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# DISEMBODIED KNOWLEDGE FLOWS IN THE WORLD ECONOMY

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# Disembodied Knowledge Flows in the World Economy

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**Abstract**

For most of the post-war period developing countries have been told that relying on licensing for technology transfer is likely to yield disappointing results. However, this view of licensing has come a full circle as technology services trade has boomed since the 1990s. We outline the main trends in the growth of disembodied technology trade vis-a-vis international licensing and the trade in R&D and technical services. We show that there is considerable heterogeneity across countries in the form of technology trade that countries specialize in and also suggest these are related to underlying appropriability conditions and IPR regimes.

JEL Classification: O32, O33, O34.

Key Words: International licensing, R&D services, technology transfer.

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## 1. Introduction

In a globalised world, countries need not depend only upon their own resources to acquire the technologies they need for production. The other resources include those that can be acquired through trade related to technology blueprints, patents, the right to use patents and various kinds of technical services. Technology trade is synonymous with technology transfer. Such trade includes both embodied (in artefacts) and disembodied (blueprints, patents and intangible or service) forms of technology. Technology gap and product cycle theories of trade, formulated to explain the shifting location of technology, focussed on embodied forms of technology trade. They attempted to explain the competitive advantages of countries who were successfully able to embed their technological advancements into the trade in new types of technology, referred to as embodied goods. However, much less is known about the factors influencing the trade and transfer of disembodied technologies.

Historical studies of successful technology transfer (e.g. from Europe to America in the inter-war period) documented the transfer only when it was embedded in key personnel who migrated elsewhere (Rosenberg 1989, Athreye and Godley 2009). These studies suggested that informal aspects of technology transfer, such as knowledge and networks that were associated with particular people, were as important as the formal elements of technology transfer. Barriers to the movement of scientists made this type of people-embedded technology transfer less common in the post-WW2 period. Instead, technology-imbued foreign direct investment (FDI) and international technology licensing became the main modes for conducting international technology transfers.[1]

Studies of technology transfer to developing countries in the post-war period showed that these transfers in licensing and other turnkey projects were inadequate. In part, this was because the transfer of the essential know-how, which would allow a developing country firm to use imported technology for their own ends, remained something that could not be fully contracted for. Developing country firms that made their own efforts to learn and master the technology were able to achieve a higher degree of technology transfer and the associated development of their own technological capabilities compared to those that did not (Bell and Pavitt 1997). One implication of these arguments was that since technological capability played a central role in recognising the tacit and context-dependent elements of technological knowledge, successful technology transfer (through trade) would be limited to partners with similar technological capabilities. Nevertheless, the perceived failure of licensing as a mode of technology transfer to the developing world was widespread.

The literature on foreign inward investment and licensing further suggested that both were sensitive to the intellectual property rights (IPR) regimes prevalent in the host country (Davies 1977, Lee and Mansfield 1996, Smarzynska Javorcik 2004, Caves 2007). The experience of government policy in trying to untangle the technology transfer aspect of FDI from the ownership of FDI in India found that foreign firms would not transfer advanced technologies without large equity shares. Therefore, the scope for technological spillover and local learning was constrained in weak IPR environments (Athreye and Kapur 2001). In the policy domain these findings were supported by calls for a tightening of IPR regimes in the developing world and its harmonisation with IPR regimes in developed countries. The Agreement on Trade-Related Aspects of Intellectual Property Rights and also the pressure on large developing economies like India and China to reform their IPR systems were proof of this tightening.

Amidst this general pessimism in academic writing about the constraints to technology trade, the growth in both the volume and variety of traded technology services in the 1990s, often involving the developing world, came as something of a surprise. Athreye and Cantwell (2007) showed a dramatic increase in the value of international licensing in the world economy since the 1990s and also a greater participation from all countries (including developing countries) in these transactions.[2] Evidence for the US suggested that

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[1] We do not cover the developments and debates in the analysis of technology-imbued FDI as this is beyond the scope of this paper that focuses on technology trade.
[2] See more details of the increase in values and extent of participation in Table 1.

income from international licensing saw an average annual increase of 12% per annum in the 1990s and that US firms licensed out four times as much technology to foreigners as they licensed in (Mottner and Johnson 2000: page 172). Caves (2007:1996) suggested, based on other cited evidence, that foreign licensing should in fact be a higher proportion of all licensing activities of a firm because of the fears about technology leakage to close domestic competitors. If true, this suggests that international licensing flows do in fact form the bulk of technology licensing in the world economy. Case study evidence on the growth of emerging market multinationals such as the Korean multinational Hyundai (studied in Hyun 1995) or the Indian business house Reliance (cited in Rosenberg 2002) or environmental technology firms such as Suzlon (India) and Suntech (China) have all showed that the licensing-in of key technologies from specialist technology suppliers in the West had a very important role to play in explaining the growth of these firms.

Other forms of technology transfer have also emerged. Many categories of technical services have rapidly increased their share of international trade such as research and development (R&D) services,[3] computer services, design services and different types of technical consultancy services. In some cases these were from countries which did not have a very strong record on IPR protection. Love and Roper (2002) also showed that the choice of internal or external R&D was motivated by the need to achieve economies of scale in R&D. This being the case, cost considerations would drive R&D outsourcing decisions far more than technological opportunity. Arora and Gambardella (2005) studied the rapid expansion of internationally traded computer services and showed that the suppliers were often placed not in developed but in emerging markets whose main assets were a relatively large stock of educated scientific labour.

The wheel has thus turned a full circle in the debate on the tradability of technology. Not only is technology tradable between countries at different levels of development, new forms of technology (services) trade have emerged where ownership of intellectual property (IP) is clear. Emerging countries are also important suppliers of some of these new technology services. Explanations for these trends have come from a diverse literature which is reviewed in Section 1 below. The three main drivers identified are: (i) the ability to write more efficient technology purchase contracts, (ii) the emergence of new business models such as IPR-based licensing, client-based R&D and (iii) models of open innovation, and the growing harmonisation of IPR regimes in the world economy due to the emergence of trade blocs and the role of agencies like the WTO.

Section 2 of this paper reviews the macro and micro sources of information on disembodied (service) forms of technology trade. Section 3 outlines the main trends in international licensing trade using Balance of Payments (BoP) data. Sections 4 and 5 analyse unpublished data on the Technology Balance of Payments from the Organisation of Economic Co-operation and Development (OECD) to show the heterogeneity in the forms of technology service provision and the influence of the prevailing IPR systems on the composition of technology exports. Section 6 provides evidence on the sector concentration of technology services trade and Section 7 concludes.

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[3] This refers to R&D outsourcing (i.e. the trade between independent suppliers of R&D services and their buyers) rather than R&D offshoring (R&D activities located in a different geography from the parent firm).

# 1. Explaining the resurgence of technology trade

## 1.1. The characteristics of technology and their influence upon the nature of licensing contracts

Early studies on international licensing saw it as an alternative entry strategy into foreign markets, particularly compared to exporting or foreign direct investment (Telesio 1979, Calvet 1981, Porter 1986). However, the technological nature of a service or information may make it less likely to be exported. Although imitation risks could induce firms to make direct investments in order to protect rents on their proprietary technology, the risks inherent in locating production facilities to exploit that technology in unknown geographical markets would make licensing an attractive option when penetrating new foreign markets. In order to license, firms would first have to patent in the new geographies and the strength of the IPR regime stands out as a key factor influencing the decision to license. Where IPR protection is weak or the political environment is risky, firms will prefer to locate multinational subsidiaries rather than license their technology (Contractor 1981, 1985). Caves, Crookell and Killing (1983) list the factors that favoured licensing over foreign direct investment: small market size as compared to minimum efficient size of activity; absence of required additional assets; speed of technological obsolescence and appropriability risks.

Detailed studies of technology contracts in the 1990s revealed a great diversity in the nature of written contracts and showed that several issues inherent in the characteristics of technology and the inadequate protection afforded by IPR were in fact overcome by appropriate contract design. Two particular characteristics of technology that influenced trading contracts were its public good nature and the inability to agree on a valuation of the technology due to asymmetric information and uncertainty about its future uses.

Arora (1995) pointed out that there are typically two transfers in a licensing agreement, viz. the right to use patented knowledge and the know-how to make it usable; sometimes distinguished as the tacit and codified forms of technology. According to Arora, the patent system enables the innovator to solve the moral hazard problem caused by irreversible transfer of know-how. If the licensee is an opportunist, then the licensor can rely on law and public institutions to prevent him from doing so. Furthermore, since the transmission of know-how is indispensable to implement the technology, the patent system also protects the patentee against infringement without incurring large search and litigation costs to protect the patented invention. From the licensee's perspective, the duality of knowledge helps avoid the problem of adverse selection in the transfer of technology. Because knowledge is partially protected by IPR regimes, the potential licensee can evaluate the technology before using it.

Arora (1996) used data on license contracts made by Indian firms and showed that the widespread practice of paying a lump sum for servicing the technology in addition to licensing fees was in fact systematically related to the tacit element of technologies – the larger the tacit element, the higher were these lump sum payments. Contrary to the assertion that only firms with considerable technological abilities could effectively buy technology, these arguments showed that it was possible to create markets for technology trade if effective contracts were written that exploited the complementarities between knowledge and the resources required for its effective use.

Another strand of research used transaction cost economies to understand the diversity of licensing contracts. This literature was extensively reviewed in Bessy and Brousseau (1998) and we draw on their arguments here. Bessy and Brousseau argued that since technological knowledge can be embodied in several physical forms and often requires access to resources in order to implement effectively, the patentee can exploit this to bundle resources together with licenses. These are particularly common in vertical relationships and can vary according to what the licensor and licensee bring as their own resources to the negotiating table. They term such agreements as 'relational' contracts and predict they will be more common among firms of similar size and capabilities than firms with very different resource and technological capabilities.

The authors also identify the multiple uses of technology as a source of uncertainty in the pricing of technology and in rendering IPR ineffective in protecting misappropriation of benefits. These are typically common in horizontal contracts (in the same industry or sector where market share is a key determinant of profitability). Here, the development of common knowledge amongst firms in the industry can be a great facilitator of licensing. Typically, the building up of such common knowledge among industry participants is aided by the use of technology platforms, significant cross-licensing (which allows firms to retaliate in case of violations), the development of industry standards and norms, and the role played by special intermediaries who keep detailed records of transactions (e.g. royalties paid for pharmaceutical licenses) that make public the information on prices and help reduce uncertainty and also the asymmetric information between licensor and licensee and thus enable pricing – all these factors can help make the licensing contracts more standardised and transactional Moreover, it is also well documented that such transactional contracts are typically dominant in a few industries such as pharmaceuticals, chemicals, electronics and computer industries (Caves et al 1983, Anand and Khanna 1996, Gambardella and Torrisi 2010). The evolution of collective institutions that favour knowledge circulation and enhance IPR protection typically occurs over time (Nelson 1993).

## 1.2 New business models and their impact on licensing and technology services

The established model for the valorisation of intellectual capital was the framework developed by Teece (1986). This framework argued that based upon the possession of complementary assets (like control of distribution or marketing channels) and the strength of IPR regimes, an innovator may be able to profit (more or less) from an innovation. Specifically, Teece (1996) argued that when innovators lacked control over complementary assets but were situated in strong IPR regimes they could profit from the licensing of their innovation to another firm, but in most cases, the possession of complementary assets would favour the exploitation of technology by the vertically integrated large firm.

The 1990s saw the emergence of a new literature on technology entrepreneurship and new business models for the generation and transfer of technologies by small firms (see Libaers et al 2010 for a taxonomy of commercialisation strategies of small technology firms). IPR-based licensing, where small firms are able to obtain patents and earn revenues by licensing them out (Athreye 2004, Hicks and Hegde 2005), became a popular practice amongst small biotechnology firms and hi-technology firms in the electronics space (amongst chip manufacturers like ARM, Qualcomm). Arora, Fosfuri and Gambardella (2001) argued that these models represented a growth in technology markets, building upon the emergence of general purpose technologies such as information technology (IT) which had increased the codifiability of knowledge in the R&D process, the fact that small firms are more likely to derive revenue advantages from licensing since resource constraints prevent them from vertically integrating to produce the final technology product and that large firms can benefit from specialised technology inputs available through technology licensing.

