International Technology Transfer, Firm Productivity and Employment

SMARANDA PANTEA, M. Sc.

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Abstract

This dissertation contributes to the empirical literature on the effects of international technology transfer on firms' productivity and employment in developing and transition countries. It combines three empirical essays which provide evidence on how participation in international activities affects firms' productivity, how it interacts with firms' absorptive capacity and how it affects firms' demand for skilled labour in 26 transition countries in Europe and Central Asia (ECA) region.

The first study investigates whether foreign ownership, supplying multinationals (MNEs) located in the same country, foreign direct investment (FDI) horizontal spillovers, exporting and importing are conduits of international technology transfer and their relative importance for firms in 26 transition economies in ECA region using Business Enterprise and Environment Performance Survey (BEEPS) 2002-2005. It contributes to the literature by analyzing the impact of all main channels of international technology transfer simultaneously and by using a firm specific measure for supply linkages with MNEs, unlike previous studies that used industry level measures. The main results suggest that foreign ownership, supplying MNEs, exporting and importing are robustly associated with higher firm productivity and we cannot reject the hypothesis that these channels are equally important.

The second study examines whether international technology transfer through foreign ownership, supplying MNEs, exporting and importing depends on firm and country absorptive capacity in 26 transition economies in ECA region using the BEEPS 2002 and 2005 waves. The main contributions of this paper are that it uses firm specific measures of access to foreign technology and measures of absorptive

capacity (workforce education, personnel training and R&D activities) which are closely related to the concept of absorptive capacity and less prone to measurement errors than productivity gap measures used in previous studies. Our results suggest that access to foreign technology and absorptive capacity are associated with higher productivity, but, contrary to our hypothesis, there is no evidence of an interaction effect between absorptive capacity and access to foreign technology.

The third study investigates how participation in international activities affects firms' demand for skilled labour and the ways in which firms respond to changes in demand for skilled labour in 26 transition economies in ECA during the period 2002-2005 using BEEPS 2002 and 2005 waves. It contributes to the literature by studying different ways in which firms respond to changes in the demand for skilled labour (hiring employees from outside the firm or training existing employees) and by studying whether there is a causal relationship between participation in international activities and demand for skilled labour. Our results suggest that firms engaged in international activities have a better educated labour force and are more likely to train their employees than domestic firms. However, this happens because firms with better skilled workforces and with formal training programmes select into participating in international activities, and not because these firms upgrade the skills of their workforces after starting to participate in international activities.

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Abbreviations

ALB - Albania

ARM - Armenia

AZE - Azerbaijan

BEEPS - Business Environment and Enterprise Performance Survey

BGR - Bulgaria

BIH - Bosnia and Herzegovina

BLR - Belarus

CEE - Central and Eastern Europe

CIS - Commonwealth of Independent States

CZE - Czech Republic

EBRD - European Bank of Reconstruction and Development

FDI - Foreign Direct Investment

FE - Fixed Effects

GEO - Georgia

GDP - Gross Domestic Product

EST - Estonia

HRV - Croatia

HUN - Hungary

KAZ - Kazakhstan

KGZ - Kyrgyz Republic

LTU - Lithuania

LVA - Latvia

MDA - Moldova

MKD - Macedonia, FYR

MNE - Multinational Enterprise

OLS - Ordinary Least Squares

POL - Poland

PPP - Purchasing Power Parity

R&D - Research and Development

ROM - Romania

RUS - Russia

SRB - Serbia and Montenegro

SVK - Slovakia

SVN – Slovenia

TFP – Total Factor Productivity

TJK - Tajikistan

UKR - Ukraine

UZB - Uzbekistan

USD – United States Dollar

USPTO - United States Patent and Trademark Office

WBES - World Bank Enterprise Survey

WDI - World Bank Development Indicators

Chapter 1 Introduction

It is well recognised that differences in productivity levels explain a large part of the differences in income per capita across countries and that technology is one of the main determinants of productivity levels (Hall and Jones, 1999; Keller, 2004). To upgrade technology, firms can either develop new technology themselves, through R&D activities, or acquire it from other firms. However, most of the creation of new technology is concentrated in a few industrialised economies. For instance in 2004, the seven largest industrialised countries accounted for more than 86% of all patents granted by USPTO (USPTO, 2008). Therefore, adoption of new technology is determined in large part by the diffusion of technology across international borders, especially in the case of developing countries and transition economies.

This topic is very relevant for transition economies. Since the beginning of the transition from centrally planned economy to market economy, many countries in Europe and Central Asia (ECA) region have experienced dramatic technology change. These countries lag behind developed countries in terms of technology and it is considered that an important reason for this lag is the lack of exposure to technology created in developed countries during the communist regime when trade and FDI were severely restricted. As part of the transition to a market economy, most of transition economies reduced restrictions on FDI and international trade. Moreover, many of them began to actively encourage the attraction of FDI and support firms to export in the expectation of benefiting from the transfer of new technology from developed countries. In addition, many transition economies in ECA have high stocks of human capital, as measured by educational attainment, which should enable them to assimilate technology created in developed countries.

There is a large theoretical and empirical literature on the topic of international technology transfer. This literature, surveyed by Keller (2004, 2009) suggests that FDI and international trade are the two most important channels of international technology diffusion.

Technology transfer through FDI implies a direct transfer of technology from parent MNE to its foreign affiliates. Most of the literature on FDI suggests that MNEs must possess some superior technological knowledge in order to compete successfully against domestic firms in a foreign country Dunning (1993) and they transfer part of this knowledge to their foreign affiliates. This technology might also spill to domestic firms that interact with foreign affiliates in the host country as competitors, customers or suppliers. Exposure to MNEs products and practices helps local firms learn about new technology, new products or new business practices (Wang and Blomström, 1992). Local firms may hire workers who were previously employed and trained by MNEs and thus have knowledge of technology and business practises used by MNEs (Fosfuri *et al.*, 2001). Suppliers of MNEs may also benefit from technology transfer from MNEs. MNEs may transfer technology or business practices to their suppliers to help them improve the quality of their products and on-time delivery and lower the production costs and prices (Javorcik, 2008).

The second major channel of international technology transfer is international trade. Specialised imported intermediate inputs embody technology created abroad and using them implicitly means using this technology (Keller, 2004). Interactions with foreign competitors and foreign customers in export markets provide information on new products and technology that allows exporters to reduce costs and to improve

quality (Greenaway and Kneller, 2007). Foreign customers might offer technical assistance to exporting firms to adapt their products and technology to the requirements of international markets especially to firms in developing countries (Pack and Saggi, 2001).

The empirical literature on this topic is very large. Keller (2004, 2009) provides surveys on the empirical evidence of technology transfer through both FDI and international trade. In addition, Blomström and Kokko (1998), Görg and Strobl (2001), Saggi (2002), Barba Navaretti and Venables (2004) and Görg and Greenaway (2004) review the effects of FDI on productivity and Greenaway and Kneller (2007) and Wagner (2007) survey the studies on international trade and productivity. Despite the theoretical justification, many empirical studies have found ambiguous results. Overall, there is evidence that supports the idea that FDI is an important channel for international technology diffusion, mainly to its foreign affiliates, but also through backward linkages with suppliers in the host countries. The evidence of technology transfer to firms in the same industry is very mixed and most of the studies find no such evidence for developing and transition countries. There is strong evidence that imports are a significant channel of international technology transfer, mainly from studies using aggregate data. There is some evidence that exporting is also a channel for international technology transfer, but the evidence is weaker and it varies across countries.

One reason for these mixed results is that studying these relationships empirically poses several challenges. One problem highlighted by Keller (2009) is the measurement of some of the main variables of interest like access to foreign

technology and absorptive capacity, which is the ability to understand, evaluate and use knowledge created outside the firm. With regard to measures of access to foreign technology, it is important to notice that most studies on FDI spillovers rely on industry level measures of access to foreign technology (Javorcik, 2004a; Blalock and Gertler, 2008; Javorcik and Spatareanu, 2008). This methodology assumes that firms within one industry have equal access to foreign sources of technology. However, in practice, firms within one industry differ in their access to foreign sources of technology depending on their interactions with foreign firms. MNEs have an incentive to share their technology with their suppliers in order to help them improve the quality of their products and reduce the cost, but not with other firms in the industry. There are also problems with the measurement of firm absorptive capacity. The most commonly used measures are productivity gap measures, which have the disadvantage that they are subject to measurement errors because the total factor productivity gap may be affected by temporary shocks that do not affect the absorptive capacity of the firm (Girma and Görg, 2007). In addition, these measures of absorptive capacity of the firms are not very informative from a policy point of view because they do not explain why the productivity gap exists in the first place.

A second problem is that most empirical studies provide only partial evidence on one channel of international technology transfer (Keller, 2004). Most of the studies on the effects of FDI on productivity examine how FDI affects firm productivity directly and through vertical and horizontal spillovers, but do not take into account the effect of participation in international trade. Similarly, studies on international trade focus on exporting or importing or both of them but without taking into consideration the effect of FDI. There is little evidence on the relative importance of

different channels, and where this evidence exists, it is usually confined to results from aggregate data. In practice, firms tend to participate simultaneously in several international activities and several studies suggest that there might be complementarities between different international activities (Kasahara and Lapham, 2008). In this case, not taking into account the effects of different channels of international technology transfer might result in biased estimates.

