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Introduction

This report is based on the firm-level research undertaken for the Work Package 5 (WP5) of the INGINEUS project and relates to Deliverable 5.2. It presents the theoretical framework and empirical analysis on the relationship between fragmentation of productive and knowledge activities. Three research papers are presented here. One of the main contributions of this report is that it is able to provide an all-encompassing understanding of the MNE strategies on R&D offshoring by using several sets of new firm-level data. The data used in each of the three papers in this report has been developed by compiling information from various sources, in order to undertake a comprehensive analysis on several related aspects of R&D offshoring by MNEs.

The first of these is the paper titled: 'The Myths and Realities of European Offshoring'. This presents a simple model of offshoring which uses direct measures of job relocation to show the nature and extent of offshoring. By using a unique dataset on offshoring developed out of the European Restructuring Monitor (ERM), it measures the employment effects of the job relocation, by both by country and by industry. The following conclusions are reached. First, European offshoring is moving mainly to Eastern Europe, particularly in the manufacturing industries. Second, India is much more important than China as a location of offshoring, mainly because of the large amount of offshoring in the service industries. Third, offshoring mainly entails movement of low-skill jobs out of Western Europe. Offshoring of R&D activity and the more high-skill jobs tend to remain within Western Europe. Fourth, most low-skill jobs, such as textiles, are moving from Europe to other low-wage countries, particularly in Asia and Northern Africa.

The second paper is titled 'Globalization, fragmentation, and within industry heterogeneity in Europe' presents interesting insights with respect to the degree, trends and cross-country differences in within industry heterogeneity across European firms. It is based on the analysis performed on a panel of firms created using employment data from the Amadeus database. The results show that the within industry heterogeneity is larger than the between industry heterogeneity and that the within component is deepening over time.

The final paper titled 'International Sourcing, Technological Complexity, and Intellectual Property Rights Protection' analyse the mode through which firms source complex products. A theoretical framework is developed in which firms tend to outsource low complex goods. As complexity rises, firms are confronted with a trade off between higher wages in the case of vertical integration and a higher imitation risk in the case of outsourcing. It shows that that the probability of outsourcing decreases with the complexity of the good. The paper confirms that the complexity of a product and the IPR protection level of a country as alternative determinants for a firm's choice between outsourcing and vertical integration.

The myths and realities of European offshoring

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Abstract

The rapid emergence of China and India as major economic players in the global economy has a lot to do with the rapid growth in offshoring during the first decade of the 2000s. Offshoring describes the relocation of business processes from one country to another, but it also involves the migration of jobs to another country, but not the people who perform them. The economic logic is to reduce costs, whether it is wage, transport, or energy costs. And it relates directly to the issue of foreign ownership as well as to Adam Smith's idea of the division of labour and gains from trade. This paper will develop a simple model of offshoring and use a unique dataset on offshoring developed out of the European Restructuring Monitor (ERM). This database contains over 500 offshoring cases from 2002 to 2010 and measures the employment effects of the job relocation, by both by country and by industry. Additional information helps to support the analysis. Several important conclusions are reached in the paper. First, European offshoring is moving mainly to Eastern Europe, particularly in the manufacturing industries. Second, India is much more important than China as a location of offshoring, mainly because of the large amount of offshoring in the service industries. Third, offshoring mainly entails movement of low-skill jobs out of Western Europe. Offshoring of R&D activity and the more high-skill jobs tend to remain within Western Europe. Fourth, most low-skill jobs, such as textiles, are moving from Europe to other low-wage countries, particularly in Asia and Northern Africa.

1. Introduction

The European Monitoring Centre on Change at the European Foundation for the Improvement of Living and Working Conditions (Eurofound) estimates that more than 250,000 European jobs may have been relocated because of offshoring between 2002 and 2010. While the number of jobs may appear quite staggering at first sight, it only represents little more than four per cent of total jobs lost to enterprise restructuring, which include bankruptcy, closure, internal restructuring, merger and acquisition, and outsourcing. It is, however, five times more likely to occur than domestic outsourcing according to the European Restructuring Monitor (ERM) database. Economic restructuring in general and offshoring in particular are reflections of the process of 'creative destruction' as described by Joseph Schumpeter, and an outcome of the globalization of the division of labour foreseen by Adam Smith and David Ricardo. This paper discusses some of these issues in the context of the case studies on offshoring collected by the ERM from mid 2002 to 2010.

Offshoring describes the relocation of business processes from one country to another and is most often associated with the labour market. Blinder (2006: 113) describes offshoring as type of outsourcing that involves "the migration of jobs to another country, but not the people who perform them." Offshoring includes in-house sourcing, or the transfer of certain tasks or stages of production within the same group of enterprises, or offshore outsourcing, or the transfer of certain tasks to another enterprise in another country. Both types of offshoring involve subcontracting, but only the first type considers the nationality of ownership as an important issue (OECD, 2007). In the latter case foreign direct investment (FDI) can be an important conduit for offshoring. Nevertheless, the nature and type of tasks being subcontracted can vary depending on the type of partnership. It can involve partial ownership, total ownership or be a strategic partnership. Finally, offshoring does not necessarily entail the migration of jobs "from rich countries to poor ones" as stated by Blinder (2006: 113), but is the result of as the strategic behaviour of the enterprise to minimize costs, whether they be wages, transportation, energy or any material and intermediate input costs. Cost minimization may also involve an improvement in the utilization of capacity across the global enterprise as a whole. This definition of offshoring is more specific than considering all jobs lost due to international competition.

Much controversy surrounds the issue of offshoring. The employment consequences of offshoring have fuelled the rise of protectionism in both the United States and the European Union. While about half of the European jobs lost since 2001 have been relocated within the European Union itself, the migration of jobs within Europe has also contributed to an increasing tendency toward protectionism within the individual Member States. Crino (2009) summarized several empirical economic studies and confirmed that offshoring has a negative impact on employment, but this effect appears localized within the relatively low-skill tasks. Knell and Rojec (2007) point out that the overall impact on economic growth relates closely to the twin issues of technology transfer and spillovers and whether the enterprise is foreign-owned or locally-owned, but this evidence appears to be rather mixed.

Most empirical studies of offshoring are based on macroeconomic estimations of aggregate data or on the share of imported intermediates. These statistics, which generally come from the national input-output tables, are used primarily to measure the extent of intra-industry trade of the country under investigation. Intra-industry trade refers to the exchange of products within the same industry, and not the trade in tasks. While both are highly related to the globalization of production, they are very different phenomena. Intra-industry trade represents international trade within industries, which is a flow of goods and services between countries, and trade in tasks represents the relocation of certain tasks in the global production network. It is what Baldwin (2006) calls the "second unbundling", where trade is focused not on sectors and industries, but on tasks in the global production system. In most discussions, offshoring is a one-off event that describes the relocation of certain tasks, which is an independent source of comparative advantage that may lead to intra-industry trade (Baldwin and Robert-Nicoud, 2007).

In this paper, we make use of a unique dataset on offshoring developed out of the European Restructuring Monitor (ERM). The ERM monitors the extent of restructuring activities in Europe and their employment consequences since 2002. Of the almost 12,000 European restructuring cases in the database, over 550 cases involve offshoring or job relocation. Information contained in the database makes it possible to measure the employment effects of the job relocation, both by country and by industry. To determine both the country of origin as well as the country where the jobs are moving to, it was necessary to read through each individual case. The database makes it possible to analyze the role that economic integration within the EU relative to the offshoring to other countries.

The paper is outlined as follows. In the following section we look at some important ideas in the history of economic thought that relate to the trade in tasks. The division of labour, or tasks, becomes an important idea that when linked with the theory of comparative advantage can be a very powerful tool for discussion the problem of offshoring. These ideas developed by the classical economists are then discussed in the context of new growth theory, new trade theory, and whether the rise of offshoring is something new that needs further theoretical development. Sections 3 describes the database used in the analysis, and then discuss the relative importance of offshoring in Europe, the location of the jobs lost and the places where the jobs are going to. In section 4 we explore some issues of structural change and offshoring. A concluding section summarizes the findings and discusses some of the ways these data could be used within a modelling framework.

Several important conclusions are reached in the paper. First, most offshoring occurs within Europe itself, but the rapid emergence of China and India as major economic players in the global economy has attracted many jobs over the decade. Second, India is much more important than China as a source of offshoring, mainly because of the large amount of offshoring in the service industries. Third. European offshoring is moving mainly to Eastern Europe, particularly in the manufacturing industries. Fourth, offshoring mainly entails movement of low-skill jobs out of Western Europe. Offshoring of R&D activity and the relatively high-skill jobs tend to remain within Western Europe. Fifth, most low-skill jobs, such as textiles, are moving from Europe to other low-wage countries, particularly in Asia and Northern Africa. Finally, the current economic crisis is creating an incentive to consolidate so as to increase capacity utilization within the group of firm, which creates the tendency for jobs to move back to plants in Western Europe.

2. Offshoring in the history of economic thought

Offshoring is not a new phenomenon, as Bhagwati (2004) et al. points out, but the extent to which it is carried out has increased significantly with the rise of international trade. The increase of offshoring is strongly associated with the fifth technological revolution, which began, according to Perez (2002) with the development of the microprocessor and the subsequent development of ICTs (information and communication technologies). This techno-economic paradigm made it possible to combine the economics of scale and scope with specialization and to decentralize production networks with direct and immediate global communications. Transportation costs became an important issue as certain tasks were moved around the global production network in an effort to minimize total costs, but it also highlighted some of the problems of moving knowledge-intensive tasks around the globe because of the nature of knowledge itself.

The classical economists recognized how offshoring could affect economic growth and employment. Adam Smith (1776) knew that an ever more sophisticated division of labour was the main source of productivity growth, and that it also implied an increasing specialization or 'fragmentation' of tasks that could transcend the confines of the local enterprise. An increasing division of labour could increase of dexterity of workers, save time lost in switching between different *tasks*, and lead to the invention of machines and organization that facilitate work. Driven by the extent of the market, specialisation divided productive operations into their constituent elements, which both saved time in changing between different tasks and facilitated the introduction of equipment and machines. In short, the interaction between market demand and the specialization of *tasks* drive innovation and economic growth. The growth of market demand, whether coming from domestic or international sources, encourages the further specialization of *tasks*, which then increases productivity and market demand. Adam Smith's description of the production process was based on a division of tasks across different productive activities or a specialization of skills or distinct capabilities. Allyn Young (1928) later suggested that industrial stratification implied a division of *tasks* among firms and industries.

International trade becomes important in this context because it not only increases the size and growth of the potential market, but as a vent for surplus, it also gives rise to specialization across countries as businesses subdivide *tasks* into well-defined activities and products. Smith, however, justified trade on the basis of absolute cost. David Ricardo (1817) advancing the idea that countries trade with each other on the basis of the relative cost of production, which became the basis for international trade theory. His idea of comparative advantage put together with the Smith-Young idea of a specialization or division of tasks leads to the idea of vertical specialization, intra-industry trade, outsourcing and offshoring.

Samuelson (2001) exemplifies how the Ricardian trade model can be used to study the issue of fragmentation and offshoring when making the case that job losses caused by a specialization of tasks across countries will not be significant. Jones (2000) described how the Smith-Young idea of a specialization or division of tasks formed the basis of the idea of fragmentation. Grossman and Rossi-Hansberg (2008) also suggest that when production fragmentation across enterprises and countries is brought into the picture, then its importance becomes more apparent. Baldwin and Venables (2010) show that international cost differences and co-location benefits determine the extent of offshoring in the fragmentation of the production process.

The classical economists suggest that offshoring and fragmentation can be thought of as a kind of technological progress and hence, an engine of economic growth. If there are increasing returns, then the process of capital accumulation and labour force growth will lead to an exponential growth in income per person. A newly defined task implies increasing returns and innovation (Schumpeter, 1934), which is key to explaining offshoring and fragmentation. Each task embodies a certain kind of knowledge, which is then used in the production of a particular product or service. Adam Smith's example of the pin factory suggests that all of the tasks are located within one factory, but they can be located outside the factory in another enterprise with the same owner or in an enterprise with different owners and they can be located in the same country or in another country. The theory of international trade provides the spatial distance necessary to complete the story.

Baldwin (2006) describes Ricardo's story of the production of cloth in England and the production of wine in Portugal as *packages of tasks* that can be *unbundled* in a way that some tasks in the production of cloth can be done in Portugal and some tasks in the production of wine can be done in England. In this story relative wage rates will not be the only factor that determines whether a task is relocated, but also the nature and type of knowledge embodied in each task. Baldwin called this the *second great unbundling*, where the stages of production were unbundled across nations. The information, communication, and technology (ICT) revolution, which was triggered by the appearance of the microprocessor in the mid 1970s, is credited with reducing the costs of organising complex activities over distances (Grossman and Rossi-Hansberg, 2008). Baldwin and Venables (2010) argue that much of the unbundling that took place in the mid 1980s was regionally based, but it is now pervasive.

Knowledge creation and accumulation are slippery subjects because they are not easy to define, as Penrose (1959) claimed. Most studies on offshoring get around the problem by combining wage rates with labour intensities to establish whether the task is knowledge-intensive or not. This is fine as a first approximation, but as Johnson, et al., (2002) point out, there are many different types of knowledge such as knowing how (procedural knowledge), and knowing that, (descriptive knowledge), knowing why (theory), and knowing whom (social). Developing new tasks is a time-consuming and costly process that requires learning by doing, learning by using and formal scientific learning. While codified technical knowledge is generally public (or non-rival) and at least partly excludable, tacit knowledge is private (rival) and excludable, making it much less tradable, as Romer (1990) argued. For this reason certain kinds of tasks that are not well defined cannot be easily relocated abroad.

Since offshoring necessarily involves increasing returns and technological learning as well as jobs being relocated abroad, some of the discussions on the employment effects of technical progress are relevant. In the third edition of Ricardo's (1817) *Principles*, took the position that mechanization (through the division of labour) could have a long-term detrimental effect on employment because "machinery and labour are in constant competition." In other words, job creation was by no means certain when new processes were introduced by into the market. New investments, new machines, new products, decreasing prices and decreasing wages are compensation mechanisms discussed by economists in the past (Vivarelli, 1995). In general, neoclassical theory incorporates an automatic compensation mechanism into the theory because of the assumption of market clearing, but if it were assumed that markets do not clear, or that the principle of effective demand (Keynes) has long-run implications, then compensation would not be automatic.

While offshoring is not a new phenomenon, it has gained in importance in recent years. This importance has led to the idea that it is driving force behind the *third industrial revolution* as Blinder (2006) called it or the *second unbundling* as Baldwin (2006) called it. The data for Europe suggest, however, that these might be overstatements, and the extent to which offshoring takes place is much less than believed, perhaps because many of the tasks are not so easily tradable. What does appear to be important is that offshoring is important to the fifth technological revolution (Perez, 2002; Freeman and Louçã, 2001) as the microprocessor (and subsequent developments in software) made it possible for telecommunications (and the internet) to improve access to information on a global scale. Transport links have gradually improved though each of the five technological revolutions since the first one began around the time of Adam Smith.

3. Measuring the employment effects of offshoring

It is difficult to measure the employment effects of offshoring, mainly because of the complexity involved in using direct measures such as surveys. Most analyses are at the theoretical level and contain very little direct evidence of the labour market consequences of offshoring. The empirical studies surveyed by Crino (2009) use indirect measures of offshoring, such as the share of imported intermediates in industrial value added or output. These statistics, which generally come from the national input-output tables, are used primarily to measure the extent of intra-industry trade in the global economy, but this does not measure the trade in tasks. A relocation of a task is a one off activity, much like foreign direct investment or a transfer of technology that appears to be part of the global production network, whereas intra-industry trade is an ongoing activity that is measured as a flow of goods or services.

We use the European Restructuring Monitor (ERM) database to measure the extent of offshoring activities in 27 EU Member States plus Norway and their employment consequences from 2002 to 2010. It provides a direct measure of offshoring that relies on media reporting. The database contains almost 12,000 cases of announced or actual reduction of at least 100 jobs or involves sites that employ more than 250 people and affect at least 10 per cent of the workforce. Restructuring cases and employment effects are identified through new reports and are gathered by an extensive network of correspondents who review various national sources. Over 550 cases of offshoring or job relocation were identified over this time period, which allows us to measure the employment effects of the job relocation, both by country of origin, country receiving the jobs and by industry. To obtain information the intended new location of the job, we had to go through each individual case study to determine where the jobs are moving and the reason why they are moving. This information is only contained within the case study itself and therefore requires some guesswork as the actual location the jobs are moving to, especially when multiple locations were identified.

A major advantage of the ERM database is that the information is from the public domain and is usually available long before the reduction of the workforce is implemented. Correspondents collect the information by scouring through newspapers and other media to determine whether a job reduction is a case of offshoring. But the dataset contains certain problems. First, the database may overestimate the actual number of workers affected by the restructuring because it contains announcements and not actual examples of offshoring. Second, there may be a company and country size bias that is caused by the way the data is collected. Third, company files often contain missing information and errors in ISIC code that need to be corrected, sometimes using guesswork. Fourth, companies tend to be reluctant to publicize job shifts to foreign countries because of the negative reception associated with offshoring, as Agnese and Ricart (2009) point out. Finally, the data may not be representative of job loss in general. Still, Eurostat statistics provide two indications that they are representative. One indication is that the number of jobs lost as reported in the ERM database correlates highly with the number of unemployed of shorter than six months over the quarterly time series. The newly created global sourcing statistics also confirm that almost half of destinations for international sourcing or core business and/or support functions are within the European Union itself and that the distribution with other countries outside the EU is very similar. Nevertheless, it is one of the few direct sources of information on the extent of offshoring in Europe.

The ERM (2006) adopted a definition of offshoring that is similar to the broad definition provided by the OECD (2007). They use the term offshored when they are between two enterprises within the transnational enterprise group, and the term offshored and outsourced to describe contracts that are between two differently owned enterprises. The focus of our analysis is on the number of jobs that relocate from individual Member States of the European Union plus Norway to any other countries, including those within Europe.

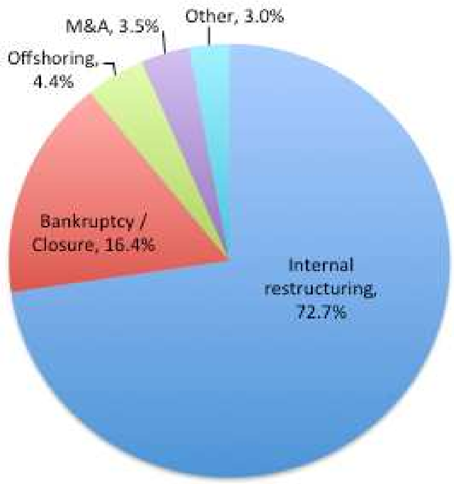
How important is offshoring in Europe? Table 1 shows that more than 226,000 jobs in Europe may have relocated to countries other than the one where it was originally located between the middle of 2002 and 2010. The European Restructuring Centre on Change began collecting data in 2002 and is incomplete. This made up approximately 4.4 per cent of the more than 4.1 million jobs lost to restructuring during the same period. Figure 1 shows the percentage share of jobs lost to restructuring in Europe from 2002 to 2010. Almost 73 per cent of the total jobs lost, or about 3 million jobs, were due to internal restructuring. About two-thirds of this number was made up through business expansion. Bankruptcy and closure made up the second highest amount, accounting for almost 700,000 jobs. Given that total employment in the 27 countries of the Europe Union plus Norway was estimated to be almost 215 million in 2002 and almost 225 million in 2010 according to Eurostat, the percentage of total jobs lost due to offshoring is very small.

