the spillover effects of domestic-based R&D, although there is a large variation across countries. On average, technologically less advanced countries benefit more from foreign-based R&D activities. We also find that the results are very sensitive to calculating the location weight using 2 countries only (as in [Griffith et al., 2006]) or calculating the total patent weight (i.e., based on all OECD countries), which suggest that unilateral estimates of international spillover effects from the previous literature, although informative, suffer from potentially large measurement error. In addition, we find that direct spillover effects significantly differ from indirect spillover effects. It also appears that the use of both indirect and direct past patent weights as instruments for current patent weights significantly improves the first stage. The second instrument based on the tax-cost of R&D also performs well, but not as much as past patent weights.

Our results imply that optimal policy design aimed to stimulate R&D investment should take into account businesses' incentives to locate innovative assets abroad. [9] Most recent estimates by the OECD suggest that the intensity of combined direct and indirect public support to business R&D has significantly increased since 2005 [OECD, 2012].[10] When evaluating the

[9]Other papers have approached the related question of whether the usual belief that foreign direct investment by domestic firms abroad negatively affects domestic activity is justified. Among them Desai et al. [2009] find the novel and interesting result that FDI by US multinationals abroad positively and significantly affects domestic employee compensation and investment.

[10]In 2009, 26 out of 34 OECD governments provided fiscal incentives to promote business expenditures on R&D, compared to just 12 countries in 1995 and 18 in 2004. Many

effectiveness of R&D tax policy, social returns from international knowledge spillovers should also be considered.

countries, such as the United States, Spain, and Germany, rely more on direct support to business R&D.

References

Aghion, Philippe and Peter Howitt (1992) "A model of growth through creative destruction," *Econometrica*, Vol. 60, No. 2, pp. 323–51, March.

Desai, Mihir A., Fritz C. Foley, and James R. Hines (2009) "Domestic effects of the foreign activities of US multinationals," *American Economic Journal: Economic Policy*, Vol. 1, No. 1, pp. 181–203.

Evers, Helen Miller, Lisa and Christoph Spengel. (2013) "Intellectual property box regimes: Effective tax rates and tax policy considerations," *ZEW Discussion Paper No. 13-070*.

——— (2014) "Intellectual property box regimes: Effective tax rates and tax policy considerations," *International Tax and Public Finance*.

Griffith, Rachel, Rupert Harrison, and John Van Reenen (2006) "How special is the special relationship? Using the Impact of U.S. R&D spillovers on U.K. firms as a test of technology sourcing," *American Economic Review*, Vol. 96, No. 5, pp. 1859–75, December.

Griliches, Zvi (1973) "Research expenditures and growth accounting," in B.R. Williams ed. *Science and technology in economic growth*: New York: Macmillan.

——— (1992) "The search for R&D spillovers," *The Scandinavian Journal of Economics*, Vol. 94, pp. S29–47.

Grossman, Gene M. and Elhanan Helpman (1993) *Innovation and growth in the global economy*, Vol. 1 of MIT Press Books: The MIT Press.

Guellec, Dominique and Sacha Wunsch-Vincent (2009) *Policy responses to the economic crisis: investing in innovation for long-term growth*, Vol. 1: OECD, Paris.

Jones, Charles I. and John C. Williams (1998) "Measuring the social return to R&D," *The Quarterly Journal of Economics*, Vol. 113, No. 4, pp. 1119–35, November.

——— (2000) "Too much of a good thing? The economics of investment in R&D," *Journal of Economic Growth*, Vol. 5, pp. 65–85.

OECD (2012) "Science, technology and industry outlook 2012Tax incentives for R&D and innovation,"Technical report, Organisation for Economic Co-operation and Development.

Romer, Paul (1990) "Endogenous technological change," *Journal of Political Economy*, Vol. 98, pp. S71–S102.

Swensson, Roger (2008) "Growth through research and development - what does the research literature say?" *Research Institute of Industrial Economics, VINNOVA Report VR 2008:19*, December.

Wieser, Robert (2005) "Research and development productivity and spillovers: Empirical evidence at the firm level," *Journal of Economic Surveys*, Vol. 19, No. 4, pp. 587–621.