Third problem is that is it is difficult to isolate the effects of international technology transfer from other effects of exposure to foreign firms. For instance, FDI can have a negative effect on domestic firms if MNEs limit labour turnover by paying higher wages and attract the best workers away from domestic firms or if MNEs entry results in the loss of local firms' market share, which will force them to operate on a less efficient scale (Aitken and Harrison, 1999). Similarly, MNEs suppliers may be negatively affected by MNEs. MNEs often find themselves in a position of stronger bargaining power in relation with their suppliers and they may impose unfair terms and conditions on the local suppliers (UNCTAD, 2001). In addition, trade and FDI can have positive effects on firm productivity through effects on market structure or economies of scale and it may be difficult to separate these effects from the technology transfer effect.

The final important problem of identifying the effect of international technology transfer is the endogeneity of participation in international activities. There is substantial evidence that suggests a positive correlation between participation in some international activities (foreign ownership, exporting and importing) and higher productivity. However, establishing a causal link between the two is

challenging because there is substantial evidence of selection of best performing firms into participation in these activities. Firms which are more productive may select into participating in exporting (Melitz, 2003; Greenaway and Kneller, 2007), importing (Kasahara and Lapham, 2008) or supplying MNEs (Javorcik and Spatareanu, 2009) are they are more likely to be acquired by foreign investors (Djankov and Hoekman, 2000).

Similar considerations apply to studies on the effect of globalisation on firm demand for skilled labour. Transfer of technology from developed countries, which is skill biased because it was created to complement to skills of the labour force in developed countries, would lead to an increase in demand for skilled labour in developing and transition countries (Acemoglu, 1998; Keller, 2004). There is a large empirical literature on this topic, surveyed among others by Acemoglu (2002, 2003), Goldberg and Pavcnik (2007), Chusseau *et al.* (2008) and Crinò (2009) and most of it found mixed empirical results. Most of these studies face similar problems with regard to measurement of the demand for skilled labour, distinguishing the effect of technology transfer of skilled biased technology from other effects of globalisation on demand for skilled labour and endogeneity of firms' participation in international activities. Most studies focus on a measure that distinguishes between production and nonproduction employees. However, employees within these two categories may differ considerably with regard to their formal education, vocational qualifications, training and work experience, which are exactly the characteristics which are important to capture skill level and which are informative for policy. It is also difficult to isolate the effects of international technology transfer from other effects of exposure to foreign firms. International trade and FDI can have a negative effect

on demand for skilled labour due to specialisation in goods intensive in unskilled labour according Heckscher-Ohlin model. In addition, trade and FDI can have a positive effect on demand for skilled labour due to other factors like increasing the incentives of firms to adopt more advanced skill biased technology in order to become more competitive in international markets. Finally, another important problem of identifying the effect of international technology transfer is the endogeneity of participation in international activities. Firms with a better skilled workforce, capable of using a more advanced technology, are more likely to participate in international activities (Yeaple, 2005).

In this thesis we study whether firm specific relationships with foreign firms like foreign ownership, supplying MNEs, exporting and importing are conduits of technology transfer and their effects on firm productivity and demand for skilled labour in 26 countries in transition in ECA. The data, which is described in Chapter 2, comes from Business Environment and Enterprise Performance Survey (BEEPS) 2002-2005, which was conducted by the World Bank and European Bank for Reconstruction and Development (EBRD) to study the perceptions and performance of firms in the private sector in transition economies in ECA. This data allows us to address many of the problems mentioned above. It contains precise information on several firm specific relationships with foreign firms (foreign ownership, supplying MNEs located in the same country, exporting and importing), information necessary to calculate firm productivity, and information on the main characteristics related to absorptive capacity and workforce skills. It also contains information on all the main channels of international technology transfer and on a range of firm characteristics and environment which allows us to isolate better the effect of international

technology transfer. It also contains a small panel component, which we use to address the issues related to endogeneity of participation in international activities.

In Chapter 3 we study the relative importance of foreign ownership, FDI intraindustry spillovers, FDI spillovers through backward linkages with MNEs, exporting and importing as channels of international technology transfer for firms in 26 transition countries in ECA region. As mentioned before there is a very large literature on this topic. However, we are motivated to study this question by the mixed findings in the empirical literature on this topic (Görg and Stobl, 2001; Görg and Greenaway, 2004), the lack of evidence on the relative importance of different channels (Keller, 2004) and the lack of evidence on firm specific measures of access to foreign technology through FDI backward linkages (Javorcik, 2004a; 2008). The main contributions of this analysis is that it studies several of the most important channels of international technology transfer in a simultaneous framework and that we use firm-specific measures for FDI spillovers through backward linkages. The results suggest that foreign ownership, supplying MNEs, exporting and importing are associated with higher firm productivity. We find no evidence of intraindustry FDI spillovers. These results are consistent with the hypotheses of technology transfer through foreign ownership and relationships with foreign customers, supplying MNEs, exporting and importing material inputs. With regard to the relative importance of different channels of international technology transfer, we cannot reject the hypothesis that these channels are equally important. However, the results from the fixed effects estimation suggest that there is also evidence that the association between participation in these international activities and higher productivity might be due to selection of most productive firms into these activities.

Motivated by the different results on international technology transfer in different countries and by the previous findings in the literature that absorptive capacity at country or at firm level plays an important role in facilitating technology transfer, the empirical analysis in Chapter 4 extends this analysis by studying how absorptive capacity affects technology transfer. There is a large literature on how absorptive capacity affects technology transfer at country and at firm level. Our study improves on this literature by studying both country and firm level absorptive capacity, by using firm specific measure of firm access to foreign technology (foreign ownership, supplying MNEs, exporting and importing) and by using measures of absorptive capacity which are precise and closely related to the concept of absorptive capacity. Our main results show that absorptive capacity is associated with higher firm productivity, but there is no evidence of an interaction effect between country or firm level absorptive capacity and participation in international activities.

In Chapter 5, we study empirically how participation in international activities affects firms' demand for skilled labour and the ways in which firms respond to changes in demand for skilled labour. The main contributions to the literature are: studying two related ways in which firms respond to changes in the demand for skills (changing the share of labour with the required skills in total employment and training their employees), examining several measures of international integration (foreign ownership, exporting, importing and supplying MNEs), one of which, supplying MNEs, has not been researched before and using several empirical, which allows us to study causal effects. Using the panel dimension of our survey, we test whether the relationship between skill upgrading and international integration is robust to controlling for unobserved fixed firm characteristics. In addition, we

explore information on firms starting, continuing and stopping to participate in international activities to examine whether firms upgrade the skills of their workforce after starting to participate in international activities or whether firms with better skilled workforce select into participation in international activities. Our results suggest that firms engaged in international activities have a better skilled workforce in terms of employees' education, occupational structure and provision of training to both production and nonproduction employees than domestic firms. However, this happens because firms with better skilled workforces and with formal training programmes select into participating in international activities, and not because these firms upgrade the skills of their workforces after starting to participate in international activities.

Chapter 6 concludes and discusses the main contributions and the main limitations of the studies included in the dissertation.

Chapter 2 Data Description

The data used in the empirical analyses comes from plant level datasets BEEPS 2002 and 2005. BEEPS 2002 and 2005 were conducted by the World Bank and EBRD with the objective to gather information on firms' performance and perception of the business environment in private sector in transition economies in ECA region. There is also a BEEPS 2009 wave from the same survey. However, we decided not to use that wave because it does not contain information on some of the main variables of interest for this study, including whether or not a firm supplies MNEs located in the same country, and because the survey and the questionnaire differ considerably from the previous waves.

In this chapter we will describe the main characteristics of the survey and explain why it is suitable for our empirical analyses. The implementation of the BEEPS 2002 and BEEPS 2005 was carried out by Synovate on behalf of the World Bank and EBRD. Their implementation is described in detail in Synovate (2002, 2005).

The survey uses standardised questionnaires and uniform sampling methods to generate internationally comparable data. This allows us to pool data for different countries and to examine whether the effect of participation in international activities on productivity and labour skills differs across countries. Information about the plants' characteristics is gathered through interviews with the general manager of the plant and other members of the staff, for instance, accountants or human resources managers.

The surveys cover a wide range of topics, including firm participation in international activities, firm performance and several measures of workforce skills. The dataset contains information on firms' participation in several international activities: foreign ownership, sales to MNEs located in the same country, exporting and importing. It is important that the dataset contains information on all these activities because the literature suggests that all of them are important channels of technology transfer and that most of the firms which are globally engaged tend to participate in several international activities simultaneously. Related to this, it is important to mention that the dataset contains plant level information on the share of output sold to MNEs, which is a precise and firm specific measure of MNEs backward linkages with local firms. The survey also contains information on sales, capital, labour, material inputs and energy, which allows us to calculate firm productivity. It also contains information on several measures of workforce skills including workforce composition by education and occupation categories and provision of training, which allows us to examine different ways in which firms respond to changes in demand for skilled labour.