Table 1: Total number of jobs offshored to other countries within Europe and outside Europe

Year	*Number of jobs offshored*
2002	2,010
2003	32,084
2004	29,273
2005	37,806
2006	46,738
2007	23,199
2008	18,165
2009	26,552
2010	10,832
Total	226,678

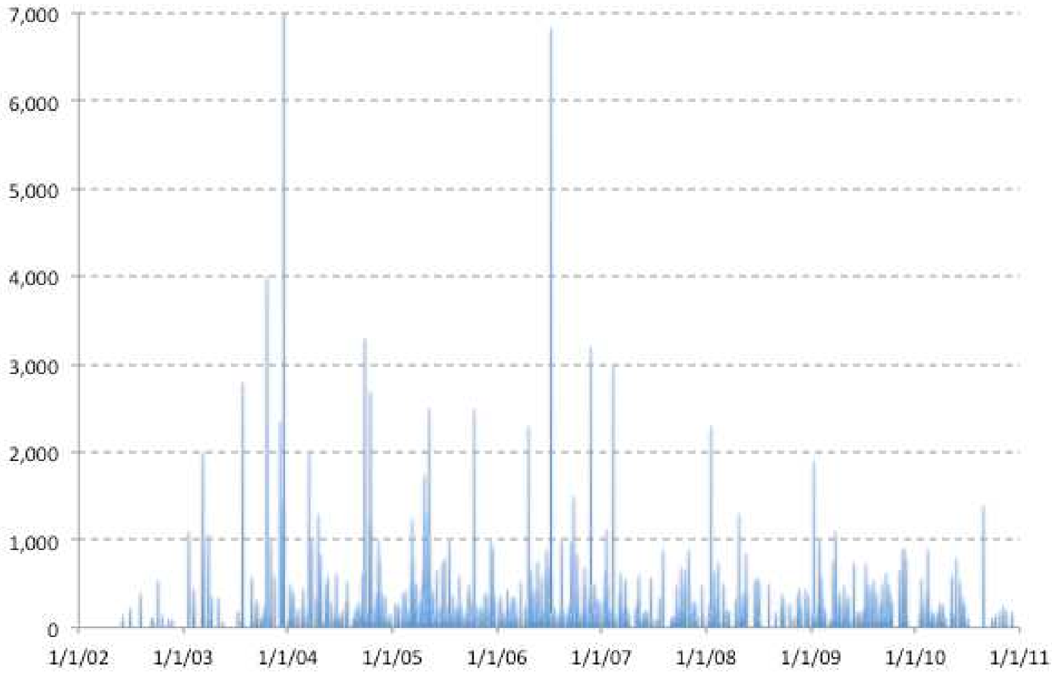
Source: ERM database

Figure 1: Percentage share of jobs lost to restructuring in Europe, 2002-2010.



Source: Own calculations based on ERM, February 2011

Figure 2: Frequency of offshoring in Europe by number of jobs, 2002-2010.



Source: Own calculations based on ERM, February 2011

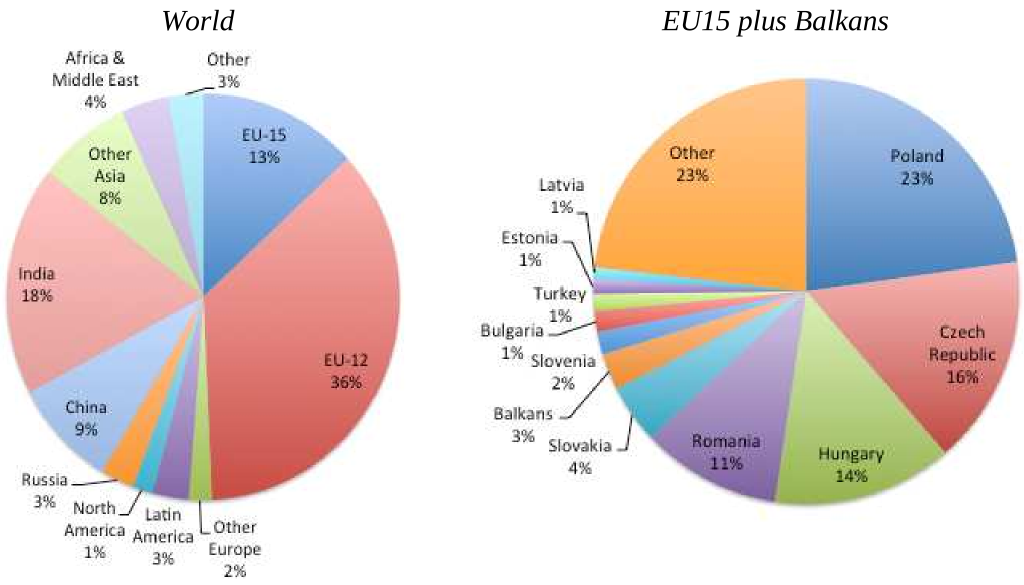
The frequency of offshoring also varies considerably over the time period of the database, as figure 2 illustrates. As each announcement is a discrete variable containing a given number of jobs that a firm plans to relocate abroad, they appear in the figure in this way. Even without averaging out the number of jobs to be relocated in a given year, it is immediately apparent that the jobs being offshored has declined markedly after the financial crash of late 2008. The figure indicates that cases with the largest number of jobs offshored were observed from 2004 to 2007. This collaborates with table 1, which shows that the number of jobs offshored had declined since the financial crisis. In the period just following the financial crisis firms tended to consolidate production, often closing down plans and relocating them back in the home country. The ERM database also indicates that more firms also opted for bankruptcy or closer after the financial crisis.

Figure 3 illustrates the main locations of European offshoring. More than half of the offshoring takes place within the European Union itself, of which the New Member States (EU-12) make up 36 per cent of the total percentage share. About 13 per cent migrated within Western Europe, while other locations are less important. Asia is by far the most important location outside of Europe, making up about 35 per cent share of the total percentage share. As expected, most of Asian offshoring goes to India (at least 18 per cent) and China (at least 9 per cent). Contrary to a general public view, China is far from being the main offshoring location. India appears to be a much more attractive location, mainly because of the better knowledge of English language, which is of major importance for call centres, which mainly appear in financial and other business services. Among the Eastern European locations, Poland (23 per cent of all offshoring to Eastern Europe), Czech Republic (16 per cent), Hungary (14 per cent) and Romania (11 per cent) are the main locations. This trend is similar to general geographical pattern of foreign direct investment (FDI) in the region. Very few jobs were relocated to non-Member States in Eastern Europe. Offshoring within Europe is predominantly an intra-EU relocation of jobs. Taking into account a considerable share of

European offshoring going to Western Europe, it is safe to conclude that approximately half of all job reallocations in the European Union are to other Member States.

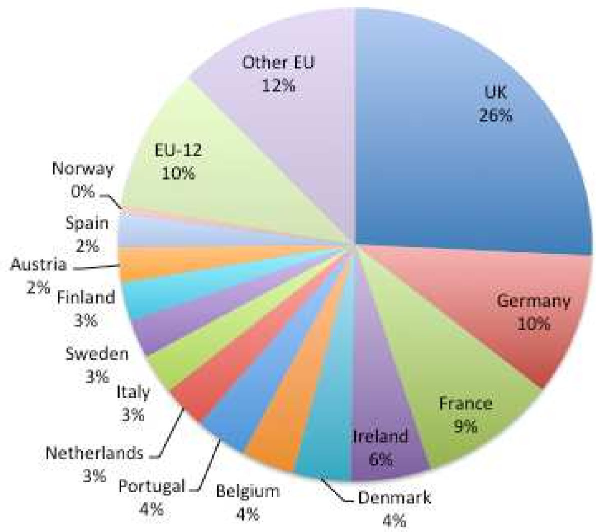
The main locations where jobs were lost due to offshoring are shown in figure 4. It shows that the United Kingdom experienced the greatest number of relocated jobs (26 per cent), followed by Germany (10 per cent), and France (9 per cent). Many of these jobs were backroom call centres in financial and business services that went to India. The rest of Europe proved to be a good location for these jobs because of the need to have perfect fluency, without any 'accents'. In one instance, some telephone call room jobs were relocated to Estonia, but were subsequently moved the following year for because of the need to have fluency. Only 10 per cent of the jobs relocated from Eastern Europe, mainly because these countries are close in geographic proximity, have a high level of education and wage levels are much lower than most of their Western European counterparts. Some reversal in this trend appeared in 2009 and 2010, as some of the global enterprises, particularly in the automotive industry, attempted to consolidate production into few plans. For example, the largest greenfield investment in Slovakia over the past twenty years was relocated back to Germany and France.

Figure 3: Location of European offshoring, 2002–2010



Source: Own calculations based on ERM, February 2011

Figure 4: Location of European job-loss, 2002–2010



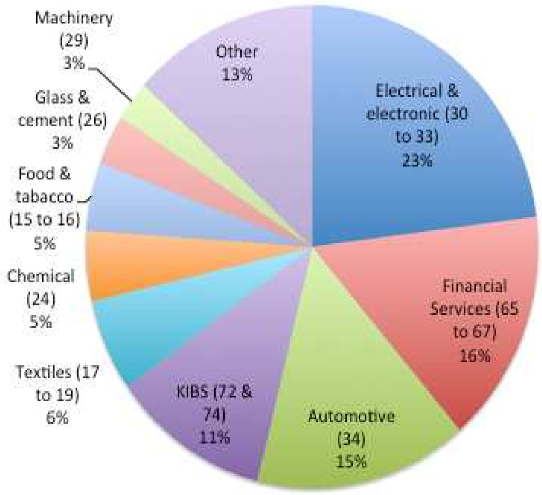
Source: Own calculations based on ERM, February 2011

5. Structural change through offshoring

Offshoring affects certain industries more than others. Figure 5 shows that the manufacturing sector dominates the European offshoring activity, with the electoral, electronic, and optical and medical equipment comprising 23 per cent of the total jobs offshored and automotive industries comprising another 15 per cent of the total. A broad variety of manufacturing industries comprise the remaining manufacturing jobs offshored, i.e. textiles, materials and construction, chemicals and pharmaceuticals, food, beverages and tobacco, and machinery. Almost one-third of the jobs relocated were in the service industries, of which 16 per cent were in financial services and 11 per cent were in the knowledge-based services, including software engineering and business services. In the automotive industry there is no doubt that job relocation is also motivated by the market-seeking rationale, while this may be less so in other industries. European offshoring activities during the 2000s were mainly concentrated in four industries, i.e. electrical and electronic equipment, transport equipment, financial and business services.

Domination of the manufacturing sector in the European offshoring activity also helps to explain the geographical structure of offshoring by recipient countries, that is, the domination of the new Member States and relatively low importance of China. Geographical proximity is likely to be an important fact, especially if transportation costs are taken into account. However, this is not so in the service sector, where India has distinctive advantages (language) over China. Domination of intra-EU deals in the European offshoring activity, thus, seems to be to a major extent a part of the post EU enlargement consolidation of the activities of global corporations. Simple cost cutting seems to be more important in the case of the service industries.

Figure 5: Structural Change through offshoring, 2002–2010



Source: Own calculations based on ERM, February 2011

Certain distinctive patterns appear in the different industries. The largest industry, which is the manufacturing of electrical, electronic and optical equipment, is traditionally seen as knowledge-intensive. Most of the relocations were in the manufacturing of electrical machinery and telecommunications equipment. Nevertheless, when the industry is broken down into tasks, it becomes apparent that not all tasks are knowledge intensive (Srholec, 2007). Many of the tasks are rather mundane and resemble those in Adam Smith's pin factory. In some cases entire factories doing assembly were relocated to countries with lower wages and the R&D department was either kept in the same location or relocated within Western Europe. Figure 6 shows that countries that lost jobs were fairly well distributed across Europe, with about 12 per cent of employment in Eastern Europe being relocated to another country. When taking the size of the country into account, Ireland and Finland could be considered as the biggest losers. About 17 per cent of the jobs lost were relocated to China and other 6 per cent went to both India and other Asia, which may include China and India. Most jobs were relocated within Europe itself, with 13 per cent going to both Hungary and Poland. The remaining jobs went to Latin America, North America and Africa and other countries in Europe. One visible trend was that Germany lost more than 4,000 jobs (about 10 per cent of total) in the manufacturing of mobile telephones during the period, but the also gained 1,000 jobs, mainly because of the need to consolidate production capacity.

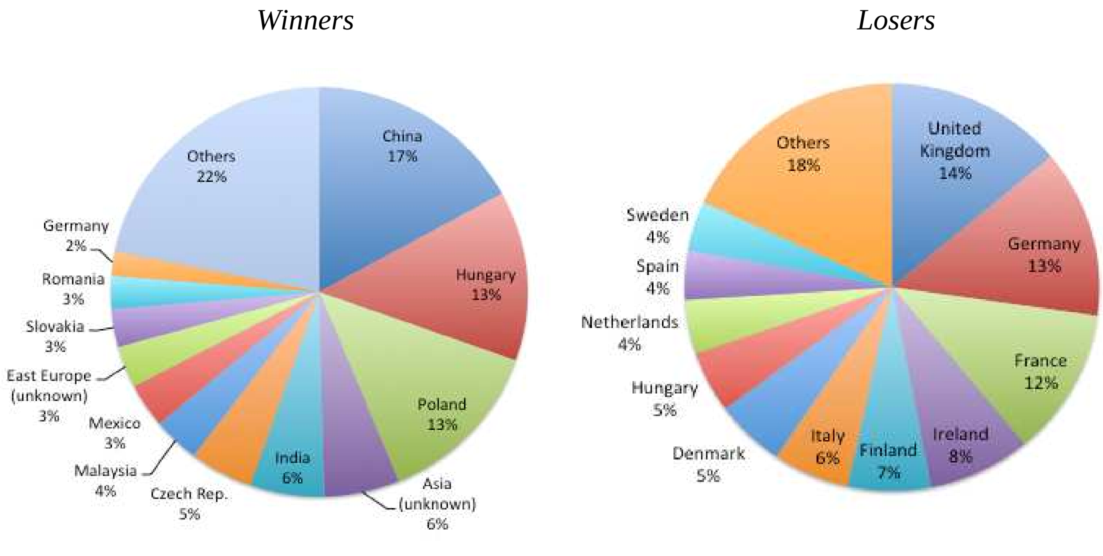
The story was very different in financial services, which include insurance, banking and other various financial services. Almost all of the jobs that were relocated were either call centres, or data entry. There was a certain similarity in that almost all of the jobs relocated were relatively low-skill, requiring either the ability to speak English fluently, or have the capability to do rapid data entry. The English requirement made India attractive, being a member of the British Commonwealth, but it also explains why the United Kingdom lost so many jobs. Figure 7 shows that at least 53 per cent of all jobs in financial services that relocated from Europe were in the United Kingdom and another 15 per cent were from an unknown country in the EU-15, including the United Kingdom. At least 63 per cent of the jobs in this industry went to India. In total, more than 23,000 jobs relocated from the United Kingdom to India from 2002 to mid 2008. But since the financial crisis of 2008, only

400 jobs, of which 100 are in business services, were planned to be offshored from the United Kingdom to India. There was also a very large relocation of 5,000 jobs in 2004 from Western Europe to the Russia, which accounted for more than 15 per cent of all offshoring activity in this industry over the eight-year period. This was mainly a strategic move by the largest Italian bank to relocate parts of its business closer to the markets it services.

The automotive industry appears different from the other three top industries for offshoring from Europe. Almost 90 per cent of the jobs lost in this industry were regained in other countries in Europe, mainly because of the high transportation costs in the industry. Almost all of the jobs were assembly, and fairly low-skill, but because of strategic divisions and the need to increase capacity utilization there was a tendency to keep certain tasks within Western Europe. Figure 8 illustrates that more than 20 per cent of the jobs lost in Europe were from Portugal and another 15 per cent were from the United Kingdom. By contrast, Germany was the main winner, gaining 18 per cent of the jobs offshored in Europe. The main reason was that many firms wanted to consolidate production and this generally meant moving production back to the headquarters or main plant. For example, the largest greenfield investment in Slovakia was closed and the assembly line consolidated with existing lines in Germany in 2009. Other low-wage eastern European countries were also winners, with 13 per cent of the jobs offshored to Romania, 12 per cent of the jobs to the Czech Republic and 10 per cent to Poland.

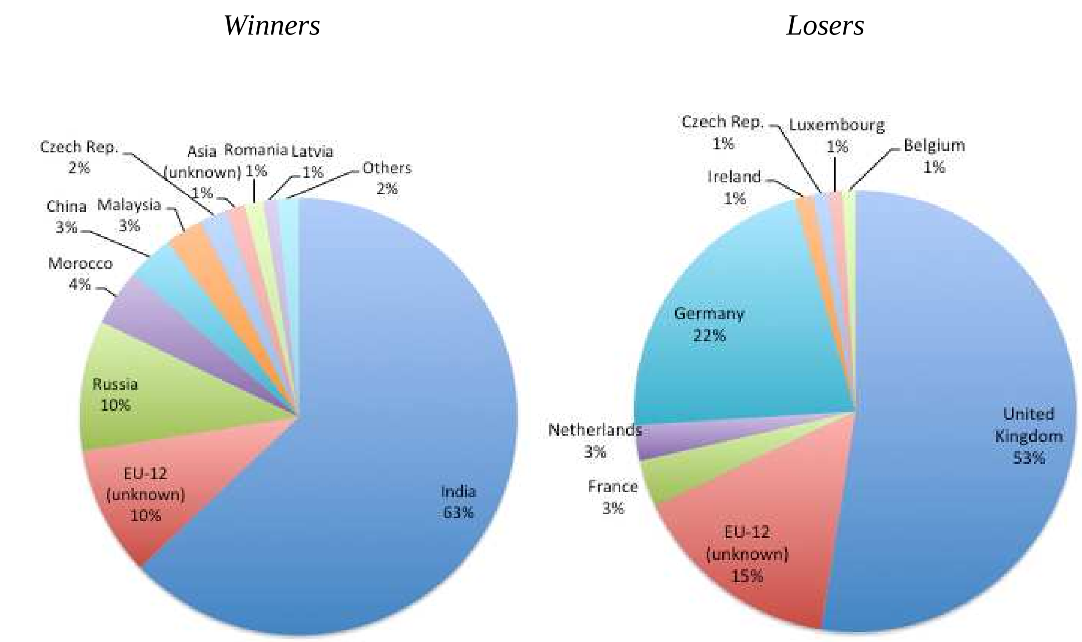
Software related services tended to relocate within Europe. As figure 9 shows, more than half of this industry moved from an unknown country in the higher-wage western European country to a relatively lower wage eastern European country. More than half of the total jobs outsourced came from a plan by Siemens in late 2003 to more 10,000 jobs to the New Member States. More than 14 per cent of the jobs offshored from Europe went to India over the years India, for the same reason that India attracted so many of the financial services.