At the same time, entrepreneurial activities in emerging economies with a high supply of scientific labour (such as Ireland, Israel and India) uncovered the provision of technical services as an important niche area of export for nations with scientifically trained personnel. The provision of customised technical services circumvented the problem of technology ownership as the IPR on a technical service always belonged to the client firm (Athreye 2005). The growth of a software exporting industry in many emerging economies (analysed in Arora and Gambardella 2005) provided a new twist to the story of technology services trade where developing nations could emerge as trading partners for developed country firms and multinationals by providing technology services of various kinds. Given the relative shortages of scientific labour in the developed world and the barriers to their movement, the growth of offshore and outsourced R&D corresponds to a well known corollary of the Heckshер-Ohlin trade model – the trade in goods and services will move to compensate for the relative immobility of labour services. The differences between licensing and the newer business models based on services provision are discussed in Box 1.

R&D outsourcing also began to gain popularity although the trend for R&D offshoring was more dominant than R&D outsourcing. From the late 1990s, large multinational enterprises began to diversify their geographical sources of R&D, which also resulted in increased intra-firm trade in R&D services. Dunning and Lundan (2007) provided some estimates of the rapid growth of this phenomenon. They estimated that in 1982, only 30% of production activities and 12% of innovative activities of the world's largest industrial companies was located overseas. However, by 2005, some European firms were conducting over 40% of their R&D abroad. The picture is similar for US companies: R&D abroad had increased from 7% in 1982 to 15% in 2004. These are still not large proportions but do indicate a steadily increasing trend towards R&D internationalisation.

Lastly, as technologies become more complex, firms are also forced into more open innovation models and dependence on specialist technological inputs and suppliers (Granstrand et al 1997). This has meant that firms typically look for various kinds of external partners in their innovative efforts, including universities, specialist suppliers of R&D services and cooperation with other firms. While innovation from suppliers in a supply chain context is not free from IPR considerations, the emergence of "open source software" which was free of IPR concerns was another new business model development – also termed rather confusingly "open innovation" (von Hippel 2010). This kind of business model exploits an information common. A piece of software may be added to by other users to provide new applications for the user community. The Linux platform is an example of this, but it is easy to see that also with chemical formulas, music – all are capable of open source innovation. Thus, the open innovation paradigm embraces two sorts of business model, one based on the openness of the innovation process where IP protection is central and another based on innovative outputs where IP protection is not an issue (Von Krogh, 2011).

## Box 1: Alternative business models in the provision of technology

Technology services, R&D services, and technology licensing represent alternative ways of selling disembodied technology. In the case of Technology and R&D services exports, the IPR for the technology bought usually resides with the client/buyer; this is more efficient in situations where technology transfer is likely to encounter a large tacit or bespoke component which requires frequent communication or monitoring. However, the information and knowledge embedded in technology and R&D services is more difficult to protect with the legal regime of IPR alone due to the movement of people between companies. The signing of non-disclosure contracts with employees is often the way large firms engaged in R&D services to protect them – anecdotal evidence suggests firms like Intel sign non-disclosure contracts that last for a minimum period of five years with their suppliers. The use of such additional contracts raises the transaction costs of this type of trade and makes it more sensitive to the quality of the legal environment and informal norms of behaviour. In contrast, licensing is more efficient when technologies are patentable (or otherwise protected under IPR) and codifiable, when IPR protection is also easier to achieve.

The cost structures underlying the two types of activities (provision of services or sale through license) are quite different. R&D services (and technology services) are usually provided on a project basis, with the client paying revenues when important milestones in the R&D project have been reached. The fixed cost components can be quite low, although marginal costs are high due to technological labour additions; while different projects are serviced or while different parts of the same project are serviced. Therefore, efficient labour utilization is key to the success of such enterprises; when this condition is met, R&D services firms can often grow very large and usually contain a reasonably well diversified talent pool within the firm. Most independent and successful software and R&D services firms have tended to be large in terms of employment and value of turnover (e.g. Logica in the UK, Wipro in India, or Auriga of Russia).

In contrast, licensing is typically valuable to the small firm that has discovered a radical new technology with many potential new applications, but which is unable to find the capital to invest in all those possible new applications (Teece 1987). In such a situation, the firm maximizes the revenue it can earn by selling the technology (Arora and Fosfuri 2003) rather than by trying to recover the rent on its proprietary knowledge over a longer period of time. Such firms with business models based on licensing (e.g. ARM, Qualcomm in Cambridge) became very prominent in the UK's industrial resurgence of the late 1980s and tend to be quite small because licensing does not require an increase in size measured as employment, while the impact of technological success is bound to be reflected by turnover and market capitalisation (Athreye 2004). In licensing-based business models, the main costs are the sunk costs incurred in the development of the proprietary knowledge and the legal costs involved in writing licensing contracts and enforcing them.

For the innovating firm, the two types of models might be complementary as many open innovation models suggest. Many large-value R&D services transactions may involve licensing agreements and because of this even though R&D services are not dependent on strong IPR, firms undertaking large-value R&D transactions may be worried by weak IPR protection (Hagedoorn et al 2009). Thus, while it is reasonable to think of these business models as alternative means of technology transfer for the economy as a whole, when looking at particular firms, they may represent complementary modes of delivering technology.

## 1.3. Intellectual Property Protection and the direction of international technology services trade

As the previous sections showed, the most important issue in the inter-firm trade in technology involving a direct transfer of tacit knowledge towards third/local parties, such as in patent licensing or arms-length contracting, R&D assistance, R&D delocalisation, is that they are also affected by the risk of knowledge dissipation in foreign markets due to inadequate appropriability (Vishwasrao 1994, Glass and Saggi 1998). This is likely to be a particularly strong concern for sellers of technology services when trading technology internationally. Stronger patent protection lowers the costs of enforcing contracts (i.e. monitoring, litigation costs, etc.) mitigating the costs of technology transfer (Contractor 1980, Caves et al 1983). Stricter IPR would increase the licensor's profit by two main effects: a higher economic return from licensing ("the size effect") and a superior rent share ("the distribution effect"). Furthermore, by reducing the relative transaction costs, i.e. fixed costs of reaching and enforcing licensing contracts, stronger patent rights may shift incentives toward licensing away from FDI or trade (Vishwasrao 1994, Fosfuri 2000, Maskus et al 2003).

The tacit nature of technology also influences the seller's choice of the form in which to affect technology transfer. When technological knowledge is tacit and complex, contracting becomes more problematic and transaction costs are the largest (Teece 1977, Balakrishnan and Koza 1993, von Hippel 1994); firms are then better off exploiting the proprietary technology by embedding it in a final product or R&D service which can be sold through exports or through foreign direct investment. However, where technology is more codified and associated with multiple uses, licensing may offer a better prospect for earning revenues. In the same context, it should also be noted that some kinds of technology trade are better protected by IPR norms than others – thus, for example, in the case of R&D services, knowledge may not be patentable and therefore prone to leakage through employee turnover. In such a situation, firms may also prefer to buy and sell technology services from countries that are clearly technologically inferior, so as to protect themselves against ready imitation.

Evidence on the direction of licensing trade is very patchy and this is available only on a country by country basis to researchers who have invested effort in collating such data. In this section we review the evidence from such studies. The earliest such effort was made by Kumar (1997). He examined trends and patterns in international licensing as represented by royalty and license receipts by developed countries and he contrasted flows of these to flows of inward FDI. His analysis, based on data for 1976–1995, suggested that much of the technology transfer in the world took place between the economies of the USA, Europe and Japan. Europe traded more than half its technology within Europe while Japan trades about 47% of its technology with the East Asian newly industrialising economies of Taiwan Province of China, South Korea, Hong Kong, China and Singapore. The USA transferred more technology to Europe than to Japan and a small share (6%) to the North American Free Trade Area countries.

There are very few recent studies on the direction of technology services trade. This is mainly for two reasons. First, aggregated and disaggregated (firm/enterprise level) data on the direction of trade are very limited and not compiled systematically by any agency. Indeed, currently such data are only available for the USA and more recently, for the UK. Second, there are major problems in assessing the role of IPR in countries that buy or receive technology payments in cross-country contexts.

Apart from issues to do with the measurement of strength of IPR protection (see Box 2), IPR changes tend to take place when the general legal infrastructure and level of development merit these changes (Odagiri et al 2010). Typically, countries have reformed IPR voluntarily only when they found that they felt they could benefit from it. A weak IPR favours buyers of technology, many of whom reside in the poorer countries of the South. The recent experience with Indian reforms suggests that the pharmaceutical and software sectors in the country actively lobbied for the change in IPR laws, although officially, the government claimed to have adopted the changes in response to TRIPS requirements (Rangnekar 2005).

In statistical parlance, these arguments suggest that the strength of IPRs is highly correlated with measures of economic development such as GDP per capita. However, theoretical arguments also imply that the strength of IPR is endogenous to the growth of technology trade and in any cross-country analyses the true value of IPR can only be assessed by the use of adequate instruments that overcome the problem of endogeneity. The endogeneity of IPR is much less of a problem when firm-level data are used.

## Box 2: Measuring the strength of IPR protection

Measuring the strength of IPR protection is a contentious subject. There are two broad measures of IPR protection that are used in the empirical literature and they highlight the different issues fairly well. The most commonly used index is the Ginarte and Park measure outlined in Ginarte and Park (1997). The authors examined the patent laws of a large number of countries quinquenially from 1960 and covered five aspects of the law: duration of protection, extent of coverage, membership in international patent treaties, provisions for loss of protection and enforcement measures (although the authors do not assess how well laws are enforced, only the availability of measures for enforcement such as infringement provisions). Each of the sub-groups is a dummy variable, so the index ranges from 1-5. IPR enforcement remains a distinctly separate matter and another approach is to survey multinational enterprise (MNE) managers who may have a better understanding of the differences in the effectiveness of IPR protection in different national systems. While the perception of IPR protection may be less related to the treaties and laws for enforcement, they will be strongly related to the actual enforcement of those laws. The World Economic Forum provides one such measure where respondents are asked to rank the effectiveness of a country's IPR protection in protecting their proprietary technological knowledge.

Throughout the 1990s, due to both harmonisation of IPR rules as countries joined trading blocs and pressure from TRIPS, many countries harmonised their IPR rules and signed up to stronger regimes of IPR protection (see Figures 1a-d in the Annex).

Figure 1 plots the perceptions about the effectiveness of Intellectual Property Protection (IPP), which is reported in the Global Competitiveness Report compiled by the World Economic Forum, against the actual ranking of countries based on their signature to various IPR treaties, as compiled by the Ginarte and Park IPR index, for the year 1997. Four groups of countries are distinguished: OECD advanced countries, OECD transition countries, BRICS and sub-Saharan Africa.

Overall, the figures show the two measures are fairly positively correlated (r=0.67). However, for some emerging markets (e.g. China and Brazil) in Figure 1a and some transition economies (e.g. Poland), the signing up to different treaties has not led to a better perception about the effectiveness of IPR in these countries. The figures also show that the size of GDP and size of licensing payments and receipts are related to IPR strength.

Some authors notably Arora (2007) and Jarvorcik (2007) recommend a more nuanced use of the Ginarte and Park Index where the index is interacted with variables that measure patent effectiveness of sectors and the quality of legal enforcement. These variables have become available systematically only relatively recently but for studies that use longitudinal analyses the Ginarte and Park measure still remains preferred as a measure of IPR strength.

Branstetter, Fisman and Foley (2006) draw on firm-level data from annual and quarterly surveys conducted between 1982 and 1999 by the US Commerce Department's Bureau of Economic Analysis. The paper relies on a natural experiment, viz. the tightening of IPR norms in seventeen destination countries to overcome the problem of IPR endogeneity. They find that for destination countries where patent protection has been strengthened, royalty payments increase for the use or sale of intangible assets made by affiliates to parent corporations, which reflect the value of technology transfer. This increase is concentrated among the affiliates of firms that make extensive use of US patents prior to reform. Investment in R&D by affiliates, which is usually viewed as a complement to technology of imports from the parent, also increases after IPR reform, as do both the level and growth rate of non-resident patenting. These increases collectively suggest that at least one component of growth in licensing flows is associated with the introduction of new technology following patent reforms. The researchers find no corresponding reaction in resident patent filings. Taken together, the results provide evidence that strengthening IPR protection results in real increases in technology transfer within multinational corporations.