The survey covers a recent period. BEEPS 2002 survey was conducted between 19th of June and 31th July 2002. BEEPS 2005 was conducted between 10th of March and 20th of April 2005. In these two surveys, most of the information refers to the current year (2002 and respectively 2005), but some of the information refers to the previous years (2001 and respectively 2004). With regard to our main variables of interest, data on participation in international activities, employment and labour force skills refers to the current year and information related to sales, capital, and material

inputs and data on formal training programmes refers to 2001 and 2004, respectively. To avoid confusion, we will refer to the year of the survey.

BEEPS 2002 and 2005 cover 26 transition economies in ECA region The countries included in 2002 are: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Georgia Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, FYROM, Moldova, Poland, Romania, Russia, Serbia and Montenegro, Slovakia, Slovenia Tajikistan, Ukraine and Uzbekistan[1].

Plants surveyed were selected from the population of registered plants in each country. The survey covers firms with at least 2 full-time employees and less than 10000 full-time employees. In both waves plants that operate in health, education, welfare, public administration, agriculture, electricity, gas, water and water waste and financial intermediation sectors were excluded. The surveys included only firms that started operation at least three years before the survey.

For both waves quota sampling was used. In quota sampling, the population is first segmented into mutually exclusive sub-groups and then judgment is used to select the subjects or units from each segment based on a specified proportion. The sample was segmented by sector and size category and in case of larger economies by region. The share of plants in industrial sectors[2] and in service sectors is determined by the contribution of industrial and service sectors to the GDP in each country. The plant size categories used in these waves are: small (2 to 49 employees), medium (50

[1] Turkmenistan is not included because of lack of data.
[2] Industry is defined here as including manufacturing, construction and mining and quarrying (Synovate, 2002, 2005)

to 249 employees) and large (more than 249 employees). The number of employees was defined as the number of full time permanent employees. The survey used judgmental adjustments to provide a better mix of the firms within industry and services sectors because they wanted the survey to reflect the performance and the perception of the business environment of different kinds of firms in the private sector. The aim was that 10% of the sample in each country should be foreign owned[3], state owned[4] and exporters[5] and firms located in small towns/countryside[6]. However, in some countries, especially smaller or less developed economies these quotas and the quota for large firms could not be met mainly due to the small number of such firms. In these cases, the quotas were eased or completely removed (Synovate, 2002, 2005).

The dataset contain two cross sections: 2002, which contains 6153 plants, 2005, which contains 9098 plans. It also contains one panel component, which contains 1025 plants. Next, we will examine how this cross sections and panel differ with regard to country, sector and firm size category composition.

Table 2.1 shows the sample composition by country.

[3] Firms were considered foreign if at least 50% of the capital was foreign owned (Synovate, 2002, 2005)
[4] Firms were considered state owned if at least 50% of the capital was state owned (Synovate, 2002, 2005)
[5] Firms were considered exporters if they exported at least 20% of their output (Synovate, 2002, 2005)
[6] Small towns/ countryside were defined as a town with less than 50 000 inhabitants.

Table 2.1 Sample composition by country

Country	2002		2005		2002 & 2005	
	Plants	%	Plants	%	Plants	%
Albania	170	2.8	204	2.2	60	5.9
Armenia	171	2.8	351	3.9	30	2.9
Azerbaijan	170	2.8	350	3.9	45	4.4
Belarus	250	4.1	325	3.6	33	3.2
Bosnia and Herzegovina	182	3.0	200	2.2		
Bulgaria	250	4.1	300	3.3	51	5.0
Croatia	187	3.0	236	2.6	47	4.6
Czech Republic	268	4.4	343	3.8	32	3.1
Estonia	170	2.8	219	2.4	51	5.0
Georgia	174	2.8	200	2.2	38	3.7
Hungary	250	4.1	610	6.7	44	4.3
Kazakhstan	250	4.1	585	6.4	45	4.4
Kyrgyz Republic	173	2.8	202	2.2	28	2.7
Latvia	176	2.9	205	2.3	43	4.2
Lithuania	200	3.3	205	2.3	45	4.4
Macedonia, FYR	170	2.8	200	2.2	16	1.6
Moldova	174	2.8	350	3.9	16	1.6
Poland	500	8.1	975	10.7	69	6.7
Romania	255	4.1	600	6.6	57	5.6
Russian Federation	506	8.2	601	6.6	35	3.4
Serbia and Montenegro	250	4.1	300	3.3	26	2.5
Slovakia	170	2.8	220	2.4	24	2.3
Slovenia	188	3.1	223	2.5	53	5.2
Tajikistan	176	2.9	200	2.2	10	1.0
Ukraine	463	7.5	594	6.5	111	10.8
Uzbekistan	260	4.2	300	3.3	16	1.6
Total	6153	100	9098	100	1025	100

Source: BEEPS 2002 & 2005

The table shows that the country composition is similar across the two cross sections and the panel sample. Firms in Bosnia and Herzegovina do not appear in the panel because the serial numbers for the firms in this country for 2002 were not available.

Sector of activity of a firm is defined based on the 4 digit ISIC Revision 3.1 code of the main output as indicated by the firm. According to the implementation notes on the survey this is the most accurate variable to classify firm by sector. In the panel, we defined the sector of the firm as the sector in which the firm operated the first

time it appears in the panel, although there are firms that change their sector of activity. Table 2.2 shows the sector composition of the samples used in this study.

Table 2.2 Sample composition by sector

Sector of activity	2002		2005		2002 & 2005	
	Plants	%	Plants	%	Plants	%
Mining and quarrying	70	1.1	93	1.0	15	1.5
Construction	775	12.6	889	9.8	115	11.2
Manufacturing	1534	24.9	3600	39.6	235	22.9
Transport, storage and communication	496	8.1	599	6.6	78	7.6
Wholesale and retail trade	1862	30.3	2184	24.0	269	26.2
Real estate, renting and business services	641	10.4	801	8.8	172	16.8
Hotels and restaurants	384	6.2	467	5.1	54	5.3
Other services	391	6.4	465	5.1	87	8.5
Total	6153	100	9098	100	1025	100

Source: BEEPS 2002 & 2005

The 2002 and 2005 samples and the panel sample are very similar in their sectoral composition. The main difference is that 2005 sample contains a larger share of manufacturing firms and a lower share of wholesale and retail trade firms than 2002 sample.

For the size category, we use the classification in the 2002 and 2005 surveys: small (less than 50 employees), medium (50 to 249 employees) and large (250 or more employees). For the panel, we used the size of the firm when it first appears in the survey, although of course firms can change their size over time. In some samples the number of observations is smaller than in the previous tables. This happens because not all the firms responded to the question regarding the number of employees. Table 2.3 shows the size composition of the samples used in this study.

Table 2.3 Sample composition by size categories

Size category	2002		2005		2002 & 2005	
	Plants	%	Plants	%	Plants	%
Small (< 50 employees)	4157	67.6	6418	70.5	713	69.5
Medium (50 -249 employees)	1140	18.5	1797	19.8	177	17.3
Large (>249employees)	856	13.9	883	9.7	135	13.2
Total	6153	100	9097	100	1025	100

Source: BEEPS 2002 & 2005

It can be noticed that the distribution by size categories is very similar in all samples. In almost all samples around 70% of the firms have less than 50 employees, around 20% are medium firms (have between 50 and 249 employees) and around 10% of the firms are large (have 250 employees or more).

Overall, the cross section and panel samples considered are similar in terms of composition by country, sector and size categories except for a few differences due to changes in the surveys.

In conclusion, this dataset is very suitable for studying the effect of international technology transfer on productivity and on skill upgrading for several reasons. First, it contains plant level information on the most likely channels of international technology transfer, information necessary to calculate firm productivity and several measures of labour skills. Information on all the most important channels of international technology transfer channels (foreign ownership, supplying MNEs, exporting and importing) allows us to study the effect of all these channels simultaneously. The fact that it contains firm specific measure of MNEs backward linkages is important because this measure reflects local plants' access to MNEs technology more precisely than the industry level measures used in previous studies, such as Javorcik (2004a) and Blalock and Gertler (2008). Information on a number

of measures of labour skill allows us to study how globalisation affects demand for different kinds of skills. Secondly, data contain comparable information for 26 transition economies, which makes it possible to study these questions in a multicountry framework, and also comparable information for firms in manufacturing and in services sectors, on which there is less research. Finally, the data covers a recent period. The main disadvantage of this dataset is that the panel component is very limited, but as the descriptive analysis above shows it is similar to the main samples in terms on country, sector and size categories composition.

Chapter 3 Which International Technology Transfer Channels Are Effective in Raising Firm Productivity?

3.1 Introduction

Firms that want to upgrade their technology can either develop new technology themselves, through R&D activities, or acquire it from other firms. However, most of the creation of new technology is concentrated in a few industrialised economies. For instance in 2004, the seven largest industrialised countries accounted for more than 86% of all patents granted by USPTO (USPTO, 2008). Therefore, adoption of new technology is determined in large part by the diffusion of technology across international borders, especially in the case of developing countries and transition economies.

The theoretical literature on this topic suggests that FDI (Markusen, 2002), horizontal FDI spillovers (Wang and Blomström, 1992; Görg and Greenaway, 2004), FDI spillovers through backward linkages (Javorcik, 2004a), imports of intermediate inputs (Coe and Helpman, 1995) and learning by exporting (Greenaway and Kneller, 2007) are the main conduits for international technology diffusion.