Figure 6: Location of European offshoring of electrical and optical equipment manufacturing, top 10 winners and losers, 2002–2010



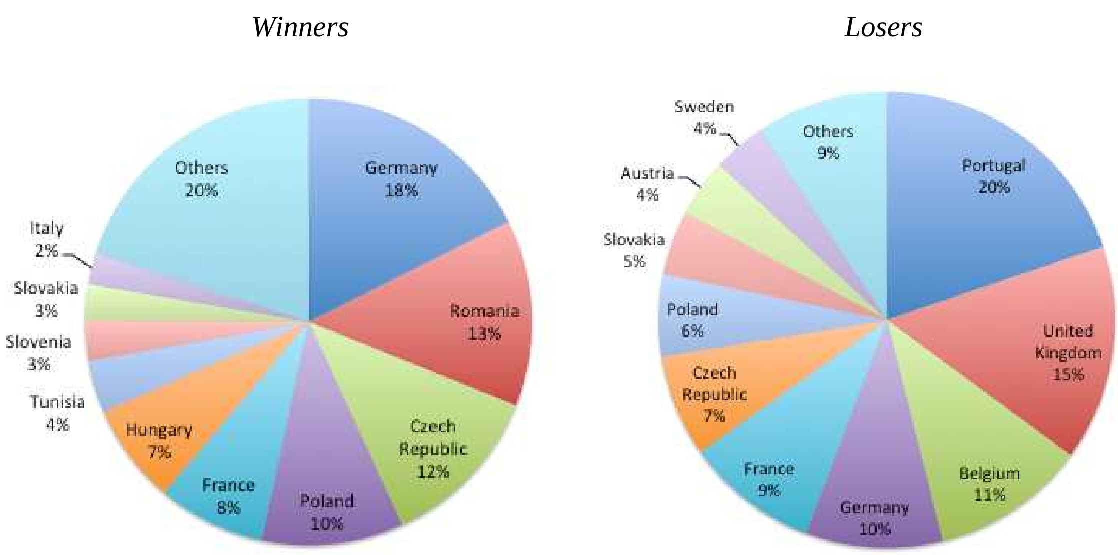
Source: Own calculations based on ERM, February 2011

Figure 7: Location of European offshoring of financial services, top ten winners and losers, 2002–2010



Source: Own calculations based on ERM, February 2011

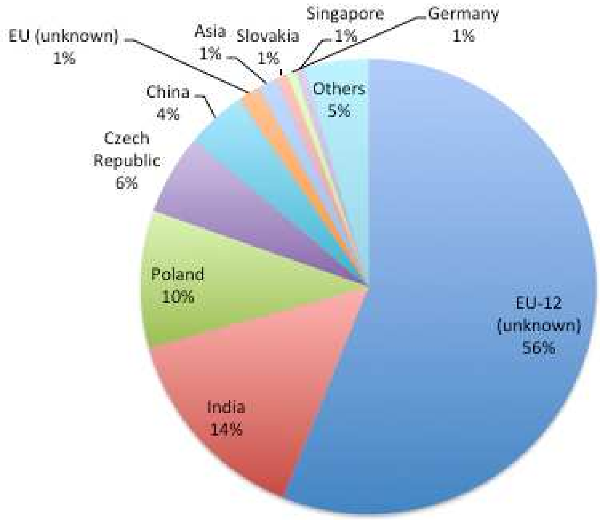
Figure 8: Location of European offshoring of the automobile manufacturing, top 10 winners and losers, 2002–2010

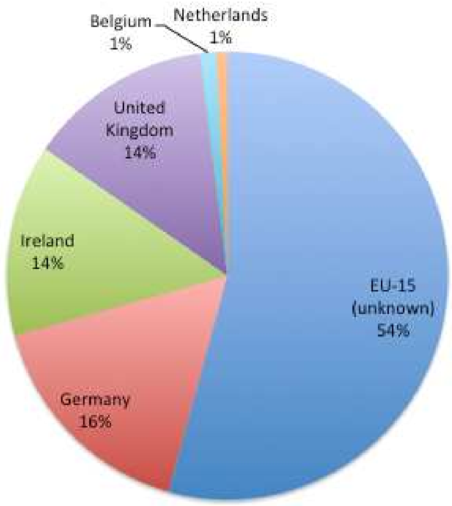


Source: Own calculations based on ERM, February 2011

Figure 9: Location of European offshoring of software services, top ten winners and losers, 2002–2010

Winners *Losers*





Source: Own calculations based on ERM, February 2011

5. Some myths on European offshoring

This paper showed the importance of using direct measures of job relocation to show the nature and extent of offshoring. To do this we used the publically available ERM case studies and determined where jobs are lost and where they are being relocated. Several important conclusions are reached in the paper. First, at least half of all European offshoring occurs within Europe itself, but the rapid emergence of China and India as major economic players in the global economy, particularly for the relocation of electric and electronic manufacturing to China and East Asia for the relocation of certain service activities to India. Second, India is much more important than China as a source of offshoring, mainly because of the large amount of offshoring in the service industries (mainly telephone call centres). Third, European offshoring is moving mainly to Eastern Europe, mainly because of lower wages, but there is evidence that the labour force is also well educated. Fourth, offshoring mainly entails movement of low-skill jobs out of Western Europe while the offshoring of R&D activity and the relatively high-skill jobs tend to remain within Western Europe. Fifth, most low-skill jobs, such as textiles, are moving from Europe to other low-wage countries, particularly in Asia and Northern Africa. Finally, the current economic crisis is creating an incentive to consolidate so as to increase capacity utilization within the group of firm, which creates the tendency for jobs to move back to plants in Western Europe.

The ICT revolution and the subsequent decline in international telecommunications and transport costs makes it easier to offshore both skilled and unskilled jobs. Blinder (2006) estimates, using fragmentary data, about one million jobs in the United States were lost to offshoring since the beginning of the ICT revolution to the end of 2005 and suggests that tens of millions of jobs are vulnerable (Bhagwati and Blinder, 2009). The first myth that this paper dispels is that the amount of jobs lost in Europe due to offshoring is not very large. Our estimates, using the ERM data, are that about 250,000 jobs were lost to offshoring from mid 2002 to 2010, and that the tendency to offshore jobs has declined since the financial crisis of 2008. A study by Harrison and McMillan (2006) also confirm that the extent of offshoring is also much smaller than estimated in the United States. The European economy is going through a process of creative destruction, however, as the ERM data shows that millions of jobs have been lost to restructuring, but this was mainly due to internal restructuring and bankruptcy or closure (see also Bhagwati, 2004).

A second myth is that most of the jobs being offshored in Europe are going to Asia, namely China and India. One of the conclusions of this paper is that a little more than half of the jobs that moved due to offshoring are inter-EU, that is they moved within the Europe itself. The industry where the job is located is important. Transportation costs remain an obstacle in many industries, such as the automotive industry, which was analysed in this study. In an effort to reduce costs, firm sometimes moved plants from high-wage Western European countries to low-wage Eastern European countries. There has been some reversal of this trend since the financial crisis, as some firms try to consolidate their capacity. There has been a tendency for the production of ICT equipment to move to eastern Asia and China in particular, mainly because of lower wage costs, and for ICT services to locate in India, mainly because they have a good knowledge of the English language in addition to low wages. European countries that are dependent on ICT manufacturing and services had a higher probability for offshoring. Nevertheless, only little more than a third of all of the jobs outsourced from Europe went to Asia and almost all of these were tasks that required little skills.

This last point becomes the third myth that the ERM database dispels. The database shows that virtually none of the European jobs offshored were high skilled. While the jobs that moved in recent years appear to be coming from a so-called high-tech industry, the specialization of labour, or the second unbundling as Baldwin (2006) calls it, made it easier to recognise the low skill tasks and then move these to low-wage countries. Knowledge intensive tasks, such as research and development (R&D) activities and core management activities, generally remain near the headquarters for strategic reasons. They are rarely offshored, but instead reduced through internal restructuring when these activities need to be reduced. R&D outsourcing may be taking place, but this is a different phenomena that offshoring. In other words, China and India are not attracting high-skill jobs from Europe, but instead creating them endogenously.

The ERM database provides a promising way to better understand offshoring and restructuring in the European context. There are several different avenues to follow when analysing these issues. One avenue is to expand on the individual case studies that are identified in the database. So far, few people looked inside the black box to see what is going on within the firm or why offshoring is really taking place. The case studies in the ERM database only include cursory information on why offshoring takes place. A second avenue would be to compare these data with unemployment data, data from the Eurostat international sourcing database, OECD foreign affiliates database and the OECD/Eurostat input-output database. Several papers on the growth of vertical specialization in international trade use input-output analysis to identify outsourcing and offshoring, but it is not clear that this proxy covers offshoring in an adequate way. Finally, a better understanding of offshoring could be gained by linking ERM cases with other databases that contain more detailed information about the firm and its network of affiliates.

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Appendix Table: *Matrix of jobs offshored from European countries to other countries both within and outside Europe.*

	Austria	Belgium	Bulgaria	Czech Rep.	Denmark	Estonia	Finland	France	Germany	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Norway	Poland	Portugal	Romania	Slovakia	Slovenia	Spain	Sweden	UK	Other	Total
Albania												241																241
Argentina																									138	33		171
Asia	75	53		500	120		423	1,149	1,200		895	91	44			570	365			100			180	790	100	975		7,630
Austria								95		41								50			60							246
Baltic countries					120																							120
Belarus													44												96			140
Belgium								51																		213		264
Bosnia																							393					393
Brazil								250				205					53									797	581	1,886
Bulgaria								445			450										440							1,335
Central America																								150				150
China	325	200		504	1,457		1,526	1,572	2,141	125	1,117	557	771				1,130	200		200		1,207	238	400	847	3,502	1,564	19,583
Costa Rica							55				640																	695
Croatia												120											34					154
Czech Republic	423	377			1,260			1,668	3,345	133	795	921			442		200			1,550				152	304	2,040		13,610
Denmark							57				90														120			267
Dominican Republic											280																	280
Dubai																										108		108
East Asia					120															180								300
Eastern Europe	1,745						130	1,093	1,073		265	120					465								425	897	13,420	19,633
Egypt																							370				581	951
Estonia							400							115											465			980
Finland					70				825																			895
France					122				660			535					132							130	160	2,482		4,211
Germany	615	4,441		150	1,497		127	284	275		1,200	65					580	110	610	425		190	198	171	250	1,446		11,554
Hong Kong								111																				111
Hungary	135	154			1,100		64	1,255	3,602		315						320		200	830				397	805	2,491		11,668
Iceland																		160										160
India	1,037	66				78	861	511	1,743		1,529						837		1,000	130				115	100	29,207	4,231	41,445
Indonesia	85																			36						80		201
Ireland									400																	140		540
Italy		165			410		425	163	290		50								100	49		500		180	74	625		3,031
Japan																										59		59
Latin America																								384	150	150		684
Latvia						300			340			105																745

Lithuania		42																										42
Macedonia													53															53
Malaysia								710		540	117	200														2,035	1,400	5,002
Malta								30																				30
Mexico									125	220	216	155					638									1,419		2,773
Middle East									58																			58
Morocco								1,862			630									550			333	615				3,990
Netherlands		100			185	221		440	275																153	125		1,499
North Africa										125																		125
North America		383							480		263						383									672		2,181
Norway																									165			165
Philippines		126									90							100									600	916
Poland	358	150		1,032	475		1,061	2,263	1,050	174	2,430	1,183			224		700			549		600		1,141	984	4,622	460	19,456
Portugal		56						107	413		50													132				758
Romania	185	794	167	2,530				854	1,134	620	90	155						70	500	800		560	115		170	125	210	9,079
Russia		43		500	120		287		67														333	35			3,420	4,805
Serbia	190									41		340										654	310					1,535
Singapore											367															430		797
Slovakia	285				910				440	774	50						50			553				76		659		3,797
Slovenia									500		470	77								425								1,472
South Africa																				450						270		720
South America								365																				365
South Korea															79											330		409
Spain		98			175			539			173	142					125			125					188	395		1,960
Sri Lanka																											770	770
Sweden		43					150				100							210			60					179		742
Switzerland		167			150				100																			417
Thailand						78		150	413								53			36				214		233		1,177
Tunisia				170				1,635				50							900									2,755
Turkey		85			337							133								517			40					1,112
Ukraine												450	44				228			550								1,272
United Arab Emirates																		50										50
United Kingdom		108		211	190			286				77					106				60			65	150	245		1,498
USA		199																				500			200	640		1,539
Vietnam													53															53
Other		320			240	120	420	3,247	909	120	915	321				113	470	130				400				835		8,865
Total	5,333	8,170	167	5,672	8,858	797	5,986	21,135	21,698	2,913	12,507	6,243	1,009	115	595	683	6,835	1,080	3,310	8,055	620	4,611	2,544	5,147	6,044	56,014	27,537	226,678

Source: Own calculations based on ERM, February 2011

Globalisation, fragmentation and within industry heterogeneity in Europe

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Abstract

Production fragmentation refers to the organization of specialized tasks into a series of production blocks, each of which make up part of the production process or global value chain. Enterprises become increasingly heterogeneous because each fragment of the value-chain requires different resources and capabilities, resulting in different scale economies. An important issue that has not been adequately discussed in the literature is whether this heterogeneity is greater within an industry then across industries, whether the degree of heterogeneity is deepening and what explains differences in this process across countries. A panel of firms was created using employment data from the Amadeus database and an analysis is performed using the method of multilevel variance decomposition to identify the trends in heterogeneity across European firms. The results show that the within industry heterogeneity is far deeper than assumed in the existing literature that the within component actually dominates over the between industry heterogeneity and that the within industry differences are deepening over time. And in the next we set out to explore these patterns which the help of panel data econometrics. The analysis indicates the degree of within industry heterogeneity is highly correlated with the level of development of a country, and is explained by the extent of the market and R&D intensity of the economy. Inward FDI and imports of goods and services appear less important.

Keywords: within industry heterogeneity, international fragmentation of production; vertical specialisation; Global Value Chains;; international outsourcing; multinational firms.

1. Introduction

Production fragmentation has been an important issue within the history of economic thought since at least the time of Adam Smith. Smith put forward the idea that an ever more sophisticated division of labour was synonymous with increases in labour productivity and hence economic growth. This specialization of labour into well-defined tasks suggests that the production process becomes increasingly fragmented over time. Production fragmentation refers to the organization of these tasks into a series of production blocks, which may be outsourced to other enterprises, whether affiliated or independent, and may be located in nearby regions or be part of a large international production network (Jones, 2000). The implication of fragmented production is that enterprises become increasingly specialized within the global value chain or production process. Moreover, the process itself becomes increasingly complex, often involving additional coordination, especially relating to transportation and communication between each production block, or what Arndt and Kierzkowski (2001) describe as service links. As each fragment of the production process requires different resources and capabilities, enterprises have different scale economies and appear as heterogeneous organizations. An important issue that has not been adequately discussed in the literature is whether this heterogeneity is greater within an industry then across industries.

Heterogeneity among competitors, which is one of the most important features of the modern market economy, has been one of the most controversial problems in the theory of competitive equilibrium. Most of the recent controversy centres on the idea that competition is perceived in competitive equilibrium theories as an end state that is synonymous with market structure, and not as a rivalrous process that allows for heterogeneity as advocated by the classical economists (Metcalfe 1998, Knell, 2008). Behavioural heterogeneity has resurfaced in various theories of imperfect or monopolistic competition because they decouple prices from competition, and has reappeared again in some recent models of monopolistic competition in international trade as put forward by Melitz (2003) and Helpman, Melitz, and Yeaple (2004). Much of the discussion in this paper takes off from the attempts made in these papers to account for the within sector heterogeneity.

The main contention of this paper is that heterogeneity is greater within an industry then across industries and that the difference is deepening over time. To our knowledge, this study is the first one to measure the extent of within-sector heterogeneity and then analyse what accounts for differences the degree of this heterogeneity across countries. A panel of firms was created using employment data from the Amadeus database and an analysis is performed using the method multilevel variance decomposition to identify the trends in heterogeneity across European firms. Using the data, we consider that segments of the value chain may be similar across industries, or what the literature describes as vertical disintegration. If firms in different industries specialize in the similar segments of the value chain, they often become more similar to each than other firms in the same industry.

We organized the paper in the following way. In the next section, the issue of behavioural heterogeneity is considered in the context of increasing fragmentation. It will focus mainly on the line of thought from Adam Smith to Allyn Young through the thought of Alfred Marshall and subsequent development of a theory of monopolistic competition. The second section will weave this issue into the discussion on fragmentation. Section three will develop a way to measure the within industry heterogeneity. The intra-class correlation coefficient (ICC) defined in this section is then applied to a firm-level dataset of over 9 million observations derived from the Amadeus database available from Bureau van Dijck Electronic Publishing in section four to show whether heterogeneity is greater within an industry then across industries whether the process of fragmentation is deepening and what are the differences in this process across countries. Section five uses a standard panel data regression model to help explain what determines these patterns of heterogeneity. A concluding section discusses what this means for the new theories of monopolistic competition in international trade in the context of fragmentation and then suggests new directions where to take the analysis.

2. Fragmentation and heterogeneity from Adam Smith to Allyn Young

Behavioural heterogeneity and fragmentation (specialization) have been central issues within economic thought since at least the time of Adam Smith. Smith (1776) knew that an ever more sophisticated division of labour was the main source of productivity growth, but it also implied that knowledge was increasing being fragmented across the different heterogeneous tasks.[1] An increasing division of labour was seen by Smith to increase of dexterity of workers, save time lost in switching between different tasks, and lead to the invention of machines and organization that facilitate work. Driven by the extent of the market, specialisation divided productive operations into their constituent elements, which both saved time in changing between different tasks and facilitated the introduction of equipment and machines. Loasby (1999) describes this process as one that encourages the development of differentiated knowledge, and therefore a set of distinctive and heterogeneous capabilities.[2]

International trade becomes essential to the argument because the division of labour is limited by the size of the market. It increases the size of the potential market and provides a vent for surplus product, but more importantly, it tends to create specialization across countries as tasks are subdivided into well-defined activities and products. By overcoming the narrowness of the domestic market, ensures that the division of labour is carried more fully and productivity growth is higher. While Smith's original example was described how eighteen distinct operations in pin factory could be identified and performed by different workers, an implication of the theory is that the division of labour could be extended to other enterprises (outsourcing), and across several different countries.

Jones (2000) emphasized the two-way link between technological progress and fragmentation. Smith's ideas about specialization suggest that economic growth precedes capital formation, but in his discussion of the accumulation of capital, Smith also explained why causality between productivity growth and the division of labour ran both directions. When the use of machinery facilitated and abridged labour, the accumulation of stock is, in the nature of things, before the division of labour. As the division of labour became more sophisticated and heterogeneous, the incentive to innovate became greater. Further, subdivision of tasks requires more capital to keep busy all the different kinds of workmen. The more the productive hands employed, as a result of the

[1] Hayek (1945) also considered the division of labour to be synonymous with the division of knowledge

[2] Cohendet and Llerena (2005) argue that the 'division of knowledge' (as expressed by the delineation of the domain of core competences) *precedes* the division of labour the firm functions as a knowledge processor giving full priority to the creation of resources.

higher division of labour, the more the capital required for wage advances as well as to equip them with proper tools and equipment. Young (1928) later stressed that capital accumulation and technological progress makes the heterogeneity of labour and capital inputs a progressive cumulative process, in which the accumulation drives the division of labour while at the same time defining its limits.

The idea of the division of labour rarely appeared in economic discourse after Adam Smith. In the twentieth century the idea became absorbed into the idea of increasing returns, which is shorthand for the potential returns to further specialization when there is growth in a particular sector, specific kind of capital, or the economy as a whole. The most notable exception was Alfred Marshall (1890), who developed this idea in the context of the representative, or average, firm in partial equilibrium.[3] Partial equilibrium focused on the determination of prices and quantities in a specific market, independent of the effect that this market might have on supply and demand, and hence prices in other markets. An inconsistency appeared in the theory, however, that implied that variable costs, including increasing and decreasing returns to scale, were incompatible with free competition. The problem was that whatever happened in one market or industry had no effect on the prices of goods in other markets. Sraffa (1926) demonstrated that increasing returns (specialization) were inconsistent with internal economies, which had the consequence of the representative firm changing position within the industry as new firms entered and others left. Allyn Young (1928) entered the discussion by justifying the need to have increasing returns in the theory. He essentially revived Smith's ideas about specialization, but described them in terms of firms and industries and how firms within an industry can become more heterogeneous through the ever more sophisticated division of labour.[4]

Young developed the idea that the division of labour as a form of industrial fragmentation more fully than Smith.[5] Writing in the latter half of the eighteenth century when industrial capitalism was in its infancy, Smith could not have fully visualized that industrial stratification implied a division of labour among firms and industries. Nor could he fully comprehend whether individual tasks or groups of tasks be performed spatially apart, and/or separated by ownership. There was also further recognition that this dynamism could generate heterogeneity and diversity of knowledge through the production of new goods and services. Young considered specialization not only an issue within a single enterprise, but one that should include many different enterprises involved in the production of a single commodity, or what might be called industrial stratification.

Industrial fragmentation is essential to the growth process. Increasing returns generated through specialization is "progressive and propagates itself in a cumulative way", as posited by Young

[3] Marshall (1890: 266) also made an important distinction between internal economies, which he considered "dependent on resources of the individual houses of business engaged in it, on their organization and the efficiency of their management", and external economies, which he considered "dependent on the general development of industry."

[4] Nooteboom (2007) described how greater specialization leads greater inter-dependencies between enterprises, including outsourcing and collaboration. Jones (2000) and Jones and Kierzkowski (2001) have a similar idea when they claim that increased specialization leads to fragmentation and intra-product trade and how this process could lead to an offshoring of certain tasks to lower-wage countries. In this context fragmentation encourages the formation of global production networks, which then encourages interactive learning through the network.