Using similar data for the UK, drawn from the International Trade in Services Surveys, Athreye, Mickiwiecz and Yong (2011) use a number of different measures of IPR strength in destination countries and sectors of origin and assess its influence on R&D services exports and technology licensing receipts from the UK. Their results paint a more complex picture of the relationship between IPR and technology trade. It has been known for a long time that some sectors of industrial activity are better protected by patenting than others – thus, it is well known that chemicals, pharmaceuticals and biotechnology benefit from the patenting regime while other sectors such as IT or technical business services are less protected. In the context of international trade in technology they show that prevalent IPR regimes may either intensify these effects or compensate for the weaknesses of IP regimes in the destination countries. So for example, a software services firm, which is weakly protected by patents, may still prefer trading with a country where the IPR environment is strong because it allows the firm to appropriate what returns are possible leverage what rents it can. On the other hand, a pharmaceutical firm with enforceable patents in its main markets may not be overly concerned with the poor IPR in a particular jurisdiction that is not its principal market. Thus, policy recommendations on IPR are rendered more complex. They also find that IPR strength matters much more for destination countries with greater technological capability (measured by the number of patent applications they make) and those countries with larger shares of multinational patenting also attract more R&D service exports as well as licensing exports.

## 2. Forms of disembodied technology trade and data sources

## 2.1 Forms of disembodied trade in technology

Early measures of technology trade and papers based upon them focussed on the trade in final products that have a high technological content in them - in other words, they focussed largely on technology trade embodied in the form of goods (Dosi and Soete 1983, Fagerberg 1987, Cimoli and Soete 1992). There are several definitions of hi-tech industries based on the employment of scientists or the R&D intensity of the industry which are used to classify exports into hi-tech and low-tech and another popular approach has been to study the export of technology in the form of the export of these types of goods.[4]

Trade in technology services, in contrast, is disembodied technology – they share two characteristics that are similar to the trade in other services. Firstly, their production occurs in proximity to the consumption of the service and so their trade is thought to suffer from a ‘proximity burden’ since consumers need to be located nearby (Christen and Francois 2009). However, technological changes, especially the increasing role played by information and communication technologies in the delivery of some services, are thought to have weakened this proximity burden. Second, service provision has an element of “jointness in production” in the sense that complementary inputs (including other services) may be needed for the effective exchange (trade) of a service to occur. One implication of this feature studied by Sampson and Snape (1985) is that service delivery could occur in many modes and direct cross-border trade is only one mode by which such trade takes place. Other modes include movement of the customer to the country of service provision (inward FDI), sales of the service through offshore affiliates and temporary movement of persons to provide these services. The use of FDI as a complementary mode of supply to exports stressed in the trade in services literature runs counter to some of the traditional thinking in the international business and management literatures where FDI is seen as an alternative to export sales (e.g. through arms-length technology licensing).

The commonest form of disembodied technology trade was the international licensing of technology (see Box 3 for a definition and issues relating to the use of royalty and licensing data). Now firms can also buy technology services internationally and the 1990s have seen several new forms of technology service trade emerge, such as traded R&D services and many kinds of technology consultancy services, including software services. Often licensing and technology service agreements may be embedded in strategic alliances between firms.

### Box 3: What are Royalty and License fees?

The most widely reported forms of disembodied technology trade are international receipts and payments for the use of intangible assets measured by the payments of royalty and license fees. The International Monetary Fund defines royalties and license fees as including “international payments and receipts for the authorised use of intangible, non-produced, non-financial assets and proprietary rights ... and with the use, through licensing agreements, of produced originals or prototypes ...”. Usually clubbed together in most usage, royalty payments are based on an underlying license agreement.

Royalties are usage payments made for the ongoing use of an asset by the ‘licensee’ to the ‘licensor’. Typically they take the form of a percentage of revenues generated by the asset. This asset may be IPR (such as a patent, but may also include books and music) or it may be for use of other natural assets such as oil or mineral resources where the licensee pays a resource rent to the owner of that asset. Although many types of activities can earn royalties, the authors’ calculations based on US data from the Bureau of Economic Analysis (which have the finest breakdown on the

[4] Two very commonly used classifications of this type are Butchart (1987) and the OECD’s classifications table from 1973 onwards.

different categories of royalty revenue) suggest that industrial processes and computer software account for over 70% of all royalty receipts and payments.

License agreements are private agreements that govern the usage of a resource for which royalty payments are being made. Since the spread of word processing in administration, we have become used to a contract on the use of that software appearing on our screens every time we install a new version of software program. These agreements may be without any restrictions but this is rare. Usually the usage rights are subject to a limitation on term, business or geographic territory, type of product, etc.

Royalty rates and license agreements have several industry-specific characteristics and these have usually been studied through an analysis of licensing contracts. Royalty payments and license agreements are often embedded in strategic alliances where one or more firms decide to pool their R&D skills and resources towards a specific effort (e.g. the Airbus).

Data on royalty and license fees have been collected for a long time, although pre-1996 many countries recorded these receipts and payments on the capital account of their BoP. Madeuf (1984) and OECD (1995: Box 12.1) contain a detailed discussion of the problems and limitations of using royalty and licence fee data to infer technology transfer. The main issues surround the problem of isolating technology revenues from transfer pricing.

The OECD has made the most systematic effort so far to measure these new forms of disembodied technology trade and identifies four categories of technology services, defining them as follows:
(i) International transfer of techniques (through the sale of patents and licences, disclosure of know-how),
(ii) International transfer (sale, licensing, franchising) of designs, trademarks and patents,
(iii) International trade in services with a technical content, including technical and engineering studies, as well as technical assistance, and
(iv) International trade in industrial R&D services (includes offshoring within multinational enterprises and outsourcing of R&D between independent firms).

## 2.2 Data Sources

Data on international trade in all four types of technology services are recorded as part of the International Trade in Services in the BoP of every country. Norms of reporting on these items have been harmonised since 1996 with the publication of the BOP Manual V.5 by the International Monetary Fund.[5] Prior to this harmonisation, there were different conventions on where the royalty and licensing data were recorded – some countries recorded them only in the capital account of the BoP. Furthermore, the BoP manual has given a finer classification of the trade in services and made it mandatory for every country to report according to this classification.

The USA uses a slightly different reporting structure which is consistent with the Manual guidelines, but more detailed with respect to the transaction itself. Thus, US data measures the extent of royalty and license trade, which is intra-firm (or affiliated) trade and also lists the most important trading countries and regions. Robbins (2008) provides an overview of US data sources for the measurement of the total market for licensing. These details are absent in the public reporting of data from other countries.

Cross-country data on trade in technology services sourced or derived from the BoP remain the single most important source of information on the international trade in technology services. These data have been collected in two publicly available databases, viz. the World Development Indicators (WDI) and the OECD's Technology Balance of Payments. The WDI collates information on Royalty and Licensing Fees across a broad grouping of developed and developing countries. The OECD's Technology Balance of Payments is more recent and the first year for which disaggregated information is reported on the different technology

[5] This manual is publicly available and downloadable from http://www.imf.org/external/pubs/ft/bopman/bopman.pdf (last accessed 12 Nov. 09)

services is 1996. These data have a smaller coverage (of OECD countries only) but report on a wider range of traded technology services. In this paper, we use both data sources. Moreover, since a large proportion of technology originates and is traded between OECD countries, in this report we will explore both published and unpublished data from the OECD's Technology Balance of Payments.

An alternative source of data is firm-level technology agreements and licensing payments. Currently, there are two main sources for this information and we draw upon information provided by these data sources, but note that the representativeness of both the firm-level data-sets is unclear – they appear to be biased towards US firms and large firms.

First, there is the MERIT-CATI database, which comprises all technology agreements reported in the media between 1975 and 1999. Various sources from the international financial and specialised technical press were consulted to systematically collect information on inter-firm partnerships. Within the databank, there is information on each partnership, and some information on companies participating in these partnerships. Hagedoorn (2002) describes these data and has published extensively on the nature of technology agreements by drawing on this dataset.

A second source of information is the Thompson Financials SDC Platinum database which covers over 6,235 technology licensing agreements involving 7,006 firms between 1976 and 2009 (Gambardella and Torrisi 2010). The advantage of these data is that they provide greater detail on the technological sector, contract details (extent of exclusivity, lump sum versus fee elements, and other restrictions) and information on typical pairs of licensor- licensee which cannot be found in the aggregate data. On the other hand, they are dependent on the voluntary disclosure by firms of their technology agreements, which may also be driven by strategic concerns.

## 2.3 Data limitations

Not only are there very few data sources available to study questions associated with the growth of disembodied trade flows, but the available data are also inconsistent and incomplete. Let us take the inconsistency issue first.

US data report both the direction of technology services trade and the extent of such trade that may be regarded as intra-firm or trade between affiliated firms. They also detail more finely the royalties earned on account of patents, trademarks, franchising activities and software licenses. This degree of detail is absent in the BoP data reported for most other countries. In the absence of these data, we might be tempted to rely on US estimates as representative, but this would be a serious mistake.

Take the example of affiliate trade. Unpublished data on affiliate trade for Germany suggest that it constituted about 43-45% of all technology services trade from 2006 to 2008, which is much less than the 60% estimated by the data on the USA from Robbins (2008). These different figures are consistent with a tradition of research on international management which suggests that MNEs from the USA and Japan tend to do much more R&D in their headquarters than do European multinationals (Bartlett et al 2008: 203-209). European multinationals are typically characterised as adopting a multi-national strategy, giving a lot of autonomy to their subsidiaries, while US MNEs are seen as operating international strategies and Japanese MNEs exploit economies of scale through global strategies. Studies based on patent data also indicate that European R&D is also more internationalised (Patel 2011).

Similar arguments could be made about the direction of trade, where the membership of a common trade bloc and the presence of strong colonial ties in trading relationships may make the direction of technology services trade from the UK or France quite different from that of the USA or even other European member states. The lack of a consistent form of reporting on the share of affiliate transactions and of the direction of trade in technology services is a huge impediment to our understanding of the nature of disembodied technology flows.

If data inconsistencies hamper an understanding of cross-border trade in technology services, there is a veritable vacuum of information on domestic technology services trade. This makes arguments about the economics of contracting and the effectiveness of different business models much harder to verify since firm-level data on domestic and international sales and purchases of technology services are not available. Peculiarly, the only measurable part of technology services trade is cross-border trade. Robbins (2008) shows the way by assembling information for the USA from records of the Internal Revenue Service, but much more could be done by way of compulsory reporting by firms of their domestic and international purchases of technology services through amendments to company reporting norms.

## 3. Trends in International licensing trade

Over the period 1990-2009, royalty and licensing receipts (and payments) in the world economy grew at an astonishing and sustained rate of 9.9% per annum. Figure 2 (see Annex) updates data presented in Athreye and Cantwell (2007) and outlines the growth of cross-border licensing trade in the world economy and also shows the acceleration of this trade since 1990.[6] Some of this rapid rise may be attributed to under-reporting or measurement issues in the pre-1996 period. Even if we focus on the period since 1999, we find a very high rate of growth of about 8.8% per annum in nominal terms and about 7.7% per annum in real terms.

The participating countries in this trade also increased phenomenally. In 1990, 62 countries made licensing payments but by 2007, this number had increased to 147 countries. Similarly, in 1990, only 43 countries received any international royalty or license fees, but by 2007, this number had increased to 143 countries. The increase in participating countries on both sides of the market suggests the gradual emergence of a large market in international licensing, perhaps facilitated by the growth of new industrialising economies of the BRICS (Brazil, Russia, India, China and South Africa) and also the harmonisation of IPR systems/regimes due to agreements like the TRIPS.

