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World Institute for Development Economics Research

Research Paper No. 2008/100

R&D (Re)location

A Bird's Eye (Re)view

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November 2008

Abstract

The paper builds a framework for the analysis of research and development (R&D) offshoring and outsourcing that encompasses several strands of the economics literature. It surveys the predictions from key theoretical models advanced in the literature on international trade, foreign direct investment (FDI), economic geography, and innovation, and compares these with empirical evidence, at both country and firm level. The review first analyses the drivers and patterns of R&D (re)location, and the role played by knowledge spillovers in shaping such phenomena. It then looks at multinational firms' strategic behaviour vis-à-vis the implications of their locational choices for both home and host countries, and accounts for the time dimension of such decisions. Finally it addresses the impact that north–south and south–north R&D flows might have on growth and development, and on the innovation capability of countries.

Keywords: research and development, R&D, offshoring, outsourcing, multinational firms, home country, host country, north–south, knowledge spillovers

JEL classification: F23, L2, O3

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This study is published within the UNU-WIDER project on the Southern Engines of Global Growth, co-directed by Amelia U. Santos-Paulino and Guanghua Wan.

UNU-WIDER gratefully acknowledges the financial contributions to the research programme by the governments of Denmark (Royal Ministry of Foreign Affairs), Finland (Ministry for Foreign Affairs), Norway (Royal Ministry of Foreign Affairs), Sweden (Swedish International Development Cooperation Agency—Sida) and the United Kingdom (Department for International Development).

ISSN 1810-2611 ISBN 978-92-9230-154-5

Acknowledgements

The authors are grateful to James Markusen for valuable discussions on a previous version of this paper. We also thank Heloisa Marone and participants at UNU-WIDER's conference 'Southern Engines of Global Growth: Financial Flows and Capital Markets', held in Rio de Janeiro on 11-12 July 2008 for helpful comments. Mariagrazia Squicciarini gratefully acknowledges the financial support of Tekes, the Finnish Technology Agency (Grant number 40254/06), and thanks the participants in the Tekes-sponsored 'Globinno' project for helpful discussion. The usual caveats apply.

Acronyms

FDI	foreign direct investment
ICT	information and communication technologies
IPR	intellectual property rights
ISIC	International Standard Industry Classification
MNEs	multinational enterprises
NIS	national innovation system
R&D	research and development
TFP	total factor productivity

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Typescript prepared by Liisa Roponen at UNU-WIDER

1 Introduction

The world has historically witnessed an ever-growing movement of people and goods, and more recently of information. However, the pace and intensity experienced over the last century, and particularly after the ‘digital revolution’ (Zysman 2008), have lead to the creation of terms like globalization that aim to capture the breath and depth of such phenomena.

Technological progress and innovation, alongside trade liberalization in the form of reduction and elimination of tariffs and non-tariff barriers, have led to two seemingly antithetical phenomena: greater economic integration and the fragmentation of production (see Santos-Paulino and Thirlwall 2004). On the one hand, the growing mobility of physical, financial and human capital, as well as of intangible assets, has made countries and regions more economically integrated. On the other hand, the various components of a good or service are simultaneously produced in various locations, often geographically distant, for assembly before reaching their target markets. Depending on the organizational settings under which such multi-locational production processes take place, they are named offshoring and outsourcing.

Framed within this broader context, the present study focuses on the (re)location—that is, research and development (R&D) offshoring and outsourcing—of FDI in general, and R&D activities in particular. It aims at building an integrated framework by surveying several strands of the economics literature, encompassing both theoretical and empirical contributions. It systematizes key findings, identifies common features and existing divergences, and addresses the relevant research gaps emerging from the R&D offshoring and outsourcing-related literatures. The aim is to investigate the (re)location of R&D activities vis-à-vis the implications that globalization might have for research incentives to conduct R&D, and the impact R&D in turn might have on the broader competitiveness and growth of both firms and countries.

We refer to (re)location phenomena, as our analysis encompasses the outsourcing and offshoring of R&D units abroad, intended either to replace already existing labs, or to add to the current portfolio of R&D activities and research units that firms may have.

In our framework, offshoring is defined as activities or tasks performed in a country other than the ‘home’ country, defined according to where the headquarters are located. It can be conducted in-house, through foreign direct investment (FDI), or at arm’s-length, that is, by buying from suppliers located in a ‘host’ country (Yeaple 2006). Outsourcing refers, instead, to tasks or activities carried out by an unrelated party and under various contractual agreements, either in the headquarters country or elsewhere (Grossman and Rossi-Hansberg 2006).

Outsourcing, offshoring, and their overall implications have been widely contended. These phenomena have been addressed by a wide literature investigating, among others, the role of transaction costs, asset specificity, and incomplete contracts in guiding the firm’s decisions of whether to make or buy in locations at home or abroad. For countries and firms alike, both offshoring and outsourcing may constitute sources of competitive (dis)advantages, shape the terms of trade, and ultimately affect the global economy. This is especially true when the (re)located tasks are high-skilled or knowledge-intensive, as is the case of research and development (R&D).

In this context, R&D refers to activities carried out on a systematic basis with the aim to increase the stock of knowledge and to use this stock of knowledge to devise new applications (OECD 2002). Although the sources of innovation may vary greatly (von Hippel 1988; Dosi 1988a), R&D constitutes one of the fundamental determinants of innovation. In turn innovation affects productivity (Griffith, Harrison, and Van Reenen 2006), and productivity shapes competitiveness and growth (Krugman 1997).[1] Skills, both cognitive and non-cognitive (Heckman 2000), enable profitable innovation and contribute to determine economic performance, and the lack of the necessary skills represents the most important innovation obstacle at the industry level (Leiponen 2005).

Skill formation and, more generally, the creation, enhancement and accumulation of human capital and new knowledge should therefore be high on the agenda of all economic agents striving to grow and compete. The importance of investing in high-skilled knowledge-intensive tasks as R&D is twofold. Investing in R&D contributes to generate innovations. Alternatively, it develops agents' ability, whether individuals or firms, to identify, assimilate, and exploit the knowledge available in the environment (Cohen and Levinthal 1989), thus enhancing innovative ability.

An institutional framework facilitating innovation and its appropriability is also needed for economic agents to have incentives to invest in R&D and human capital. Technological progress, which is a primary source of economic growth, requires the existence of suitable conditions for the appropriability of (industrial) R&D and to support innovative activities in general. When this is not the case, agents under-invest (in new technologies) with respect to the social optimum (see Levin et al. 1987, and the literature that followed), thus hindering development and growth. The existence of appropriate intellectual property rights (IPRs), as well as their enforceability, is hence a necessary pre-condition for investing in R&D. Furthermore, IPRs protection and human capital formation need to be framed within a broader institutional context supporting innovative activities and technological progress within a national innovation system (NIS) (Lundvall 1992).[2] Evidently, the efficiency and effectiveness of any system, whether at the national or regional level, depend on and are moulded by the structural characteristics of the country/region considered, especially their factor endowment and development level.[3]

This is true when adopting a 'cross-section perspective', that is, considering all phenomena simultaneously, and when taking the time dimension into account. Interrelations and dynamic aspects are, in fact, susceptible to change economic, social, and political scenarios dramatically, as well as the understanding of their underlying determinants.

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1 'Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker (Krugman 1997: 11).

2 'Regional innovation systems' are called into cause if the geographical dimension considered is the region. See Braczyk, Cooke, and Heidenreich (1998).

3 Among others, financial, ethnic, religious, political, educational, and even colonial features (Acemoglu, Johnson, and Robinson 2001) may all contribute to shape the NIS. Although it would be interesting to take such aspects into account when studying R&D offshoring and outsourcing, they go beyond the scope of the present study.

A notable example of such changes in the global production and investment patterns is the recent economic performance of developing countries like China, India, and Brazil, and their engaging in more sophisticated production activities (see Puga and Tefler 2007; Hausmann, Hwang, and Rodrik 2007; Santos-Paulino 2008). These phenomena challenge the traditional assumption that knowledge creation is mainly or exclusively the domain of advanced economies. Recent evidence conversely suggests that developing economies strategically rely on skills and knowledge creation to grow and develop, and that these are not assets that are endowed with the developed countries only. This is why attention here is paid to the role of new players, especially from the 'south', in shaping global dynamics, and those of R&D in particular.

The remainder of the paper is organized as follows. Section 2 discusses R&D, its role and the relationship between R&D investments, innovation, and productivity growth. It also addresses the determinants, motives, and modes of R&D (re)location and R&D-related FDI, and draws a broad picture of the geography of foreign R&D that emerges. Section 3 briefly addresses R&D relocation (i.e., offshoring and outsourcing) from a macroeconomic perspective, and leads to the deeper microeconomic analysis carried out in section 4. This reviews R&D offshoring and outsourcing at the firm level, focusing on incomplete contracts, differences in productivity, and the various organizational settings that may arise. The role of the newcomers, especially of rapidly growing developing economies, is considered in section 5. Section 6 concludes, discusses the main policy implications of the analysis, and points out possible directions for future research.

2 Investing in R&D: why, how, and where?

R&D activities should accomplish two main functions: (i) to stimulate innovation; and (ii) to enhance absorptive capacity (Cohen and Levinthal 1989), thus facilitating the imitation of discoveries of others (Griffith, Redding, and Van Reenen 2004). With respect to the former, the empirical literature, mainly microeconometric studies in the tradition of the model by Crépon, Duguet and Mairesse (1998), generally finds that innovation output is significantly determined by innovation effort (e.g., Griffith et al. 2006), and that productivity is positively related to higher innovative output. As for the latter, evidence suggests that R&D enhances technology transfer (Griffith, Redding and Van Reenen 2004) and that it can affect productivity growth by facilitating the absorption of new technologies (Parisi, Schiantarelli, and Sembenelli 2006). Results hold at both the firm and the country level, and suggest that country industries that lag behind the productivity frontier may be able to catch up fast by heavily investing in R&D (Griffith, Redding, and Van Reenen 2004).

The analyses carried out at the macro level confirm these microeconomics results. Coe and Helpman (1995) empirically investigate the impact of both domestic and foreign R&D on a country's total factor productivity (TFP), and find that both home and foreign R&D benefits domestic productivity, the more an economy is open to foreign trade. Returns to R&D also appear to be high in terms of domestic output and international spillovers. Zhu and Jeon (2007) find (bilateral) trade and FDI to constitute important conduits for international R&D spillovers, although FDI impact on growth is relatively small. More recently, Coe, Helpman, and Hoffmaister (2008) provide additional evidence in support of the impact of domestic and foreign R&D stocks on TFP, even after controlling for human capital, and suggest that institutional differences importantly affect the degree of R&D spillovers and TFP. More generally with respect to the impact that inward FDI may have on the productivity of domestic firms, Haskel, Pereira, and Slaughter (2007) find a significantly positive correlation between a domestic plant's TFP and the foreign-affiliate's share of activity in that plant's industry, a fact that is consistent with positive FDI spillovers.