[5] Chandra (2004) claims that Young explained the *mechanics* of endogenous growth more fully than Smith. Smith's discussion of growth, however, is broader than Young, and includes not only the rudiments of a theory of capital accumulation, but also the role of institutions, systems, and conditions for a competitive exchange economy to work.

(1928: 533), which implies that variable costs are always external to the industry.[6] In this context, production fragmentation is a response to changes in the market conditions external to the firm. As the division of labour extends across industries the representative firm will gradually lose its identity. As this happens, Young (1928: 538) the internal economies of the industry will "dissolve into the internal and external economies of the more highly specialised undertakings which are its successors, and are supplemented by new economies."[7]

There is also strong evidence that the representative firm also lacked empirical support. Marshall's representative firm suggests that a certain size firm with average access to internal and external economies is normal for the industry, which implies that firms are homogenous in terms of the economies of scale within the industry. The idea of imperfect or monopolistic competition decoupled prices and competition, which provided an alternative way to look at heterogeneity. Chamberlin (1933) and Robinson (1933) identified several sources of heterogeneity that could dominate price competition, including product differentiation, product innovation, packaging and design, availability of credit, advertising, and marketing. From the empirical perspective, Gilbrat (1931) found that all firms within an industry had the same chance of growing, regardless of its size, or what is now known as Gilbrat's 'law of proportionate effect'.[8] Steindl (1945) provided the first empirical criticism of Marshall's representative firm by pointing to the presence of risk, limits to borrowing, high mortality rate and monopolistic domination as reasons for the persistence of heterogeneity among firms.[9] This stylized fact generated a large and growing literature on the measurement of firm growth and heterogeneity and on the shape of the long-run cost curve (see Sutton, 1997; Knell 2008).[10]

3. The measurement of heterogeneity

The analysis makes extensive use of the Amadeus database available from Bureau van Dijck Electronic Publishing.[11] The sample is restricted to firms with at least 5 people employed at any

[6] Chandra (2004) points out that increasing returns was a macro concept for Young rather than a micro one that depends on economies of scale. Similarly, Kaldor (1966) conceives returns to scale as a as a macroeconomic phenomenon

[7] Young (1928: 538) claimed "over a large part of the field of industry an increasingly intricate nexus of specialized undertakings has inserted itself between the producer of raw materials and the consumer of the final product."

[8] Using a skewed lognormal distribution, he demonstrated that if the rates of growth of firms are identically and independently distributed, the distribution of the firms' size tends asymptotically to a lognormal, or that firms follow a random walk.

[9] Heckman (2001) also emphasized this point in his Nobel address when he described the empirical importance of heterogeneity and pointed to the analogous problem of the 'average person'.

[10] More recent studies suggest that behavioural heterogeneity and technological diversity are essential. Sutton (1998) demonstrates how differences in the innovative behaviour of large versus small firms can generate persistent differences in firm size and a concentrated market structure. Dosi (2005) provides evidence that inter-firm heterogeneity is extensive and persistent over time. Peters (2005) suggests that there is a similar skewed pattern of behaviour among innovative firms and that heterogeneity is persistent over time.

[11] Helpman, Meltz and Yeaple (2004) use the same database and assemble a sample of 260,000 firms.

time from 1999 to 2008. The total dataset we used in the estimation contained over 9 million observations for employment from 31 countries from 1999 to 2008. The industry is identified by the NACE, rev. 1. classification at 3-digit level.

Variance decomposition analysis is used to compute the importance of within industry heterogeneity. We propose the multilevel modelling method to measure the heterogeneity (Luke 2004). The aim of the approach is to determine whether the observed differences in scale economies among firms can be attributed to heterogeneity between industries or within them. To capture these differences in heterogeneity, we estimate a basic two-level multilevel model. A multilevel model predicts values of some dependent variable based on predictors at more than one level. For example, we may want to examine to which extent firm’s scale economies is specific to the firm and to which extended it is given by the industry. In this case the firm represents level-1 and the industry level-2 of the analysis. The following two-level model can delineate the multilevel nature of the problem:

Level 1: $Y_{ij} = \beta_{0j} + r_{ij}$

Level 2: $\beta_{0j} = \gamma_{00} + u_{0j}$,

In Level 1, Y is the dependent variable, or ICC_{ij} index, where *i* is the firm, *j* is the industry, and β_{0j} is the level-1 intercept. In level-2 unit *j*; γ_{00} is the mean value of the level-1 dependent variable, r_{ij} is the unmodeled variability (error) for unit *i* and u_{0j} is the unmodeled variability (error) for unit *j*.

This indicates that a different level-1 model is estimated for each of the j level-2 units. Each industry in our study may have a different average of the dependent variables (β_{0j}). In other words, we are allowing the intercept β_{0j} to vary across industries. A critical aspect of this model is that the level-2 equation implies that the level-1 intercept is a function of level-2 variability, so that we can treat the intercepts as outcomes of the industry level. By substituting the level-2 equation into the level-1 equation we arrive to a reduced basic mixed-effects model:

Reduced: $Y_{ij} = \gamma_{00} + u_{0j} + r_{ij}$,

which is composed of a single fixed effect γ_{00} and two random effects r_{ij} at level-1 and u_{0j} at level-2. In our analysis, rij is variability accounted to the firm-level and u0j is variability of the same dependent variable between industries. The former is the variability between firms within an industry, which represent the within industry heterogeneity, while the latter is the variability between industries, which refers to inter-industry heterogeneity.

Multilevel models become more complex if level-1 or level-2 predictors are introduced. For our purpose, however, it is enough to estimate the simplest possible two-level model with no predictors outlined above. The only purpose of this so-called unconstrained or null-model, is to disentangle how much of the variance of the dependent variable can be attributed to level-1 as compared to level-2 of the model, i.e. to the firm as compared to the industry level.[12] Since the multilevel model splits the random effect between the different levels, we can calculate the intra-class correlation coefficient (ICC), which is defined as follows:

$$ICC = \frac{\sigma_{u0}^2}{\left(\sigma_{u0}^2 + \sigma_r^2\right)} = \frac{u_{0j}}{\left(u_{0j} + r_{ij}\right)}$$

The ICC measures the proportion of variance in the dependent variable that is accounted for by the level-2 units. In our analysis, the ICC refers to percentage of variance in the log of the number of employees that is explained by the industry.

Table 1 provides the intra-class correlation coefficient (ICC) for European countries, 1999 to 2008. The figures in the table show the percentage share of heterogeneity that can be explained by inter-industry variability. For example, if the ICC equals to 0.25 it means that industry accounts for 25 per cent of the variability of number of employees (in logs) among firms. The information contained in the table does not appear in any previous study, and its real uniqueness is in showing the trends over countries and time. Consequently, we can look at the tables in terms of levels, trends and growth rates.

When we examine the table in terms of levels, it is best to use 2007 as a benchmark because the sample is unbalanced and the Amadeus database is not complete across time. Data for 2008 does not appear complete in the database as of the end of 2009. The table shows that the within industry heterogeneity predominates. A relatively little of the heterogeneity is inter-industry. There is also evidence that the share of within industry heterogeneity is increasing, as the ICC index noticeably decreased in most countries in the sample; especially in the former centrally planned economies. This may indicate that the division of labour is becoming more sophisticated but it can also indicate that the definition of an industry, as described in the ISIC and NACE accounting systems, is becoming fuzzier as Allyn Young predicted.

Table 1: The intra-class correlation coefficient (ICC) for Europe, 1999 to 2008.

Country/ICC	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Austria	..	..	..	..	0.181	0.190	0.234	0.208	0.207	0.200
Belgium	0.233	0.222	0.219	0.225	0.219	0.204	0.196	0.196	0.186	0.192
Bosnia	..	..	0.390	0.387	0.389	0.374	0.374	0.291	0.278	..
Bulgaria	0.379	0.368	0.371	0.357	0.359	0.342	0.319	0.318	0.319	..
Croatia	0.331	0.290	0.287	0.312	0.311	0.318	0.305	0.301	0.280	0.264
Czech Rep.	..	..	..	0.271	0.276	0.281	0.301	0.286	0.267	..
Denmark	..	..	..	..	..	0.167	0.157	0.143	0.147	0.135
Estonia	0.231	0.262	0.247	0.245	0.228	0.247	0.254	0.261	0.247	0.214

[12] It can be shown, that the null-model is equivalent to one-way random-effects ANOVA model (Luke 2004), where we assume that the group means are randomly varying. If we would add predictors only to the level-1 equation, the model becomes a random effects ANOVA.

Finland	..	..	..	..	..	0.199	0.179	0.191	0.179	0.179
France	0.248	0.245	0.259	0.240	0.251	0.245	0.244	0.246	0.256	0.258
Germany	..	..	..	..	0.325	0.300	0.247	0.190	0.185	0.232
Greece	0.242	0.246	0.249	0.247	0.238	0.236	0.235	0.237	0.241	0.233
Hungary	..	..	..	..	..	..	..	0.318	0.263	0.278
Ireland	0.102	0.070	..	..	..	..	..	..	0.086	..
Italy	0.146	0.141	0.161	0.160	0.143	0.124	0.124	0.139	0.136	0.127
Latvia	..	..	..	..	..	0.268	0.242	0.227	0.244	..
Lithuania	..	..	..	0.354	0.348	0.306	0.284	0.277	0.276	0.268
Netherlands	0.400	0.470	0.460	0.417	0.376	0.366	0.415	0.436	..	..
Norway	0.334	0.334	0.332	0.334	0.262	0.322	..	..	0.297	0.254
Poland	0.275	0.254	0.261	0.257	0.257	0.251	0.245	0.254	0.259	..
Portugal	..	..	..	..	..	..	..	0.275	0.257	..
Romania	0.431	0.434	0.430	0.401	0.358	0.316	0.280	0.298	0.271	..
Russia	..	..	..	..	0.266	0.223	0.216	0.203	0.222	..
Serbia	..	..	0.366	0.355	0.378	0.387	0.371	0.374	0.370	..
Slovakia	..	..	..	..	..	..	0.325	0.322	0.372	..
Slovenia	..	..	..	0.306	0.306	0.299	0.296	0.296	0.280	0.279
Spain	0.232	0.240	0.219	0.213	0.200	0.195	0.197	0.193	0.178	..
Sweden	..	..	..	0.215	0.211	0.211	0.200	0.193	0.197	0.184
Switzerland	..	..	..	..	..	0.220	0.203	0.191	..	..
Ukraine	..	..	0.427	0.393	0.403	0.411	0.398	0.373	0.356	0.330
U.K.	0.139	0.133	0.130	0.123	0.121	0.113	0.108	0.104	0.103	0.101

Source: Author's own calculation based on available data for firms with 5 more employees in the October 2009 Amadeus database.

4. The patterns of heterogeneity

Cursory evidence shows that the pattern of heterogeneity is highly correlated with the level of development. Figure 1 illustrates that real GDP per worker explains about 65 per cent of the variation in between industry and within industry heterogeneity over the ten-year period that the database covers. The Netherlands and Norway (before 2007) were excluded from this illustration, because they appear as outliers. Both economies are small and more specialized than other countries in our sample. Countries with a relatively high level of productivity therefore tend to have a relatively higher share of heterogeneity within an industry then across industries and vice versa.

Figure 1, however, does not explain why this happens. This requires analysing certain national characteristics that have been identified in the theoretical literature as being relevant for explaining the degree of heterogeneity. Four variables are considered:

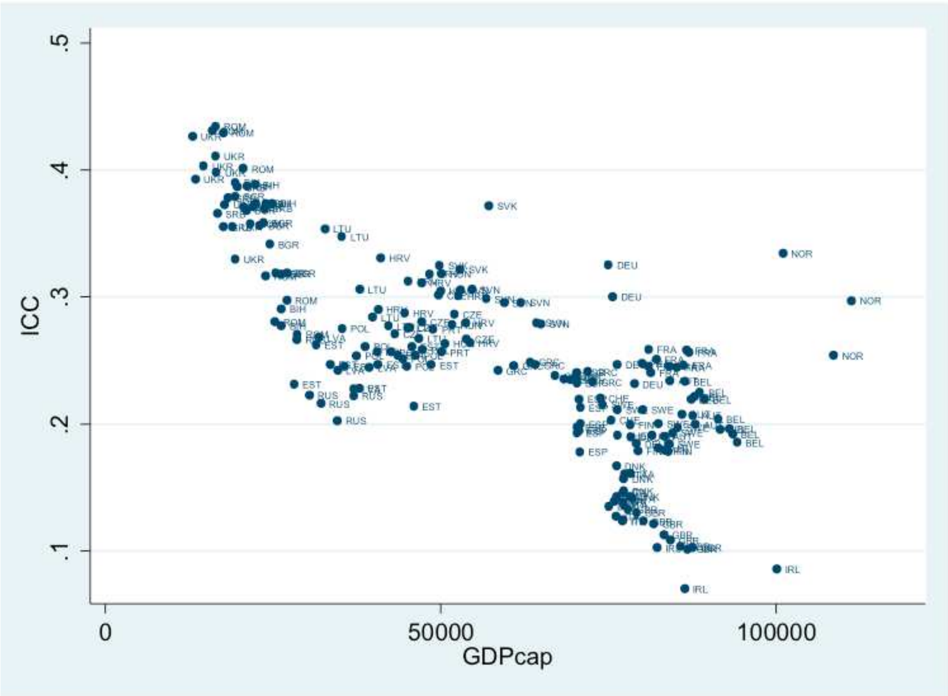
1. MKT refers to the size of the market. This variable is defined as the sum of the domestic absorption (total GDP minus the trade balance) and exports in millions of 2010 USD (converted to 2010 price level with updated 2005 EKS PPPs). The GDP data has been obtained from the Conference Board Total Economy Database, while the share of imports and exports from the World Bank's World Development Indicators 2010.
2. R&D refers to the intensity of research and development activity of the economy. This variable is defined as the gross domestic expenditure on research and development as a percentage of GDP. The data has been obtained from Eurostat on-line. Missing data for Ukraine and Bosnia and Herzegovina were imputed from the World Bank's World Development Indicators 2010. However, Bosnia and Herzegovina comes out to be a major outlier in this variable with the R&D levels very close to zero, so this country is excluded from the comparisons.
3. FDI refers to the stock of direct investment in the economy. This variable is defined as the inward stock of FDI as a percentage of GDP and was obtained UNCTAD. FDI is a received investment that involves a long-term relationship and reflects a lasting interest in and control by a resident entity in one economy of an enterprise resident in a different economy.
4. IMP refers to the imports of goods and services as a percentage of GDP and was obtained from the World Bank's World Development Indicators 2010. In addition, trade in services was distinguished from trade in goods in the analysis and the latter is further segmented on the base of Broad Economic Categories (BEC), rev. 3 trade classification into i) Imports of final capital goods: Imports of final capital goods including transport equipment (BEC, rev. 3 codes 41, 51 and 52); ii) Imports of intermediates thereof: Imports of parts and accessories of capital goods including transport equipment (BEC, rev. 3 codes 42 and 53); iii) Imports of consumption goods: Imports of durable, semi-durable and non-durable consumption goods not elsewhere specified (BEC, rev. 3 codes 61, 62 and 63); and iv) the residual category of other imports of goods, including food, beverages, fuels, lubricants industrial supplies not elsewhere specified and other goods not elsewhere specified (BEC, rev. 3 codes 11 to 32 and 7). The trade data by the BEC categories has been obtained from the UN Comtrade Database 2010.

All of the explanatory variables are used in logs in the following to limit the impact of outliers. Figure 2 plots the ICC and MKT variables against each other. The size of the market appears to matter, as the MKT variable explains about 26 per cent of the variation in between industry and within industry heterogeneity, when data from the Bosnia and Herzegovina, Netherlands, Ireland are excluded from the sample.

Figure 3 plots the ICC and R&D variables. This reveals that the R&D intensity of the economy matters even more in whether the heterogeneity is within industry or between industry. If data from the Netherlands and Ireland, which appear to be the main outliers again, and Bosnia and Herzegovina, which is not depicted in the figure, are excluded from the sample, the R&D variable explains about 32 per cent of the heterogeneity. What is clear is that countries with a relatively low level of R&D spending have a relatively higher percentage share of heterogeneity that can be explained by inter-industry variability. Countries with a relatively high level of R&D tend to have a relatively more heterogeneity within an industry then across industries within the economy. Hence, R&D spending generates heterogeneity. Arguably, this agrees with the Schumpeterian literature on this topic (Nelson and Winter, 1982; Aghion and Howitt, 1998).

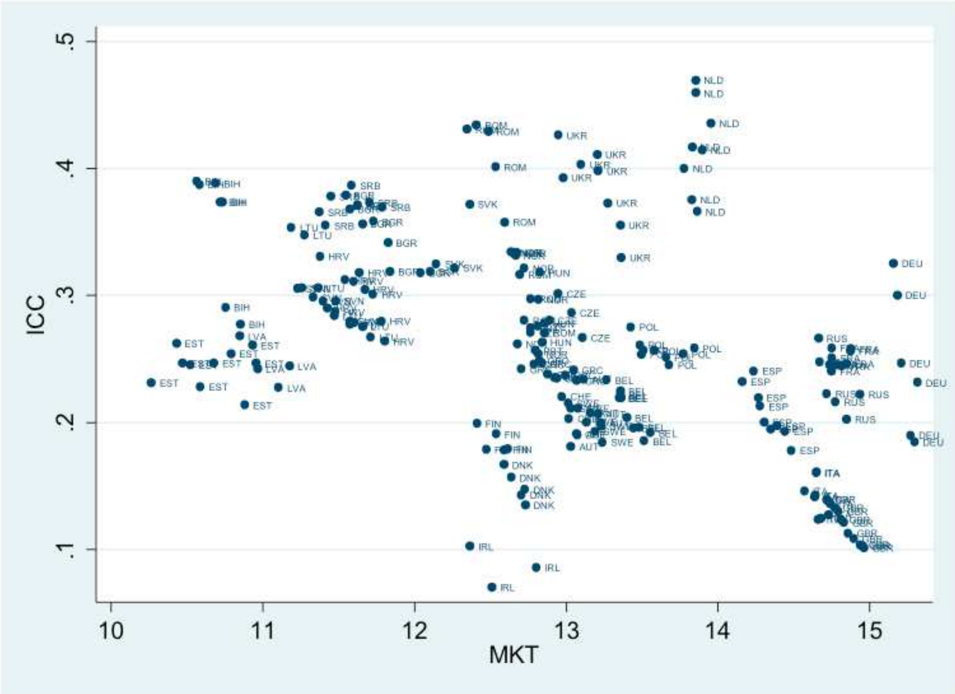
Figures 4 and 5 illustrate that FDI and IMP explain noticeably less of the variation in within industry heterogeneity. More specifically, if Bosnia and Herzegovina, Netherlands, Ireland are left out, FDI explains only 3.5 per cent, while IMP explains about 11 per cent. But it is interesting to note that FDI appears to be negatively associated to ICC, in a similar fashion as MKT and R&D, whereas there seems to be a positive connection between the IMP variable and ICC. In other words, the former are associated with deeper heterogeneity, while the latter with more homogenous population of firms with industry. This can be attributed to the fact that IMP represents a competition effect, which moves the economy into deeper specialization in the existing endowments, and therefore tends to eradicate within industry heterogeneity, whereas FDI represents a knowledge transfer effect, which carries the inflow of new ideas, resources and endowments, and therefore leads to more heterogeneity in the economy.