We looked more closely at the shares and rates of growth in three groups of countries: high-, middle-and low-income countries. These are reported (both nominal and real values) in Table 1 (see Annex), although our discussion here uses the nominal values.[7] In terms of share, the largest values are for the high-income economies. They alone account for over 98% of all licensing receipts and over 90% of payments in 1999 and drive the average rates of growth in the world economy. Middle-income countries had a smaller share in 1999 but show rapid rates of growth – about 17% per annum for receipts and payments. Although not reported here, within the group of middle-income economies, transition economies showed high rates of growth of licensing receipts (20% per annum) relative to payments (13% per annum), while the BRICS countries collectively showed the opposite trend – they had a much higher rate of growth of licensing payments (21% per annum) relative to the growth of licensing receipts (16%). Low income economies showed modest rates of growth – 7% for licensing receipts and -2.25% for payments – but looking at the data in real terms suggest a more sharply decreasing rate of growth of -7.3% per annum for payments.

Tables 2 and 3 (see Annex) add more detail to the findings in Table 1. They present the change in import and export share of countries and order countries by the largest increases and decreases in share. Thus, Table 2 shows that between 2005 and 2009, Ireland and China increased their share of international licensing payments by 4.9% and 2.1% respectively while the United States of America (USA) and United Kingdom (UK) decreased their share of international licensing payments by 4.1% and 1.9% respectively. Looking across the columns of Table 2 we find that over the period 2000-2009, prominent among the new countries gaining shares in international licensing payments are the BRICS economies, Ireland and former East European nations like Hungary and Poland. Many of the BRICS countries make their appearance in

[6] Data for this figure (particularly the pre-1980 period) is drawn from diverse sources and listed in more detail in Athreye and Cantwell (2007).

[7] There are numerous problems with finding the appropriate deflator for licensing revenues. The commonly used deflators GDP and CPI are thought not to contain the right price indices to take account of inflation in licensing prices. A thoughtful and thorough review of the issues involved is contained in Robbins (2009) who also proposes using a deflator based on capital rentals in each country.

the table charting increases in international licensing receipts, but here also there are many more European countries which, together with Korea, seem to have seen increases in export shares. The UK, on the other hand, has seen major declines in international licensing receipts.

## 4. Cross-country heterogeneity in forms of disembodied technology trade

Disembodied technology trade can take different forms and one advantage of the OECD data which we noted earlier is that they provide a fine breakdown of different kinds of disembodied technology trade. Moreover, since the OECD countries account for over 97% of licensing receipts and 77% of licensing payments, this finer detail is helpful to understand the importance of the various forms of technology trade in the aggregate as well.[8]

The OECD data allow us to distinguish between the outright sale and purchase of patents, receipts and payment of royalty and license fees for the use of intangible assets, trade in technology related services and receipts and payments on account of R&D services. The form of technology trade chosen may depend upon characteristics of the technology (the extent to which tacit knowledge and continuous monitoring or customisation are important) and also on the institutional environment surrounding appropriability such as the tightness of IPR protection. Figure 3 (see Annex) shows the percentage share of each type of technology trade in the total technology receipts of countries for which we have unpublished data available.[9]

The form of disembodied technology trade preferred is quite different across countries. In the case of France, the UK and USA, the largest proportion of technology receipts is on account of royalty and license fees due to the out-licensing of technology and other intangible assets. Hungary, Sweden and Finland also use this form of transfer quite extensively in their receipts. For most of the other OECD countries, receipts on account of technology related services are the biggest component of technology receipts. R&D carried out abroad is a relatively small proportion of technology receipts in all cases.

Figure 3 (see Annex) shows the importance of the different types of transfer in technology payments. Here too we find that the UK, France and the USA prefer to trade in royalty and licensing fees. We also find that for Ireland, Hungary, Greece and Australia technology transfer through royalty and licensing fee payments (in-licensing) is the largest item on their international technology payments. For the other EU countries, technology related services dominate in payments. Outsourcing of R&D (captured by technology payments made on account of R&D services rendered abroad) is very high for Finland and Sweden, followed by Belgium, the UK and the USA.

The reasons for this heterogeneity in the form of traded technology could be many. First, this may simply reflect the underlying characteristics of the technologies being traded. More tacit technologies are likely to be traded as technology related services or customised R&D services. Second, the form may be influenced by the appropriability conditions of technology. Licensing is profitable only in the face of tight IPR which can be enforced reasonably quickly. Technology related services may depend less upon IPR changing hands as, in the sale and purchase of technological services, the intellectual property always belongs to the buyer of the service. Lastly, they may relate very closely to alternative business models for the provision of technology chosen by firms in different national contexts (see Box 1 earlier for examples).

Table 4 (see Annex) reports on the annual average rates of growth of each type of technology transfer. Transition countries like Poland, Hungary, the Czech Republic and the Slovak Republic show very high rates of growth for some components. Particularly interesting is the finding that they appear to show a rapid growth in the purchase and sale of patents when compared to other categories. This may simply be a reflection of the small base from which they started out. But the dominance of purchase and sale of

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[8] These are estimated from the same WDI data analysed in Table 1.
[9] We ignore the purchase and sale of patents here because the data on them are not consistently available for all countries.

intangible technological assets in economies known to have weak IPR regimes also suggests that trading in technology related services is not the only response to the presence of weak IPR regimes. Inventors located in such countries may prefer to trade in the asset (patent) rather than the incomes from it (licensing).

## 5. Impact of IPR on the form of technology trade

Our conjectures in Section 4 about the relationship between IPR protection in the domestic economy and the preferred form of technology services trade can be subject to further empirical analysis using a framework similar to that used to analyse the supply of exports to international markets. The key dependent variable is the proportion of technology receipts earned through international licensing, export of R&D services and the export of technology-related services. The data spans 1998-2007 and covers 19 OECD countries whose data are reported in Figures 3 and 4 (see Annex).

In the export supply of technological services, the key variables would be 1) own demand (which would reduce exports), 2) the supply of technological labour (which would be positively related to exports of technology services) and 3) the price commanded for these services which is not easily observable for technological goods and services.

Although the price for many technological services is unobserved, they are likely to be correlated with the strength of the IPR regime. This is because under strong IPR regimes, the suppliers of innovation are allowed some monopoly power which protects them against imitative competition and allows them to charge slightly higher prices. So countries with stronger IPR are likely to pay higher prices for valuable technology services and vice versa.

The measurement of IPR strength, even in OECD countries, is not unproblematic (see Box 2 earlier). In particular, IPR for OECD countries through 2000-2005 is sensitive to European Union (EU) enlargement, commitments to join the WTO and various other free trade agreements. For estimation purposes, therefore, it is better to rely on the strength of IPR before these changes came into being, viz. the strength of IPR in 1995.

The results of our econometric analysis are reported in Table 5 (see Annex). In all cases, the first column reports the results of the baseline model with one–way time fixed effects (to account for business cycle and other time-varying unobservable factors). Because the IPR data only vary by country, we are unable to include country fixed effects but, following Wooldridge (2007), we include the initial conditions correction so that country heterogeneity is taken into account.

The single outstanding result of Table 5 is that the strong level of domestic IPR protection predicts higher shares of licensing revenues and weak domestic IPR protection predicts a higher share of technology related services. The strength of IPR protection does not have a clear effect on the share of R&D services. The coefficient on IPR protection drops when we make the correction for initial conditions.

Next we probe the effect of the level and change in the level of IPR in shifting the share of revenue due to licensing, export of R&D services and technology related services. To do this, we simply substitute the value of IPR in 1995 as a sum of the average level of IPR (1960-90) and the change in IPR between 1990 and 1995. Mathematically,

$$IPR(1995) = IPR(1960\text{-}90) + \Delta IPR .$$

Results of this estimation are reported in Table 6 (see Annex). As before, the first column reports the baseline model with time-varying unobservable fixed effects and the second column reports the results of applying the initial condition correction. Consistent with Table 5, we find that countries with stronger IPR protection in the 1960-90 period reported higher shares of licensing revenue and countries with weak IPR protection in the same period reported higher shares of technology related services in the technology receipts, while R&D services were not influenced by the strength of IPR protection. However, an increase in the strength of IPR protection increased the share of licensing revenue and decreased the share of technology related services.

Lastly we examine whether an increase in the strength of IPR protection will influence the volume of technology services trade. The volume of trade is traditionally measured as the sum of exports and imports and we compute the volume share of licensing, R&D services and technology services as a share of the overall volume of technology services trade. These results reported in Table 7 (see Annex) are somewhat mixed. While strong IPR protection has an influence on the volume share of licensing and R&D services, strengthening IPR regime has no clear effect on increasing the volume share of either type of trade. However, the influence of strengthening IPR protection is to decrease the volume share of technology related services.

Thus, the results above support our conjectures and indicate that the IPR regime of the domestic economy influences the form of technology service exports.

## 6. Industrial concentration of technology services trade

The unpublished OECD data also contain details about the breakdown of technology receipts and payments by industries of origin, although these data are available only for six countries and at a very high level of aggregation (two-digit industrial classification). One question of interest is to what extent the growth in technology trade reflects ‘new economy’ activities and globalisation in the non-manufacturing sector. Non-manufacturing activities that could be important are the growth of data mining and trade in databases in the Finance and the Publishing industrial sectors, and the spread of new activities like business services, franchising, and the growth of the gaming industry. Table 8 (see Annex) reports on the share of manufacturing in technology trade activities – first for payments and then receipts. Manufacturing accounted for a large percentage of technology payments in all countries we have data for from the OECD, except Belgium. In Belgium, payments on account of banking, insurance and real estate and transport, communications and services, far exceeded the share of manufacturing. In the case of technology receipts, we find that the share of manufacturing activities in technology receipts was low for Austria, Belgium and the Czech Republic. In all three countries, technology receipts from the banking, insurance and real estate sectors comprised a large share of total receipts. Thus, some kinds of service economies are certainly driving the growth of disembodied technological trade.

Next, we look at the manufacturing sectors in which technology trade is concentrated, using the same data. The third column of Table 8 reports the CR5 concentration ratio of technology exports (or imports) in manufacturing.[10] The large values of the CR5 ratio in both technology payments and receipts in all countries suggested technology trade is concentrated only in a few sectors. The one exception is the case of Japan where payments appear to be quite spread out over many industrial sectors.

The fourth column specifies the five largest manufacturing sectors for each country that we have data for. Sectors are reported in decreasing order of importance. We see that the manufacturing sectors that dominate technology trade are different from country to country although chemical products, computer and office machinery and non-electrical machinery appear to be fairly globalised in terms of technology trade.

[10] The CR5 ratio measures the export (import) of the largest five manufacturing sectors as a share of all technology exports (imports) from the manufacturing sector.

More detail on the sector composition of licensing trade is found in the work by Gambardella and Torrisi (2010: page 22). Using firm-level data on known licensing contracts, they report that the majority of the licensing contracts in their sample have occurred in IT-semiconductors-electronics, chemicals-pharmaceutical-biotech and engineering technological classes. They also show that licensing tends to correspond to the country's technology specialisation indices as computed from patent databases.

The sectors of licensing activity that emerge from the firm database and OECD's more aggregate data are quite remarkably congruent and similar to those from previous studies on licensing (Caves et al 1983, Anand and Khanna 1996). The theoretical review suggests that such concentration in particular sectors occurs when horizontal contracts prevail. This can happen when the technology is general purpose and applicable in different uses.

Gambardella and Torrisi (2010) also use these data to shed light on the technology flows between sectors and this information is presented in Table 9 (see Annex). As can be seen from Table 9, the largest flows of technology through licensing are, in fact, within the same technological sectors, although related sectors (such as chemicals and drugs and computers and electronic equipment sectors) benefit from licensing arrangements. In addition, sectors like instrumentation and the knowledge-intensive business services (KIBS) sell to a range of other sectors.

## 7. Conclusions

Resurgence of the licensing trade since the 1990s holds promise for countries that hope to use trade to buy the technologies they want or need, including many in the developing world. Existing data suggest that high-income countries are dominant in this trade, that such licensing activity is concentrated in a handful of sectors, and that intellectual property protection is a key variable influencing the choice of destination in international licensing.

Less understood is the cross-country heterogeneity in the forms of technology services trade since the 1990s, e.g. the trade in R&D services, and the mushrooming of technology services from countries with large stocks of educated scientific labour. We exploit hitherto unpublished data from the OECD's Technology Balance of Payments to show that this form of export bears close relation to the prevalent strength of IPR in the domestic economy. Weaker IPR regimes favour the export of technology services while stronger IPR regimes favour the export of technology licenses.