The possible impact of foreign R&D on growth and innovation of home and host countries has contributed to bring R&D (re)location to the centre of the debate on innovation policies and development strategies (OECD 2007b). Contributing to this debate, Iwasa and Odagiri (2004) and Griffith, Harrison and Van Reenen (2006) show that parent operations may be affected positively by overseas R&D geared towards technology sourcing, that is, that reverse technology flows associated with R&D FDI may exist.

Cai, Todo, and Zhou (2007) investigate the impact of multinational enterprises' R&D on local entrepreneurship and R&D activities in China's 'Silicon Valley', and find that the research activities of a certain industry's multinationals stimulate the entry of domestic firms into the same industry, and enhance the R&D activities of newly entering domestic firms. Conversely, multinational enterprises' (MNEs) production activities or domestic firms' R&D do not have such an effect, fact that is explained by the former being technologically more advanced than domestic firms.

Despite this evidence, which refers to both home and host countries benefitting from R&D (re)location, policymakers worldwide are worried about the possible effects of R&D internationalization. In particular, they are concerned about the possibility that their knowledge might be adversely affected because of R&D offshoring and outsourcing. To address these concerns, we first analyse the drivers and motives that push firms to locate R&D units abroad, and consider the global geographical patterns that emerge.

2.1 Drivers, modes, patterns and enablers of foreign R&D (re)location

Cost saving seems to be the primary motivation for sourcing (Squicciarini and Loikkanen 2008), whereas research joint ventures are mostly triggered by innovation, specialization, and the pursuit of cost and risk sharing (Adams and Marcu 2004; Narula and Duysters 2004). The computer and information technology revolution has facilitated R&D (re)location by contributing to rapid technological change, with increases in the pace of technological change inducing increases in outsourcing in the home country as well as offshore. Both theoretical modelling and empirical evidence suggest, in fact, the existence of a positive correlation between the IT level of the user and its outsourcing share of IT-based services (Bartel, Lach, and Sicherman 2005). Better IT-based communications are also likely to increase the pace and extent to which R&D is outsourced and offshored, since the equilibrium share of R&D located abroad depends, among other factors, on the efficiency of international knowledge transfer (Belderbos, Lykogianni, and Veugelers 2008). Minimizing communication costs may thus reduce spatial and cultural distances, and allow firms to implement their R&D and innovation strategies.

Drivers and motives

A key question that arises when investigating foreign R&D (re)location is what drives the decision by corporations to locate in a certain country or in a specific place? The literature finds the location of foreign R&D to depend on a variety of factors: besides the specific type of R&D establishment considered, home versus host country advantages (Le Bas and Sierra 2002), spatial proximity, cultural distances, institutional similarities, relational linkages, and virtual linkages all shape MNEs' location decisions with respect to foreign R&D (Squicciarini and Loikkanen 2008).

The purpose—or motive—of a R&D unit locating abroad is, in itself, a key driver of foreign R&D. In this respect, many are the taxonomies proposed and discussed in literature. The most cited of these makes a distinction between the R&D establishments intended to enhance the capability of firms and to create new knowledge, that is, *knowledge-creation* establishments; and R&D aimed at exploiting the headquarters' existing stock of knowledge, that is, *knowledge-exploitation* establishments (Kuemmerle 1997, 1999a). Our study follows this terminology when referring to knowledge-creation and knowledge-exploitation R&D (re)location. The existing alternative classifications distinguish between:

- technology transfer and indigenous technology units versus global technology units (Ronstadt 1978);
- exploitation versus exploration laboratories (Chiesa 1996);
- home-base augmenting versus home-base exploiting (Kuemmerle 1997, 1999a);
- science-based versus market-based (Gerybadze and Reger 1999);
- research versus development (von Zedtwitz and Gassmann 2002); and
- capacity enhancement versus capacity exploration (Ambos 2005).

Of interest also is Bardhan and Jaffee's (2005) analysis emphasizing the increasing interdisciplinary nature and the complex organizational requirements of research projects. The authors underline that these research features, coupled with the growing global nature of firms, call for the necessity to hire researchers from many disciplines but only on a temporary basis, and thus favour R&D offshore outsourcing.

Drivers vis-à-vis modes

Evidence suggests that the various types of R&D establishments follow distinct location patterns and are attracted by different location characteristics. Knowledge-creation R&D establishments (i.e., research centres) are basically clustered in only five regions of the world, namely, the Northeast United States, California, United Kingdom, Western Europe, and the Far East. Conversely, knowledge-exploitation R&D activities (i.e., development centres) are dispersed in a much wider spectrum of regions (von Zedtwitz and Gassmann 2002). Furthermore, knowledge-creation R&D establishments are located close to universities and to government research laboratories, whereas knowledge-exploitation establishments are primarily located close to markets or manufacturing facilities (Kuemmerle 1999b). The presence of scientific institutions seems to have a positive effect on both the incidence and level of MNE subsidiaries' investments in R&D. Government support also is proven to correlate positively with the incidence (but not the level) of subsidiary R&D, whereas highly competitive environments might have a negative effect, at least in small countries (Davis and Meyer 2004). Further in this respect, Autant-Bernard (2006) investigates how firms' characteristics and regional features influence the location of R&D units. She finds that market size, the amount of ideas available, low competition levels, and (surprisingly!) low academic research levels in the target region increase the probability that firms will set up R&D labs in the region. The study also indicates that knowledge diffusion across regions induces significant spatial dependence.

Evidence also suggests that corporations tend to build different types of R&D units according to their nationality, that is, their home country. For instance, the foreign R&D establishments of British and Swedish MNEs have increasingly existed in isolation and been separated from the firms' production networks (Pearce 1989; Håkanson and Nobel 1993b), whereas German and Japanese firms generally tend to co-locate with their R&D and manufacturing units (Aoki 1990; Imai 1991; Nonaka 1992; Kenney and Florida 1994; Ambos 2005). This might imply that the former group has focused on knowledge-creation units, whereas the latter has concentrated on knowledge-exploitation units.

In the early days of R&D offshoring and outsourcing, knowledge-exploitation was at the root of MNEs' decisions to set up their R&D laboratories abroad. This explains why research on R&D internationalization in the 1970s focused on technology transfer and local adaptation of foreign R&D units (Ronstadt 1977, 1984). As postulated in Vernon's (1966) product life-cycle model, technology is produced and developed at home by multinational corporations, and then transferred to subsidiaries in the host countries. R&D units thus served the need of local manufacturing units, and adapted the technology created elsewhere to the local demand. Mirroring this, Ronstadt (1977, 1984) propose a modelling structure where one or several home-county central laboratories are complemented by several marginal R&D units (knowledge-exploitation R&D). His pioneer work, which was pervasive throughout the 1970s, was, however, later challenged by the decentralized structure chosen by laboratories of large corporations. This was especially the case for the labs whose headquarters were based in smaller developed nations, such as Sweden and the Netherlands, which internationalized a high share of their high-tech industries' R&D. In the 1990s, studies mainly focusing on large corporations proposed additional types of R&D internationalization patterns, as can be seen in the work of Bartlett and Ghoshal (1990), Håkanson (1990), Howells (1990), Asakawa (1996), Chiesa (1996), and Kuemmerle (1997) among others. Niosi (1995, 1999) further underlines the importance of MNEs setting up global integrated networks of R&D and of establishing international technology alliances to deal better with more open and risky environments.

Modes vis-à-vis patterns

Although knowledge-exploitation R&D establishments recently seem to be the norm, MNEs' international R&D has progressively taken the form of knowledge-creation R&D establishments. In addition, multinationals seem to locate their knowledge-creation establishments in close proximity to few selected locations where the innovation activities of particular industries are geographically agglomerated (Cantwell and Janne 1999). MNEs' strategies hence seem to be based on developing external ties with the other innovating agents located in selected milieu, while at the same time enhancing knowledge transmission and exchange within the internal R&D network.

The geographic agglomeration of innovation can be explained by the nature of knowledge and the way it is transmitted (Cantwell 1991; Feldman 1993; Almeida and Kogut 1997), that is, by being partly tacit and un-codified (Nelson and Winter 1982); and by knowledge spillovers being geographically bounded (Jaffe 1986; Jaffe, Trajtenberg, and Henderson 1993; Feldman 1994; Audretsch and Feldman 1996).[4] In addition, transaction costs and economics of scale and scope (Krugman 1991) may also contribute to explain the geographic agglomeration of innovation activities at all levels, whether the region or the city.[5] In this respect, Martin and Ottaviano (1999) propose an endogenous growth model featuring endogenous industry location. They show that global R&D spillovers, high growth rate and a high level of transaction costs are associated to FDI directed to the south, and furthermore, that with enough local R&D spillovers, lower transaction costs would increase the rate of growth. Hence, industrial concentration can be beneficial to both north and south regions if its impact on the rate of innovation is large enough, and it compensates the south for its industry loss. The importance of externalities for innovation and urban growth is also at the centre of the meta-analysis by de Groot, Poot, and Smit (2007) aiming to evaluate the statistical robustness of the existing evidence on agglomeration externalities, in particular Marshall-Arrow-Romer, Jacobs's, and Porter's externalities.[6] They find strong support for the theorized (e.g., Duranton and Puga 2001) positive effect of diversity over innovation and urban growth. According to de Groot and co-authors, the effect of specialization, competition, and diversity is not very different in Europe and the USA, but is indeed the case in Asia, where the positive effect triggered by diversity is relatively large.

Patterns vis-à-vis enablers

Agglomeration, whether regional or urban, enables localized learning processes (Malmberg and Maskell 1997; Maskell and Malmberg 1999), which in turn attract newcomers to the existing loci. This phenomenon, coupled with the cumulative nature of knowledge (Lundvall 1988), might ultimately lead to a scenario where the areas specialized in particular technologies reinforce their competitive advantages. This may in turn trigger further agglomeration and is likely to widen the gap existing between the technology leaders and the others (Cantwell and Janne 1999). Institutional, cultural, and relational proximities—where relational proximity is intended as informal exchanges based on personal relations—can further strengthen this embedding, that is, the external ties with the chosen location (Nelson 1988; Lundvall 1988, 1992; Gertler 1995, 1997).

MNEs then exploit their internal R&D network to internalize the knowledge created elsewhere: MNEs' internal cooperative R&D networks take care of diffusing knowledge within the firm and across geographic distances, so that other locations can also benefit

4 Knowledge can be more easily transmitted and absorbed through direct and frequent face-to-face contact (Dosi 1988b). Knowledge spillovers are, in any case, more thoroughly dealt with in section 2.2.

5 More generally, Leamer and Storper (2001) discuss agglomeration and the geographical fragmentation of production and the role internet might have on those.

6 Marshall-Arrow-Romer externalities relate to industrial concentration and specialization; Jacob's externalities relate to economic and social diversity leading to cross-sectoral spillovers; and Porter externalities relate to the intensity of competition.

from it (Zeller 2004). Organizational,[7] technological, and virtual proximities enable the functioning and performance of such internal ties, and shared organizational principles, rules and codes can promote coherence within the firm and compatibility among collaborating firms (Blanc and Sierra 1999). Likewise, technological proximity based on shared technological experiences, bases and platforms, together with the virtual proximity enabled by ICT, can provide a standard environment facilitating knowledge exchange within the firm's internal network (Zeller 2004). Interesting in this respect is Gersbach and Schmutzler's (2006) theoretical model of FDI and R&D offshoring where intrafirm communication plays an important role. Finally, the circulation of R&D personnel may also enhance communication within the MNE internal networks.