Figure 1: The relationship between per capita GDP and the ICC coefficient, 1999-2008



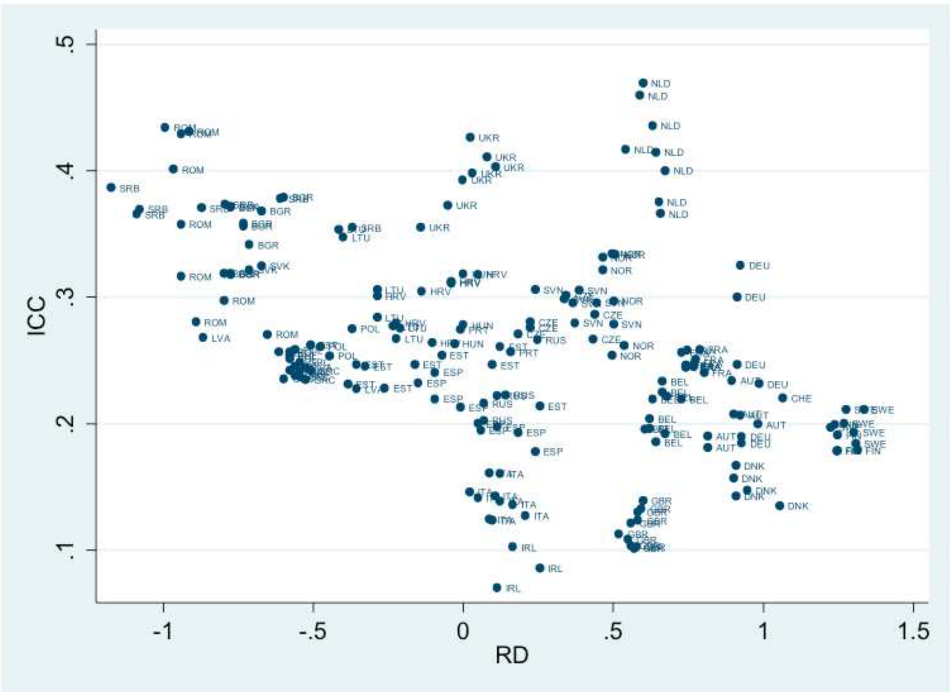
Source: Author's own calculation based on Table 1 and The Conference Board Total Economy Database, January 2011.

Figure 2: The relationship between the size of the market and the ICC coefficient



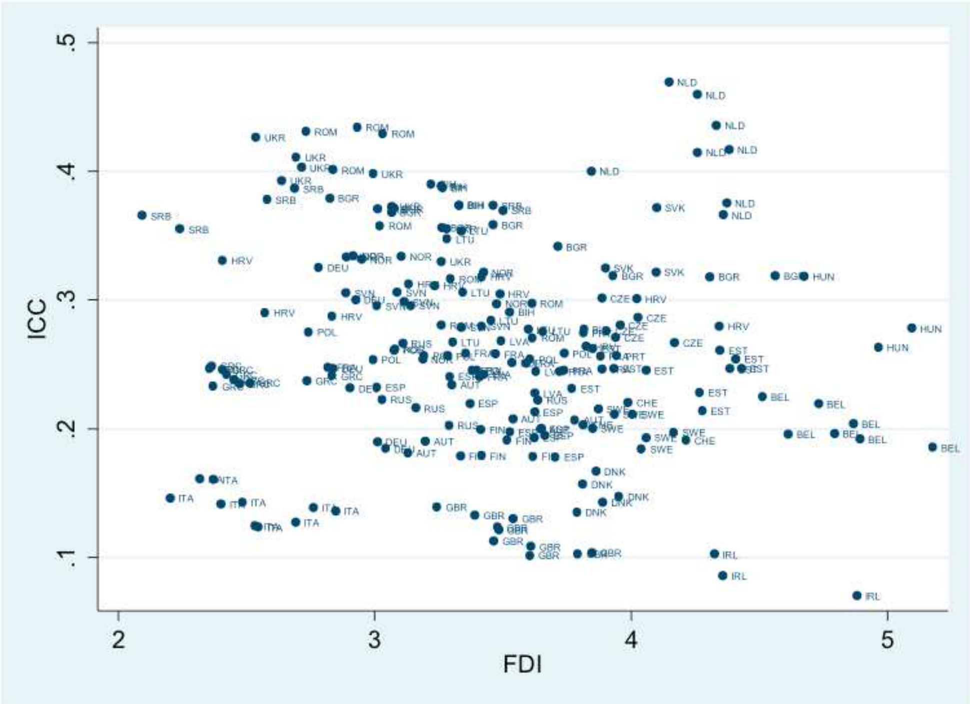
Source: Author's own calculation based on Table 1 and The Conference Board Total Economy Database, January 2011 and the World Bank World Development Indicators 2010.

Figure 3: The relationship between R&D intensity and the ICC coefficient



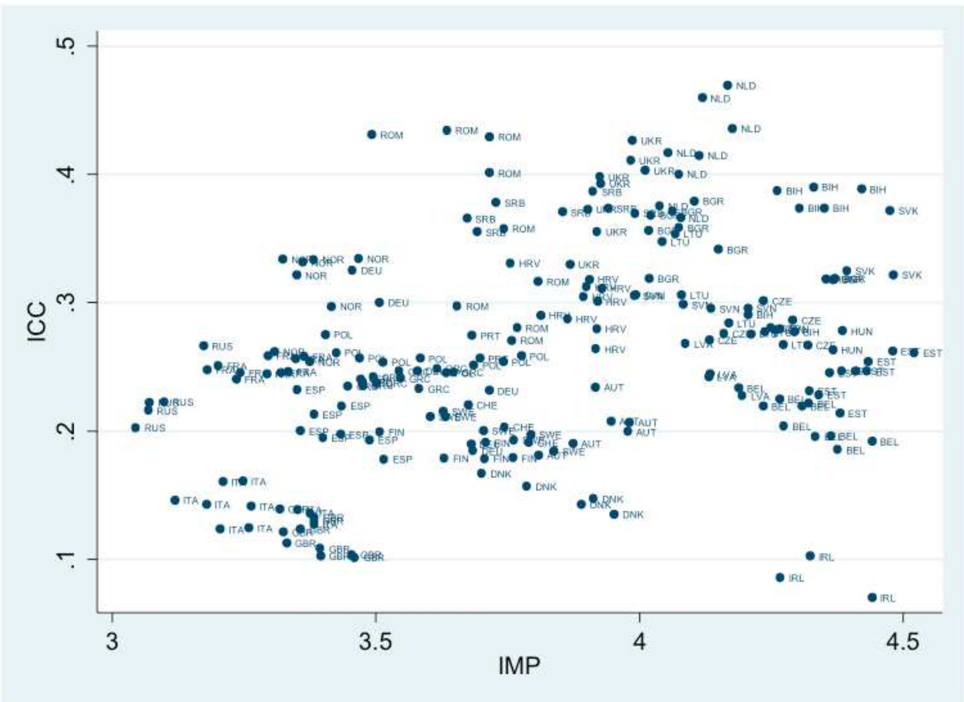
Source: Author's own calculation based on Table 1 and the OECD MSTI database, 2010 supplemented with statistics from the World Bank World Development Indicators 2010.

Figure 4: The relationship between FDI stock and the ICC coefficient



Source: Author's own calculation based on Table 1 and UNCTAD FDI database, 2010.

Figure 5: *The relationship between exports and the ICC coefficient*



Source: Author's own calculation based on Table 1 and the World Bank World Development Indicators 2010.

5. Regression results

Let us consider a standard panel data regression model as follows:

$$ICC_{jt} = \beta X_{jt} + u_j + e_{jt}$$

where *j* is a country, *t* is a year, *β* is a vector of coefficients associated with observable variables, the idiosyncratic error term e_{ij} is assumed uncorrelated with the columns of (X_{jt}, u_j) and has zero mean and constant variance σ^2_e conditional on X_{jt}. The latent country effect u_j is assumed to be a time-invariant random variable, distributed independently across countries, with variance σ^2_u. In other words, we assume that u_j and e_{jt} are uncorrelated to the regressors and to each other.

Table 2 gives the results of traditional panel data estimators: the generalized least squares (GLS) random-effects estimator in the first column; the within fixed-effects estimator in the second column and the between-effects estimator in the third column, respectively. The ICC index, of which lower values denote deeper within industry heterogeneity, is the dependent variable. All of the predictors MKT, R&D, FDI and IMP are included in logs in order to limit the influence of outliers. As explained above, however, Bosnia and Herzegovina, Ireland and the Netherlands turned out to be major outliers to the extent that cannot be solved by using logs, and hence have been excluded from the sample.

First, the random-effects estimator exploits both the within- and between-country variation, i.e. the differences between countries as well as within them over time, and is therefore more efficient than the other two estimators. All of the predictors come out with highly statistically significant coefficients, except only of IMP. On one hand, the negative coefficient of MKT strongly supports the Smithian hypothesis that the size of the market allows for deeper heterogeneity of firms within industries. On the other hand, the negative coefficient of the R&D-intensity of the economy supports the Schumpeterian hypothesis of heterogeneity driven by innovation. So both the demand and supply side arguments seem to be strongly supported by the results.

Table 2. Dependent variable: ICC

	(1) Random		(2) Within		(3) Between	
Constant	0.746***	(0.140)	1.504***	(0.294)	0.174	(0.292)
MKT	-0.030***	(0.009)	-0.101***	(0.028)	-0.005	(0.013)
R&D	-0.034***	(0.012)	-0.008	(0.018)	-0.045**	(0.019)
FDI	-0.027***	(0.008)	-0.007	(0.011)	-0.032	(0.026)
IMP	-0.001	(0.021)	0.024	(0.028)	0.069	(0.050)
σ_u	0.053		0.114		0.054	
σ_e	0.022		0.022			
ρ	0.856		0.965		..	
F	..		15.51***		5.45	
Wald χ^2	70.34***		..		..	
R^2 within	0.26		0.29		0.13	
R^2 between	0.41		0.25		0.49	
R^2 overall	0.42		0.28		0.45	
Hausman's statistic	χ^2=10.81*		..		..	
Number of countries	184		184		184	
Number of observations	28		28		28	

Note: Standard errors reported in brackets; *, **, *** denote significance at the 10, 5 and 1 percent levels.

Somewhat less straightforward are our expectations on signs of the coefficients of the variables of inward openness to direct investment and trade, because these are likely to be mixed bags of positive and negative effects. If their competition effect prevails forcing the economy into exploiting existing resources, endowments and comparative advantages, and therefore eradicating heterogeneity, there should be a positive coefficient. But if more openness to globalization lubricates inflow of knowledge from abroad, in other words if direct investment and trade function as channels of technology diffusion, there should be a dynamic effect generating more heterogeneity, and therefore a negative coefficient. Since the estimated sign is negative the latter effect dominates the results. But this is only the case of FDI penetration, because the coefficient of IMP is very close to zero.

As we have already seen in the descriptive overview, there is much more variety across countries than across time, because of the relatively short period covered by the data. Hence, it is not surprising to find out that the proportion of the total variance contributed by the panel-level (i.e. country-level) variance component, denoted by the estimate of σ_u and ultimately by the parameter ρ, is clearly dominates the results. In other words, the latent country effect u_j is very strong and therefore can have possibly important consequences for the consistence of the random-effects estimate, as further examined below. The overall fit is quite satisfactory at about 42 percent, where the between differences are much better accounted for than the within deviations in the model. Again, this is likely to reflect the short time-span of the data.

The within- and between-estimators consider only the respective part of the variation. More specifically, the within fixed-effects estimator exploits the deviation of ICC_{jt} and X_{jt} from country means, i.e. exploits only the variation over time within countries and ignores the differences across countries. In the between estimator, in contrast, the country means of ICC_{jt} are regressed on the country means of X_{jt}, i.e. replacing the annual records by country's averages over the period, so this estimator ignores the variation over time. Hence, a comparison of the within and between estimators allows us to identify whether the relevant sources of variation are around the country means over time or in those means themselves. The results indicate that the R&D, FDI and IMP variables are primarily relevant for explaining the between variation, whereas the MKT variable matters predominantly within. But except of the couple of them that come out statistically significant at the conventional levels the coefficients are not estimated very precisely, arguably because of the relatively low number of both countries and years. Hence, focusing only on the within or between variation does not seem to be productive given the data in hand.

However, the GLS random-effects estimator is more efficient than within fixed-effects estimator, but requires additional orthogonality assumptions. In particular, the random estimator assumes that the explanatory variables are uncorrelated to u_j, i.e. $E(u_j \mid X_{jt}) = 0$, whereas the within estimator does not require this assumption in order to be consistent. Hausman (1978) proposed a test that evaluates the validity of this assumption. Hausman specification test considers the null hypothesis that the coefficients estimated by the within and the random procedures are the same. If there is no systematic difference between them, both of the estimators are consistent. But a rejection casts a doubt on whether the random-effects results are unbiased, because some of the explanatory variables can be correlated to the latent u_j. Hausman's test reported in the lower part of the table rejects the null at 10 percent significance level.[13] Hence, there seems to be a weak misspecification in the random effects model, which we need to keep in mind, but there does not seem to be a serious bias.

So far we have used only the IMP variable for the total trade in goods and services. Arguably, the reason why this variable appears largely irrelevant for explaining the within-industry heterogeneity is that there are different kinds of trade with possibly different impacts on the dependent variable. Hence, in the next step, we distinguish between five components of trade as follows: 1) services; 2) final capital goods; 3) parts thereof; 4) consumer goods; and 5) the residual category of other goods; for more on the definition of these variables see the descriptive section of the paper above. Since these variables are excessively correlated to each other, we cannot include them into the regression simultaneously for concerns of multicollinearity. Hence, we test their explanatory power stepwise by replacing the overall IMP variable by the respective segment of trade at each step.

Table 3 shows the results. The main outcome is that only the propensity to import (final) capital and consumer goods is positively associated to the deeper within industry heterogeneity of firms, whereas the propensity to import their parts and accessories, the other goods (including food, fuels and other commodities primary or processed) and the propensity to import services does not seem to make a difference. Hence, only the import of final goods appears to be linked to heterogeneity, while the trade with intermediate inputs and services does not have a clear connection here. Arguably, this is surprising given the emphasis on the connection between the increasing fragmentation of production and the intra-product trade and the importance of services links

[13] Because the differenced covariance matrix is non-positive definite, the covariance matrices are based on the estimated disturbance variance from the consistent estimator. And because there are no time-invariant predictors, the estimated intercept is included in the comparison, too.

between the different fragments including various papers included in Arndt and Kierzkowski (2001). More empirical research along these lines needs to be done to explain these patterns in the data.

6. Concluding remarks on the issues of heterogeneity and globalization.

A panel of firms was created using employment data from the Amadeus database and an analysis is performed using the method of multilevel variance decomposition to identify the degree, trends and cross-country differences in within industry heterogeneity across European firms. The results show that the within industry heterogeneity is larger than the between industry heterogeneity and that the within component is deepening over time. Using panel data econometrics we attempt to explain the differences of this heterogeneity across countries and how these patterns develop over time. The analysis indicates that the degree of within industry heterogeneity is highly correlated with the level of development of a country, and is predominantly explained by the extent of the market and R&D intensity of the economy. Inward FDI and imports of goods and services appear less important.

Paul Krugman (1979, 1980) made an important contribution to the theory of international trade that integrated monopolistic competition and increasing returns into the theory. This contribution revealed the importance of within sector heterogeneity for theoretical and empirical models of trade (Meltz, 2008). Melitz (2003) incorporated heterogeneity into Krugman's trade model by allowing for firms to produce their own distinctive differentiated good and that the productivity of each firm is randomly distributed, and found that the extent of heterogeneity was quite high.[14] Helpman, Meltz and Yeaple (2004) developed a regression-based measure of dispersion based on a Pareto distribution, and use a large sample of U.S and European firms to show that there is considerable heterogeneity within an industry.[15] By allowing for productivity differences across firms, Melitz and Helpman, et al. show that low-productivity firms with relatively low-productivity tend to serve the domestic market, whereas firms with relatively high-productivity tend to serve foreign markets. When horizontal FDI is included, Helpman, et al. also shows that the most productive firms invest abroad whereas the least productive ones export. Antràs and Helpman (2004) recognize that different organizational forms persist and show that headquarter-intensive sectors tend to integrate with foreign suppliers, whereas component-intensive sectors tend to adopt outsourcing strategies.

The *Economic Journal* debate on the representative firm of the late 1920s (see Robertson, 1930) that Sraffa started established that heterogeneity within an industry is an important issue for economic theory. Subsequent empirical analyses shown that there is a considerable amount of heterogeneity across enterprises, especially when the size and productivity are taken into consideration. Young's (1928) contribution to the debate suggests that as production becomes more

[14] Bernard and Jensen (1995) provide an early influential paper showing that exporters and non-exporters differ within industries.

[15] In the paper they take the standard deviation of log(sales) by industry ($1/(k-\sigma+1)$).

fragmented across firms, firms will become more heterogeneous, and the more globalized this process becomes, the more important that international trade and cross-border ownership becomes.

Our paper provided a way to measure the *relative importance* of within an industry heterogeneity using the Amadeus Database. This approach helps to better appreciate the extent of within industry heterogeneity across many different European countries and how this evolved over time. It should also in the design of further analysis that could take into account other behavioural variables that determine heterogeneity, such as differences in productivity, R&D and other innovative activities, and internationalization of firms, if the availability of statistics permits.

Table 3: Dependent variable: ICC

	(1)		(2)		(3)		(4)		(5)	
	GLS		GLS		GLS		GLS		GLS	
Constant	0.829***	(0.127)	0.929***	(0.112)	0.776***	(0.109)	0.888***	(0.118)	0.808***	(0.115)
MKT	-0.033***	(0.009)	-0.038***	(0.009)	-0.031***	(0.009)	-0.037***	(0.009)	-0.032***	(0.009)
R&D	-0.029**	(0.014)	-0.039***	(0.013)	-0.032**	(0.013)	-0.032**	(0.013)	-0.033**	(0.013)
FDI	-0.032***	(0.007)	-0.018**	(0.008)	-0.032***	(0.007)	-0.021**	(0.009)	-0.029***	(0.008)
IMP o/w services	-0.017	(0.019)	..		..		..		..	
capital goods	..		-0.056***	(0.015)	..		..		..	
parts thereof	..		..		-0.003	(0.012)	..		..	
consumer goods	..		..		..		-0.044**	(0.021)	..	
other goods	..		..		..		..		-0.011	(0.013)
σ_u	0.055		0.055		0.054		0.055		0.053	
σ_e	0.022		0.021		0.022		0.021		0.022	
ρ	0.865		0.874		0.863		0.868		0.859	
R^2 within	0.294		0.353		0.290		0.311		0.295	
R^2 between	0.385		0.353		0.383		0.384		0.367	
R^2 overall	0.374		0.365		0.382		0.383		0.368	
Wald χ^2	75.94***		94.37***		75.60***		81.80***		76.63***	
Hausman's statistic	χ^2_5=8.13		χ^2_5=5.52		χ^2_5=9.81*		χ^2_5=6.15		χ^2_5=10.15*	
Number of countries	28		28		28		28		28	
Number of observations	184		184		184		178		178	

Note: Standard errors reported in brackets; *, **, *** denote significance at the 10, 5 and 1 percent levels.

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Appendix: Number of enterprises in the total sample, 1999-2008.