There is a large literature that examines empirically these potential channels of technology transfer surveyed by Keller (2004, 2009) and Saggi (2002). In addition, empirical studies on FDI were surveyed by Blomström and Kokko (1998), Görg and Strobl (2001), Barba Navaretti and Venables (2004) and Görg and Greenaway (2004) and empirical studies on international trade and productivity were surveyed by Greenaway and Kneller (2007) and Wagner (2007).

The empirical evidence on technology transfer through these channels is mixed. There is considerable evidence that suggest that foreign owned firms are more productive than domestic owned firms. However, there is also evidence that these differences might be due to foreign investors buying the most productive domestic firms, or due to foreign firms, being larger or using more resources per worker. The empirical evidence for intra-industry FDI spillovers is mixed and in developing and transition countries most studies have found that intra industry FDI spillovers are insignificant or even negative (Görg and Greenaway, 2004). There is more evidence consistent with productivity spillovers through backward linkages (Javorcik, 2004a; Blalock and Gertler, 2008; Javorcik and Spatareanu, 2008; 2009). There is considerable evidence that exporters and importers are more productive and domestic firms, but there is also evidence that this is due to self selection of the most productive firms into exporting and importing.

Although there is a large empirical literature on each of these channels of international technology diffusion, most empirical studies provide only partial evidence on one channel (Keller, 2004). Most of studies on FDI examine how FDI affects firm productivity directly and indirectly through vertical and horizontal spillovers, but do not take into account the effect of participation in international trade. Similarly, studies on international trade focus on exporting or importing or both of them, but do not take into consideration the effect of FDI. There is little evidence on the relative importance of these different channels, and where this evidence exists, it is usually confined to results from aggregate data. In practice, firms tend to participate simultaneously in several international activities and several studies suggest that there might be complementarities between different international

activities (Kasahara and Lapham, 2008). In this case, not taking into account the effect of different channels of international technology transfer might result in biased estimates.

Another problem in the literature is related to the measurement of spillovers, especially FDI spillovers (Javorcik, 2008; Keller, 2009). Most of the empirical evidence on FDI spillovers relies on industry level measures of access to foreign technology (Javorcik, 2004a; Blalock and Gertler, 2008; Javorcik and Spatareanu, 2008). This methodology assumes that firms within one industry have equal access to foreign sources of technology. However, in practice, firms within one industry differ in their access to foreign sources of technology. MNEs have an incentive to share their technology with their suppliers in order to help them improve the quality of their products and reduce the cost, but not with other firms in the industry.

Motivated by these mixed findings in the empirical literature on this topic and the lack of evidence on the relative importance of different channels and the problems related to the measurement of spillovers through backward linkages mentioned above, we study the relative importance of foreign ownership, FDI intraindustry spillovers, FDI spillovers through backward linkages, exporting and importing as channels of international technology transfer for firms in 26 transition countries in ECA region. We use the BEEPS 2005 and 2002 dataset conducted by the World Bank and EBRD.

We contribute to the literature in several ways. First, we recognise that access to foreign sources of technology will differ across firms within an industry and,

therefore, we use firm-specific measures of global engagement for all channels of international technology transfer except FDI horizontal spillovers. One of the main contributions is that we use firm specific measures for FDI vertical spillovers though backward linkages. Most of the previous studies on FDI productivity spillovers through backward linkages (Javorcik, 2004a; Blalock and Gertler, 2008; Javorcik and Spatareanu, 2008) rely on an industry level measure of foreign presence in downstream industries calculated using input–output tables. This methodology does not identify MNEs suppliers and thus, it assumes that all firms in an upstream industry have access and benefit from the technology MNEs transfer to their local producers. The dataset used here allows one to identify the MNEs' local suppliers and to use a firm-specific measure of linkages with MNEs, which reflects better their access to MNEs' technology.

Second, we analyse the impact of many of the main channels of international technology transfer (foreign ownership, FDI intraindustry spillovers, FDI spillovers through backward linkages, exporting and importing) simultaneously and assess their relative importance. This is important because in practice firms frequently participate in several international activities simultaneously and there might be complementarities between different international activities (Kasahara and Lapham, 2008).

This study is closest to Gorodnichenko *et al.* (2007), who examine similar questions using the same data source. This paper was written simultaneously to this dissertation and without our knowledge. Our study differs from theirs in several ways. First, Gorodnichenko *et al.* (2007) method is to relate changes in sales

revenues to a combination of changes and levels of measures of internalisation. We use a simpler measure which relates levels of productivity to contemporaneous levels of the explanatory variables, as is standard. Second, we extend the sample to include 26 countries rather than the 17 countries used by Gorodnichenko *et al.* (2007). Third, we conduct a number of robustness checks: we consider whether the intensity of global engagement matters; and we relax the assumption that the production function is Cobb-Douglass, we relax the assumptions that the coefficients of production inputs are the same across countries and sectors, we examine whether the relationship is robust to controlling for fixed firm characteristics.

Our results suggest that foreign ownership, supplying MNEs, exporting and importing are associated with higher firm productivity, which is consistent with our hypotheses of technology transfer through these channels. We find no evidence that intraindustry FDI spillovers are associated with higher firm productivity. With regard to the relative importance of different channels of international technology transfer, we cannot reject the hypothesis that foreign ownership, supplying MNEs and exporting and importing are equally important.

The chapter is organised as follows. Section 3.2 reviews the theoretical and empirical literature on this topic. Section 3.3 describes the data used and provides preliminary evidence of the relationship between firm performance and participation in international activities. Section 3.4 explains the methodology used to study the effect of engaging in international activities on productivity and productivity growth. Section 3.5 presents and discusses the main results and robustness checks. Section 3.6 concludes.

3.2 Literature Review

This section reviews the economic theory and the empirical evidence on these channels of international technology diffusion.

3.2.1 Review of Theoretical Literature

Technology transfer through FDI implies a direct transfer of technology from parent MNE to its foreign affiliates and has long been considered one of the major channels of international technology transfer. Most of the literature on multinationals suggests that MNEs must possess some firm specific advantages in order to compete successfully with domestic firms which have better knowledge of their local environment (Dunning, 1993). These advantages consist of firm-specific, knowledge-intensive assets, which can take the form of superior technology and business practices, reputation, trademarks or other assets. According to the knowledge capital model (Markusen, 2002) an important feature of firm specific knowledge intensive assets is that the services of these knowledge based assets can be used simultaneously at different locations. This way these knowledge based assets give rise to firm level, or multiplant economies of scale. When an MNE undertakes foreign production it exports services of these firm specific assets to its foreign affiliates. In turn, this means that foreign affiliates of MNEs should benefit from this knowledge transfer (Markusen, 2002) and this should reflect in higher productivity of foreign owned firms compared to domestic owned firms.

FDI affects not only the foreign affiliates that receive technology from their parent MNEs, but also other domestic firms in the host country with which foreign affiliates interact as competitors, customers or suppliers. Blomström and Kokko (1998) define productivity spillovers from FDI as an increase in productivity of the domestic firms

as a result of the presence of MNEs. As this definition suggests, productivity spillovers from FDI represent an indirect channel of technology transfer from MNEs to other firms than their foreign affiliates. Also, it is important to notice that this definition of FDI spillovers includes both productivity gains from technology transfer from foreign firms but also productivity gains resulting from the effects of FDI on market structure. The literature on the productivity spillovers from FDI distinguishes between horizontal spillovers (spillovers to firms in the same industry as the foreign affiliate) and vertical spillovers (spillovers to firms in upstream or downstream industries).

Horizontal spillovers are productivity spillovers from foreign firms in the same industry. The establishment of foreign affiliates in a host country may affect domestic firms in the same industry through several mechanisms. Exposure to MNEs products and practices helps local firms learn about new technology, new products or new marketing techniques (Wang and Blomström, 1992). Local firms may hire workers who were previously employed and trained by MNEs and thus have knowledge of technology and business practises used by MNEs (Fosfuri *et al.*, 2001). Increased competition from foreign owned firms may induce the local firms to reduce their inefficiencies and allocate more resources for learning from foreign affiliates and adopting new technology (Wang and Blomström, 1992). Foreign affiliates may also have a negative impact on local firms. By paying higher wages MNEs may limit labour turnover and even attract the best workers away from domestic firms. In addition, the entry of MNEs may result in the loss of local firms' market share, which will force them to operate on a less efficient scale and, thus, decrease their productivity (Aitken and Harrison, 1999).