Evidence suggests that both external and internal links are managed differently in the R&D centres located in different host countries. For instance, German MNEs' R&D centres in Europe tend to have stronger external ties, whereas their R&D centres in Asia have weaker external connections. As for the internal ties, American establishments have relatively weak ties with their German headquarters, but Asian establishments have much stronger linkages with headquarters (Ambos 2005).

2.2 Appropriability: the role of IPR and knowledge spillovers

One feature characterizing R&D investments is that the knowledge thus created is only partially appropriable by the firms. Being a non-rival and partly non-excludable good, knowledge may, in fact, spillover to other firms and thus enhance their TFP (Arrow 1962). Cassiman and Veugelers (2002) distinguish between 'incoming' and 'outgoing' spillovers, that is, respectively: those information sources (typically of public domain) from which firms may profit; and the leaking-out of knowledge from companies, a loss from which the firms suffer. Appropriability depends, *inter alia*, on: the characteristics of the technology itself; the barrier existing in the market where the technology is to be used; the existence and enforceability of IPR; and the capability of other firms to absorb external knowledge (see e.g., Levin et al. 1987; Geroski 1991; Geroski, Machin, and Van Reenen 1993).

Appropriability and IPR

Carrying out R&D abroad may offer sourcing opportunities, but it nevertheless might impinge upon the ability of firms to appropriate the results of their R&D activities. The likelihood of this happening increases with the difficulty to protect knowhow and in the presence of weak intellectual property right regimes. Evidence on American MNEs provided by Branstetter, Fisman, and Foley (2006) highlights that firms with large patent portfolios are responsive to improvement in the IPR regimes of the host countries. In particular, they find that the royalties paid for the technology transferred to offshore affiliates, in the form of use or sale of intangible assets, increase by the time the host developing countries undertake IPR reforms. Likewise, when IPR regimes improve, affiliate R&D expenditures and the total growth and levels of foreign patent applications also increase. Along the same line, other studies find evidence that weak

7 Interesting with respect to MNEs' organizational structure is the analysis by Antràs, Garicano, and Rossi-Hansberg (2006) of how the formation of cross-country teams affects the organization of work and the structure of wages. They contemplate the assignment of heterogeneous agents into hierarchical teams, with less skilled agents specializing in production and more skilled agents in problem solving.

IPR regimes deter FDI in high-technology sectors where intellectual property plays an important role, and discourage investors (Smarzynska Javorcik 2004; Naghavi 2007). Moreover, MNEs deciding about the volume and composition of their investments take into account the host country's system of intellectual property protection (Mansfield 1994; Lee and Mansfield 1996). Mansfield (1994), based on survey data, offers evidence on the fact that the degree of IP protection offered by developing countries influences not only MNEs' willingness to establish subsidiaries and to undertake joint ventures, but also the extent to which MNEs transfer their technology. Such features appear to be more prominent in high-technology industries. More generally, country- and industry-specific characteristics significantly affect the ability of the host-country firms to 'use and abuse' the possible lax protection enforced in the country. Poor institutional environments, especially poor IPR regimes, may hence erode the innovation value that might be appropriated, thus pushing firms to keep knowledge-intensive activities away from weak IPR countries.

Motivated by empirical evidence on the existence of a close relationship between MNEs and knowledge capital, Ethier and Markusen (1996) examine the role of internalization and its relation to location factors. In their model, MNEs face the decision of exporting versus licensing, or acquiring a subsidiary in the host country. Ethier and Markusen (1996) assume that intellectual property protection is not to be guaranteed in the host country. Consequently, a trade-off exists between costly efforts to export an innovated product versus the possible dissipation of knowledge capital that production abroad might trigger. The analysis of the cost and technology parameters that support the different possible choices leads them to multiple equilibrium outcomes.[8] Particularly interesting is their result that similarities in factor endowments may promote direct investment, in line with FDI's empirical evidence.

Building on Ethier and Markusen (1996), Markusen (2001) theoretically investigates whether and to what extent contract enforcement (see also Nunn 2007) and intellectual property protection influence both FDI into host economies, and the welfare of the host country. In his two-period product-cycle model, MNEs may decide either to export or establish a subsidiary. In the host country, in the first period agents learn from the MNE the necessary technology to produce the good and, in the second period, can defect to start a rival firm. Markusen's (2001) main result is that both the MNE's profit and the host-country's welfare would improve when contract enforcement creates incentives for MNEs to produce in the host economy rather than exporting to it. The model supports the developed countries' claim that stronger legal protection for the investors would benefit developing countries, thanks to the additional investments it triggers. Albeit, on the other hand, Markusen (2001) also finds support for developing countries' claim that protection enriches MNEs only. Which view dominates ultimately depends on the initial conditions, and on whether or not FDI occurs even in the absence of strong protection for the investors.

8 Among the possible choices are (i) the importance of intellectual property relative to the fixed cost of the host-country production; (ii) the discount rate; (iii) the transfer cost of exporting; (iv) the home-country wage versus the host one; and (v) the number of the home-country product innovators.

IPR regimes and the China and India 'paradox'

Despite firms generally stating that inadequate IPR protection in emerging economies like India and China is a challenge (84 per cent in the report of the EIU 2004), R&D offshoring and outsourcing to developing countries have been growing rapidly over the last years.[9] Zhao (2006) explains this apparent paradox by arguing that MNEs' efficiency in transferring, integrating, and rapidly building on the technologies developed under different IPR regimes enables firms to conduct R&D in countries where IPRs are weak. The author finds evidence in support of Ghemawat's (2003) arbitraging argument and suggests that the contributions generated in the different labs gain value only when combined with the complementary knowledge and resources held within the firm.[10] This internal complementarity-based structure of the MNEs acts as a sort of 'immune system' (Zhao 2006: 1185) against the possibly adverse external environments in which R&D is carried out. MNEs may thus take advantage of low-cost access to quality human capital, for example, and be able to appropriate the value of the R&D activities carried out, despite weak IPR protection. This internalization argument is indirectly supported also by Branstetter, Fisman, and Foley's (2006) evidence about improvements in the IPR system of the host country translating into real increases in technology transfer within the MNEs.

Appropriability and knowledge spillovers

Whether diffusion or lack of appropriability prevails, depends also on the channels through which spillovers work. Among the most important ones are geographical proximity, and the agglomeration and localization effects that knowledge spillovers may trigger. Seminal in this respect are the findings by Jaffe, Trajtenberg, and Henderson (1993) that knowledge spillovers are indeed localized; and the results by Audretsch and Feldman (1996) suggesting that innovative activities cluster more in industries where knowledge spillovers play a decisive role. In order to measure the geographical breadth of knowledge spillovers, Keller (2002) estimates the amount of spillovers from R&D expenditures. He finds technology to be substantially local, the benefits from spillovers to decline with distance, with 1,200 km sufficing to halve the amount of spillovers. He also encounters evidence of language skills being important for their diffusion (which is the case of India). Bottazzi and Peri (2003) instead identify and estimate the effect of research externalities in generating innovation across space, and show spillovers to be very localized, that is, in a radius of 300 km.

Therefore, R&D spillovers, geographical proximity, and the localization and agglomeration of these may determine not only R&D location decisions, but also, and importantly, R&D offshoring and outsourcing strategies.

Modelling R&D (re)location in presence of knowledge spillovers

Ekholm and Hakkala's (2007) general equilibrium model assumes production and R&D to be located separately, and to be subject to agglomeration forces that may interact with one another. On the one hand, R&D generates knowledge spillovers, thus fostering

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9 See also section 2.3 about the geography of R&D.

10 Ghemawat (2003) holds that the arbitrage of international difference is at the foundation of firms' international strategies.

agglomeration. On the other hand, economies of scale and trade costs (envisaged as iceberg-type costs)[11] drive agglomeration in production, as happens in the new economic-geography models (Krugman 1980, 1991). This agglomeration in production translates into the so-called *home-market effects*, that is, the advantages of large economies in attracting the production of final goods. Ekholm and Hakkala's (2007) two-country model assumes, *inter alia*, that factors of production are perfectly mobile between sectors, but completely immobile between countries. Firms from one country have an incentive to relocate R&D activities elsewhere only if the cost of separating R&D from production is less than the potential reduction of R&D costs they would obtain through relocating. Already intermediate trade cost-levels make the home-market effect stronger and give firms incentives to stay in the home country. The reach array of Ekholm and Hakkala's (2007) predictions offers insights about the welfare effect that R&D (re)location might generate. When R&D spillovers are completely localized and in the presence of a home-market effect, for moderate to strong R&D spillovers and for low to moderate level of trade costs a stable equilibrium exists, characterized by the concentration of R&D activities in the smaller region (e.g., Finland). They also see that skilled labour should benefit from the agglomeration of R&D activities, but unskilled labour would suffer from it, due to more expensive final goods.

Contributing to the discussion on R&D location and the role of knowledge spillovers, Belderbos, Lykogianni, and Veugelers (2008) examine the strategic interaction between the R&D localization decisions of two MNEs. These multinationals, one technology leader and one technology laggard, are based in different countries but both operate in both countries. The Belderbos-Lykogianni-Veugelers model takes into account the two facets of R&D: its positive impact on absorptive capacity which, in turn, increases the benefits arising from incoming spillovers; and the direct positive effect R&D has on the firms' knowledge base. In equilibrium, R&D localization decisions depend on:

– the degree of product market competition;
– the efficiency of international intra-firm transfers;
– the extent of locally-bounded inter-firm spillovers; and
– the fact of being a technology leader or a laggard, which in turn is defined by size of R&D investments.[12]

In line with Norbäck (2001), Belderbos, Lykogianni, and Veugelers (2008) find that when intra-firm transfers are efficient and the gap with the laggard is sufficiently large, technology leaders rely more on home market R&D. In such circumstances, laggards tend to do the opposite, i.e., more importantly, to invest in R&D abroad to benefit from the spillovers generated by their competitors. The model predicts that greater R&D spillovers would reduce overseas R&D by leaders, due to appropriability concerns. In line with empirical evidence, it also suggests that MNEs are reluctant to localize in countries where IPRs regimes are weak, and that, independently of their technology lead, firms tend to agglomerate in countries with stronger IPR protection. Finally,

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11 Assuming iceberg trade costs implies holding that if τ units of goods are shipped from one country to another, where $\tau > 1$, only 1 unit of goods arrives at the final destination.

12 See Sanna-Randaccio and Veugelers (2007) for a game-theoretic approach to decentralized R&D and multinational knowledge spillovers.

product market competition encourages leading firms to invest in R&D abroad to capture a larger share of the local market.