More systematic data on the direction of trade of the different categories of technology services are needed to assess if these newer forms of technology trade and transfer could offer hope to countries that find themselves in IPR regimes that cannot be improved overnight. This is beyond the scope of the efforts of individual researchers but not of multilateral organisations that oversee the collection of trade and IP statistics.

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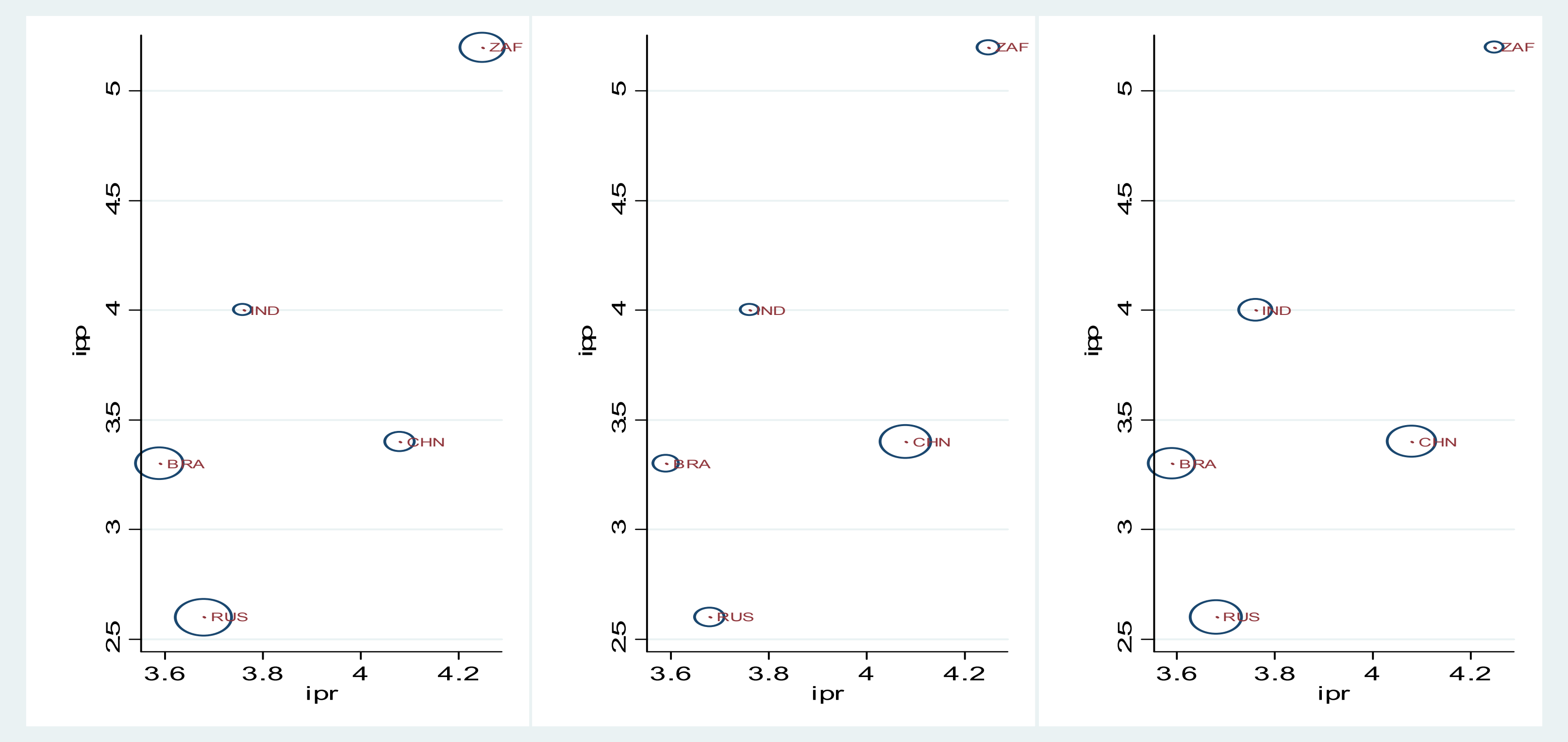
*Global Competitiveness Report*, World Economic Forum, various issues.

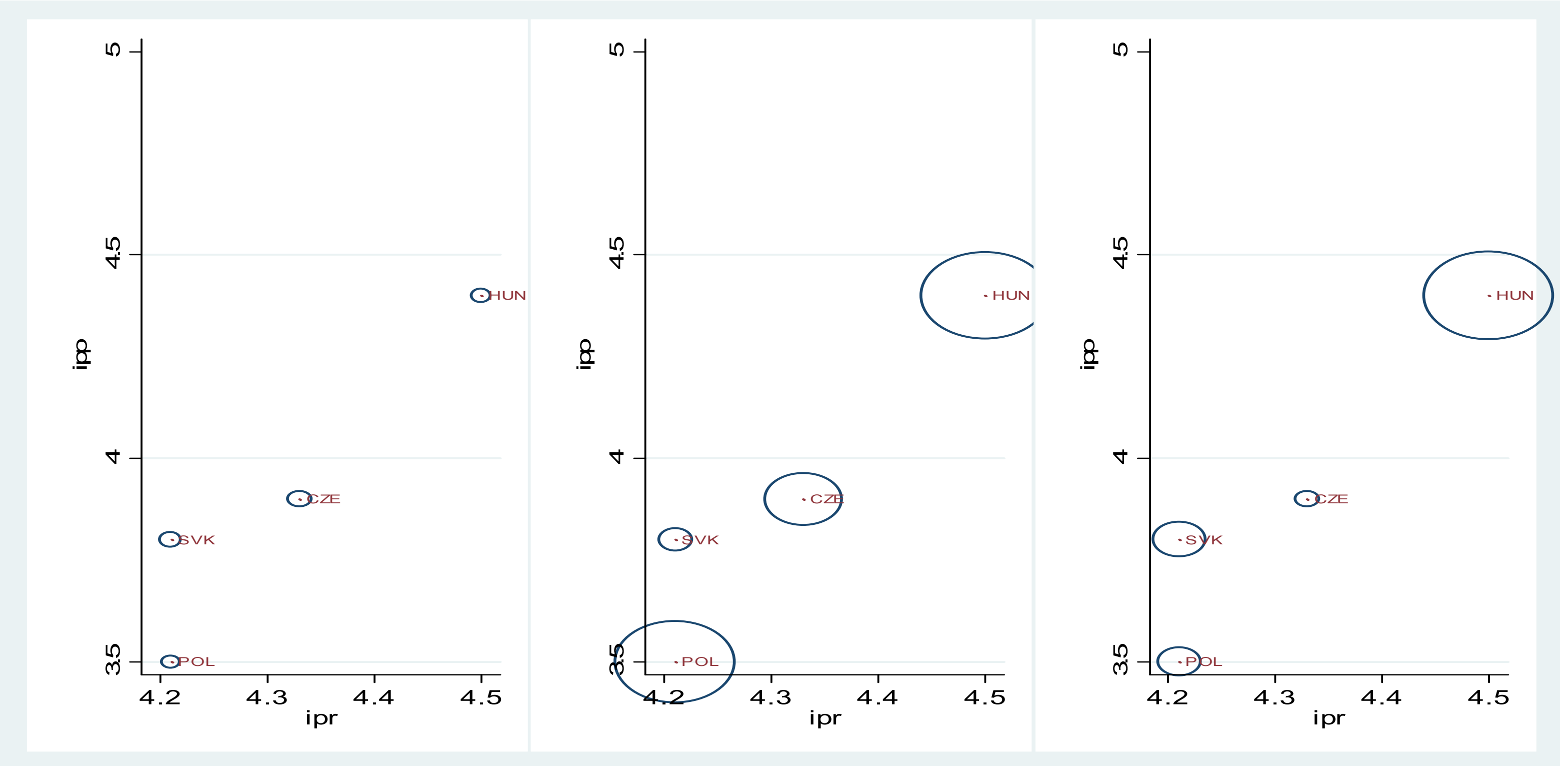
**Figure Annex**

**Figure 1a: IPR and IPP in the year 2007, by country; BRICS**



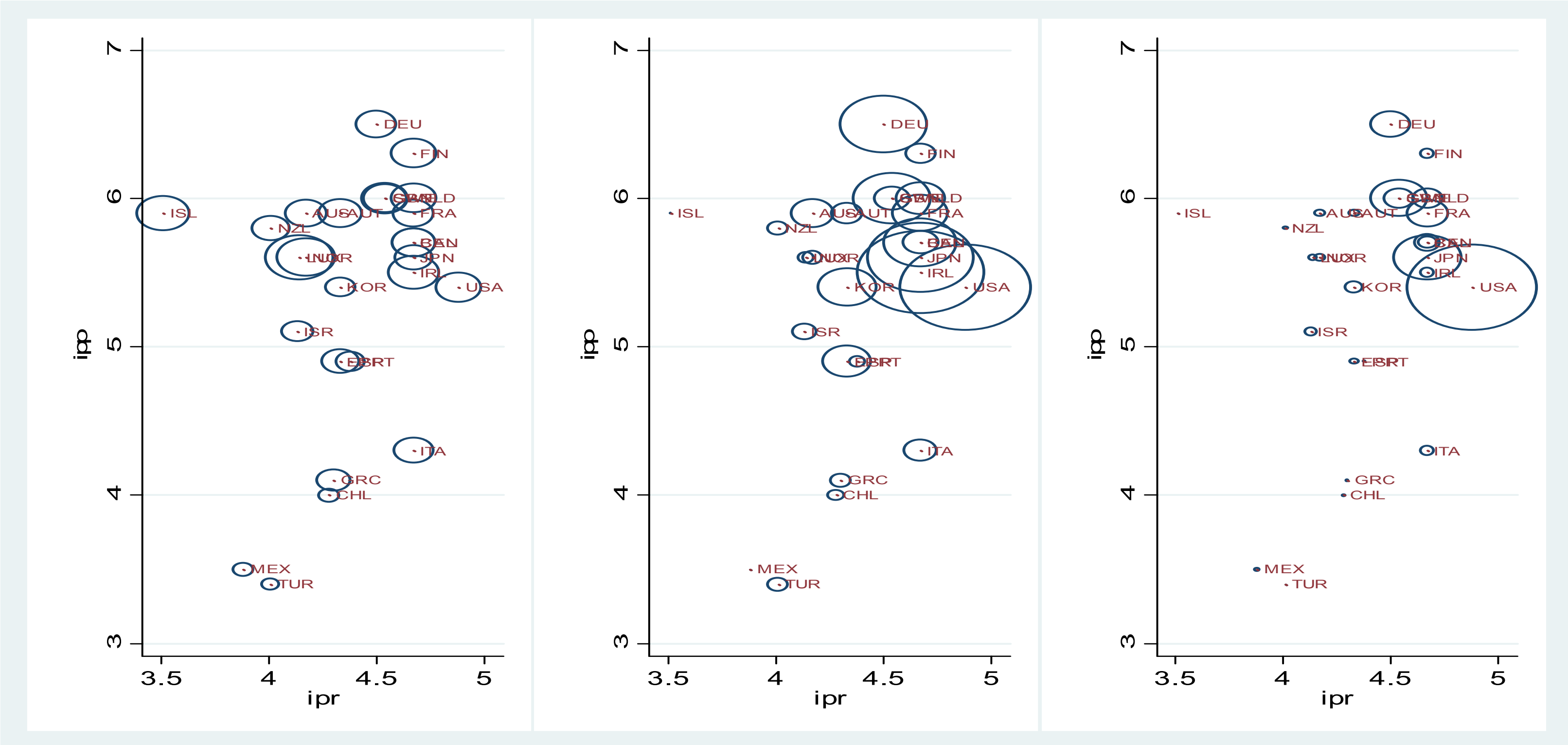

Note: Size of circle in left figure is proportional to the weight of GDP per capita of 2007; Size of circle in middle figure is proportional to the royalty license fee payments of 2007; Size of circle in right figure is proportional to the royalty license fee receipts of 2007.