Another channel for productivity spillovers from MNEs to domestic firms is linkages established by MNEs with local suppliers (backward linkages) and local customers (forward linkages). MNEs may benefit from transferring technology or business practices, such as quality control or inventory management techniques, to their suppliers to enable them to produce higher quality intermediated inputs, improve their on-time delivery, and lower prices. There is anecdotal and survey evidence that MNEs offer assistance to their local suppliers. There are several theoretical models that suggest how local firms may benefit from supplying MNEs. Pack and Saggi (2001) propose a theoretical model in which firms from industrialised countries transfer technology to their suppliers in developing countries in order to enable their suppliers to lower the prices of inputs. Lin and Saggi (2007) develop a similar theoretical model in which MNEs have an incentive to transfer technology to their suppliers in developing countries, but only if they accept an exclusivity clause that prevents them from selling the MNEs' rivals. Local suppliers accept the contract only if the benefits from the technology transfer from MNEs and the MNEs demand for their output transfer exceeds a certain threshold. MNEs may improve the performance of suppliers without transferring technology to them. In the presence of economies of scale, increased demand for their output will generate productivity gains for MNEs suppliers (Markusen and Venables, 1999). Another situation in which MNEs may improve the performance of suppliers without transferring technology is when MNEs impose tougher requirements regarding product quality, on time delivery and costs, but without offering any assistance (Javorcik, 2008). In order to comply with these requirements, domestic suppliers improve their production process and this increases their productivity.

The second major channel of international technology transfer is international trade. Theoretical models by Ethier (1982), Markusen (1989) and Grossman and Helpman (1991) show that firms that import intermediate inputs can enjoy productivity gains due to access to a greater number of varieties of inputs or inputs of higher quality that embody new more advanced technology. International technology transfer can take place also through learning by exporting. Interactions with foreign competitors and customers provide information on new products and technology that allows exporters to reduce costs and to improve quality (Greenaway and Kneller, 2007). Foreign customers might offer technical assistance to exporting firms to improve their products and technology in order to fulfil their requirements regarding quality and costs (Pack and Saggi, 2001). This is particularly true in the case of developing countries. Exporting may also lead firms to increase their production and, in the presence of economies of scale, their productivity will increase. Finally, exposure to intense competition in international market may force firms to become more efficient by reducing X inefficiency (Greenaway and Kneller, 2007).

3.2.2 Review of Firm Level Empirical Studies

There is a large literature that examines empirically these potential channels of technology transfer at firm level. General surveys on international technology transfer are provided by Keller (2004, 2009) and Saggi (2002), and for technology transfer through FDI by Görg and Strobl (2001) and Görg and Greenaway (2004) and for learning by exporting by Greenaway and Kneller (2007) and Wagner (2007). This survey of the empirical evidence on international technology transfer will concentrate on the evidence for transition and developing countries.

Most empirical studies on international technology transfer investigate whether a particular measure of exposure to foreign technology is associated with higher productivity or productivity growth after controlling for other firm characteristics that may affect firm productivity. This is done by estimating a production function augmented with a variable that measures exposure to foreign technology. They estimate variants of the following specification:

$$\ln Y_{it} = \alpha_i + \beta_K K_{it} + \beta_L L_{it} + \beta_{FT} FT_{it} + \beta_X X_{it} + u_{it}$$

In this specification the natural logarithm of output or value added of the firm *i* at time *t* is regressed on production inputs (*L* and *K*) and a measure of foreign technology (*FT*), other control variables including time, industry and region dummies. A positive and significant coefficient of the variable that measures foreign technology is interpreted as evidence consistent with international technology transfer hypothesis.

The channels through which a firm has access to foreign technology are one or several of the following: foreign ownership, horizontal FDI spillovers, FDI spillovers through backward linkages, exporting and importing intermediate inputs.

Foreign ownership is usually measured as a dummy variable that takes the value 1 if 10% or more of the firm's equity is foreign owned and 0 otherwise, although there are also studies that measure foreign ownership as the share of equity that is foreign owned (Aitken and Harrison, 1999; Javorcik, 2004a) and studies which distinguish between minority foreign owned firms and majority foreign owned firms (Djankov and Hoekman, 2000, Damijan *et al.* 2003; Yudaeva *et al.* 2003).

The most commonly used measures for foreign presence in a sector are the share of output accounted for by foreign firms in the total of output of the industry or the share of employment accounted for by foreign firms in the total employment in the industry.

FDI spillovers through backward linkages are usually measured as the foreign presence in downstream sectors from the point of view of local firms and it is usually calculated as:

$$Backward\_Linkages_{jt} = \sum_k \alpha_{jk} Horizontal_{kt}$$

In this formula, k is a sector downstream of sector j. $Horizontal_{kt}$ measure the foreign presence in a downstream sector calculated in terms of output at time t. α indicates the percentage of output of sector j that is supplied to sector k and it is taken from input output tables. These measures were used by Javorcik (2004a), Javorcik and Spatareanu (2008) Blalock and Gertler (2008) and Nicolini and Resmini (2010). This measure of backward linkages has several disadvantages. First, it assumes that all the firms in an industry use the same technology, the one specified in the input output tables. Second, it does not identify MNEs suppliers and, thus, it assumes that all firms in an upstream industry have access and benefit from the technology MNEs transfer to their local suppliers. However, MNEs have incentives to transfer their technology only to their suppliers and therefore the access to MNEs' technology may differ across firms within an industry. Recently several studies used firm level measures of supply linkages with MNEs (Gorodnichenko *et al.*, 2007; Javorcik and Spatareanu, 2009; Vacek, 2010). These studies measure supply linkages with MNEs either as a dummy variable that takes the value 1 if the firm sells part of its output to

MNEs (Javorcik and Spatareanu, 2009) or measure that take into account the share of output sold to MNEs (Gorodnichenko *et al.*, 2007; Vacek, 2010).

Most common measure of exporting is an indicator value that distinguishes between firms that export part of their output and firms that do not export (Bernard and Jensen, 1995; Bernard and Wagner, 1997; Bernard and Jensen, 1999; Castellani, 2002). Several studies also measured exporting as the share of output exported (Castellani, 2002; Kraay, 1999; Girma *et al.*, 2004). Similar measures are used for importing.

One of the main problems with estimating the effect of participation in international activities on productivity using the specification above is the possible endogeneity of the participation in international activities. Foreign owned firms tend to acquire the most productive domestic firms (Djankov and Hoekman, 2000). Entering export markets requires sunk costs, such as market research, establishment of distribution and logistics networks, and modification of the existing products to comply with different regulation and different consumer tastes, and therefore only most productive firms will self select into exporting (Melitz, 2003). Many studies found evidence of self selecting of the most productive firms into exporting (Bernard and Jensen, 1995; Bernard and Wagner, 1997; Bernard and Jensen, 1999; Castellani, 2002). Supplying MNEs located in the same country may be associated with similar sunk costs because MNEs tend to have higher requirements than domestic firms in terms of quality, on time delivery and prices (Javorcik, 2008; Javorcik and Spatareanu 2009). Javorcik and Spatareanu (2009) found evidence selection of the most productive domestic firms in supplying MNEs in Czech Republic. Importing

material inputs may also be associated with sunk costs. These costs could be related to the complexity of the organisation of production (Altomonte and Bekes, 2009). Kasahara and Lapham (2008) and Altomonte and Bekes (2009) found evidence that the most productive firms self select into importing in Chile and Hungary, respectively.

If participation in international activities is endogenous, as studies mentioned above suggest, than firms that are foreign owned, supply MNEs, export or import might have higher productivity *ex ante*. In this case $ForeignTechnology_{it}$ is correlated with u_{it} and then the estimates of β_{FT} will partly reflect these correlations and the estimated effect will be larger than the causal impact. Fixed effects estimation can be used to mitigate this problem if the selection into participating in foreign activities is caused by fixed differences between firms. Many studies use this method. However, fixed effects estimation does not solve the problem of time varying omitted variables which might be correlated with participation in international activities. In order to deal with this problem many studies use instrumental variables or GMM methods.

Another problem related to estimating the equation above is the potential correlation between input levels and the unobserved productivity shocks (Olley and Pakes, 1996). These shocks are firm specific productivity shocks which are not observed by the econometrician, but they are observed by the firm and therefore they affect the inputs employed. Under these circumstances, the OLS estimates of the coefficients of the inputs and the total factor productivity calculated using these estimates are biased (Olley and Pakes, 1996; Levinsohn and Petrin, 2003). To address this concern, more recent empirical studies (Keller and Yeaple, 2009; Javorcik, 2004a;

Nicolini and Resmini, 2010) use the semiparametric methods developed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) to estimate total factor productivity. Most empirical studies report the results from different estimations in order to deal with all these potential problems.

The effect of foreign ownership on firm productivity has been studied extensively in the context of transition economics. Most studies found that foreign owned firms are more productive than domestic owned firms, but also that these differences might be due to foreign investors buying the most productive domestic firms, or due to foreign firms being larger or using more resources per worker. After controlling for these characteristics the effect of foreign ownership on productivity is mixed. Djankov and Hoekman (2000) provide evidence that foreign owned firm in Czech Republic grow faster in terms of total factor productivity than domestic firms. Kinoshita (2000) found that foreign ownership has no significant impact on firm productivity in Czech Republic. Konings (2001) provides evidence that foreign owned firms perform better than domestic owned firms in Poland, but not in Bulgaria and Romania. Yudaeva *et al.* (2003) find that foreign owned firms in Russia are more productive than domestic owned firms. Damijan *et al.* (2003) find that foreign owned firms grow faster than domestic owned firms in Czech Republic, Estonia, Poland, Romania and Slovenia, but not in Bulgaria, Hungary and Slovakia.