Enterprises	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
TOTAL	365,705	449,065	564,801	675,939	803,313	952,713	1,087,956	1,266,190	1,523,378	1,011,919
Austria	642	1,164	3,046	6,354	11,893	16,487	17,993	18,886	23,377	22,226
Belgium	22,609	24,523	26,169	27,890	29,419	31,148	33,065	37,109	39,369	37,709
Bosnia	640	605	1,307	1,970	2,337	2,645	3,038	3,088	3,375	82
Bulgaria	13,474	16,508	18,195	20,081	27,273	36,804	38,178	41,850	50,810	3,140
Croatia	6,095	6,730	7,616	8,685	9,855	10,755	11,766	13,250	14,535	14,545
Czech Rep.	4,152	5,195	6,863	10,566	13,779	20,580	23,396	27,005	25,644	9,772
Denmark	0	0	0	0	70	16,173	18,531	20,479	22,631	23,447
Estonia	4,661	5,292	5,678	6,385	7,081	7,713	8,958	9,958	10,743	8,053
Finland	0	0	251	913	2,683	9,627	10,534	12,081	12,864	12,240
France	63,471	91,309	99,528	110,162	118,890	137,208	146,268	131,980	167,876	152,554
Germany	2,801	4,281	7,555	17,422	27,745	32,829	45,099	71,535	85,009	58,137
Greece	9,559	10,417	10,916	11,404	12,235	13,001	13,799	14,139	14,269	13,112
Hungary	187	264	319	2,227	401	521	1,724	3,440	16,412	5,405
Ireland	6,573	5,177	130	8	1	91	493	1,029	9,623	2,851
Italy	45,180	54,282	60,097	78,727	68,873	53,630	59,669	93,935	109,306	123,593
Latvia	1,390	1,614	2,030	2,577	3,357	10,024	12,081	15,034	17,801	3,195
Lithuania	866	1,063	1,237	2,686	4,049	4,968	6,284	7,985	20,976	19,459
Netherlands	5,062	5,176	6,141	7,131	7,216	7,753	12,014	14,617	50,780	29,217
Norway	14,025	15,998	17,405	18,177	19,231	22,435	680	1,676	30,721	27,523
Poland	7,710	9,290	9,507	11,125	11,839	12,486	14,145	13,530	13,636	5,903
Portugal	858	893	842	919	1,227	1,339	1,380	70,603	71,590	907
Romania	19,041	22,763	26,342	28,943	35,322	42,262	49,583	55,504	69,243	75,826
Russia	0	0	0	0	60,187	89,577	135,704	129,269	95,819	50,396
Serbia	3,110	3,132	8,258	8,944	11,503	12,801	14,145	16,497	18,969	5,483
Slovakia	554	834	1,108	1,437	2,089	2,758	6,010	7,804	7,930	2,070
Slovenia	0	0	0	2,985	3,564	4,243	4,638	5,009	5,080	4,950
Spain	81,907	98,311	120,034	139,915	155,308	173,405	198,182	215,484	216,083	279
Sweden	23,285	26,909	29,442	31,856	34,392	37,298	40,972	44,430	47,414	49,180
Switzerland	1,515	2,273	2,233	10,437	2,797	14,273	15,049	17,035	86,675	95,635
Ukraine	2,331	7,093	61,381	71,808	81,606	88,717	99,350	105,713	112,292	118,679
U.K.	23,504	27,114	30,139	33,300	35,962	37,797	40,942	44,590	48,927	33,102

Note: Countries and years in red were excluded from the calculation of ICC coefficients.

Source: Author's own calculation based on available data for firms with 5 more employees in the October 2009 Amadeus database.

International sourcing, product complexity and Intellectual Property Rights

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International Sourcing, Product Complexity and Intellectual Property Rights*

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April 18, 2011

VERY PRELIMINARY AND INCOMPLETE – COMMENTS WELCOME

Abstract

In this paper, we propose the technological complexity of a product and the level of Intellectual Property Rights (IPR) protection in a source country to be the co-determinants of the mode through which firms purchase their goods. We study a multinational firm's choice between in-house production and outsourcing given heterogeneity at the product- (complexity), firm- (productivity) and country- (IPRs) level. Our findings suggest the above three dimensions of heterogeneity to be important for complex goods, where firms face a trade-off between higher wages in the case of vertical integration and higher imitation risks in the case of outsourcing. We test these predictions by combining data from a French firm-level survey on the mode choice for each transaction with a newly developed complexity measure at the product-level. Our fractional logit estimations confirm the proposition that firms are reluctant in sourcing complex goods from independent suppliers. However, countries featuring high IPR protection encourage multinationals to outsource the production of highly complex goods.

Keywords: Sourcing decision, product complexity, intellectual property rights, fractional logit estimation

JEL: F12, F23, O34

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1 Introduction

'The intellectual property issue remains the most complicated thing we have to deal with,' says Pat Toole, general manager of I.B.M. Engineering and Technology Services. 'If we can all figure it out, farming out design will be a common model in the future. If we can't, it won't.' (New York Times, 30 December 2004). The appraisal matches the results of a survey conducted by the Economist Intelligence Unit (EIU) in the same year, in which 84% of all executives state that they perceive the lack of Intellectual Property Rights (IPR) protection in emerging markets as a challenge when outsourcing their R&D. In stark contrast to the emphasis the business world puts on IPR protection when outsourcing upper parts of the value chain, the issue has attracted little attention in the economic literature. This paper tries to fill this gap by analyzing how IPR protection determines the mode through which firms source complex products. The topic naturally connects two research strands.

First, it relates to a range of studies investigating the impact of IPRs on Foreign Direct Investment (FDI)(see e.g. Glass and Saggi, 2002, Glass, 2004 and Branstetter et al., 2007).[1] While the results in these papers directly hinge on the capacity and the costs of imitation in a destination country, Glass and Wu (2007) show how the phenomenon could also depend on the type of innovation. More closely-related to our argument, Nicholson (2002) studies the mode choice of international sourcing and claims the fear of loosing a proprietary asset to be the main consideration when deciding between FDI and licensing. At low levels of IPR protection, technologically sophisticated firms tend to internalize. A more stringent IPR regime, however, mitigates the imitation risk and may induce a shift towards licensing. As these models do not make a reference to product heterogeneity, their propositions have been tested empirically using aggregate data.

Second, a series of influential papers shift the argument to the choice between purchasing from an affiliate, or from an independent supplier, where the latter gives rise to a hold-up problem when contracts are incomplete (Antràs and Helpman, 2004, 2008).[2] A recent branch of this literature in particular highlights the role of technological intensity in creating hold-up problems in an outsourcing relationship. Acemoglu et al. (2010) finds that the technology intensity of the final good producer has a positive effect on the probability of vertical integration (while the opposite is true for the technological intensity of the intermediate good supplier).[3] Grover (2007) interacts the intensity of the sourced input with technology transfer costs and confirms the results from Antras and Helpman (2004, 2008) to only hold for a certain range of technological complexity of the input. More in line with the approach, Costinot et al. (2009) reinterpret the source of contractual frictions as arising from the non-routineness of tasks. Since these cannot be fully specified ex-ante, ex-post adaptation becomes necessary. Due to better communication and less opportunistic behavior among affiliated parties, outsourcing only takes place for tasks below a certain complexity threshold. Focusing on the relation between technology and the outsourcing decision, the message is clear: Higher technology complicates the relation with the supplier and makes it optimal to vertically integrate. Yet, the role of IPR protection remains absent in these studies.

In this paper, we combine the two strands of literature above starting at the insight that the technological complexity of an intermediate or final good is an alternative determinant of a multi-

[1]See Saggi (2002) for a review of the early literature on FDI and technology transfers.

[2]Among the few studies testing these predictions at the firm-level, Defever and Toubal (2007) and Kohler and Smolka (2009) confirm the existence of an interaction between input intensity and firm productivity which shapes the organizational form of international production.

[3]Without referring to the property rights theory, Abramovsky and Griffith (2006) come to the opposite conclusion. Past investments in information and communication technologies enable firms to purchase business service inputs from independent suppliers abroad as they lower transaction and adjustment costs.

national firm's choice between in-house production and outsourcing. In contrast to the existing studies, we depart from the hold-up problem but emphasize the interaction between the complexity of the sourced good and the IPR protection prevailing in the source country. We build a theoretical framework in which heterogeneous firms tend to outsource low complex goods. As complexity rises, firms are confronted with a trade off between higher wages in the case of vertical integration and a higher imitation risk along with a technology transfer cost in the case of outsourcing. Stronger IPR protection in the source country reduces costs associated with the imitation risk, while a higher endowment of skills (absorptive capacity) reduces the costs of technology transfer. Moreover, firms endowed with better technologies are clearly in a better position to face the extra costs associated with outsourcing. We show that a three-dimensional heterogeneity, namely complexity at the product-level, productivity at the firm-level, and IPR protection at the country-level, build up the decision of a multinational whether to outsource a product or acquire it through intra-firm trade.

We test these propositions using data from a French firm-level survey on the mode choice for each transaction. We derive the complexity of a product by merging three different data sets, (i) ratings of occupations by their intensities in 'problem solving' from the U.S. Department of Labor's Occupational Information Network, (ii) employment shares of occupations by sectors from the Bureau of Labor Statistics Occupational Employment Statistics and (iii) French make tables from Eurostat. We use a fractional logit model to account for the fact that our response variable is bounded between one and zero. The estimation results confirm the model's prediction that the probability of outsourcing increases with the productivity of a firm and decreases with the complexity of the good. The imitation risk of the source country matters as better IPR protection increases the probability of outsourcing. Likewise, better absorptive capacity increases the propensity to outsource by decreasing the costs of technology transfer. A sample split confirms IPR protection to only be relevant when firms outsource highly complex products.

The closest work to ours is Berkowitz, Moenius, and Pistor (2006), which shows higher quality legal institutions located in the exporter's country to enhance international trade in complex products. They argue this to be due to a production cost effect, assuming the production of complex products to contain some degree of outsourcing, and hence depend on contracts. Better institutions enable the exporting country to cheaply and quickly enforce contracts and resolve business disputes, thereby lowering production costs of complex products by reducing the likelihood of hold-up on the production chain. Since these issues are less important for simple goods, better legal institutions enhance a country's comparative advantage in complex goods. While Berkowitz, Moenius, and Pistor (2006) study the general impact of institutions on international trade in complex products, we explore the importance of a specific institution on *the type of trade* (intra- versus extra-firm) undertaken by a firm with an exporting country. In addition, we use a more specific measure of product complexity more adequate for our aim to differentiate products with respect to their technology content, whereas Berkowitz, Moenius, and Pistor (2006) use the Rauch (1999) classification to distinguish between simple and complex products. Finally, we base our study on the imitation risk faced by a multinational firm instead of contract-related issues, which has served as the basis of the outsourcing decisions in previous literature.

The rest of the paper is organized as follows: Section 2 presents the proposed theory, Section 3-6 introduce the data, the empirical methodology, the descriptive statistics, and estimation results respectively. Section 7 concludes.

2 Theoretical Framework

We start by developing a simple theoretical framework, which helps us pin down the main idea. Consider a world with J countries, in which a multinational firm already active in a country $j \in \{1..J\}$ can source intermediate or final goods via two different modes, $X \in \{O, V\}$. Three different sources of heterogeneity drive the selection of firms into the different organizational modes: Firms are heterogeneous in the spirit of Melitz (2003) with respect to their technology, φ, products are heterogeneous with respect to their complexity, z, and countries are heterogeneous with respect to their protection of IPRs, λ, and their absorptive capacity, δ.

2.1 Consumption

The consumption of imports is subject to a Constant Elasticity of Substitution (CES) utility function,

$$U = \left[\int_{\omega \in \Omega} \left(z_{\kappa}(\omega)^{\gamma} x(\omega) \right)^{\frac{\sigma-1}{\sigma}} d\omega \right]^{\frac{\sigma}{\sigma-1}}, \tag{1}$$

where $x(\omega)$ refers to the quantity and $z_{\kappa}(\omega)$ refers to the technological complexity of variety ω. Subscript $\kappa \in (L; H)$ distinguishes between simple (non-complex) products, and more technologically sophisticated ones that maintain a continuous measure of complexity. In the rest of the paper, we normalize the basic level of complexity to one, i.e. $z_L(\omega) = 1$. Referring to the literature on product quality (see Hallak, 2006, Hallak and Sivadasan, 2009 and Crozet et al., 2009), the parameter $\gamma \in (0; 1)$ captures consumer preferences for more technologically sophisticated products. This gives a complexity-augmented demand for imports of

$$x(\omega) = \frac{E}{P} z_{\kappa}(\omega)^{\gamma(\sigma-1)} \left(\frac{p(\omega)}{P} \right)^{-\sigma} \tag{2}$$

with E as the expenditure and $P = \left[\int_{\omega \in \Omega} \left(\frac{p(\omega)}{z_{\kappa}(\omega)^{\gamma}} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$ as the price-complexity index.

2.2 Production

Multinational firms operate under monopolistic competition. Suppliers in country j transform homogeneous labor, the only factor of production, into intermediate or final goods that are sold to multinational firms at a price equal to marginal costs. Basic goods production involves only wage costs w_j. Under vertical integration (V), the multinational firm owns its supplier and has to pay – in line with empirical findings – a wage premium $\alpha = \frac{w}{w_j} > 1$ over the wage level in country j. Under outsourcing (O), the independent supplier operates independently and pays local wages, hence, $\alpha = 1$. Since basic goods production does not involve any fixed cost, sourcing from independent suppliers involves a (variable) cost advantage and is, generally, preferred over vertical integration.

We parameterize the costs associated with imitation risk as

$$r_j(\omega) = z_{\kappa}(\omega)^{\frac{1}{\lambda_j}} \tag{3}$$

where $0 < \lambda_j \leq 1$ denotes the level of IPRs with a higher λ_j indicating stronger protection. Notice that for simple goods $r_j(\omega) = z_L(\omega)^{\frac{1}{\lambda_j}} = 1$, which implies the irrelevance of IPRs when products do not contain sophisticated technologies to be imitated. On the other hand, imitation costs are increasing in the level of complexity, $\frac{\partial r_j(\omega)}{\partial z_H} > 0$, and decreasing in IPR protection $\frac{\partial r_j(\omega)}{\partial \lambda_j} < 0$. Inequality $\frac{1}{\lambda_j} \geq 1$ accounts for the fact that highly complex products are especially sensitive and require more protection. An increase in IPR protection lowers the imitation risk outsourcers face in country j, and this effect is stronger for complex products.[4] Vertically integrated firms own the property rights over the available technology in their affiliate and are therefore not confronted with the risk of being imitated, hence $r_j(\omega) = 1$.[5]

Complex goods production also involves a fixed technology transfer cost $T(\delta_j)$, which can be thought of as an effort to achieve a better fit of the independent supplier's production to the multinational firm's needs. While we assume zero technology transfer costs under integration, δ_j denotes the absorptive capacity in country j, where a higher δ_j indicates more advanced local skills, hence better capacity by an independent supplier to learn and perform the customization required by a multinational. Technology transfer costs are therefore decreasing with absorptive capacity, $\frac{\partial T(\delta_j)}{\partial \delta_j} < 0$. Since this cost is sunk, outsourcers are confronted with the risk of their transferred technology being imitated.

The production technology is described through a Cobb-Douglas cost function,

$$c_j(\omega) = \frac{1}{\varphi}\big(\alpha w_j\big)^{\mu}\big(r_j(\omega)\big)^{1-\mu}. \tag{4}$$

with φ as the productivity a firm draws from a common distribution $G(\varphi)$. Multinational firms charge prices with a mark-up over marginal costs,

$$p_j(\omega) = \frac{\sigma}{\sigma-1}\frac{1}{\varphi}\big(\alpha w_j\big)^{\mu}\big(r_j(\omega)\big)^{1-\mu}. \tag{5}$$

Specifying the mark-up adjusted demand level as $A = \left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} EP^{\sigma-1}$ and using equations (2), (4) and (5), we derive the profits under both modes:

$$\pi_v\left(\varphi, z\right) = A\left(\frac{\alpha w_j}{\varphi}\right)^{1-\sigma} z_\kappa(\omega)^{\gamma(\sigma-1)}\sigma^{-1}, \tag{6a}$$

$$\pi_o\left(\varphi, z\right) = A\left(\frac{w_j z_\kappa(\omega)^{(\frac{1}{\lambda_j})}}{\varphi}\right)^{1-\sigma} z_\kappa(\omega)^{\gamma(\sigma-1)}\sigma^{-1} - T(\delta_j). \tag{6b}$$

While both profit functions are increasing in productivity level, φ, profits under outsourcing (vertical integration) increase faster if $z_\kappa(\omega)^{(\frac{1}{\lambda_j})} < \alpha \left(z_\kappa(\omega)^{(\frac{1}{\lambda_j})} > \alpha\right)$. $T(\delta_j)$ ensures the existence of a product-country specific productivity cut-off that is given by equating (6a) and (6b):

---

[4]This can be seen from the partial derivative $\frac{\partial r_j(\omega)}{\partial \lambda_j} = -\frac{z_\kappa(\omega)^{\frac{1}{\lambda_j}}\log(z_\kappa(\omega))}{\lambda_j^2}$.

[5]Note that $\lim_{\lambda\to 1} r_j(\omega) = 1$, hence, the assumption that vertically integrated firms fully control their own property rights is equivalent to country j providing full property rights protection.

$$\widehat{\varphi} = \left(\frac{A}{\sigma T(\delta_j)}\right)^{\frac{1}{1-\sigma}} \frac{w_j \left(z_\kappa(\omega)^{(\frac{1}{\lambda_j})} - \alpha\right)}{z_\kappa(\omega)^\gamma}. \tag{7}$$

The cut-off is decreasing in α and increasing in $z_\kappa(\omega)$, as long as the cost parameters associated with complexity exceed the consumers' strength of preference for complexity. Note that productivity of a firm is not a relevant factor in the outsourcing decision for simple products as $z_L(\omega)^{(\frac{1}{\lambda_j})} - \alpha = 1 - \alpha < 0 \Rightarrow \widehat{\varphi} < 0$. The probability that a firm with complex products decides to outsource is then given by the probability that it draws a productivity above the product- and country-specific cut-off,

$$\Pr(O = 1) = \Pr\left\{\varphi \geq \left(\frac{A}{\sigma T(\delta_j)}\right)^{\frac{1}{1-\sigma}} \frac{w_j \left(z_H(\omega)^{(\frac{1}{\lambda_j})} - \alpha\right)}{z_H(\omega)^\gamma}\right\}. \tag{8}$$

The above equation suggests that a higher mark-up adjusted demand level A, lower competition σ, lower relative marginal cost advantage in the form of a high α, and higher absorptive capacity δ_j, decrease the productivity cut-off and thereby increase the individual firm's probability to source their product from independent suppliers.

3 Data

We test the above-developed proposition with data on the trade organization of French firms, which can, thanks to its product and geographical breakdown, be matched with a complexity measure at the product-level and a property rights index at the country-level.

3.1 Sourcing Mode

To capture the share of intra- and extra firm trade, we rely upon information from a confidential firm-level survey, the French National Institute of Statistics and Economic Studies (INSEE) conducted in 1999. The survey provides information on the trade organization of French firms.[6] It is addressed to all French multinational firms which trade more than 1 million Euro and which are owned by manufacturing groups that control at least 50% of the equity capital of a foreign affiliate.

The survey provides a detailed geographical breakdown of French firms' import at the product-level (HS4 or CPA) as well as their sourcing modes – through independent suppliers and/or related parties. The data covers 83% of the French industrial industry total imports of industrial products. A French intra-firm transaction is defined as trade with a related party which is either directly controlled by the firm (firm's affiliates) or controlled by the group to which the firm belongs (group's affiliates).

[6] *Échanges internationaux intra-groupe.*

3.2 Product Complexity

Our measure of product complexity is similar to Costinot et al. (2009) and Keller and Yeaple (2009). The U.S. Department of Labor's Occupational Information Network (O*NET) provides expert information on the importance and the level of complex problem solving skills for 809 8-digit occupations as defined in the Standard Occupational Classification (SOC). Each occupation o embodies a complexity of

$$z_o = i_o^{\alpha} + l_o^{\beta} \tag{9}$$

where the weights α and β give the contributions of the two complexity components importance $i \in [1, 5]$ and level $l \in [0, 7]$.[7]

In line with Costinot et al. (2009), we assume that every country in the sample uses the same technology and rely therefore on employment information form the U.S. Bureau of Labor Statistics' Occupational Employment Statistics (OES). The 1999 data contains the number of employees by occupation in every 3-digit industry k (according to the Standard Industrial Classification (SIC)).[8] The occupational intensity b_o^k of each industry is then given by

$$b_o^k = \frac{L_o^k}{\sum_o L^k}, \tag{10}$$

where L_o^k is the employment level of occupation o in industry k. Although the SIC gathers data on those organizations, which work with, or produce the same product or service, under the same industry heading, it does not relate atypical products. By exploiting information on primary and secondary outputs of the French 1999 make table from Eurostat, we derive a precise product complexity measure $x(z, b)$.[9] Table A.1 summarizes the 32 product categories in our sample ranked according to their complexity.

$$z_{\kappa}(\omega) = \frac{x^k(\omega)}{\sum_k x(\omega)} \left(z_o b_o^k \right) \tag{11}$$

3.3 Other Explanatory Variables

The SESSI[10] survey does not provide information on firms' characteristics. We retrieve the information necessary to compute firm-level Total Factor Productivity (TFP) from the EAE[11] database. The data can be merged directly with the SESSI data thanks to a common firm identifier. The EAE contains information on the balance sheet and income statement of all firms located in France that have more than 20 employees from 1996 to 1999. It has firm-level information on sales, capital, labor and intermediates use, as well as the 4-digit *NAF700* sector classification of the firm.[12] We

[7] We tried different weights that have been used in the literature (see Blinder, 2009 and Jensen and Kletzer, 2007). We normalized the different scales of the complexity components to a $[0, 1]$ scale using the min-max method, $I = \frac{i_o - \min(i)}{\max(i) - \min(i)} \left(L = \frac{l_o - \min(l)}{\max(l) - \min(l)} \right)$.