Another interesting contribution about the localization of R&D activities and knowledge spillovers is Gao's (2007) analysis on the relationship between falling trading costs and growth, and on the mechanisms linking factor endowments, trade costs, production location, and growth. In Gao's model, assumptions and predictions appear very much in line with both stylized facts and with some of the developments lately witnessed by the world economy. Among these are the rising inequality of skilled/unskilled wages, relative skill abundance, persistence of international differences in factor prices, and the acceleration of globalization. His model combines the ceaseless product expansion typical of endogenous growth models, the factor abundance, and intensity of the Heckshner-Ohlin type models, and the increasing returns and trade costs featured by the new economic geography models. In this two-country two-sector setting, skilled and unskilled labourers populate both the north and south, with labour that is inter-sectorally mobile but internationally immobile. R&D takes place in the manufacturing sector only, with the aim of creating new varieties of output.

An interesting feature of Gao's model is the inclusion of the financial market: firms enter freely into R&D and finance the cost of R&D by issuing equity on the stock market. Relying on the localized nature of knowledge spillovers, the model assumes spillovers to occur only within countries, and rules out the possibility that knowledge might spillover between the developed and the developing world. Gao (2007) suggests that a reduction in trade costs would ultimately lead to a contraction of output production and an expansion of R&D in the north driven by the changes induced in the cross-country distribution of manufacturing. The rise in R&D would in turn increase growth in the world and raise the living standard in the south, thanks to industry spreading there. This globalization of production, that is, the relocation of certain production activities, however, would also increase the skilled/unskilled wage inequality in countries both in the north and the south.

2.3 The geography of foreign R&D

Although R&D internationalization constitutes a prominent feature of the more recent trends characterizing globalization (among others, Guellec and van Pottelsberghe 2001), R&D remains the least internationalized activities among firms (also Belderbos, Lykogianni, and Veugelers 2008). Such features are in line with the model's predictions by Autor, Levy, and Murnane (2003) about the tasks that might be more easily offshored. These authors subdivide tasks according to whether they involve manual or non-manual labour. Manual labour tasks can be routine or non-routine, whereas non-manual tasks can take the form of routine cognitive processes, complex communication, or require expert thinking. They suggest that routine tasks, whether cognitive or manual, can be offshored, as they can be computerized and well formalized in rules. Conversely, those functions involving more complex non-routine tasks, as R&D, should be harder to offshore.

The data suggest that, on the one hand, R&D under foreign control has since 1995 followed FDI closely, and has grown at a faster pace than the corresponding turnover or import (Figure 1). But on the other hand, major OECD countries' foreign R&D amounts to a mere 1/9 of foreign controlled turnover (US$71 billion in 2003; OECD 2007a). Empirical evidence shows that foreign R&D has mainly concentrated in developed countries, either as home or host, and especially in the so-called 'triad' countries: the US, Japan, and Western Europe (Gassmann and von Zedtwitz 1999; Meyer-Krahmer and Reger 1999; Archibugi and Iammarino 2002; Ambos 2005; OECD 2007b). However, in recent years, emerging countries such as Ireland, some in Eastern Europe, China, India, and Brazil have joined the triad countries in becoming favourite locations for foreign R&D (UNCTAD 2005; OECD 2008).[13]

Since the 1990s the share of total R&D expenditure performed by foreign R&D has increased for most OECD countries, reaching 16 per cent in 2004 (OECD 2007a). However, this ratio varies widely amongst countries. While countries such as Japan had less than 5 per cent of industrial R&D performed by foreign affiliates, other economies like Ireland and Hungary featured shares well above 60 per cent (see Figure 2).

The internationalization pattern of innovation output looks akin to that of innovation inputs, with most countries experiencing an increase in the share of foreign ownership of domestic inventions, as suggested by patent data. Norway, Hungary, Austria, and France in particular show extremely high increases over the period 2001-03, compared to the previous decade (see Figure 3). Conversely, in countries like Turkey, India, Poland, and Singapore, the share of foreign-owned innovations has decreased with respect to the years 1991-93. This might indicate a better ability of the home firms to appropriate the outcome of the innovative activities carried out. This trend might have been driven as well by the increase in R&D and innovation-related investments made by these countries over the period considered. Finally, it is interesting to notice that in 2001-03 over 50 per cent of domestic inventions were owned by foreign residents in countries like Russia, Luxembourg, Mexico, and Hungary (OECD 2007c).

Evidence on foreign R&D laboratories indicates that Europe, the US, and Asia (although to a less extent) are the preferred locations of foreign R&D investments originating from the USA, UK, Germany, Japan, and Sweden (Pearce and Singh 1991; Håkanson and Nobel 1993a; Granstrand 1999; Ambos 2005). This is true at the aggregate level, but sector differences exist in the geographical concentration of foreign R&D, exhibiting a pattern similar to that observed in the case of manufacturing units. The sectors with the highest R&D expenditures also guide R&D internationalization, although in a slightly different order. For example, in 2003 five industries lead the R&D investments made by the business-sector: ICT manufacturing,[14] with annual R&D expenditures of about US$100 billion,[15] followed distantly by the automotive, pharmaceutical, chemical (excluding pharmaceutical) industries, and the ICT services to firms[16] (OECD 2008). The four most internationalized R&D industries are among those that spent the most on R&D, namely pharmaceuticals, automobiles, chemicals (excluding pharmaceuticals), and ICT manufacturing.[17] With almost 50 per cent of

13 Additional analysis about emerging players is presented in section 4.

14 ICT manufacturing includes: office, accounting, and computing machinery (ISIC 30); radio, TV, and communication equipment (ISIC 32); and medical, precision, and optical instruments (ISIC 33).

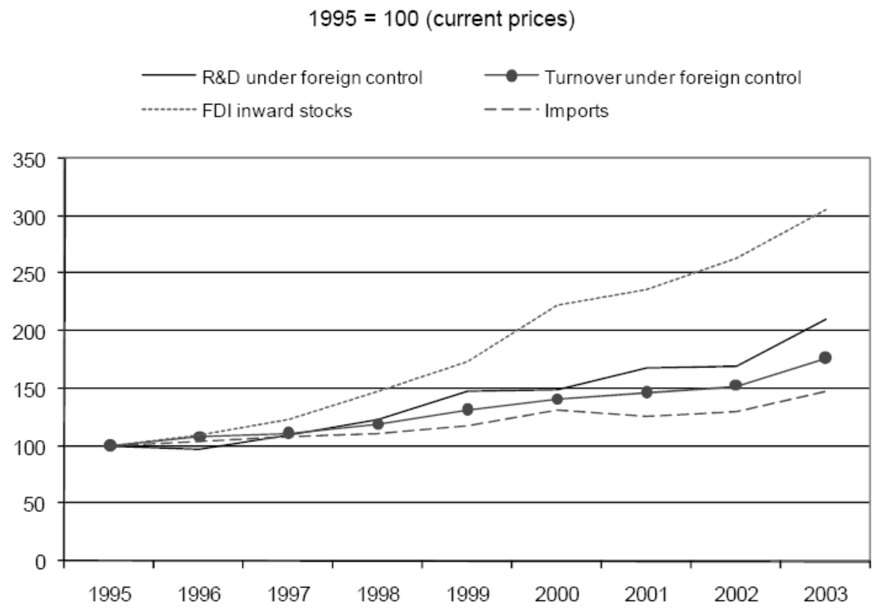
15 Constant PPP dollar at 2000 prices.

16 ICT service includes post and telecommunications (ISIC 64); computer and related services (ISIC 72).

17 ICT service data not available.

R&D under foreign control, pharmaceuticals R&D is the most internationalized, whereas last comes the R&D of the ICT manufacturing sector.

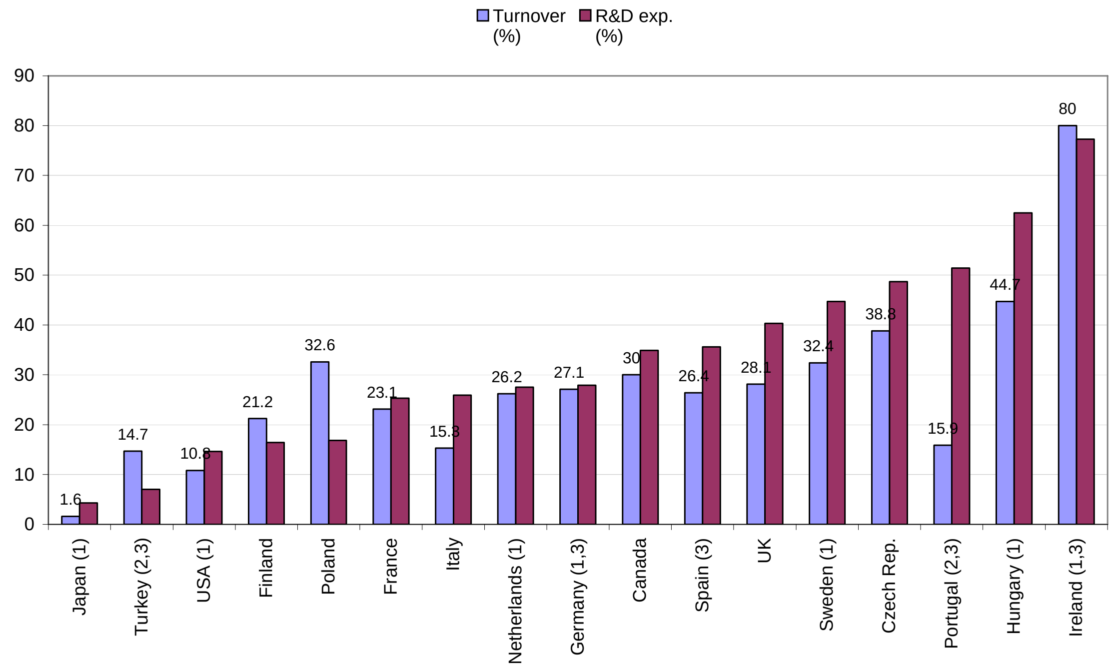
Figure 1
Evolution of the main driving forces of globalization of goods and services in the OECD area*



Note: * Countries included: United States, Japan, United Kingdom, France, Germany, Canada, Netherlands, Sweden, Czech Republic, Finland, Hungary, Ireland, and Poland.

Source: OECD (2007).