Despite the theoretical justification for potential horizontal FDI spillovers the evidence, most studies on transition economies found evidence of insignificant or even negative spillovers. Aitken and Harrison (1999) find evidence of negative spillovers for domestic firms in Venezuela. Djankov and Hoekman (2000) find

similar evidence of negative spillovers for domestic firms in Czech Republic. Konings (2001) find evidence of insignificant FDI spillovers to domestic firms in Poland and negative spillovers in Bulgaria and Romania. Damijan *et al.* (2003) study the horizontal spillovers in eight transition countries and find evidence of positive horizontal spillovers for domestic firms only in Romania and negative spillovers in Czech Republic and Poland and insignificant spillovers for domestic firms in Bulgaria, Estonia, Hungary, Slovakia and Slovenia. Yudaeva *et al.* (2003) found positive spillovers for domestic firms in Russia and Sinani and Meyer (2004) found positive spillovers for domestic firms in Estonia. Halpern and Muraközy (2007) found insignificant horizontal spillovers for domestic firms in Hungary, except for the firms which are located close to foreign owned firms which benefit from positive spillovers.

Most of the econometric studies on backward linkages in developing and transition countries find evidence of productivity spillovers through backward linkages. Evidence of positive spillovers though backward linkages are found by Javorcik (2004a) for Lithuania, Halpern and Muraközy (2007) for Hungary, Gorodnichenko *et al.* (2007) for 17 transition economies, Blalock and Gertler (2008) for Indonesia, Javorcik and Spatareanu (2008) for Romania, Javorcik and Spatareanu (2009) and Vacek (2010) for Czech Republic, Nicolini and Resmini (2010) for Bulgaria, Poland and Romania. In addition, there is both anecdotal and survey evidence that MNEs assist their local suppliers with financing, improving the quality of their product and upgrading the skills of their workforce (Javorcik, 2008; Javorcik and Spatareanu, 2009; Vacek, 2010).

There is also considerable evidence of technology transfer through intermediate inputs as conduits for technology transfer at country level (Coe and Helpman, 1995; Coe, Helpman and Hoffmaister, 1997). At firm level there is considerable evidence that importers are more productive than firms that do not import (Amiti and Konings, 2007; Kasahara and Rodrigue, 2008, Altomonte and Bekes, 2009, Muûls and Pisu, 2009; Andersson *et al.* 2008), but also that this difference in productivity might be due to self selection into importing Altomonte and Bekes (2009). A few studies like Amiti and Konings (2007), Kasahara and Rodrigue, (2008) and Andersson *et al.* (2008) found evidence that firms improve their productivity through importing after controlling for self selection.

The evidence on learning by exporting is also mixed. Most empirical studies found evidence that firms self select into exporting, but no evidence that participating in exporting increases firm productivity (Bernard and Jensen, 1995; Bernard and Wagner, 1997; Bernard and Jensen, 1999; Castellani, 2002). However, there are a few studies that found evidence of learning by exporting. Two studies that analysed whether firms learn by exporting in countries in transition are Damijan *et al.* (2007) and De Loecker (2007). Both studies focused on Slovenia and both found evidence of learning by exporting after controlling for self selection and both found that this effect is stronger for firms that export to high-income countries.

Overall, despite the predictions of the theoretical literature that FDI, productivity spillovers from FDI (horizontal and vertical), imports of intermediate inputs and exporting are conduits for international technology diffusion empirical evidence is ambiguous. Most empirical studies on international technology transfer found that

exposure to foreign technology through foreign ownership, supplying MNEs, exporting and importing are associated with higher productivity, while horizontal FDI spillovers are often associated with insignificant or negative effects on productivity. There is also evidence that the differences in productivity between domestic and foreign owned firms, MNEs suppliers, exporters and importers might be due to selection of most productive firm in participation in these international activities. In addition, most studies provide only partial evidence on one channel of international technology transfer and most of the studies on FDI use industry level measures of FDI spillovers. We address some of these issues by studying international technology transfer in a large number of transition economies in ECA region using firm-specific measures of global engagement for all the main channels of international technology transfer.

3.3 Data Description

The data used in this chapter comes from BEEPS 2005 and 2002 dataset conducted by the World Bank and EBRD. The main characteristics of the survey are described in the previous chapter. The sample of firms used in the empirical analyses is smaller than the original dataset because a large number of plants do not report data on sales, capital, material inputs or energy, imports, exports and share of output sold to MNEs[7]. The sample used in the empirical analysis excludes observations with missing values for these variables, observations with negative value added and observations in the lowest and highest percentile of the distribution of capital per worker. After excluding these observations the sample is reduced from 9098 to 3690 observations for 2005 wave, and from 6153 to 2880 observations for 2002. We compare the sample used in the empirical analysis with original sample with regard

[7] The main reason for this appears to be that firms were reluctant to provide this information despite reassurances of confidentiality Synovate (2002, 2005).

to distribution across countries, sectors and size categories. In Table 3.1, we summarise the distribution of the sample across countries.

For 2005, the number of firms in the sample used in the empirical analysis is much smaller in several countries (Azerbaijan, Belarus, Kazakhstan, Russia and Uzbekistan) than in the original dataset. In these countries, either a large share of firms did not provide the necessary information, or, in the case of Azerbaijan, the information provided not was considered accurate and reliable by Synovate (Synovate, 2005).

Table 3.1 Sample composition by country

Country	2002				2005			
	All sample		Regression sample		All sample		Regression sample	
	Plants	%	Plants	%	Plants	%	Plants	%
Albania	170	2.8	99	3.4	204	2.2	100	2.7
Armenia	171	2.8	63	2.2	351	3.9	200	5.4
Azerbaijan	170	2.8	36	1.3	350	3.9	-	-
Belarus	250	4.1	179	6.2	325	3.6	67	1.8
Bosnia and Herzegovina	182	3.0	83	2.9	200	2.2	73	2.0
Bulgaria	250	4.1	102	3.5	300	3.3	135	3.7
Croatia	187	3.0	75	2.6	236	2.6	134	3.6
Czech Rep.	268	4.4	107	3.7	343	3.8	243	6.6
Estonia	170	2.8	90	3.1	219	2.4	114	3.1
Georgia	174	2.8	67	2.3	200	2.2	81	2.2
Hungary	250	4.1	158	5.5	610	6.7	369	10.0
Kazakhstan	250	4.1	119	4.1	585	6.4	106	2.9
Kyrgyzstan	173	2.8	60	2.1	202	2.2	90	2.4
Latvia	176	2.9	94	3.3	205	2.3	94	2.6
Lithuania	200	3.3	144	5.0	205	2.3	124	3.4
Macedonia, FYR	170	2.8	43	1.5	200	2.2	87	2.4
Moldova	174	2.8	94	3.3	350	3.9	65	1.8
Poland	500	8.1	184	6.4	975	10.7	622	16.9
Romania	255	4.1	131	4.6	600	6.6	244	6.6
Russia	506	8.2	179	6.2	601	6.6	111	3.0
Serbia and Montenegro	250	4.1	53	1.8	300	3.3	117	3.2
Slovakia	170	2.8	78	2.7	220	2.4	95	2.6
Slovenia	188	3.1	112	3.9	223	2.5	111	3.0
Tajikistan	176	2.9	119	4.1	200	2.2	47	1.3
Ukraine	463	7.5	309	10.7	594	6.5	212	5.8
Uzbekistan	260	4.2	102	3.5	300	3.3	49	1.3
Total	6153	100	2880	100	9098	100	3690	100

Source: BEEPS 2002, 2005

The dataset provides the 4 digit industry codes for the main line of product or service of the firm. The survey uses ISIC Revision 3.1 codes. In many 2 digit sectors the number of plants is very small. Therefore, we grouped the sectors by similar activities. Table 3.2 presents the sectors, the corresponding ISIC codes and the number of observations in each sector.

Table 3.2 Sample composition by sector

Sector (ISIC codes)	2002				2005			
	All sample		Regression sample		All sample		Regression sample	
	Plants	%	Plants	%	Plants	%	Plants	%
Mining and quarrying (10, 11, 12, 13, 14)	70	1.1	38	1.3	93	1.0	47	1.3
Construction (45)	775	12.6	440	15.3	889	9.8	401	10.9
Food, beverages and tobacco (15, 16)	381	6.2	196	6.8	1,068	11.7	456	12.4
Textiles, apparel and footwear (17, 18, 19)	205	3.3	87	3.0	679	7.5	277	7.5
Wood and furniture (20, 36)	181	2.9	91	3.2	245	2.7	105	2.9
Paper (21)	23	0.4	14	0.5	24	0.3	15	0.4
Publishing and printing (22)	107	1.7	58	2.0	156	1.7	64	1.7
Chemicals and chemical products (23, 24)	78	1.3	40	1.4	102	1.1	38	1.0
Rubber and plastics (25)	45	0.7	23	0.8	74	0.8	31	0.8
Non metallic mineral products (26)	99	1.6	54	1.9	113	1.2	49	1.3
Basic metals and metal products (27, 28)	151	2.5	95	3.3	630	6.9	338	9.2
Machinery and equipment (29)	120	2.0	58	2.0	359	4.0	156	4.2
Electrical apparatus (31)	65	1.1	35	1.2	51	0.6	28	0.8
Electronics (30, 32)	17	0.3	6	0.2	23	0.3	14	0.4
Precision instruments (33)	18	0.3	7	0.2	33	0.4	16	0.4
Motor vehicles and other transport vehicles (34, 35)	44	0.7	20	0.7	43	0.5	14	0.4
Wholesale and retail trade (50, 51, 52)	1862	30.3	857	29.8	2,184	24.0	855	23.2
Hotels and restaurants (55)	384	6.2	159	5.5	467	5.1	190	5.2
Transport, storage and communications (60, 61, 62, 63, 64)	496	8.1	190	6.6	599	6.6	195	5.3
Real estate, renting and business activities (70, 71, 72, 73, 74)	641	10.4	263	9.1	801	8.8	245	6.6
Other community, social and personal service activities (92, 93)	391	6.4	149	5.2	465	5.1	156	4.2
Total	6153	100	2880	100	9098	100	3690	100

Source: BEEPS 2002 & 2005

Despite the loss of firms compared to the original data source we note that the sector composition of the sample used in the empirical analysis is very similar to the sector composition in the original sample in both years.