[8] Crop production, animal production and private households are not surveyed. After matching the O*NET data to the OES data, 695 occupations remain in the sample.

[9] Since direct concordance tables of the NACE Rev. 1.1 classification and the SIC 1987 classification are not available, correspondence is achieved via the NAICS 2002 classification.

[10] *Service des Études et des Statistiques Industrielles.*

[11] *Enquête d'Annuelle d'Entreprises*: annual French firm-level survey

[12] *Nomenclature d'Activité Française*: nomenclature of French activities.

calculate TFP following the semiparametric approach of Olley and Pakes (1996), which corrects for the endogeneity of firms' input choices.

We restrict our analysis to manufacturing sectors. However, we do not consider the manufacture of food products, beverages and tobacco because the EAE has no information for these sectors. We exclude firms active in the manufacture of coke, refined petroleum products and nuclear fuel since the sourcing modes in this industry are likely to be determined by factors such as national sovereignty (Antràs, 2003).

We measure the strength of IPR protection in 1995 (and 2000) with the Ginarte and Park (1997) and Park and Wagh (2002) patent rights index, which is available for 115 countries of the sample. Information on the population share with completed secondary education for 1995 comes from Barro and Lee (2010) and serves as a proxy for a country's absorptive capacity. As outlined in Section 2.2, we assume that higher absorptive capacity reduces the sunk technology transfer costs since it facilitates the training of the supplier. We calculate the wage premium vertically integrated firms pay as the difference between French wages and source country wages by industry in 1998. Both variables are taken from the CEPII Trade, Production and Bilateral Protection Database. To test the robustness of our main results, we additionally employ a range of gravity variables, such as distance, GDP, the existence of an RTA or a common legal origin. All these variables are provided by CEPII.

4 Empirical Methodology

Not all firms in our sample entirely rely on one or the other sourcing strategy. In 8.76% of all cases, firms use mixed strategies even for sourcing the same product from the same country. We therefore use the share of an input that is imported by a multinational from an independent supplier located in a foreign country as the dependent variable. This share lies within the $[0;1]$ interval. Because many values are still at the boundaries, we use a fractional response model as in Papke and Wooldridge (1996).

The SESSI survey only includes multinational firms, which by definition have at least one affiliate in a destination country. This does not exclude the possibility that firms may import only from outside suppliers in some countries, i.e. only engage in outsourcing in some countries without having an affiliate there. However, our model aims to compare the proportion of business undertaken through an existing affiliate (intra-firm trade) with that outsourced to an outside supplier, given the complexity level of a product and the institutional quality in a destination country. The relevant measure of comparison is therefore the proportion of outsourcing versus intra-firm trade, when the firm has an existing related party in a given country.

We follow Defever and Toubal (2010) and implement a control function approach which uses a two stage estimation procedure to correct for this issue. In the first stage, we analyze the likelihood to have an existing related party in the foreign country. This methodology is only valid if we can identify determinants of the binary selection variable which explain the probability of having a related party and which do not belong in the estimating equation. We identify two variables at the firm-level that are correlated with the presence of a related party and not with the sourcing choice. We include the number of French related parties and a dummy variable that indicates whether the firm is owned by an Ultimate Benefial Owner (UBO).[13] Our specification includes also gravity

[13]We retrieve this information from the LIFI data, which can be merged easily via a common firm identifier.

determinants such as market size (GDP), distance, border, official language and common legal origin.[14] Furthermore, we add measures of trade and FDI openness from the Heritage Foundation and an entry cost variable like in Djankov et al. (2002). Finally, we we also control for the firm' TFP. The second stage estimates on the sourcing choice include the inverse Mills ratio from the first stage.

Since the dependent variable is measured at the transaction-level, while our main variables of interest are measured at the product- (complexity) and at the country- (IPR) level, the i.i.d. assumption is unlikely to hold. We correct the standard errors by employing two-way clustering at the product- and at the country-level (see Cameron et al., 2006).

5 Descriptive Statistics

We start with presenting some descriptive statistics on the means and standard deviations of the key variables of interest. In order to compare the two sourcing modes, we assign the value of 1 if the outsourcing share is ≥ 0.5 (*Outsourcing*) and the value of 0 (*Vertical Integration*) otherwise. Table 1 shows that outsourcers are on average more productive and import less complex goods from countries with higher IPR protection levels and higher absorptive capacity.

Table 1: Summary statistics

	Vertical Integration	*Outsourcing*	Total
Complexity	0.272	0.268	0.270
	(0.0605)	(0.0575)	(0.0586)
IPR	4.141	4.274	4.226
	(0.661)	(0.477)	(0.555)
Abs. capacity	23.73	24.76	24.39
	(11.78)	(11.15)	(11.40)
TFP, lag	5.351	5.468	5.425
	(0.908)	(0.964)	(0.945)
Wage diff.	1.745	1.546	1.629
	(1.138)	(1.057)	(1.095)

Note: This table presents descriptive statistics for the sample of firms with group affiliates in the source country. The main statistics are the means of the explanatory variables by mode. Standard deviations are in parentheses.

Source: Own calculations.

Table 2 displays the correlations among the main explanatory variables, separately for vertically integrated firms (upper triangle) and outsourcers (lower triangle). We observe a positive correlation between IPR and complexity and between absorptive capacity and complexity, especially in the case of outsourcing. This strengthens our predictions about the impact of these variables: Firms appear to source technologically intensive goods from independent suppliers only in locations where high IPR protection lowers their risk of being imitated and where a high educational level lowers their costs of transferring technology. Absorptive capacity and TFP are negatively correlated, suggesting that productive firms can afford to source from countries with less human capital.

[14] The distance and border variable are computed using the location of the firm in France.

Table 2: Correlation matrix

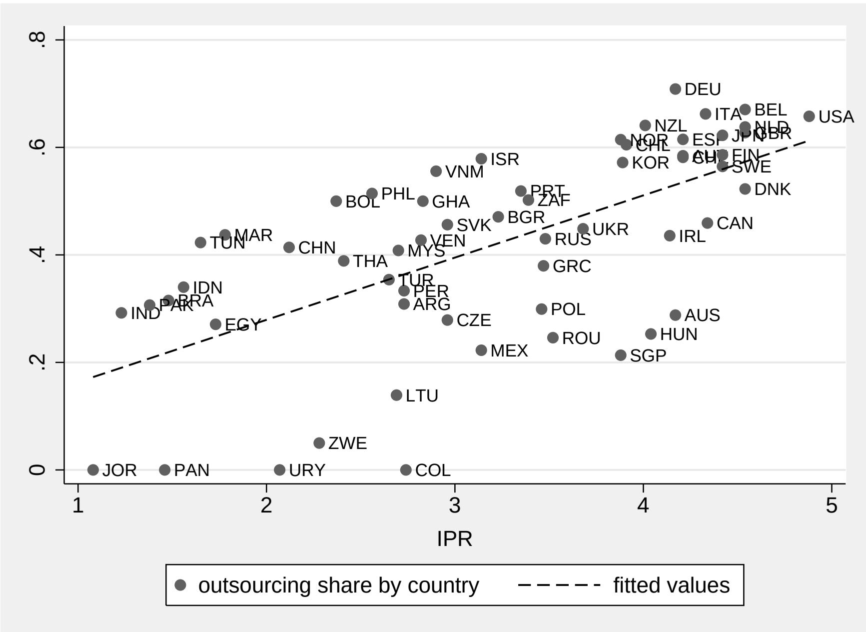
	Complexity	IPR	Abs. capacity	TFP, lag	Wage diff.
Complexity	-	0.0895	0.0217	-0.0102	0.0098
IPR	0.2055	-	0.1975	-0.0361	-0.6028
Abs. capacity	0.0559	0.1997	-	-0.0640	0.1672
TFP, lag	-0.0606	-0.1043	-0.0613	-	-0.0291
Wage diff.	-0.0423	-0.5169	0.2476	0.0152	-

Note: This table presents correlations between the main explanatory variables for the sample of firms with group affiliates in the source country. The correlations are calculated by mode. The upper triangle gives the correlations for V-type, the lower triangle gives the correlations for O-type firms.

Source: Own calculations.

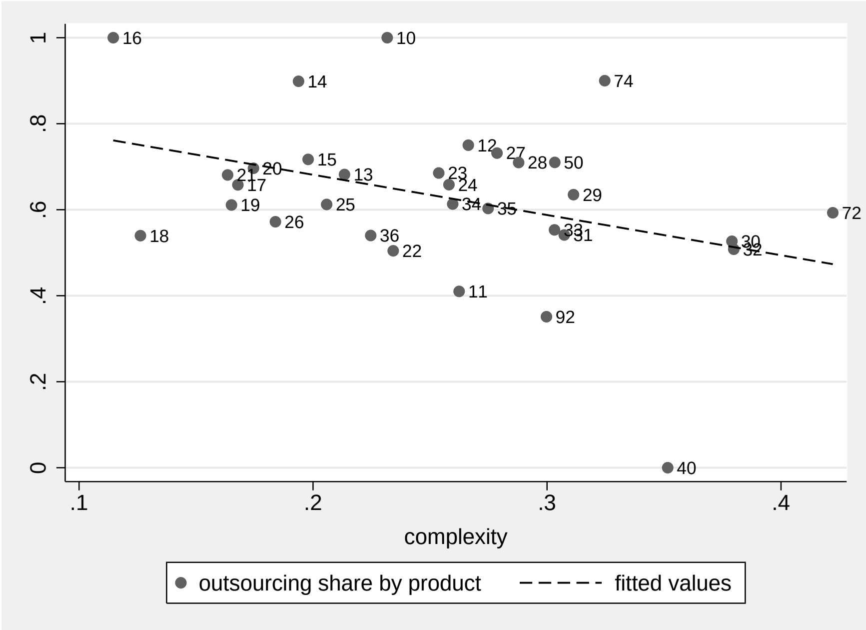
Figure 1 depicts the positive correlation between the IPR level and the outsourcing share. The upward sloping fitting line indicates that the outsourcing share is, on average, higher in countries with stronger IPR protection. Countries, which receive high shares of outsourcing, like Germany, Belgium or the US, are also among the countries that rank highest according to the Ginarte-Park-Wagh index. By contrast, French multinationals highly rely on related parties when sourcing from countries with lower IPR levels, like India or Jordan.

Figure 1: IPR protection and outsourcing share



The correlation between complexity and the average outsourcing share by product, is negative, as Figure 2 shows. Basic products, like tobacco (16), are generally imported from independent suppliers, whereas complex products, like IT- and telecommunication-related products (30, 32, 72) are largely, sourced from affiliated suppliers.

Figure 2: Complexity and outsourcing share



Note: 10: Coal & lignite; peat; 11: Crude petrol. & natural gas; services incidental to oil; 12: Uranium & thorium ores; 13: Metal ores; 14: Other mining & quarrying products; 15: Food products & beverages; 16: Tobacco products; 17: Textiles; 18: Wearing apparel; furs; 19: Leather & leather products; 20: Wood & products of wood & cork (excp. furniture); artic; 21: Pulp, paper & paper products; 22: Printed matter & recorded media; 23: Coke, refined petroleum products & nuclear fuels; 24: Chemicals, chemical products & man-made fibres; 25: Rubber & plastic products; 26: Other non-metallic mineral products; 27: Basic metals; 28: Fabricated metal products, except machinery & equipment; 29: Machinery & equipment n.e.c.; 30: Office machinery & computers; 31: Electrical machinery & apparatus n.e.c.; 32: Radio, television & communication equipment & apparatus; 33: Medical, precision & optical instruments, watches and clocks; 34: Motor vehicles, trailers & semi-trailers; 35: Other transport equipment; 36: Furniture; other manufactured goods n.e.c.; 40: Electrical energy, gas, steam & hot water; 50: Trade, maint. & repair services of motor vehicles & mtr; 72: Computer & related services; 74: Other business services; 92: Recreational, cultural & sporting services.

6 Estimation Results

We start with presenting the baseline results on the entire sample before splitting the sample to test for the proposed non-linearities in product complexity. We complement our analyses with various robustness checks.

6.1 Baseline Results

Table 3 reports the marginal effects from the estimation of the two stage approach. In the first stage, we report the estimates of a probit model that analyzes the likelihood to find a related party in the foreign country. In the second stage, we analyze the effects of IPR and product complexity on the share of outsourcing and include the inverse Mills ratio from the first stage in the different models. The sign on the inverse Mills ratio indicates the nature of the correlation between the errors in the selection equation and the second stage equation. In our case, it is negative and highly significant irrespective of the estimated specifications. This suggests that those firms most likely to have a foreign related party are also less likely to source from independent supplier.

The estimates of the first stage equation reveal that the presence of a related party is determined by the number of French related parties and the nationality of the UBO. As expected, both covariates enter significantly and positively in the selection equation. The estimate of firm's TFP is small and statistically insignificant. This suggests that the location of related parties does not depend on the firm's decision but on the group to which the firm belongs. With the exception of GDP and distance, most gravity determinants are insignificant. We find, however, that policies towards FDI, as captured by the FDI openness variable, are affecting the probability of having a foreign related party positively. The entry costs variable shows the expected negative impact.

The results of the second stage equation are reported in columns (S1) to (S7). The estimates of the IPR and complexity variables are particularly robust across the different specifications. They are both in line with our theoretical expectation. In particular, we find a positive and significant impact of IPR on the outsourcing share with a marginal effect of 0.518 in specification (S6). The estimate of the complexity variable is also significant. The marginal effect is negative and ranges from -0.356 to -0.407.

In column (S4), we introduce the country's absorptive capacity. This variable, measured by the percentage of the country's population that has completed at least secondary schooling, is an approximation of the costs incurred by the ex-ante technology transfer. The marginal effect is positive and significant. This finding is in line with equation (6) which suggests that the technology transfer costs to customize the input to the multinational firm's needs accrues only in the case of outsourcing. A higher absorptive capacity lowers this cost and favors thereby outsourcing.[15]

In column (S5), we add the one-year lagged TFP level of the French multinational. The marginal effect is positive and significant. It suggests that most productive multinational firms are more likely to outsource. In line with our theoretical framework, productive firms find it easier to overcome the technology transfer costs and tend to outsource a higher share of their international activities.

The IPR regime and the decision to source complex inputs may be correlated with some host country characteristics such as the corruption level and the level of investment risk. As Javorcik (2004) points out, multinational firms are less likely to operate with their affiliates in risky and corrupt countries. We include these additional variables in the estimation. The investment risk variable is the 1999 ICRG investment profile. It provides information on contract viability and expropriation, profits repatriation and payment delays.[16] We find that lower investment risk favors outsourcing. The corruption index is the 1999 Transparency International Corruption Perception Index which pools information from ten different surveys of business executives, risk analysts and the general public. The estimate is small and insignificant. The corruption level does not influence the sourcing mode of French multinationals. While the effect of corruption is insignificant, the introduction of the investment risk variable yields a more precise estimation of the IPR estimates.

In column (S7), we additionally control for the wage difference between the home country, France, and the source countries J. Since the wage difference is positive only for less developed countries whilst the major part of French firms' imports come from well developed countries such as Germany and the US, the inclusion of the variable in logs results in a loss of over 50% of all observations. Even though, we do not find the predicted positive impact of the wage difference on the outsourcing share, it is interesting to observe that the effects of complexity and the IPR protection level become stronger for this sample.[17] The country's absorptive capacity and the quality of its business environment now turn out to have no impact on the outsourcing share. The corruption variable is negative and estimated with a very low degree of precision.

As shown by Hanson et al. (2005), the trade activities of multinational firm involve intermediate

[15]The result is in line with previous studies: Bernard et al. (2010) report empirical evidence that a country's greater skill abundance reduces the share of intra-firm trade of US firms. Grover (2007) develops a theoretical model according to which intra-firm trade falls relative to extra-firm trade as absorptive capacity rises.

[16]A higher index indicates a lower risk of investment.

[17]2/3 of imports in this restricted sample come from Italy, Spain and the United Kingdom.

Table 3: Impact of complexity and IPR regimes on the sourcing choice (marginal effects presented).

Variables	(First Stage)	(Second Stage)						
		(S1)	(S2)	(S3)	(S4)	(S5)	(S6)	(S7)
IPR	0.071^a	0.037^b		0.036^b	0.033^b	0.035^a	0.0518^b	0.082^b
	(6.026)	(2.429)		(2.363)	(2.280)	(2.380)	(2.698)	(2.151)
Product complexity	0.330^a		-0.356^a	-0.344^a	-0.354^a	-0.395^a	-0.407^a	-0.533^a
	(2.869)		(-3.079)	(-3.017)	(-3.047)	(-3.447)	(-3.546)	(-3.200)
Abs. Capacity	0.001				0.024^a	0.024^a	0.015^a	0.008
	(0.192)				(3.879)	(3.794)	(1.815)	(0.426)
TFP, lag	0.001					0.034^b	0.034^b	0.057^b
	(0.093)					(2.022)	(2.018)	(3.325)
GDP	0.050^a							
	(9.297)							
Distance	-0.046^a							
	(-6.014)							
Adjacency	-0.018							
	(-0.515)							
Official Language	-0.009							
	(-0.515)							
Common legal orgin	0.016							
	(1.027)							
Trade openness	-0.001							
	(-1.315)							
Investment openness	0.004^a							
	(4.762)							
Entry costs	-0.015^a							
	(-5.394)							
No. of French related parties	0.164^a							
	(16.680)							
UBO, foreign group	0.258^a							
	(10.083)							
Investment risk							-0.012^c	-0.000
							(-1.899)	(-0.053)
Corruption							-0.002	-0.021^c
							(-0.350)	(-2.609)
Wage difference								-0.019
								(-1.175)
Inverse Mills		-0.304^a	-0.340^a	-0.311^a	-0.321^a	-0.316^a	-0.318^a	-0.316^a
		(-9.77)	(-12.07)	(-9.74)	(-11.07)	(-10.65)	(-10.67)	(-9.428)
Obs.	67142	39730	39730	39730	39730	39730	39730	15028
Pseudo R^2	0.166	0.0537	0.0534	0.0545	0.0559	0.0582	0.0588	0.0711

Robust standard errors adjusted for clustering around the country and products' identity in the second stage. The standard error are clustered at firm level in the first stage equation. $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

inputs which are a key element of their global production network. We analyze the effect of IPR and complexity on the outsourcing decision of intermediate products. In Appendix A.2, Table A.2 reports the marginal effects using a sample containing intermediate inputs only. We follow the methodology developed in Defever and Toubal (2007) and identify imported intermediate inputs as purchased inputs registered in an HS3-digit sector other than the one in which the French multinational reports its main activity. The results are qualitatively similar to those reported in

Table 3. The marginal effects are, however, estimated with a higher level of precision, suggesting that the sample of intermediate inputs provides a better fit for our analysis.

6.2 Outsourcing and Non-Linearities in Complexity

We find that the level of complexity has, on average, a negative impact on the outsourcing share. A greater level of complexity should deter outsourcing because complex products are associated with a higher risk of imitation. Intuitively, the decision to source products with a very high degree of complexity from an outside supplier should be strongly influenced by the level of IPR protection. In Table 4, we investigate the effect of IPR and complexity on the sourcing mode, separately for high and low complex products. Table 4 reports the second stage equation, the estimation of the selection equation is similar to the one presented in Table 3. The sample of high complexity products corresponds to all transactions with a level of complexity which is above the complexity variable median value ($z = 0.279$). The estimated marginal effects are presented in the upper Panel A of Table 4. We report the results of the low complexity sample in the lower Panel B. As in the baseline regressions, we find that the inverse Mills ratios are statistically significant and negative in both subsamples.