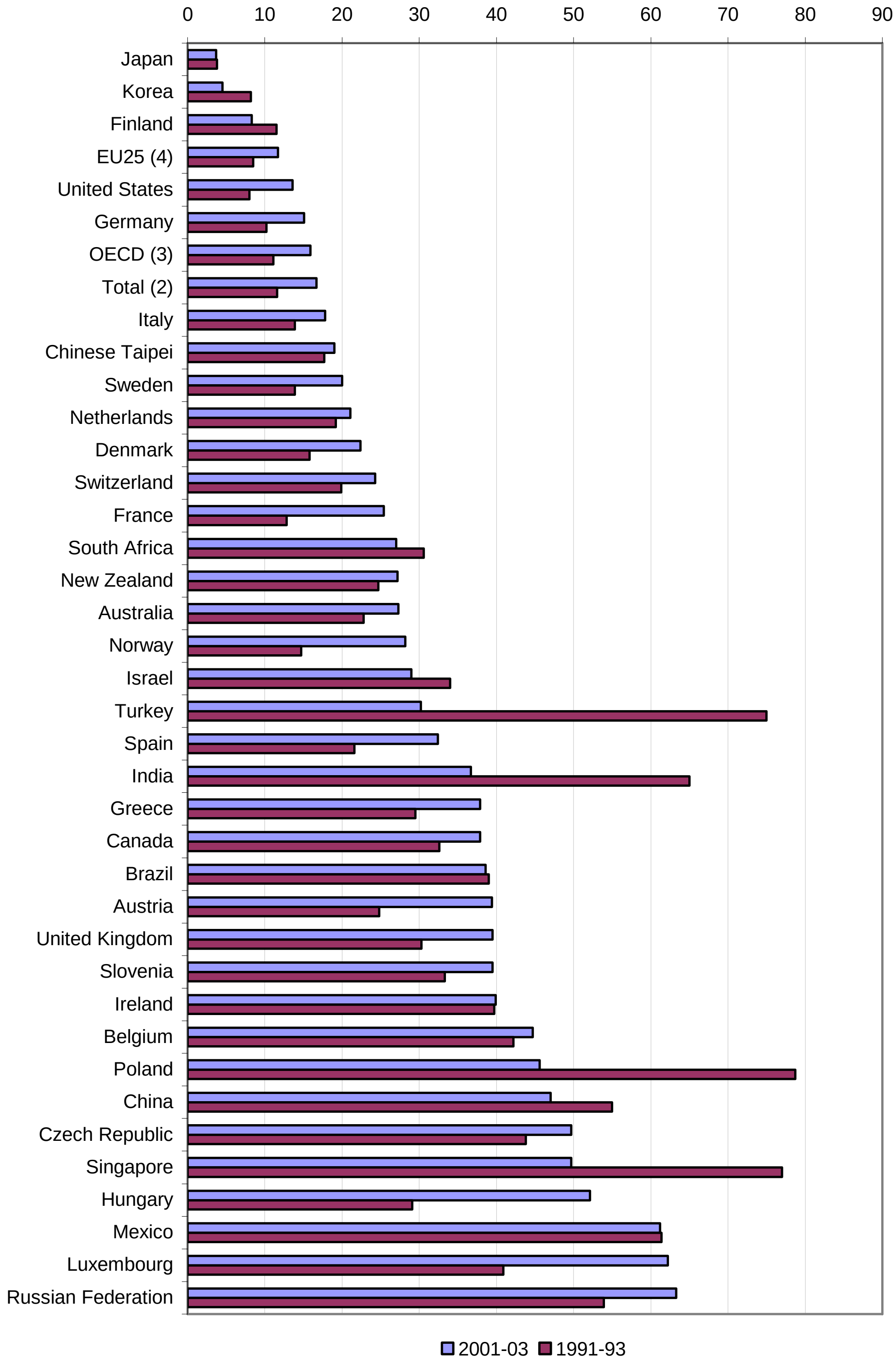
Figure 2
R&D expenditures and turnover of affiliates under foreign control
(as share of total R&D and turnover), 2004



Notes: (1) 2003: (2) 2001; (3) Manufacturing sector only.

Source: Authors' own elaboration on data from OECD (2007a).

Figure 3
Foreign ownership of domestic inventions (in %) 2001-03, versus 1991-93



Notes: Patent counts are based on the priority date, the inventor's country of residence, using simple counts. (1) Share of patent applications to the European Patent Office (EPO) owned by foreign residents in total patents invented domestically. Figure 3 only covers countries with more than 200 EPO applications over 2001-03. (2) All EPO patents that involve international co-operation. (3) Patents of OECD residents that involve international co-operation. (4) The EU is treated as one country; intra-EU co-operation is excluded.

Source: Authors' own elaboration on data from OECD (2007c).

Table 1
Main offshoring and outsourcing studies

Author & year	Type T/E	Objective	No. of countries A	D	Total	No. of Inds		Key parameters	Mechanisms driving FDI decisions	Contracts
Ethier & Markusen (1996)	T	Models MNEs' decision of costly exporting VS dissipating knowledge capital by producing abroad. Addresses the nexus of increasing returns to scale, international trade, growth and technological competition and dissemination	-	-	2	-	Het.	• Importance of IP relative to fixed cost of host-country production • Discount rate • Transfer cost of exporting • Wage (host vs home country) • No. of home-country product innovators	• Costly exporting • Possible dissipation of the MNE's proprietary assets due to absence of IP in host country	Incomplete (inability to enforce contracts)
Antrás & Helpman (2004)	T	Explore how differences in technology interact with organizational choices in shaping industrial structure, trade flows, and FDI	1	1	2	N	Het.	• Wage differentials (labour is the unique factor of production) • HQ services & manufactured components • Differences in technology & productivity	• Fixed organization costs • Differences in fixed & variable costs • Interdependence between trade, investment and organization	Incomplete
Grossman & Helpman (2002)	T	Study firms' decision about where to outsource where consumer products can be produced either by vertically integrated firms or by pairs of specialized companies	1	1	1	1	Het.	• Production costs • Wage differentials • Search costs • Inputs specialization (partial & complete) • Prices & variety	• Size of country & 'thickness' of its markets • Technology & innovation possibilities • Elasticity of demand for consumer goods • Secondary market in intermediate inputs	Incomplete
Grossman & Helpman (2005)	T	Study firms' decision about where to outsource and how improvements in the investment technologies affect the location of outsourcing activities	1	1	2	1	Het.	• Production costs • Wage differentials • Search costs • Customization costs • Cost infrastructures for communication & transportation	• Size of country & 'thickness' of its markets • Information accessibility • Technology & specialization possibilities • Differences in contracting environment	Incomplete
Grossman, Helpman, & Szeidl (2006)	T	Shed light on the determinants of integration strategy when firms face a richer array of organizational choices	2	1	3	1	Het.	• Size of transport costs for intermediate & final goods • Relative size of fixed costs for different types of subsidiaries • Share of consumer market of south	• 'Unit cost', 'source-of-components', and 'agglomeration' complementarities	Complete (vertically integrated firms)

Table 1 continues

Table 1 (con't)
Main offshoring and outsourcing studies

Author & year	Type T/E	Objective	No. of countries A	D	Total	No. of Inds		Key parameters	Mechanisms driving FDI decisions	Contracts
Belderbos, Lykogianni, & Veugelers (2008)	T	Examine the strategic interaction between R&D localization decisions of 2 MNEs, and the incentives to locate R&D abroad for a technology leader and a technology laggard	2	-	-	2	Het.	• R&D economies of scale • Firms' knowledge base: (own R&D resources internal knowledge transfer external knowledge sourcing) • R&D localization ratio	• Efficiency of intra-firm transfers • Extent of locally bounded inter-firm spillovers • Degree of product market competition	Complete (vertically integrated firms)
Yeaple (2006)	E	Assess if MNEs are factor service intermediaries, by analysing variation in intra-firm trade of US MNEs across countries and industries	25	33	58	51	Het.	• Imports unit value by US parent firm from foreign affiliate • intra-firm trade, i.e., ratio of intra-firm trade (US MNEs) to total US imports • FDI offshoring, i.e., ratio of industry-specific exports of intermediate inputs (US parents) to foreign affiliates over total US exports sales	• Factor price differences • Industry's technology • Comparative advantage in some portion of production process (host) vis-à-vis HQ services (US)	Incomplete
Fujita & Thisse (2006)	T	Investigate how spatial division of labour changes when communication and trade costs become lower, and what are the implications for the various groups of workers (high vs low skills)	1	1	2	2	-	• Differences in wages • Communication costs • Trade costs	• Labour dualism (skilled vs non-skilled labour) • Communication costs between core and periphery • Trade costs • N.B. only production can be decentralized	Complete (vertically integrated firms)
Grossman & Rossi-Hansberg (2008)	T	Propose a conceptualization of global production processes that focuses on tradable tasks and study how falling costs of offshoring affect factor prices in the source country	1	1	2	2	-	• Wage differential • Technological advances in communication & transport (reduce the cost of offshoring tasks requiring a given skill level) • Intensity of task, i.e., amount of domestic factor used to perform a typical task at home • High & low skill tasks are substitutable	• Prospect of factor-cost savings	Complete (vertically integrated firms)

Notes: Type of study: T=theory, E=empirical;
Countries: A=advanced, D=developing.

In conclusion, the data briefly presented in this section confirm R&D (re)location to be a very complex, diversified, and relatively recent phenomenon. Numerous possibilities hence arise for further research, especially research combining empirical assessment with some existing theoretical frameworks like those discussed next.

3 Macro and micro approaches to R&D (re)location

The economic literature on R&D (re)location mainly follows two analytical strategies. The first approach takes a macroeconomics perspective on international trade and investment. It generally relies on the difference in factor endowments, including human capital and skills, and technology, their relative prices, and on (within-sector) heterogeneity in productivity. It also considers decreasing communication and transport costs to explain the observed ever-growing global economic interconnectedness. These analyses of the modern *global supply chains* (Grossman and Rossi-Hansberg 2008), producing complex industrial goods and knowledge-intensive services, encompass the exchange of complete goods as well as of specific tasks. The second approach principally relies, instead, on incomplete contract theory and analyses the various organizational settings that companies choose when going global. It offers a micro perspective over the drivers, components, and possible outcome equilibria characterizing R&D offshoring. An alternative analytical strategy, followed by Antràs and Helpman (2004) for example, combines the within-sector heterogeneity à la Melitz (2003) with the micro/firm-structure-based analyses à la Antràs (2005).

Many of the contributions considered in this overview do not explicitly address R&D offshoring and outsourcing, but focus rather on offshoring and outsourcing in general. Therefore, in surveying these, we concentrate on that part of the analyses regarding the (re)location of high-skill knowledge-intensive activities and on those features that may contribute to a better understanding of R&D offshoring and outsourcing. Moreover, in the present review we mainly concentrate on the analysis of R&D offshoring and outsourcing from a micro-perspective since we believe that, as Feenstra (2008), the microeconomic structure of R&D (re)location determines the macroeconomic patterns observed.

In most cases, the papers considered here, whether theoretical or empirical, can be systematized according to some specific features. These are:

- the number of countries considered;
- their development level;
- where the headquarters are located and where production, assembly, etc., take place;
- whether differences in productivity exist;
- skills distribution, the specification of communication and transport costs, and other key parameters characterizing home and host countries;
- the mechanisms driving FDI decision; and
- the degree of contract completeness underlying the FDI investment (see Table 1 for a schematization of the main offshoring and outsourcing studies considered).