Table 3.3 presents the composition of the sample by size categories. The plant size categories used in these waves are: small (2 to 49 employees), medium (50 to 249 employees) and large (more than 249 employees). The number of employees was defined as the number of full time permanent employees.

Table 3.3 Sample composition by size category

Size category	2002				2005			
	All sample		Regression sample		All sample		Regression sample	
	Plants	%	Plants	%	Plants	%	Plants	%
Small	4157	67.6	1846	64.1	6419	70.6	2559	69.4
Medium	1140	18.5	606	21.0	1802	19.8	789	21.4
Large	856	13.9	428	14.9	877	9.6	342	9.3
Total	6153	100	2880	100	9098	100	3690	100

Source: BEEPS 2002 & 2005

The table shows that the composition of the original samples and those used in the empirical analyses are similar with regard to composition across size categories.

Overall, we conclude that the samples used in the empirical analyses and the original sample are similar in terms of composition by country, sector and size categories except the sample used in the empirical analysis is much smaller in Azerbaijan, Belarus, Kazakhstan, Russia and Uzbekistan than in the original dataset.

3.3.1 Participation in International Activities

We use five key measures of exposure to foreign technology. *Foreign-ownership* is measured by a dummy variable indicating whether more than 10% of the plant's capital is owned by foreign investors. *FDI in the sector* within each country is calculated as the share of employment accounted for by foreign plants in total

employment in the sector *j* and country *c* to which the plant belongs[8]. *Supplying MNEs* are measured by a dummy indicating whether the plant sells any of its output to MNEs located in the same country[9]. The definition of *exporting* and *importing* we use includes plants that import and export directly and indirectly, through distributors[10]. Table 3.4 show descriptive statistics for the five measures of exposure to foreign technology.

Table 3.4 Five measures of exposure to foreign technology

	2002		2005	
	Mean	Std. Dev	Mean	Std. Dev
Foreign owned	0.16	0.36	0.11	0.31
FDI in the sector	0.23	0.24	0.23	0.21
MNEs supplier	0.16	0.37	0.16	0.37
Exporter	0.29	0.45	0.29	0.45
Importer	0.59	0.49	0.55	0.50

Source: BEEPS 2002, 2005.

The proportion of foreign owned plants in the selected sample falls from 16% in 2002 to 11% in 2005. This could be due to different quotas of foreign firms of the BEEPS waves. BEEPS 2002 wave aimed to include 15% of foreign owned firms. However, due to the small universe of such firms in several countries, especially smaller ones and less advanced in their transition, the quota was reduced to 10% and in some cases it was reduced even further. BEEPS 2005 aim to include at least 10% of foreign owned firms, but in case this share was difficult to achieve the quota was

[8] Another possible channel of international technology transfer is outward FDI. Unfortunately, we do not have data on outward FDI investments of the firms in the dataset. However, according to UNCTAD (2006), in 2005 more than 95% of the outward FDI in transition economies in ECA came from Russian Federation and it was directed towards other transition economies and most of it was in primary sector. Therefore, we believe that this international activity was not an important channel of international technology transfer during the period studied.

[9] MNEs can also affect local firms through forward linkages. We do not have data on the forward linkages of MNEs with local firms. However, previous studies on this topic in transition economies (Javorcik, 2004; Gorodnichenko *et al*, 2007; Vacek, 2010) found that they do not have a significant effect on local firms.

[10] This is in contrast to previous studies on exporting and importing effects, which typically consider only direct imports and exports. For the purpose of this study, both direct and indirect exports and imports are relevant. Both direct and indirect imports embody technology developed abroad and both direct and indirect exports imply that firms are exposed to competition in export markets and have access to information about new products and /or quality requirements, either directly or through a intermediary firm.

reduced[11]. In both years, around 16% of plants supply MNEs, 29% export some of their output and over half of the firms use imported inputs.

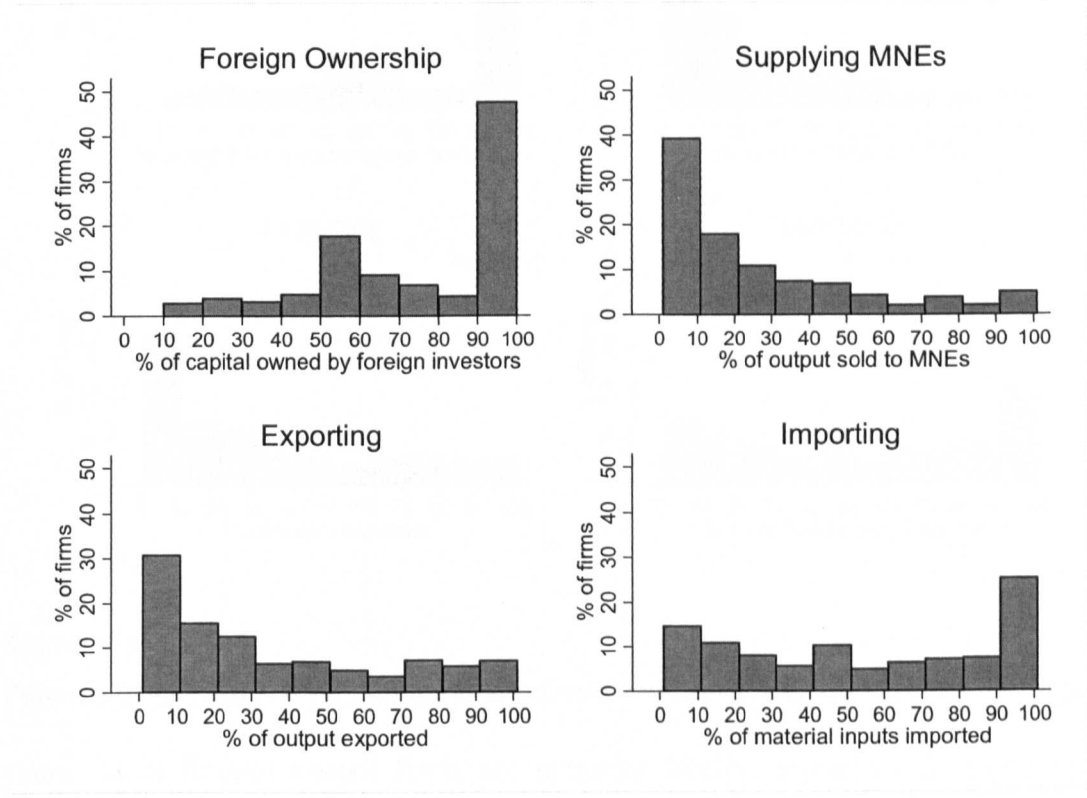
To compare these patterns with the stylized facts regarding participation in international trade documented in previous studies we calculate the share of firms that export and import directly in manufacturing sectors. In 2005, 37.8% of the manufacturing firms exported directly. For comparison, previous studies found that the percentage of manufacturing firms that exports directly was 27% for US (Bernard *et al.*, 2005), 36% for Sweden (Andersson *et al.*, 2008), 41.2% for Belgium (Muûls and Pisu, 2009) and 37.9% for Hungary (Altomonte and Bekes, 2009). The percentage of manufacturing plants that imported material inputs directly is 36.8%. For comparison, Bernard *et al.* (2005) report that 14% of the US firms were importers, Andersson *et al.* (2008) found that 27% of firms import in Sweden, Muûls and Pisu (2009) found that 43.2% of Belgian firms import and Altomonte and Bekes (2009) found the 29.9% of Hungarian firms import. In conclusion, the share of firms that export or import directly is large, but is comparable to the shares found in other small and open European countries.

As well as binary indicators of participation in international activities, we also consider the intensity of participation. For foreign owned plants, intensity is defined as the ratio of foreign owned capital to total capital. For supplying MNEs, intensity is defined as the ratio of sales to MNEs located in the same country to total sales of the plant. Export intensity is the ratio of exports to total sales. Import intensity is the ratio of imports of intermediate inputs in total costs with material inputs. Figure 3.1

[11] The quota for foreign firms in the sample may introduce sample bias. We estimate all the main equations also on the sample of the domestic firms in order to check that our results are not affected by this problem.