**Figure 1b: IPR and IPP in the year 2007, by country; OECD transition countries**



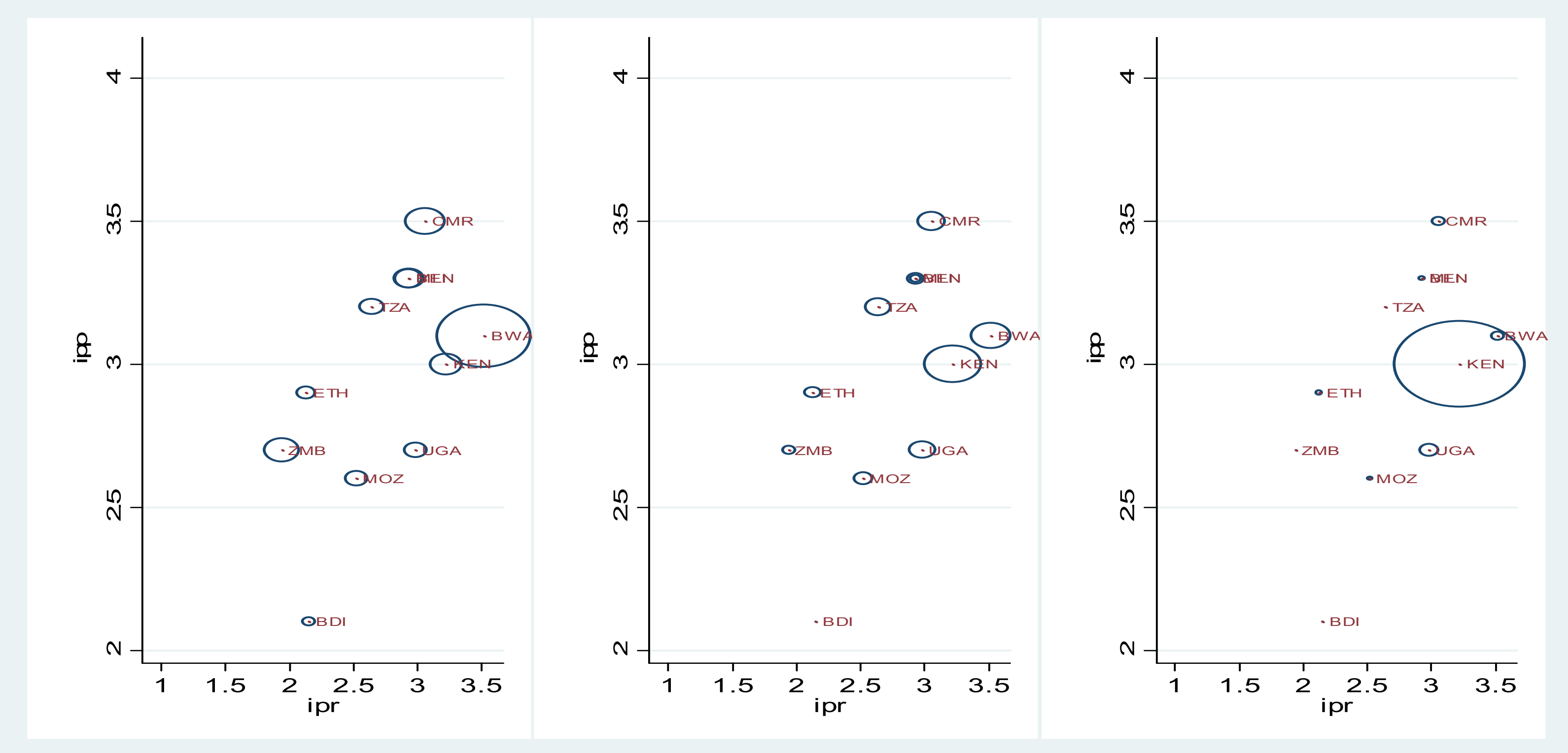

Note: Size of circle in left figure is proportional to the weight of GDP per capita of 2007; Size of circle in middle figure is proportional to the royalty license fee payments of 2007; Size of circle in right figure is proportional to the royalty license fee receipts of 2007.

**Figure 1c: IPR and IPP in the year 2007, OECD advanced countries**



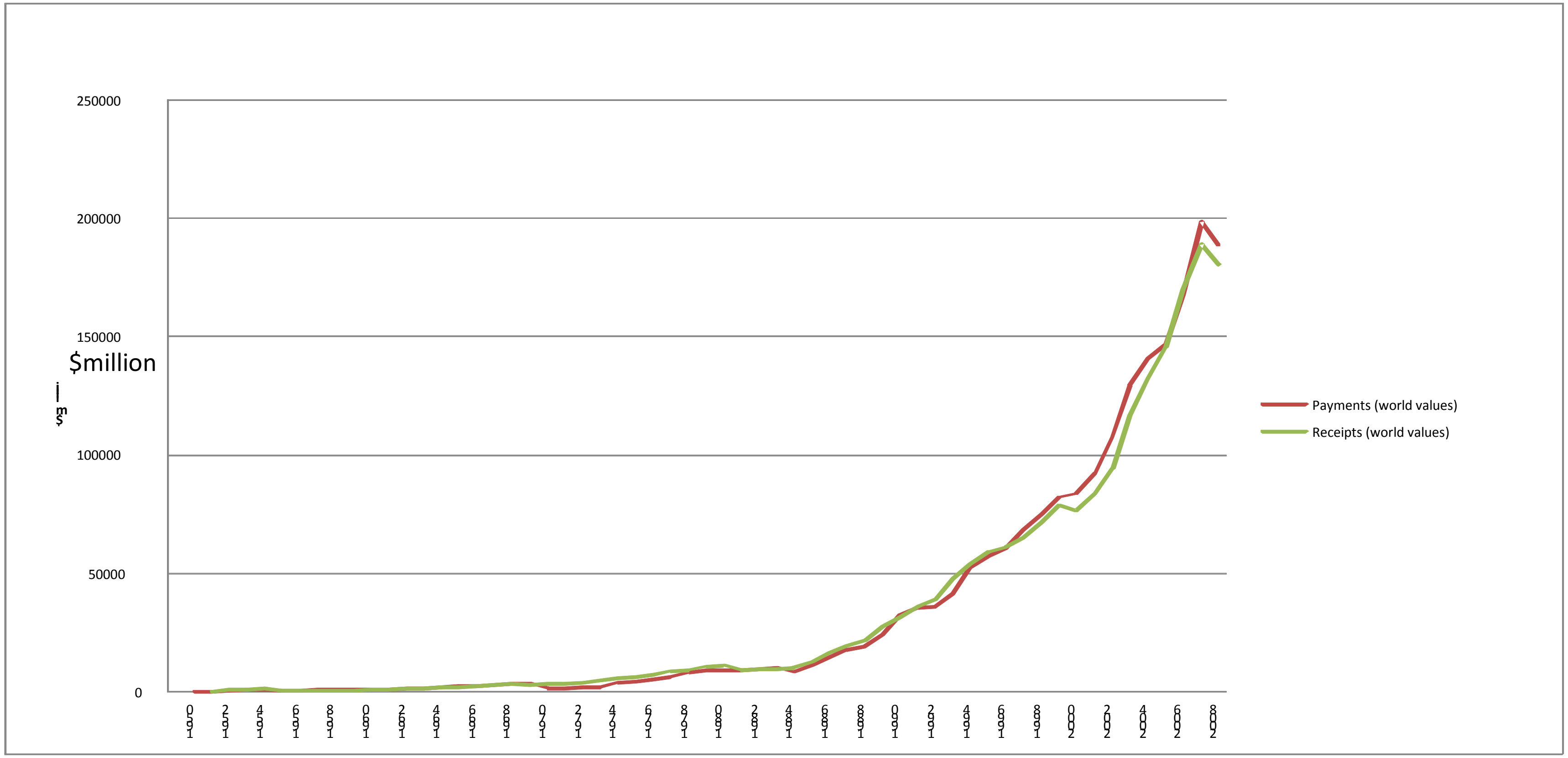

Note: Size of circle in left figure is proportional to the weight of GDP per capita of 2007; Size of circle in middle figure is proportional to the royalty license fee payments of 2007; Size of circle in right figure is proportional to the royalty license fee receipts of 2007.

**Figure 1d: IPR and IPP in the year 2007, Sub-Saharan Africa**



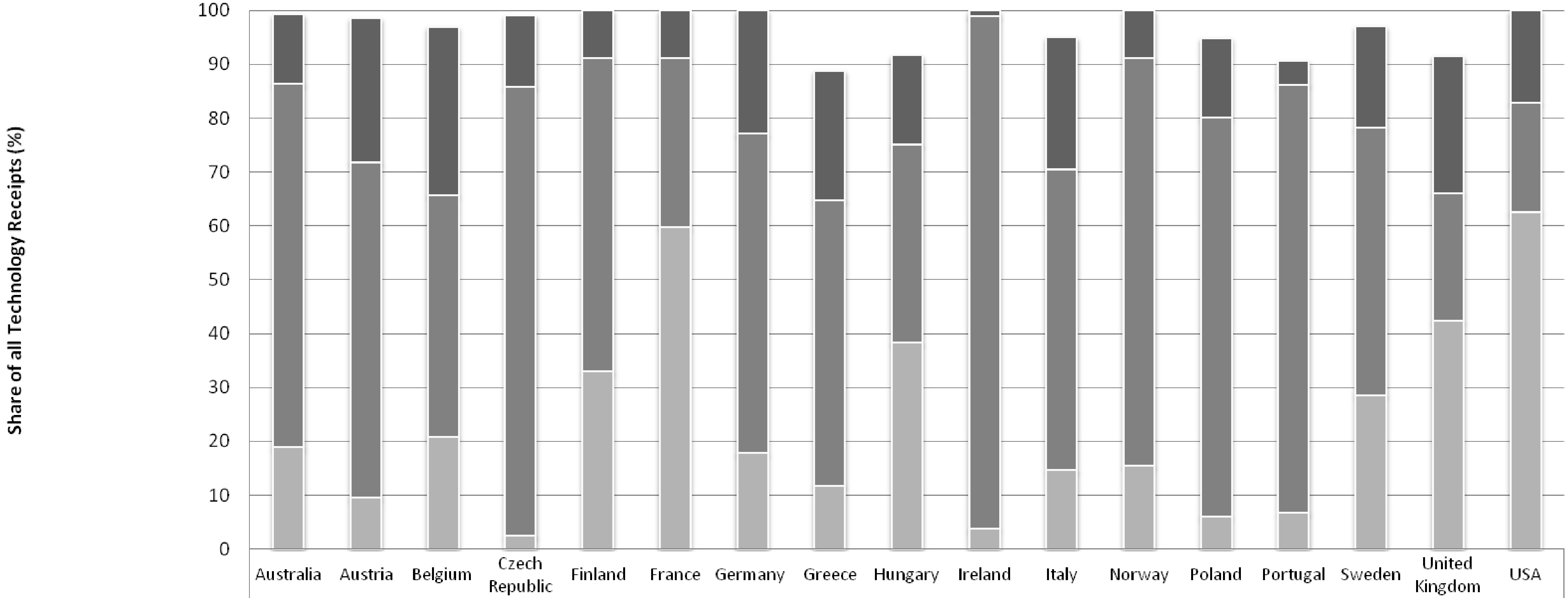

Note: Size of circle in left figure is proportional to the weight of GDP per capita of 2007; Size of circle in middle figure is proportional to the royalty license fee payments of 2007; Size of circle in right figure is proportional to the royalty license fee receipts of 2007.

**Figure 2: Growth in international royalty and licensing payments and receipts (1950-2009)**




Source: Authors' computation based on diverse data sources.