The results of Table 4 show striking differences with respect to the effect of IPR on low and high complexity products. While for a high level of complexity, the levels of IPR and complexity are relevant for the sourcing decision, they do not appear to be relevant for low complexity levels. In Panel A, the marginal effects of the IPR variables are significant and vary from 0.050 to 0.173. We additionally find a negative and significant impact of the complexity variable. Interestingly, the marginal effects of the IPR and complexity variables are larger than the ones reported in Table 3. These results suggest that the levels of IPR and complexity are even more important for the sourcing decision of highly complex products. The human capital endowment does not lower technology transfer costs for highly complex products. Notice, that the marginal effect of the IPR variable is more important in this specification.

Concerning the results presented in Panel B, we still find a positive and significant effect of the absorptive capacity. A country's endowment with human capital lowers technology transfer costs and favors the outsourcing of low complex goods.

Table A.3 in Appendix A.2 reports the marginal effects using the intermediate inputs sample. The results are qualitatively similar and estimated with a higher degree of precision.

6.3 Robustness Checks

We provide two robustness checks: First, we use the Rauch classification to challenge our measurement of product complexity. Second, we employ measures of institutional quality which are broader than our preferred property rights index.

6.3.1 Differentiated versus Homogenous Products

We follow Berkowitz et al. (2006) and reinterpret Rauch's product classification in terms of product complexity. We classify products that are traded on an organized exchange or are referenced price as having a low degree of complexity. Differentiated products are, by contrast, considered to exhibit a high level of complexity. In Table 5, we report the marginal effects of the first and second stage estimations using this classification.

Table 4: Outsourcing and the non-linear impact of complexity (marginal effects presented).

Panel A: high level of complexity							
IPR	0.055[a]		0.052[b]	0.050[b]	0.051[b]	0.073[a]	0.173[a]
	(2.627)		(2.474)	(2.502)	(2.548)	(2.992)	(4.493)
Product complexity		-0.676[b]	-0.609[c]	-0.594[c]	-0.678[c]	-0.683[b]	-1.008[c]
		(-1.997)	(-1.791)	(-1.741)	(-1.957)	(-1.975)	(-1.831)
Abs. Capacity				0.022[a]	0.022[a]	0.012	-0.009
				(3.811)	(3.709)	(1.283)	(-0.538)
TFP, lag					0.037[b]	0.037[b]	0.052[a]
					(2.383)	(2.382)	(2.840)
Investment risk						-0.011	-0.006
						(-1.420)	(-0.494)
Corruption						-0.006	-0.021[b]
						(-0.754)	(-2.168)
Wage difference							-0.004
							(-0.190)
Inverse Mills	-0.256[a]	-0.304[a]	-0.257[a]	-0.267[a]	-0.255[a]	-0.260[a]	-0.263[a]
	(-6.266)	(-7.712)	(-6.260)	(-6.890)	(-6.459)	(-6.652)	(-5.418)
Obs.	20972	20972	20972	20972	20972	20971	7744
R^2	0.0693	0.0681	0.0702	0.0714	0.0736	0.0744	0.0973
Panel B: low level of complexity							
IPR	0.016		0.017	0.013	0.016	0.027	0.026
	(0.703)		(0.757)	(0.580)	(0.710)	(1.017)	(0.657)
Product complexity		-0.300	-0.318	-0.337	-0.395	-0.407	-0.844[c]
		(-0.836)	(-0.880)	(-0.930)	(-1.036)	(-1.077)	(-1.843)
Abs. Capacity				0.026[a]	0.026[a]	0.018[b]	0.012
				(4.640)	(4.399)	(2.017)	(0.624)
TFP, lag					0.033	0.034	0.063[b]
					(1.359)	(1.365)	(2.500)
Investment risk						-0.013	0.005
						(-1.325)	(0.760)
Corruption						0.001	-0.020[b]
						(0.128)	(-2.349)
Wage difference							-0.026
							(-1.466)
Inverse Mills	-0.348	-0.365	-0.353	-0.362	-0.362	-0.363	-0.358
	(-10.43)	(-11.75)	(-10.78)	(-11.94)	(-12.10)	(-12.22)	(-8.96)
Obs.	18758	18758	18758	18758	18758	18758	7284
R^2	0.0484	0.0484	0.0487	0.0504	0.0531	0.0536	0.0629

Robust standard errors adjusted for clustering around the country and products' identity in the second stage. First stage regression as in Table 3. $t-statistics$ in parenthesis. [a], [b] , [c] significantly different from 0 at 1%, 5% and 10% level, respectively.

The results suggest that for simple goods, the level of complexity and of IPR does not affect the outsourcing share.[18] We find that IPR and complexity matter for the outsourcing share of

[18]In the reduced sample that includes the wage differences, the level of IPR is significant but only at 10%.

Table 5: Using the Rauch's classification (marginal effects presented).

Variables	(First Stage)	(Second Stage)			
		Homogenous		Differentiated	
IPR	0.071^{a}	0.032	0.053^{c}	0.052^{b}	0.083^{b}
	(5.995)	(1.574)	(1.897)	(2.418)	(2.040)
Product complexity	0.313^{a}	-0.316	-0.303	-0.380^{a}	-0.519^{a}
	(2.738)	(-1.373)	(-0.763)	(-2.873)	(-2.809)
Abs. Capacity	0.002	0.015	0.020	0.016	0.013
	(0.285)	(1.595)	(0.725)	(1.619)	(0.600)
TFP, lag	0.003	-0.013	0.001	0.049^{a}	0.077^{a}
	(0.211)	(-0.650)	(0.074)	(2.683)	(3.777)
GDP	0.049^{a}				
	(9.251)				
Distance	-0.047^{a}				
	(-6.129)				
Adjacency	-0.019				
	(-0.546)				
Official language	-0.008				
	(-0.491)				
Common legal orgin	0.013				
	(0.846)				
Trade openness	-0.001				
	(-1.377)				
Investment openness	0.004^{a}				
	(4.759)				
Entry costs	-0.015^{a}				
	(-5.320)				
No. of French related parties	0.165^{a}				
	(16.585)				
UBO, foreign group	0.258^{a}				
	(10.010)				
Investment risk		-0.014	-0.000	-0.010	0.001
		(-1.505)	(-0.030)	(-1.409)	(0.125)
Corruption		0.003	-0.016^{c}	-0.005	-0.026^{a}
		(0.440)	(-1.825)	(-0.697)	(-3.197)
Wage difference			-0.025		-0.021
			(-0.958)		(-1.340)
Inverse Mills		-0.287^{a}	-0.339^{a}	-0.323^{a}	-0.309^{a}
		(-8.294)	(-8.188)	(-9.032)	(-7.887)
Obs.	65165	10598	3508	30647	11895
R^2	0.166	0.0463	0.0678	0.0666	0.0771

Robust standard errors adjusted for clustering around the country and products' identity in the second stage. The standard error are clustered at firm-level in the first stage equation. $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

differentiated products. The marginal effects are in line with those of the baseline specifications.

6.3.2 Alternative Measures of Institutions

We provide three alternative measures for the IPR regime. Even though two of them are imperfect substitutes for the Ginarte-Park-Wagh index, they provide useful information about contract enforcement and property rights protection.

The first variable is the average Ginarte-Park-Wagh IPR index for the year 1995 and 2000. The enforcement of the WTO agreement on the trade-related aspects of intellectual property rights (TRIPS) in 1995 may have changed the ranking of countries according to their IPR protection level, and therefore makes the use of the IPR index at a later date desirable. Since the Ginarte-Park index was calculated only every five years prior to 2000, we use the average between 1995 and 2000.

The second alternative measure is the Heritage Foundation property rights index. Although not directly related to intellectual property rights, it provides information on the extent to which *"a country's laws protect private property rights and the degree to which its government enforces those law'"*. It also accounts for the possibility of expropriation of private property. This index takes large scores for higher level of protection. The third index is the Kaufmann *et al.* index of rule of law. It captures the confidence in a country's contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

The introduction of the three alternative measures of IPR does not affect the complexity impact on the outsourcing share. The marginal effects of the complexity level enter negatively and significantly in the second stage equations. We find the average IPR index to have a significant and positive impact on the outsourcing share of multinational firms. The marginal effect is of an order of magnitude larger than the one found in Table 3. Interestingly, the introduction of the average IPR index renders the absortive capacity variable insignificant.

The marginal effect of the Heritage Foundation and the rule of law variables are positive and statistically significant. A country's judicial quality and the possibility to enforce contracts influence positively the likelihood to source from an independent supplier. Since both indices inform about a country's ability to enforce contracts, our findings are in line with models that build on the theory of incomplete contracts (see e.g. Grossman and Helpman, 2002, Antràs, 2003 and Antràs and Helpman, 2004).

7 Conclusions

This paper has investigated the decision of multinational groups to source complex goods from independent or affiliated suppliers. We have developed a theoretical framework that proposes the complexity of a product and the IPR protection level of a country as alternative determinants for a firm's choice between outsourcing and vertical integration.

As measures of the technological intensity at the product-level are not available, we have built a new measure reflecting the complex problem solving skills involved in the production of a good. The estimations confirm the theoretical presumption that firms use independent suppliers when sourcing non-complex goods. When sourcing complex goods, costly technology transfers expose firms to the risk of being imitated. This imitation risk increases in the complexity of the imported good and decreases in the level of IPR protection available in the source country.

As much as the paper contributes to the way, economists think about intra-firm trade, it bears an important policy conclusion: If developing countries want to attract the upper parts of the value chain, they must build trust into the protection of intellectual property rights.

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A Appendix

A.1 Product Complexity Ranking

Table A.1: Product complexity ranking

Code	Description	Complexity
72	Computer & related services	.4221271
32	Radio, television & communication equipment & apparatus	.3798102
30	Office machinery & computers	.3790194
40	Electrical energy, gas, steam & hot water	.3515674
74	Other business services	.3246673
29	Machinery & equipment n.e.c.	.3113132
31	Electrical machinery & apparatus n.e.c.	.3073564
50	Trade, maint. & repair services of motor vehicles & mtrcls; retail sale of auto fuel	.3033172
33	Medical, precision & optical instruments, watches and clocks	.3031925
92	Recreational, cultural & sporting services	.2997497
28	Fabricated metal products, except machinery & equipment	.2878633
27	Basic metals	.2786216
35	Other transport equipment	.2748125
12	Uranium & thorium ores	.266358
11	Crude petrol. & natural gas; services incidental to oil & gas ext. excl. surveying	.2624262
34	Motor vehicles, trailers & semi-trailers	.2596836
24	Chemicals, chemical products & man-made fibres	.2580898
23	Coke, refined petroleum products & nuclear fuels	.2537238
22	Printed matter & recorded media	.2342544
10	Coal & lignite; peat	.2317005
36	Furniture; other manufactured goods n.e.c.	.2246486
13	Metal ores	.2134478
25	Rubber & plastic products	.205822
15	Food products & beverages	.1978979
14	Other mining & quarrying products	.1938014
26	Other non-metallic mineral products	.1839178
20	Wood & products of wood & cork (excp. furniture); articles of straw & plaiting matls	.1745415
17	Textiles	.167882
19	Leather & leather products	.1651444
21	Pulp, paper & paper products	.1634918
18	Wearing apparel; furs	.1262338
16	Tobacco products	.1146149

Source: Own calculations.

A.2 Additional Empirical Results

Table A.2: Impact of complexity and IPR regimes on the sourcing choice intermediate products (marginal effects presented).

Variables	(First Stage)	(Second Stage)						
		(S1)	(S2)	(S3)	(S4)	(S5)	(S6)	(S7)
IPR	0.069^a	0.044^a		0.042^a	0.040^a	0.041^a	0.059^a	0.121^a
	(4.852)	(3.326)		(3.149)	(3.306)	(3.319)	(4.017)	(4.099)
Product complexity	0.358^a		-0.522^a	-0.508^a	-0.518^a	-0.545^a	-0.550^a	-0.623^a
	(3.269)		(-4.649)	(-4.577)	(-4.634)	(-4.925)	(-4.950)	(-3.775)
Abs. Capacity	0.005				0.024^a	0.025^a	0.017^a	0.008
	(0.692)				(5.403)	(5.434)	(2.658)	(0.489)
TFP, lag	0.005					0.037^c	0.037^c	0.064^a
	(0.381)					(1.916)	(1.907)	(3.589)
GDP	0.053^a							
	(8.099)							
Distance	-0.044^a							
	(-5.082)							
Adjacency	0.001							
	(0.032)							
Official language	-0.017							
	(-0.900)							
Common legal orgin	0.018							
	(0.977)							
Trade openness	-0.001							
	(-0.482)							
Investment openness	0.003^a							
	(3.465)							
Entry costs	-0.018^a							
	(-5.488)							
No. of French related parties	0.162^a							
	(15.915)							
UBO, foreign group	0.260^a							
	(9.369)							
Investment risk							-0.009^c	-0.002
							(-1.650)	(-0.158)
Corruption							-0.005	-0.017^b
							(-0.908)	(-2.186)
Wage difference								-0.001
								(-0.055)
Inverse Mills		-0.292^a	-0.337^a	-0.307^a	-0.316^a	-0.309^a	-0.311^a	-0.304^a
		(-8.391)	(-10.546)	(-8.638)	(-9.687)	(-9.107)	(-8.925)	(-7.797)
Obs.	48,539	28,54	28,54	28,54	28,54	28,54	28,54	10,092
R^2	0.163	0.0643	0.0650	0.0665	0.0682	0.0712	0.0718	0.0865

Robust standard errors adjusted for clustering around the country and products' identity in the second stage. The standard error are clustered at firm level in the first stage equation. $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table A.3: Outsourcing of intermediate inputs and the non-linear impact of complexity (marginal effects presented).

Panel A: high level of complexity							
IPR	0.244^a		0.050^a	0.048^a	0.048^a	0.068^a	0.167^a
	(3.017)		(2.754)	(2.859)	(2.914)	(3.514)	(3.815)
Product complexity		-0.901^a	-0.838^a	-0.823^a	-0.906^a	-0.910^a	-1.121^b
		(-3.076)	(-2.812)	(-2.729)	(-2.978)	(-3.009)	(-2.329)
Abs. Capacity				0.019^a	0.019^a	0.011	-0.006
				(5.399)	(5.065)	(1.518)	(-0.425)
TFP, lag					0.053^a	0.053^a	0.075^a
					(3.049)	(3.035)	(3.497)
Investment risk						-0.009	-0.005
						(-1.372)	(-0.392)
Corruption						-0.007	-0.019
						(-1.196)	(-1.921)
Wage difference							0.007
							(0.291)
Inverse mills	-0.231^a	-0.276^a	-0.235^a	-0.243^a	-0.224^a	-0.228^a	-0.227^a
	(-5.285)	(-6.545)	(-5.365)	(-5.839)	(-5.411)	(-5.431)	(-3.738)
Obs.	16	16	16	16	16	16	5,644
R^2	0.0711	0.0710	0.0730	0.0740	0.0789	0.0797	0.0977
Panel B: low level of complexity							
IPR	0.031^a		0.033	0.029	0.033	0.044	0.076
	(1.389)		(1.426)	(1.337)	(1.401)	(1.827)	(2.524)
Product complexity		-0.183	-0.220	-0.245	-0.257	-0.255	-0.526
		(-0.729)	(-0.878)	(-0.970)	(-1.003)	(-1.019)	(-1.259)
Abs. Capacity				0.030^a	0.031^a	0.025^b	0.017
				(4.263)	(4.335)	(2.248)	(0.663)
TFP, lag					0.028	0.028	0.058^b
					(1.045)	(1.046)	(2.207)
Investment risk						-0.008	0.004
						(-0.725)	(0.337)
Corruption						-0.002	-0.013
						(-0.289)	(-1.259)
Wage difference							-0.007
							(-0.331)
Inverse mills	-0.354^a	-0.377^a	-0.358^a	-0.368^a	-0.366^a	-0.367^a	-0.356^a
	(-9.070)	(-10.844)	(-9.502)	(-10.354)	(-10.244)	(-10.071)	(-7.273)
Obs.	12,54	12,54	12,54	12,54	12,54	12,54	4,448
R^2	0.0680	0.0673	0.0682	0.0709	0.0731	0.0734	0.0856

Robust standard errors adjusted for clustering around the country and products' identity in the second stage. First stage regression as in Table A.2. $t-statistics$ in parenthesis. ^{a}, ^{b}, ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.

Table A.4: Alternative measures of IPR (marginal effects presented).

	Average IPR (1995-2000)			**Heritage Foundation (1999)**			**Rule of Law (1999)**		
Average IPR	0.083^a	0.064^a	0.096^b						
	(5.727)	(3.134)	(2.245)						
IPR (HF)				0.002^a	0.003^a	0.001			
				(4.632)	(5.587)	(0.681)			
Rule of law							0.048^a	0.151^a	0.201^a
							(4.119)	(5.462)	(3.506)
Product complexity	0.332^a	-0.404^a	-0.536^a	0.321^a	-0.416^a	-0.447^a	0.325^a	-0.399^a	-0.446^a
	(2.882)	(-3.533)	(-3.246)	(2.836)	(-3.562)	(-2.658)	(2.854)	(-3.435)	(-2.587)
Abs. capacity	0.001	0.013	0.006	0.007	0.019^a	0.052^a	0.007	0.013^b	0.031^b
	(0.088)	(1.620)	(0.344)	(1.174)	(4.047)	(3.687)	(1.041)	(2.464)	(2.331)
TFP, lag	0.001	0.034^b	0.057^a	0.000	0.034^b	0.056^a	0.000	0.034^b	0.058^a
	(0.095)	(2.019)	(3.314)	(0.028)	(2.092)	(3.330)	(0.017)	(2.094)	(3.409)
GDP	0.049^a			0.059^a			0.062^a		
	(9.026)			(11.218)			(11.704)		
Distance	-0.046^a			-0.050^a			-0.048^a		
	(-6.144)			(-6.351)			(-5.799)		
Adjacency	-0.018			-0.012			-0.013		
	(-0.500)			(-0.326)			(-0.373)		
Official language	-0.009			-0.008			0.010		
	(-0.523)			(-0.477)			(0.604)		
Common legal orgin	0.014			0.024			0.023		
	(0.908)			(1.527)			(1.404)		
Trade openness	-0.001			0.000			0.001		
	(-1.132)			(0.328)			(0.864)		
Investment openness	0.004^a			0.004^a			0.004^a		
	(4.696)			(5.848)			(5.713)		
Entry costs	-0.016^a			-0.019^a			-0.018^a		
	(-5.600)			(-6.485)			(-6.307)		
No. of French related parties	0.164^a			0.164^a			0.164^a		
	(16.683)			(16.614)			(16.639)		
UBO, foreign group	0.258^a			0.257^a			0.257^a		
	(10.086)			(10.054)			(10.071)		
Investment risk		-0.012^c	0.001		-0.005	0.015^c		-0.010^c	0.003
		(-1.936)	(0.121)		(-0.807)	(1.851)		(-1.722)	(0.463)
Corruption		-0.002	-0.020^b		-0.009^c	-0.030^a		-0.037^a	-0.071^a
		(-0.345)	(-2.570)		(-1.863)	(-2.608)		(-4.310)	(-4.226)
Wage difference			-0.018			-0.059^a			-0.039^b
			(-1.168)			(-2.972)			(-2.516)
Inverse mills		-0.315^a	-0.316^a		-0.323^a	-0.339^a		-0.316^a	-0.323^a
		(-10.66)	(-9.72)		(-13.77)	(-11.58)		(-12.68)	(-11.28)
Obs.	67142	39730	15028	67,288	39791	15076	67288	39791	15076
R^2	0.166	0.0591	0.0714	0.164	0.0584	0.0667	0.164	0.0596	0.0707

Robust standard errors adjusted for clustering around the country and products' identity in the second stage. The standard error are clustered at firm level in the first stage equation. $t-statistics$ in parenthesis. ^{a}, ^{b} , ^{c} significantly different from 0 at 1%, 5% and 10% level, respectively.