3.1 FDI at the macro level

Bhagwati, Panagariya, and Srinivansan (2004) address the most common misunderstandings mainly arising from the public rhetoric on foreign investments via outsourcing and offshoring. Importantly, they argue that outsourcing is a 'trade phenomenon', subject to standard theoretical assumptions and empirical qualifications. That is, services traded internationally at arm's length generate gains from trade, and their effects on production, national income, and economic welfare (i.e., employment and wages) are not qualitatively different from those of the conventional exchange in goods.[18] The decision to outsource, according to the authors, could be also determined by two alternative dynamics. First, it can be due to technological innovations that convert previously non-tradable services into services traded internationally—independently of the country's factor endowment. Second, skills accumulation in the south (e.g., China and India), in activities such as information technology, can foster services (re)location. These would ultimately lead to more global interconnectedness and trade.[19]

Grossman and Rossi-Hansberg (2008) build a novel analytical framework aimed at modelling how different countries add value to global supply chains, global production processes enabled by the recent improvements in communication and ICT. The authors propose a conceptualization of offshoring that relies on tradable tasks, and then use it to investigate the implications for the labour markets, production patterns, price, and welfare (particularly income or wages inequality).[20] The analysis covers both home and host countries and evolves from the standard trade theory (i.e., Heckscher-Ohlin model). It features two countries, one industrialized and one developing; two industries; perfect competition; and an arbitrary number of factors of production. Tasks and their offshoring are classified according to the skill content into 'L' (low) and 'H' (high) tasks.[21] The model decomposes the impact of offshoring on the labour market (i.e., wages) into three components. First, a *productivity effect,* which always works to the benefit of low-skill labour, derives from the cost savings that firms enjoy when they already offshore and offshoring prospects improve. Second, a *relative price effect* captures the labour market implications of any movement in the terms of trade resulting from offshoring. Third, a *labour supply effect*, operating in general equilibrium environments, derived from the re-absorption of those workers formerly carrying out the tasks now offshored. The authors show that the productivity effect, which has been largely overlooked in the literature, could dominate the others: improved possibilities for offshoring increase the wages of domestic low- and high-skill workers performing the same tasks. Benefits are higher for those firms using more intensively the task that can more easily be performed abroad, whether L or H task. Improved prospects for

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18 Traditional models of trade have been adapted to incorporate trade in intermediate inputs (e.g., Feenstra 1998; Jones 2000).

19 Baily and Lawrence (2004) empirically prove that the impact of offshored services to India on the US labour market is highly overstated.

20 See Feenstra (2008) for a broad and extensive analysis of both the microeconomic structure and the macroeconomic implication of offshoring in the global economy.

21 Markusen (2005) formulates a series of models capturing the main characteristics of offshoring. He then uses these models to identify the effects that technological or institutional changes might have on the offshoring of white-collar services.

offshoring tasks would, therefore, have the same effect as factor-augmenting technological progress. If the adjustment in relative prices or in factor prices is not too large, the increased improvement in productivity of the factor whose tasks become easier to offshore could be translated into gains that can be shared by all domestic parties.

Applying Grossman and Rossi-Hansberg's (2008) results to the case of R&D offshoring implies holding that countries should not suffer from (re)location patterns, but rather gain from them. This looks somewhat counterintuitive to many who rely on different theoretical models or on 'empirical evidence' when arguing against the possible threats of globalization. Among the theoretical contributions offering results in (at least partial) contrast to Grossman and Rossi-Hansberg (2008), there is a model proposed, for example, by Fujita and Thisse (2006). The authors conclude that, as the market economy is imperfectly competitive, the fragmentation of firms hurts all workers, whether skilled or unskilled, located in the core region. However, this negative effect is somehow counterbalanced by the fact that fragmentation is beneficial to the workers located in the periphery and, therefore, contributes to narrowing down the gap between rich and poor countries.

Eaton and Kortum (2006) arrive at a different conclusion when exploring the determinants of research specialization across countries and its consequences for relative wage. They examine whether and what extent faster international technology diffusion and lower trade barriers might impact on the incentive to innovate. Their model predicts that when no diffusion takes place, countries invest the same share of R&D resources, independently of the existing trade barriers or research productivity. When trade barriers are not too high, faster diffusion shifts research activity towards countries that are relatively better at carrying out R&D. This in turn raises the relative wage in the recipient countries to the extent that the more the diffusion, the larger the share of technologies in the exclusive domain of the country that is better at research. Finally, Eaton and Kortum show how openness to trade does not alter research specialization or impinge upon it: more research-productive countries, like Finland for example, are also richer due to the same research efforts generating more new technologies.

4 From macro to micro

Coase's (1937) highly influential essay on the nature of the firm provides an early insight about the spatial distribution of firms' transactions and activities (the making or buying decisions), and how these alternatives are affected by innovation and technological progress. He distinguishes between the allocation of resources—and the coordination of the various factors of production—in a firm, and allocation in the economic system (vertical integration).[22]

Recently literature shows that firms expanding internationally through FDI generally do so in the pursuit of savings in factor costs, transportation costs, and trading costs, as

[22] See Lafontaine and Slade (2007) for a thorough survey of the main empirical studies addressing the types of transactions best brought within the firm, and the consequences of vertical integration decisions for economic outcomes as prices, quantities, investment, and profits.

well as economies of scale (Grossman, Helpman, and Szeidl 2006). Increasingly influential in driving R&D and production (re)location are also the economic reforms undertaken by developing countries, notably trade and financial liberalization, and IPR protection. These have resulted in fast economic growth and technological progress, thus reinforcing developing countries' institutions (Nicolini 2007), and further fostering their integration in global markets.

Traditionally, international trade theory has subdivided multinational firms according to the type of organizational setting used. Vertical MNEs are those that establish the different stages of production in different countries, normally due to cross-country differences in factor prices (Helpman 1984). Conversely, MNEs are termed *horizontal* when these replicate most or all of their processes in several locations, mainly motivated by potential transport and trading costs savings (Markusen 1984, 1995. See also Helpman, Melitz, and Yeaple 2004, for an analysis firm's choice between exporting and carrying out horizontal FDI.) Horizontal firms have for some time seemed more prevalent in the world, with MNEs' activity mainly concentrated in countries similar in both size and relative endowments (Carr, Markusen, and Maskus 2001).[23] However, more recent studies, based on empirical evidence, suggest that firms often follow mixed strategies. These *complex integration strategies*, as they are known, involve both vertical and horizontal integration, depend upon the specific host countries considered, and may determine complementarities between them, having thus important implications for the structure of FDI (Yeaple 2003).

Markusen's *knowledge capital model* (see, in particular, Markusen et al. 1996 and Carr, Markusen, and Maskus 2001, 2003) successfully combines both horizontal and vertical motives for FDI, in a hybrid approach that relies on three main assumptions:

- R&D and the other knowledge-based and knowledge-generating activities can be geographically separated from and supplied to production facilities at a relatively low cost.
- Knowledge-intensive activities are relatively more skilled-labour intensive than production.
- Knowledge-based activities are characterized by their being (partially) joint-input activities, that is, they can be simultaneously used by multiple production plants.

The first two assumptions motivate vertical integration, whereas the last one motivates horizontal investments. Vertical MNEs hence arise when countries differ in their relative endowment, while being of similar size. In this case, firms will have an incentive to concentrate their headquarters in the skilled-labour abundant country, and to produce in the skilled-labour scarce one. Conversely, countries similar in both size and relative endowments will see horizontal multinationals prevail. Carr, Markusen, and Maskus (2001, 2003) empirically test the importance of multinational activity between countries as a function of: countries' size and size difference; relative endowment differences; trade and investment costs; and some interactions among these variables, and find the data to support the predictions of the theory.

[23] According to Markusen and Venables (2000) MNEs are more likely to exist the more similar countries are in both relative and absolute endowments.

An alternative interesting configuration proposed by Ekholm, Forslid, and Markusen, (2007) is that of *export-platform* FDI, that is, affiliate production for export to third countries. In such cases, production can be exported to third countries only (*third-country EP*), to both parent and third countries (*global EP*), or solely to the home country (*home-country EP*). The model by Petit and Sanna-Randaccio (2000) instead specifically investigates the relationship between investing in R&D and being multinational, and shows that the firms investing more in research are also the MNEs. A positive relationship between multinational expansion and R&D investment emerges when investment in research, in turn, increases the likelihood of multinational expansion.

Empirical evidence regarding the prevalence of intra-firm vis-à-vis arm's-length trade (or foreign outsourcing) is, in any case, limited and somewhat non-conclusive. That is, a significant increase in foreign outsourcing (e.g., Abraham and Taylor 1996), is accompanied by a rise in domestic outsourcing or intra-firm trade (Hanson, Mataloni, and Slaughter 2003).

4.1 FDI decisions at the firm level

In their analysis of the determinants of the integration strategies of MNEs, Grossman, Helpman, and Szeidl (2006) consider three countries: two symmetric northern countries and one low-wage south country. Firms that have different productivity levels produce differentiated products. They carry out two production activities alongside headquarter (HQ) services, and these consist of producing intermediate goods and assembling them into a final product. Production of intermediate goods as well as assembly can be geographically separated and performed in one or several locations. The industry is described by the size of the transport costs of both intermediate and final goods; the relative size of fixed costs for the various types of subsidiaries; and the share of consumers located in the south. Important complementarity links shape firms' decision of where to locate activities. First, *unit-cost complementarities* always exist, according to which a firm locating one production activity to a low-wage country achieves lower unit costs. These, in turn, push the firm to produce bigger volumes, thus creating greater incentives for the firm to locate also other production activities in the low-wage country. Second, for an intermediate range of transport costs for final goods, *source-of-components* complementarity may exist. This may ultimately lead the firm to move assembly operations to low-wage countries if intermediate goods are also produced at low cost. Finally, when intermediate goods are costly to transport, *agglomeration complementarities* exist, as the firm has the incentives to locate production and assembly operations close by. Both unit cost and agglomeration complementarities imply that industries facing higher FDI costs for intermediate goods would exhibit a lower share of firms engaged in assembly abroad. Moreover, for an intermediate range of transport costs for final goods, higher FDI costs for intermediate goods would push more firms to assemble goods in the home country. The Grossman-Helpman-Szeidl (2006) model depicts a relationship between the size of the fixed costs of FDI in components and the composition of FDI in assembly that depends on the size of transport costs. Fixed FDI costs are those that have to be incurred for communication with, and the governance of, the foreign affiliates.

Analysing R&D offshoring to developing countries through the lenses of the Grossman-Helpman-Szeidl (2006) model would lead to the following predictions. In the case of costless international transport, it is the high-productivity firms that perform all operations, including R&D, in the low-wage south country. Conversely, when intermediate goods can be transported costlessly but final goods are costly to transport, there would be an increasing share of firms that engage in FDI in assembly as fixed cost of FDI in components fall. This would happen regardless of the shipping costs for final goods. As the authors themselves acknowledge, the model's rich analysis and array of predictions fall short of being able to encompass both the make-or-buy decision and the organization of MNEs. Grossman, Helpman, and Szeidl (2006) in fact assume that firms produce and assemble in-house, and thus overlook the case of R&D outsourcing.[24]

Antràs and Helpman (2004), in contrast, provide a more comprehensive analysis, where both outsourcing and offshoring are considered. They propose a two-country north-south theoretical framework encompassing a firm's decisions as to where to locate production, that is, home versus abroad; and how to organize it, that is, outsourcing versus offshoring. The study explores how differences in technological and organizational characteristics across sectors as well as within sectors' productivity variation, impact upon international trade, FDI, and firms' organizational choices. The paper combines two important strands of the literature: Melitz's (2003) within-sector heterogeneity, and Antràs (2003) firms' organizational structure, as determined by incomplete contracts and homogeneous productivity. Firms' decision whether to offshore or outsource depends on the types of good traded, that is, intermediate (components) or final goods. In the case of intermediate inputs, such as R&D, sourcing abroad is driven by the possible benefits of lower variable costs in the south versus lower fixed costs in the north. Once firms decide to source abroad, they then choose between integrating vertically and outsourcing. To this end, the final-good producers consider the ownership advantages that might arise from vertical integration, as opposed to those deriving from outsourcing to independent suppliers of components. Such decisions will ultimately be shaped by the wage differential between the north and the south, by characteristics of the industries, and by the degree of productivity dispersion between firms. The relative prevalence of different organizational arrangements will also be influenced by: the trading costs of intermediate inputs; the extent and distribution of bargaining power; the size of the ownership advantage, which might differ between countries; and the intensity of HQ services.