## Figure 3: Relative importance of the different components of the TBP: Receipts

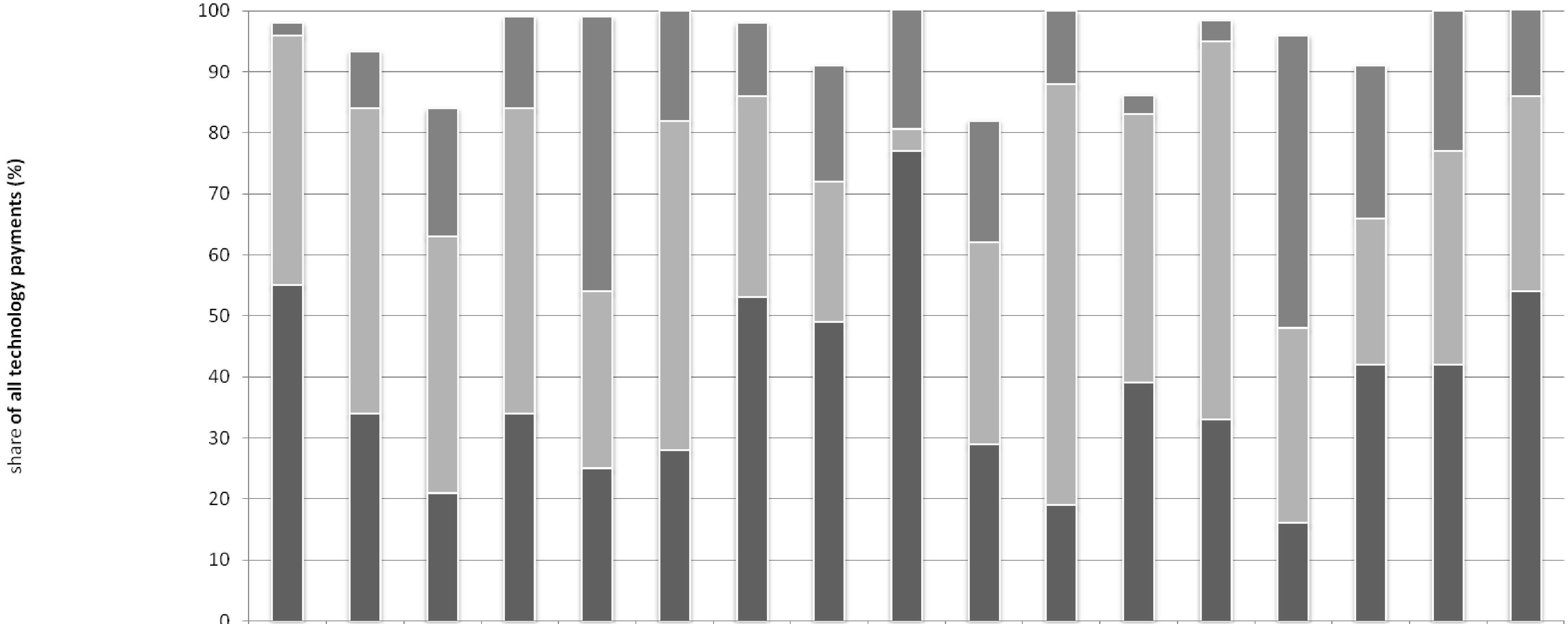



| | Australia | Austria | Belgium | Czech Republic | Finland | France | Germany | Greece | Hungary | Ireland | Italy | Norway | Poland | Portugal | Sweden | United Kingdom | USA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R&D carried out abroad | 13 | 27 | 31 | 13 | 9 | 9 | 23 | 24 | 17 | 1 | 24 | 9 | 15 | 4 | 19 | 25 | 17 |
| Technology-related services | 68 | 62 | 45 | 83 | 58 | 31 | 59 | 53 | 37 | 95 | 56 | 76 | 74 | 79 | 50 | 24 | 20 |
| Royalties and licence fees | 19 | 10 | 21 | 2 | 33 | 60 | 18 | 12 | 38 | 4 | 15 | 15 | 6 | 7 | 29 | 42 | 63 |

Source: Authors' computation from unpublished OECD data.

Notes: Purchase and sale of patents has been left out since data on this are not consistently available. Data for France pertain to 2003, for others the reference year is 2007.

**Figure 4: Relative importance of the different components of the TBP: Payments**




| | Australia | Austria | Belgium | Czech Republic | Finland | Germany | Greece | Hungary | Ireland | Italy | Norway | Poland | Portugal | Sweden | UK | USA | France |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R&D carried out abroad | 2.1 | 9.4 | 21 | 15 | 45 | 18 | 12 | 19 | 20 | 20 | 12 | 3.2 | 3.4 | 48 | 25 | 23 | 15 |
| Technology-related services | 41 | 50 | 42 | 50 | 29 | 54 | 33 | 23 | 3.7 | 33 | 69 | 44 | 62 | 32 | 24 | 35 | 32 |
| Royalties and licence fees | 55 | 34 | 21 | 34 | 25 | 28 | 53 | 49 | 77 | 29 | 19 | 39 | 33 | 16 | 42 | 42 | 54 |

Source: Authors' computation from unpublished OECD data.

Notes: Purchase and sale of patents has been left out since data on this are not consistently available. Data for France pertain to 2003.

**Table 1: Shares and rates of growth (1999-2009), selected country groups, nominal (N) and deflated (D) values in US $million**

| Country Group | 1999 | | 2009 | | Share in 1999 | | Share in 2009 | | Avg. annual rate of growth | |
|---|---|---|---|---|---|---|---|---|---|---|
| **All countries** | Nominal | Deflated | Nominal | Deflated | Nominal | Deflated | Nominal | Deflated | Nominal | Deflated |
| *RLF receipt values* | 71362.70 | 72710.52 | 180514.9 | 153190.1 | | | | | 9.72 | 7.74 |
| *RLF payment values* | 74753.99 | 77373.65 | 188376.8 | 153138.6 | | | | | 9.68 | 7.07 |
| **High income countries** | | | | | | | | | | |
| *RLF receipt values* | 70586.82 | 71959.44 | 176716.1 | 151119 | 98.91 | 98.97 | 97.90 | 98.65 | 9.61 | 7.70 |
| *RLF payment values* | 67964.66 | 70370.91 | 155881.4 | 135162.5 | 90.92 | 90.95 | 82.75 | 88.26 | 8.66 | 6.74 |
| **Middle income countries** | | | | | | | | | | |
| *RLF receipt values* | 759.8839 | 736.7714 | 3765.188 | 2055.244 | 1.06 | 1.01 | 2.09 | 1.34 | 17.36 | 10.80 |
| *RLF payment values* | 6705.073 | 6930.979 | 32428.24 | 17942.38 | 8.97 | 8.96 | 17.21 | 11.72 | 17.07 | 9.98 |
| **Low income countries** | | | | | | | | | | |
| *RLF receipt values* | 15.99409 | 14.31751 | 33.6785 | 15.87138 | 0. 02 | 0. 02 | 0.019 | 0. 01 | 7.73 | 1.04 |
| *RLF payment values* | 84.26246 | 71.7618 | 67.09778 | 33.77832 | 0. 11 | 0. 09 | 0. 04 | 0. 02 | -2.25 | -7.26 |

*Notes:* (1) The GDP deflator provided in the World Development Indicators is used to compute the deflated values.

(2) Country groups used are World Bank categories

**Table 2: Shifts in the direction of RLF payment, the top ten countries that gained/lost the most in imports share**

| Top ten gainers | 2005-2009 | | 2001-2005 | | 1996-2000 | | 1990-1995 | |
|---|---|---|---|---|---|---|---|---|
| | Ireland | 0.049 | Ireland | 0.023 | United States | 0.062 | Japan | 0.183 |
| | China | 0.021 | China | 0.015 | Ireland | 0.041 | Ireland | 0.027 |
| | Germany | 0.015 | Singapore | 0.008 | Singapore | 0.026 | Brazil | 0.008 |
| | Russian Federation | 0.010 | Russian Federation | 0.007 | China | 0.016 | Thailand | 0.005 |
| | France | 0.006 | Hungary | 0.005 | Canada | 0.011 | New Zealand | 0.004 |
| | India | 0.005 | Canada | 0.004 | Malaysia | 0.007 | Egypt, Arab Rep | 0.002 |
| | Korea, Rep. | 0.005 | South Africa | 0.004 | Poland | 0.004 | Kenya | 0.001 |
| | Belgium | 0.004 | Hong Kong, China | 0.003 | Egypt, Arab Rep. | 0.004 | Poland | 0.001 |
| | Brazil | 0.003 | Czech Republic | 0.002 | Brazil | 0.003 | Norway | 0.001 |
| | Argentina | 0.002 | Australia | 0.002 | Venezuela, RB | 0.002 | Peru | 0.001 |
| **Top ten losers** | | | | | | | | |
| | United States | -0.041 | Japan | -0.029 | Japan | -0.040 | Italy | -0.063 |
| | United Kingdom | -0.019 | United States | -0.024 | Germany | -0.035 | United Kingdom | -0.055 |
| | Japan | -0.015 | United Kingdom | -0.010 | United Kingdom | -0.031 | Germany | -0.051 |
| | Canada | -0.008 | Germany | -0.006 | France | -0.022 | France | -0.026 |
| | Netherlands | -0.005 | Brazil | -0.005 | Netherlands | -0.022 | Spain | -0.020 |
| | Singapore | -0.004 | Korea, Rep. | -0.004 | Sweden | -0.007 | Netherlands | -0.018 |
| | Malaysia | -0.004 | Mexico | -0.004 | Australia | -0.006 | Australia | -0.017 |
| | Italy | -0.004 | Egypt, Arab Rep. | -0.003 | Austria | -0.005 | Korea, Rep. | -0.013 |
| | Austria | -0.003 | Argentina | -0.002 | Spain | -0.005 | Sweden | -0.013 |
| | New Zealand | -0.001 | Italy | -0.002 | Korea, Rep. | -0.004 | Argentina | -0.010 |

**Table 3: Shifts in the direction of RLF receipts, the top ten countries that gained/lost the most in export share**

Top ten gainers (gain in world export markets %)

| Top ten gainers | 2005-2009 | | 2001-2005 | | 1996-2000 | | 1990-1995 | |
|---|---|---|---|---|---|---|---|---|
| | Germany | 0.022 | France | 0.013 | Japan | 0.015 | Japan | 0.112 |
| | United States | 0.011 | Germany | 0.010 | Canada | 0.014 | Korea, Rep. | 0.004 |
| | France | 0.005 | Sweden | 0.008 | Finland | 0.010 | Netherlands | 0.004 |
| | Ireland | 0.004 | Netherlands | 0.006 | Ireland | 0.006 | Ireland | 0.001 |
| | Korea, Rep. | 0.003 | Hungary | 0.005 | Korea, Rep. | 0.006 | Egypt, Arab Rep | 0.001 |
| | Mexico | 0.003 | Ireland | 0.003 | Israel | 0.004 | Spain | 0.000 |
| | Belgium | 0.003 | Singapore | 0.003 | Spain | 0.002 | New Zealand | 0.000 |
| | Brazil | 0.002 | Italy | 0.003 | China | 0.001 | Israel | 0.000 |
| | Spain | 0.002 | Korea, Rep. | 0.002 | India | 0.001 | Brazil | 0.000 |
| | Malaysia | 0.001 | Finland | 0.001 | Croatia | 0.001 | Angola | 0.000 |
| Top ten losers | | | | | | | | |
| | United Kingdom | -0.03 | United States | -0.047 | Germany | -0.021 | United States | -0.058 |
| | Japan | -0.01 | Canada | -0.011 | Netherlands | -0.014 | Italy | -0.030 |
| | Canada | 0.00 | United Kingdo | -0.007 | United Kingdom | -0.011 | Germany | -0.016 |
| | Italy | 0.00 | Japan | -0.004 | United States | -0.007 | France | -0.014 |
| | Hungary | 0.00 | Israel | -0.001 | France | -0.003 | Sweden | -0.005 |
| | Indonesia | 0.00 | Croatia | -0.001 | Mexico | -0.002 | Norway | -0.003 |
| | Egypt, Arab Rep. | 0.00 | Hong Kong SAR | -0.001 | Austria | -0.001 | Australia | -0.002 |
| | India | 0.00 | Paraguay | -0.001 | Sweden | -0.001 | Hungary | -0.001 |