Although Antrás and Helpman's (2004) theoretical model does not provide specific insights about R&D dynamics, it does offer general predictions about the patterns of foreign trade and investment between advanced and developing countries. By emphasizing the role of wage gaps and of the differences in productivity and knowledge creation, it nevertheless opens up important questions about the possible welfare outcomes of such relocation patterns.

Building on Antràs and Helpman (2004), Yeaple (2006) undertakes an empirical analysis aimed at explaining the variation in the intra-firm trade patterns by American MNEs across countries and industries. His findings confirm intra-firm trade to be important in those industries where parent firms need to invest substantially for production in developing countries. The heterogeneity of the firms also proves to be an important factor affecting offshoring FDI to less developed countries. Yeaple's (2006)

24 See also Grossman, Helpman, and Szeidl (2005) for an analysis of the complementarities between outsourcing and foreign sourcing.

results, confirmed by Nunn and Trefler (2008), seem to suggest also that the higher the skill intensity, the higher the R&D intensity. Such a mechanism would indirectly back Leiponen's (2005) argument about skill shortage hindering development. This would be especially true for the least developed countries and would instead contribute to explaining India's recent competitive surge.[25]

4.2 Incomplete contracts, R&D offshoring—outsourcing and the organization of the firm

Grossman and Helpman advance a series of studies in which firms face the choice of whether to concentrate their activities in a single country or internationally and of whether to internalize the activity in the firm or to outsource. Although these papers refer to FDI offshoring and outsourcing in general, they allow for inter- and intra-firm/industry skill differentials and are thus relevant for the analysis of skill intensive tasks such as R&D.

The Grossman-Helpman general equilibrium model (2002) aims to evaluate the firm's decision between outsourcing or in-house production in a close economy. In this framework, differentiated consumer products can be produced either by vertically integrated firms or by pairs of specialized companies. The model features: multiple equilibriums; incomplete contracts; search and production costs, including the sensitivity of manufacturers to production costs; technology differences, economy size differences; and increasing returns to scale. Evolving from previous literature, the model allows for a secondary market in intermediate inputs, leading to bargaining between suppliers and final producers. Hence, both sides have an outside choice driven by prices and variety.

Grossman and Helpman (2003) instead examine the trade-offs between international outsourcing and FDI, that is, firms that outsource and those that buy their inputs via FDI. The paper assumes that producers of final consumer goods are located in the north (N), and that it is cheaper for them to acquire inputs in the south (S). In this model, the final organizational forms, that is, whether outsourcing will prevail, is determined by: productivity differences between specialized and integrated producers of inputs; industry size; degree of contract incompleteness; and wage differentials. With respect to contract incompleteness, the recent framework by Acemoglu, Antràs, and Helpman (2007) analyses the relationship between contractual incompleteness, technological complementarities, and technology adoption. They show that greater contractual incompleteness leads to the adoption of less advanced technologies, and that the impact of contractual incompleteness is more pronounced the more complementary intermediate inputs are. Focusing instead on MNE's managerial incentives, Grossman and Helpman (2004) investigate productivity differences vis-à-vis firms' organizational choices and conclude that, depending on the characteristics of the industry, trade liberalization, which reduces trade costs, may promote either FDI, that is, offshoring or outsourcing.

Finally, in a general equilibrium framework Grossman and Helpman (2005) investigate the decisions to outsource and trade under monopolistic competition. The starting point

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[25] India appears among the least developed countries in Yeaple's framework.

is that firms must outsource the production of intermediate inputs and/or services, whether in the home country or elsewhere. In this two-country model, the north is technologically and legally advanced but has high labour costs. Conversely, the less advanced south shows lower wages but also less complete contracts, and lacks the knowhow to design and assemble various differentiated goods. Outsourcing is envisaged as a search process affected by the relative size of countries, the difference in their factor endowments—both labour and technology—and by market ‘thickness’. The latter implies the number of suppliers existing in a market and the number of its customers. In addition to exploiting differences in relative costs, north firms aim to find suppliers able to customize their input, and to enjoy favourable contacting environments. A stable equilibrium emerges when, as the south expands, its share of global outsourcing increases, together with the share of intra-industry trade to world total trade, and the ratio of trade to world income. Grossman and Helpman (2005) suggest that disproportionate improvements in the customization technology of the south shifts outsourcing from the north to the south.

5 From host to home countries: the role of the new players

According to Reddy (2000, 2005), the evolution of foreign R&D location can be segmented into four main phases (Table 3):

– the initial period;
– the growth period;
– the *internationalization to globalization* period, and
– the *evolving globalization* period.

Throughout these phases, the motive for foreign R&D has changed substantially: from being a mere device to gain entry into foreign markets, foreign R&D now serves a variety of purposes. These include increasing foreign market share, enhancing R&D competitiveness, attracting the best talents, and cutting down R&D costs (see also Squicciarini and Loikkanen 2008). Evidence, mainly in the form of case studies, suggests that MNEs have modified their strategies accordingly. From setting up knowledge-exploitation units, they now increasingly tend to establish knowledge-creation units, with the objective of dealing with the pressure generated by the constant changes in the global economic environment, technology, markets, competition setting, and broader industrial paradigm.

During this process, developing countries have started gradually (but steadily) to populate the scene, as both host and home countries for foreign R&D. In recent years, MNEs have, in fact, accelerated their pace of R&D investments in developing economies. While overall foreign R&D doubled in only ten years (from US$30 billion in 1993 to US$67 billion in 2002), the share of foreign R&D hosted by developing countries increased from 2 per cent in 1996 to 18 per cent in 2002. Before the 1990s, almost all foreign R&D remained within the triad countries, but in recent years, although EU countries still direct their foreign R&D mainly to developed markets, the US and Japan have shifted more of their foreign R&D towards developing countries.

Table 3
The evolution of foreign R&D

Period	Main purpose	MNEs' strategies	Main industries	Characteristics
Initial period				
1960s	Gain entry into foreign market	Utilize technology transfer units to adapt products & processes to local markets	Mechanical, electrical engineering, automobile	Very small number of firms; mostly in developed countries
Growth period				
1970s	Increase foreign market shares	Often acquire established local R&D. Local units develop new & improved products, customized for local markets In such cases host governments rely on industrial policies to push MNEs to transfer technology	Branded and packaged consumer goods, chemical and allied products	Increasing number of units; mostly in developed countries
Internationalization to globalization				
1980s	Enhance R&D competitiveness	Improve inter-organizational collaboration by setting up more knowledge creation R&D units	Microelectronics, pharmaceuticals, biotechnology, and new materials	Changing from internationalization to globalization (vertical specialization and linkages); mostly in developed countries
Evolving globalization				
1990s	Attract talents and cut down R&D costs	Tap into talent pools in dispersed geographic locations, especially those with large pools of low-cost talents	Microelectronics, biotechnology, pharmaceuticals, chemicals, and software	Increasing in scale; foreign R&D in some developing countries and transitional economies

Source: Authors' own elaboration based on Reddy (2000, 2005).

Similarly to what is observed in the case of FDI in general, MNEs' foreign R&D investment is mostly concentrated in only few emerging countries, i.e., Brazil, China, Hong Kong, India, Mexico, Singapore, and South Africa. In particular, China, India, and Brazil are currently considered three of the top ten destinations for foreign R&D expansion (EIU 2004).[26] Their attractiveness is mainly due to their endowment of low-cost and well-trained scientists and engineers, and is supplemented by fast growing domestic markets and by increasing FDI in manufacturing (Sun, von Zedtwitz, and Simon 2007). In the particular case of China, whereas early foreign R&D in China was mainly intended to monitor the growing Chinese market and to satisfy the government's request, in more recent years MNEs have mainly focused on co-locating R&D and manufacturing units, to tap into the rich supply of human talent available. The increased technology efforts of Chinese domestic companies have further pressured foreign companies to enhance their R&D activities in the country in order to being able to maintain their competitive edge in China (Walsh 2007). Microsoft's R&D unit in China constitutes a good example of such evolution: from being a simple technical service and product localization units, it transformed itself into a fully technology development unit, where both research and development are carried out (Chen 2007).

26 By 2005 MNEs had set up 750 foreign R&D centres in China, at a pace that grew five times since 2003 (Walsh 2007).

Evidence on foreign R&D in general also suggests that some of the developing countries and transition economies that have already seen significant investments in R&D under foreign control are increasingly becoming favourite locations for the same. Examples are Hungary, which in 2004 had more than 50 per cent of its business R&D under foreign control, and Brazil and the Czech Republic, with more than 40 per cent (UNCTAD 2005). The fact that not all developing countries are benefiting from these more integrated R&D global networks implies that some countries, especially in Africa and South America, may fall further behind, due to their having been excluded from the process.

Another emerging feature is also that foreign R&D is concentrated not only in selected developing countries, but also clustered in few locations within the national borders. Examples are Beijing, Shanghai, and Shenzhen in China, with 60 per cent of the foreign R&D laboratories in China located in Beijing, 18 per cent in Shanghai, and 6 per cent in Shenzhen—and Bangalore in India (Yuan 2005). This 'over-concentration' of foreign R&D may be due to R&D resource concentration, as well as to the necessity to offset uncertainty, and to imitative behaviours (Sun and Wen 2007).

Hosting foreign R&D investment might have both direct and indirect effects on developing countries. On the one hand, developing countries may benefit directly from the sponsorships and subcontracts that foreign R&D make to local firms and local R&D units. In addition, hosting R&D implies the possibility that technology is transferred to local personnel. This in turn—through recruiting and retaining local talents into the foreign R&D local units—may contribute to minimize brain-drain, (Reddy 2005; UNCTAD 2005). On the other hand, the indirect benefits that developing countries may enjoy thanks to foreign R&D investment include both spinoff and spillover effects. The spinoff effect refers to technology transfer to local firms, to the possible spinoff companies set up by former employees of MNEs, and to the acquisition of new skills by the MNEs' local suppliers driven by the necessity to meet the higher standards set by MNEs. Generally, spillover effects take the form of the entrepreneurial development of the local scientific community and of the development of the R&D culture of the host country, as local firms feel the pressure to innovate in the presence of the MNEs' R&D units (Reddy 2005). In turn, foreign companies also feel pressure to conduct more R&D when local companies increased their innovation capability (Walsh 2007).

In any case, foreign R&D may also have a negative impact on developing economies. Foreign R&D may, in fact, compete for the local and possibly scarce R&D resources, thus diverting human talents from local firms and research institutes. In addition, when too few linkages are created by the MNEs with the local firms or institutes, the host country may enjoy little benefits in terms of knowledge diffusion and knowledge absorption. Finally, MNEs establishing foreign R&D through mergers and acquisitions of local R&D firms or institutions may even hurt the local innovation capability. An example of such detrimental effect has been the case of Brazil in the 1990s, when MNEs acquired local firms in the automotive and telecommunications industries and scaled down the R&D activities of the acquired firms (UNCTAD 2005).

Aitken and Harrison (1999) provide one of the few contributions that go beyond the mixed qualitative evidence offered by the existing numerous case studies. They try to assess the role of FDI in generating technology transfer to domestic firms and to understand if and to what extent joint ventures or wholly owned foreign subsidiaries exhibit higher productivity that their domestic counterpart. To seek evidence on this and about technology spilling over from foreign MNEs to domestically owned firms, they rely on data on Venezuelan firms. The findings suggest a positive relationship between increased foreign equity participation and plant performance. However, such a positive plant-effect proves to only be robust for smaller plants, thus indicating that foreign investments might be directed towards the more productive plants. Aitken and Harrison (1999) also show that the productivity of the domestically owned plants is inversely proportional to foreign investments. This might mirror a market-stealing effect, whereby domestic firms suffer from negative spillovers. Adding up the positive own-plant effect and the negative spillover one, the balance of FDIs on domestic plant productivity ends up being quite small.

An innovative study by Markusen and Trofimenko (2008) investigates the gain from productivity and knowledge transmission arising from the presence of foreign firms. They develop a model in which knowledge is transmitted through foreign experts visiting local plants and training the plant's workers, and test it on Colombian manufacturing data. They find that the use of foreign experts has substantial, although not always immediate, positive effects over the wages of the domestic workers and on the value added per worker. The results they obtain also back the theoretical assumptions that learning from experts triggers beneficial effects that are not merely transitory, and that learning becomes embodied in the workers themselves.

5.1 MNEs' strategies

In recent years, firms have gradually moved from being closed innovation systems[27] to becoming open and networked innovation systems (Arora, Fosfuri, and Gambardella 2001; Chesbrough 2003; Ernst 2005). Moreover, due to the involvement of venture capital and to some regulatory changes[28] firms are under increasing pressure from their shareholders/investors to raise the productivity of their innovative activities and to quicken commercialization (Ernst 2005).

To do so, MNEs have started both to internalize their assets (as suggested by Penrose 1959; Teece 1986; Barney 1991; Chesbrough 2003), and to externalize them, in order to create and use knowledge.

Internalization has two main dimensions. To internalize knowledge creation, MNEs may offshore their R&D activities and locate their units in close proximity to specialized global knowledge centres. Acquisition of local innovative start-ups is the usual shortcut for internalizing outside innovation, as illustrated by the R&D globalization of some Swiss pharmaceutical giants in Boston and San Diego (Zeller 2004). To internalize knowledge usage, MNEs increasingly rely on their networks, so that the knowledge created at one node of the network can be quickly transmitted to other nodes of their global innovation system. Externalization, instead, implies externalizing both knowledge creation, through outsourcing, and knowledge usage, by

27 A 'closed innovation system' has two main characteristics: (i) a firm creates ideas to use only for itself and (ii) a firm uses only ideas that have been created internally (Chesbrough 2003).

28 Important changes of the financial institutions in the US include: (i) the launching of NASDAQ in 1971; (ii) the reduction of capital gain tax from 49 per cent to 28 per cent in 1978, and (iii) the expansion of pension fund investments into more speculative assets (Lazonick 2007).

means of licensing. On the one hand, outsourcing can enhance firms' competitiveness, as firms may thus become able to leverage certain knowledge elsewhere and focus on further developing their specific competitive advantages. On the other hand, technology licensing enables firms to better appropriate the economic rents accruing from the knowledge created by the firm (Iansiti 1997; Iansiti and West 1997; Grindley and Teece 1997).

Both internalization and externalization have implications for firms, also and especially from developing countries. For instance, outsourcing can serve as a shortcut for latecomers to catch up, so that they can focus on their core technology areas while directly using non-core technologies developed by outsiders (Ernst 1997 2000). Offshoring can enhance the knowledge creation capability of firms, especially of the MNEs headquartered in the developing countries and aiming to catch up, since they need to be close to knowledge centres much more than their developed countries' counterparts.

5.2 Developing countries as home countries

In addition to the increasing amount of foreign R&D investment hosted, developing economies have recently been transforming themselves into foreign R&D home countries.

As Puga and Tefler (2007) underline, the recent success of China (see also Zhou and Leydesdorff 2006) and India in international markets lies in their ability to integrate in complex supply chains by delivering shop-floor incremental innovation to foreign firms. The old product-cycle view, holding that all innovation, including incremental ones, would be done in the north is no longer tenable. The number of foreign R&D establishments owned by multinationals that are headquartered in developing countries has, in fact, climbed up over the last years (von Zedtwitz 2005). Frequently quoted examples of such dynamics are Embraer, the world's third largest supplier of mid-range aircraft from Brazil; Huawei, a global telecom-equipment company from China; and Infosys, a leading IT service provider from India.

Developing-country MNEs have not only established R&D labs in developed countries such as the US, but have also located units in developing countries other than the home one. For instance, a number of firms from Singapore, Korea, Malaysia, and China have invested in the software service in India (Reddy 2005).

These phenomena have motivated a number of studies to investigate the major forces that might explain the increasing intensity and the complex nature of foreign R&D. Among the factors analysed there are: (trade) liberalization, technological change, market transformation, competition, and the broader industrial organization in general.

First, liberalization has a direct impact on the globalization of R&D, as the liberalization of trade, capital flows, FDI policies, and privatization have considerably reduced both the cost and the risk of international transactions. As a result, MNEs have become more mobile and able to build their global commodity chains (Gereffi and Korzeniewicz 1994; Gereffi 1999) and global production networks (Dicken et al. 2001; Henderson et al. 2002). Global innovation networks, appeared mainly at the beginning of this century, added another dimension to MNEs' global production networks (Ernst 2005).

Second, technological change, also in the form of increasingly modular technologies, has enabled fragmentation and specialization of knowledge creation (Prencipe, Davies, and Hobday 2003). In particular, information and communication technologies have created new opportunities for globalization, by means of facilitating both the dispersion of firms' resources and the capability and integration of specialized clusters into internalized network (Ernst 2005).

Third, competition and industrial settings have been deeply affected by liberalization and the digital revolution. Markets have become increasingly integrated, and this in turn has made competition more complex. Firms now need to be present in dispersed markets but optimally coordinates in order to achieve integration. This has often implied a shift towards vertical specialization (Ernst 2005), in line with Antràs' (2003) model predictions about the structure chosen by (relatively) more capital intensive industries.

The increasing presence of developing countries in the global R&D scenario reflects the transformation that foreign R&D has undergone. MNEs have particularly favoured those emerging nations where infrastructure building, human resource building, and academic exchange with the developed world have contributed to improving the host environment (UNCTAD 2005). Becoming increasingly interested in the market potential of the emerging countries, MNEs also seek more talents for the knowledge-creation units established there.

6 Conclusions

This paper attempts to critically and systematically integrate the predictions from key theoretical models advanced in the literature related to international trade, FDI, economic geography, and innovation, and to compare them with empirical evidence, at both country and firm level.

The insights gained—whether related to the relocation of tasks and resources, or to investment, innovation, and production location decisions—are useful for economic policy and firms' decisions alike. These micro- and macroeconomic studies, investigating the geographical shifts occurring in the patterns of innovation and production, formalize a new trade paradigm and constitute a considerable step forward in understanding the fragmentation of production, and the rapid spread of knowledge and technology across firms and countries. Importantly, as Feenstra (2008) underlines in his Ohlin Lecture, this new feature of globalization implies that, given the ability of utilizing labour in other countries, domestic resources are no longer the constraint binding international trade in goods nor, as we have discussed, to tasks or skill-intensive activities such as R&D.

Most microeconomic-founded models, in fact, depart from the post Ricardian theory of trade in the way they treat the factors of production, by subdividing labour into skilled and unskilled, which Feenstra and Hanson (1996 1999) re-label as *activities*, and Grossman and Rossi-Hansberg (2008) *tasks*. Their analyses show that comparative advantages will ultimately determine which activities and tasks will be sent abroad, similarly to the case of trade in goods (Bhagwati, Panagariya, and Srinivasan 2004).

A noteworthy insight from this literature is that it is not just the less-skilled activities being relocated to the south, but can be the high-skilled ones as well. This challenges the conventional comparative advantages assumption at the basis of the north–south models of trade and investment. Moreover, the studies surveyed emphasize that skill differentials both cause, and are affected by, the recent internationally fragmented innovation and production settings, and shape trade and factor earnings.

More generally, factor price differences across countries, trading costs, countries' size and openness, relative skill endowments, productivity differentials, completeness of contracts and their enforceability, knowledge production and spillovers, and IPR regimes all shape foreign sourcing and the specific R&D location patterns that emerge.

At the global level, greater economic integration and the fragmentation of innovation and production affect price determination, the terms of trade and productivity, and ultimately shape business cycles (Feenstra 2008). Therefore, the overall impact of offshoring and outsourcing in general—and of R&D in particular—cannot be seen in isolation, as it is part of the complex globalization phenomenon.

However, in order to analyse R&D (re)location as part and parcel of globalization and knowledge dynamics, some shortcomings of the literature should be addressed. Among them, three are of particular relevance. First, the mobility of all factors, and especially that of human capital, would deserve more attention. It would be interesting to see what happens when factors of production are not only mobile across sectors (as it is normally held, e.g., Gao 2007, and Ekholm and Hakkala 2007) but also across countries, and if and to what extent human capital mobility is affected by skills. Second, it would be extremely important to model offshoring and outsourcing, and in particular R&D (re)location, as a multi-country phenomenon, thus going beyond the typical two or three country models. In doing so, models would be better able to capture the determinants, dynamics, and effects and the increasingly proliferating multilateral agreements. We are indeed aware of the difficulties implied by this exercise, but multi-country models would also benefit empirical research, since they would constitute a more 'adaptable' base for empirical analysis. Third, and in relation to the above, the necessity exists to collect data more systematically and broadly to be used for the empirical assessment of the effect that R&D (re)location might have on the innovativeness and productivity of both home and host countries. Merging and matching R&D data to trade data would further allow empirical verification of how much the existing models capture in reality.

The rich array of theory and empirical evidence about firms' (re)location, also of R&D, suggests that trade in tasks affects global income inequality, particularly in the south, due to skill differentials and relative return to skills. Such an impact, however, is not necessarily negative either in the south, as the cases of China and India reveal, or in the north. In the case of the north, the literature shows that offshoring tasks might have the same effect as factor-augmenting technological progress, thus challenging the popular view that (re)location might have a negative impact on welfare.

In any case, this 'is a new and exciting topic, which may well replace increasing returns and imperfect competition, endogenous growth and political economy as the next major area in trade' (Feenstra 2004: 406–7), FDI, and innovation.

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