**Table 4: Annual average rate of growth of technology receipts and payments (%)**

| Country | Period | Technology Receipts: Sales of Inventions | Technology Receipts: Royalty & License Fees | Technology Receipts: Technology Related Services | Technology Receipts: R&D Abroad | Technology Payments: Purchases of Inventions | Technology Payments: Royalty & License Fees | Technology Payments: Technology Related Services | Technology Payments: R&D Abroad |
|---|---|---|---|---|---|---|---|---|---|
| Australia | 1999-2007 | | 4.3 | 9.5 | 9.8 | | 6.2 | 10.3 | 0.6 |
| Austria | 1995-2008 | | 13.5 | 12.2 | 17 | | 7.5 | 7.7 | 13.8 |
| Belgium | 1996-2007 | 16.2 | 7.4 | 5.2 | 8.5 | 32.0 | 3.4 | 8.3 | 14.1 |
| Czech Republic | 1997-2008 | 24.6 | -1.2 | 19.0 | 19.9 | 15.6 | 14.4 | 10.3 | 27.8 |
| Finland | 1999-2008 | | 5.2 | 16.2 | 11.3 | | 14.7 | 9.7 | 48.6 |
| France | 1981-2003 | | 9.3 | 9.1 | 2.4 | | 3.3 | 6.9 | 7.3 |
| Germany | 1986-2008 | | 7.1 | 14.6 | 8.7 | | 4.9 | 14.7 | 8.8 |
| Greece | 1998-2007 | 50.7 | 22.8 | -5.7 | 16.4 | 31.7 | 13.0 | -0.3 | 31.9 |
| Hungary | 2004-2007 | 81.7 | 12.6 | 19.3 | 13.5 | 21.7 | 11.8 | 11.7 | 0.5 |
| Ireland | 2003-2007 | | 35.8 | 11.5 | -4.5 | | 4.0 | 14.0 | 14.2 |
| Italy | 1992-2008 | 5.2 | 5.1 | 1.4 | 10.9 | -4.5 | -4.8 | -2.1 | 3.8 |
| Norway | 1988-2007 | | 10.8 | 16.5 | 16.1 | | 6.4 | 14.6 | 14.7 |
| Poland | 2000-2007 | 98.6 | 8.7 | 24.9 | 30.1 | 47.2 | 7.5 | 10.6 | 14.2 |
| Portugal | 1996-2007 | 29.9 | 14.4 | 15.6 | 10.3 | 11.0 | 4.5 | 5.8 | 4.2 |
| Slovak Republic | 1998-2006 | 17.4 | 18.3 | 19.0 | 10.3 | 38.1 | 4.9 | 12.8 | 6.2 |
| Spain | 1996-2007 | 6.6 | 7.5 | na | na | 16.7 | 6.9 | na | na |
| Sweden | 1998-2007 | 1.4 | 13.2 | 13.7 | 23.0 | 6.8 | 4.7 | 2.5 | 23.5 |
| Switzerland | 1985-2007 | na | na | na | na | na | na | na | na |
| UK | 1996-2007 | 25.9 | 5.1 | 4.4 | 12.0 | 29.2 | 1.3 | 7.5 | 9.4 |
| USA | 2001-2007 | na | 4.1 | na | 11.8 | na | 3.2 | na | 24.8 |

**Source:** Authors' computations from unpublished OECD data. Figures for France pertain to 2003, all others are 2007.

**Table 5: Impact of IPR on the form of technology receipts (with time-fixed effects)**

| | Share of Royalty and License Fees (RLF) | | Share of R&D Service Exports (RD) | | Share of Technology Related Services (TRS) | |
|---|---|---|---|---|---|---|
| IPR index in 1995 | 0.305*** | 0.152*** | 0.0720 | 0.0464 | -0.222*** | -0.233*** |
| | (0.06) | (0.04) | (0.06) | (0.04) | (0.05) | (0.04) |
| Country's GDP | -0.177*** | -0.0913*** | -0.00454 | 0.00499 | 0.0827** | 0.115*** |
| | (0.04) | (0.02) | (0.04) | (0.03) | (0.04) | (0.03) |
| Scientific articles | 0.0143 | 0.00453 | 0.0189 | -0.000288 | 0.00218 | 0.0305*** |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| RLF (initial period) | | 0.583*** | | | | |
| | | (0.04) | | | | |
| RD (initial period) | | | | 0.771*** | | |
| | | | | (0.04) | | |
| TRS (initial period) | | | | | | 0.434*** |
| | | | | | | (0.06) |
| Constant | 0.682** | 0.320* | -0.190 | -0.168 | 0.622** | -0.183 |
| | (0.28) | (0.18) | (0.32) | (0.18) | (0.27) | (0.25) |
| R-squared | 0.316 | 0.728 | 0.117 | 0.721 | 0.280 | 0.497 |
| No. observations | 172 | 172 | 157 | 157 | 140 | 140 |

Note: * p<.10; ** p<.05; *** p<.01

**Table 6: Impact of IPR level and change on the form of technology receipts (with time-fixed effects)**

| | Share of Royalty and License Fees (RLF) | | Share of R&D Service Exports (RD) | | Share of Technology Related Services (TRS) | |
|---|---|---|---|---|---|---|
| IPR (1960-90) | 0.453*** | 0.192*** | 0.0892 | 0.0368 | -0.294*** | -0.302*** |
| | (0.06) | (0.05) | (0.08) | (0.04) | (0.05) | (0.04) |
| ΔIPR (1990-95) | 0.477*** | 0.171*** | 0.00340 | -0.00563 | -0.204*** | -0.151*** |
| | (0.08) | (0.06) | (0.09) | (0.04) | (0.06) | (0.05) |
| Country's GDP | -0.142*** | -0.0961*** | -0.0356 | -0.0346 | 0.0889** | 0.166*** |
| | (0.04) | (0.03) | (0.06) | (0.03) | (0.04) | (0.04) |
| Scientific articles | 0.00823 | -0.00302 | 0.00800 | -0.0117 | 0.0104 | 0.0500*** |
| | (0.02) | (0.01) | (0.02) | (0.01) | (0.01) | (0.01) |
| RLF (initial period) | | 0.579*** | | | | |
| | | (0.04) | | | | |
| RD (initial period) | | | | 0.828*** | | |
| | | | | (0.04) | | |
| TRS (initial period) | | | | | | 0.432*** |
| | | | | | | (0.06) |
| Constant | -0.283 | 0.296 | 0.270 | 0.427 | 0.663 | -0.788** |
| | (0.47) | (0.32) | (0.58) | (0.30) | (0.42) | (0.39) |
| R-squared | 0.433 | 0.749 | 0.095 | 0.762 | 0.376 | 0.586 |
| No. observations | 153 | 153 | 138 | 138 | 123 | 123 |

Note: * p<.10; ** p<.05; *** p<.01

**Table 7: The impact of IPR level and change on the Volume of trade (Exports +Imports)**

| | Volume Share of Royalty and License Fees (RLF) | | Volume Share of R&D Service Exports (RD) | | Volume Share of Technology Related Services (TRS) | |
|---|---|---|---|---|---|---|
| IPR (1960-90) | 0.446*** | 0.0137 | 0.108** | 0.118*** | -0.151** | -0.254*** |
| | (0.06) | (0.05) | (0.05) | (0.03) | (0.07) | (0.06) |
| ΔIPR (1990-95) | 0.338*** | -0.0663 | 0.0603 | 0.0624 | -0.280*** | -0.244*** |
| | (0.08) | (0.07) | (0.07) | (0.04) | (0.09) | (0.07) |
| Country's GDP | -0.250*** | -0.0502 | 0.00534 | -0.0327* | 0.120*** | 0.174*** |
| | (0.04) | (0.03) | (0.03) | (0.02) | (0.04) | (0.04) |
| Scientific articles | -0.0367** | -0.0188 | -0.00696 | -0.0330*** | -0.0604*** | -0.0109 |
| | (0.02) | (0.01) | (0.01) | (0.01) | (0.02) | (0.02) |
| RLF (initial period) | | 0.628*** | | | | |
| | | (0.04) | | | | |
| RD (initial period) | | | | 1.175*** | | |
| | | | | (0.06) | | |
| TRS (initial period) | | | | | | 0.421*** |
| | | | | | | (0.05) |
| Constant | 1.445*** | 0.824*** | -0.222 | 0.277 | 0.470 | -0.402 |
| | (0.43) | (0.30) | (0.35) | (0.20) | (0.44) | (0.40) |
| R-squared | 0.272 | 0.650 | 0.094 | 0.716 | 0.231 | 0.431 |
| No. observations | 198 | 198 | 198 | 198 | 198 | 198 |

Note: * p<.10; ** p<.05; *** p<.01

**Table 8: Concentration of technology trade in manufacturing, 2006 (%)**

| Country | % share of manufacturing in technology trade | CR5 ratio of manufacturing concentration in technology trade | Largest five manufacturing sectors in technology trade |
|---|---|---|---|
| **Technology Payments** | | | |
| Austria | 58.7 | 95.5 | Wood, paper, printing, publishing; chemical products; motor vehicles; non-electrical machinery n.e.c.; food beverages, tobacco |
| Belgium | 17.9 | 74.9 | Chemical products; Non-electrical machinery n.e.c.; Textiles, apparel, fur and leather; Office and computing machinery; Basic metals |
| Czech Republic | 62.1 | 74.1 | Motor vehicles; Radio, TV and communication equipment; Non-electrical machinery n.e.c.; Rubber, plastics; Food, beverages, tobacco |
| Germany | 57.0 | 77.6 | Motor vehicles; Chemical products; Other transport equipment; Electrical machinery; Radio, TV and communication equipment |
| Italy | 67.1 | 64.6 | Office and computing machinery; Chemical products; Non-electrical machinery n.e.c.; Petroleum, nuclear fuel; Textiles, apparel, fur, leather |
| Japan | 90.4 | 31.6 | Chemical products; Non-electrical machinery n.e.c.; Non-metallic mineral products; Electrical machinery; Furniture and other manufacturing industries n.e.c. |
| **Technology Receipts** | | | |

| | | | |
|---|---|---|---|
| Austria | 24.7 | 90.0 | Chemical products; Wood, paper, printing, publishing; non-electrical machinery; non-metallic mineral products; furniture and other manufacturing industries |
| Belgium | 15.9 | 97.3 | Chemical products; Electrical machinery; Office and computing machinery; Motor vehicles; Fabricated metal products (excl. Machinery) |
| Czech Republic | 26.5 | 84.6 | Motor vehicles; Non-electrical machinery n.e.c.; Radio, TV and communication equipment; Chemical products; other transport equipment |
| Germany | 56.9 | 76.7 | Chemical products; Motor vehicles; Electrical machinery; Other transport equipment; Radio, TV and communication equipment |
| Italy | 65.8 | 62.9 | Petroleum, nuclear fuel; Non-electrical machinery n.e.c.; Office and computing machinery; Chemical products; Textiles, apparel, fur, leather |
| Japan | 97.6 | 80.3 | Motor vehicles; Chemical products; Non-electrical machinery n.e.c.; Electrical machinery; rubber and plastics |

Source: Authors' computations from unpublished OECD data

**Table 9: Licensing flows between sectors (% of total number of agreements)**

| Licensor | Licensee | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Drugs** | **Chemicals** | **Computers** | **Electrical/ electronic Equipment** | **Transport** | **Instruments** | **KIBS** | **Sum of agreements** |
| **Drugs** | **64.78** | 3.65 | 0.37 | 0.22 | 0.07 | 4.62 | 11.69 | 1343 |
| **Chemicals** | 16.85 | **42.82** | 1.93 | 3.31 | 2.49 | 4.42 | 9.39 | 362 |
| **Computers** | 0.16 | 1.63 | **27.08** | 22.35 | 3.10 | 5.55 | 27.73 | 613 |
| **Electrical/electronic Equipment** | 0.75 | 2.13 | 17.00 | **46.38** | 1.00 | 4.88 | 20.50 | 800 |
| **Transport** | 1.96 | 6.86 | 7.84 | 12.75 | **27.45** | 5.88 | 24.51 | 102 |
| **Instruments** | 18.99 | 2.79 | 6.42 | 10.61 | 1.68 | **29.89** | 13.97 | 358 |
| **KIBS** | 10.56 | 2.41 | 9.81 | 10.43 | 1.17 | 2.65 | **45.62** | 1620 |

Source: Gambardella and Torrisi (2010), Table 4 and Table B.1