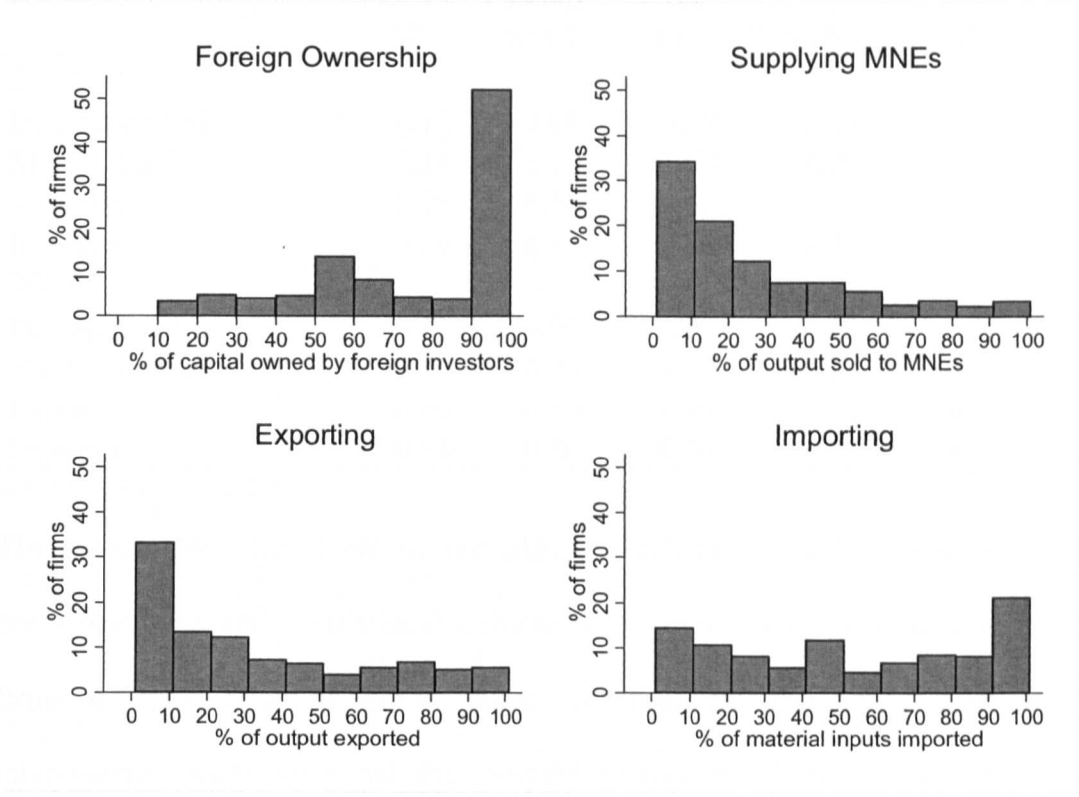
and Figure 3.2 show the distribution of the intensity of foreign ownership, supplying MNEs, exporting and importing among the firms that engage in these activities in 2002 and 2005.

Figure 3.1 Intensity of global engagement (2002)



Source: BEEPS 2002

Figure 3.2 Intensity of global engagement (2005)



Source: BEEPS 2005

Patterns of intensity of participation in international activities are very similar in both years. Most foreign owned firms are majority foreign owned or wholly foreign owned. Most exporters export only a small share of their output; although a significant minority exports more than half of their output (average export intensity is 35%). Similarly, most of the MNEs suppliers sell only a small part of their output to MNEs, but 25% of MNEs suppliers sell more than half of their output to MNEs (average share of output sold to MNEs is 30%). Most importers purchase a large share of their inputs from abroad. 60% of the importers import more than 50% of their material inputs (average import intensity is 56%).

An important aspect of plants' participation in international activities considered is whether firms engage in several international activities simultaneously. Table 3.5 summarises the relationship between participation in international activities.

Table 3.5 Simultaneous participation in different international activities

	All	Foreign owned	MNEs supplier	Exporter	Importer
2002					
Foreign owned	0.16	1.00	0.29	0.29	0.21
MNEs supplier	0.16	0.30	1.00	0.29	0.20
Exporter	0.29	0.54	0.53	1.00	0.39
Importer	0.59	0.81	0.75	0.79	1.00
2005					
Foreign owned	0.11	1.00	0.20	0.22	0.16
MNEs supplier	0.16	0.30	1.00	0.28	0.23
Exporter	0.29	0.59	0.49	1.00	0.41
Importer	0.55	0.80	0.76	0.78	1.00

Source: BEEPS 2002, 2005

The table shows that most of the plants which are globally engaged tend to participate in several international activities simultaneously. For instance, the foreign firms are more likely to export, supply other MNEs, and import part of their intermediate inputs compared than domestic firms. Similarly, plants with supply linkages with MNEs, importers and exporters are more likely to be engaged in other international activities compared with the average plant. In particular, it is clear that firms engaged in all international activities are very likely to use imported inputs. Over 75% of firms involved in international activities other than importing, use imported material inputs. This suggests that there might be complementarities between different international activities. Therefore, it is important to account for all channels of international technology transfer when estimating the impact of participation in these activities on firm productivity.

3.3.2 Characteristics of Internationally Integrated Firms

How do the characteristics of plants engaged in international activities differ from plants which are not involved in those activities? Previous studies have shown that exporters are larger, more productive, pay higher wages, and use more inputs per worker than non exporters (Bernard and Wagner (1997) for Germany, Bernard and

Jensen (1999) for US, among others). Similar evidence has been found for foreign owned firms as compared to domestic firms (Doms and Jensen (1998) for US, Djankov and Hoekman (2000) for Czech Republic) and importers as compared with non importers (Bernard *et al.* (2005) for US, Muûls and Pisu (2009) for Belgium). In this section, we examine whether foreign affiliates, exporter and importers in our sample display similar characteristics. In addition, we study whether suppliers of MNEs have similar characteristics. Table 3.6 reports summary statistics for various plant characteristics for purely domestic firms and for firms engaged in different international activities.

Table 3.6 Characteristics of internationally integrated firms

	Domestic	Foreign owned	MNEs Supplier	Exporter	Importer
2002					
Sales	1069.73	4388.26	4779.60	4115.10	2716.78
Labour	75.63	171.20	221.14	242.80	170.39
Capital	312.39	2269.44	2409.16	1918.78	1206.31
Sales/employee	15.33	27.75	28.92	26.08	22.54
Capital/employee	6.91	13.11	14.04	11.57	9.76
Tertiary education	0.28	0.42	0.40	0.34	0.33
2005					
Sales	1261.91	8314.48	6183.90	7246.76	5061.56
Value added	599.75	3702.18	2937.29	3362.70	2363.59
Labour	44.24	147.92	107.00	152.69	110.07
Capital	426.06	3216.23	2279.67	2872.19	1877.09
Sales/employee	31.49	56.03	54.21	49.87	45.58
Value added/ employee	15.34	25.44	25.11	23.63	20.85
Capital/employee	16.79	22.86	23.28	22.67	20.11
Average wage	4.70	5.91	6.38	6.63	5.70
Tertiary education	0.20	0.34	0.28	0.27	0.26
R&D activities[12]	0.08	0.33	0.28	0.35	0.24

Source: BEEPS 2002, 2005. All the monetary values are in current '000s USD

Table 3.6 shows that foreign firms, suppliers of MNEs, exporters and importers are larger in terms of sales, value added and number of employees and capital than domestic firms. These differences are very large. They are also more productive in

[12] We do not present the share of firms that conducts R&D for 2002 because only 30% of the firms in the sample answered this question.

terms of both sales per employee and value added per employee. However, they also use more capital per worker, have a better educated workforce, and are more likely to invest in R&D.

Participation in international activities varies considerably across countries and sectors and, as shown above, most globally integrated firms tend to engage in several international activities simultaneously. Therefore, to examine the characteristics of globally engaged firms we estimate a regression of the firm level characteristics in logarithmic form on dummies controlling for participation in international activities and sector and country fixed effects. Similar methods have been used to study premia related to exporting by Bernard and Jensen (1999), among others. Table 3.7 reports the results of these regressions.

Table 3.7 Premia associated with international integration

	Foreign owned	MNEs Supplier	Exporter	Importer	Obs.	R^2
2002						
Sales	0.476**	0.479**	0.944**	0.438**	2880	0.336
	(0.087)	(0.097)	(0.086)	(0.071)		
Labour	0.251**	0.234**	0.826**	0.324**	2880	0.241
	(0.079)	(0.091)	(0.082)	(0.067)		
Capital	0.483**	0.533**	0.938**	0.388**	2880	0.355
	(0.097)	(0.102)	(0.101)	(0.084)		
Sales/employee	0.223**	0.251**	0.117**	0.113**	2880	0.530
	(0.054)	(0.044)	(0.044)	(0.032)		
Capital /employee	0.228**	0.314**	0.111	0.061	2880	0.367
	(0.088)	(0.085)	(0.074)	(0.061)		
Tertiary education	0.085**	0.083**	0.044**	0.033**	2880	0.280
	(0.014)	(0.014)	(0.013)	(0.012)		
2005						
Sales	0.857**	0.350**	1.058**	0.444**	3690	0.322
	(0.088)	(0.076)	(0.075)	(0.070)		
Value added	0.860**	0.336**	1.068**	0.430**	3690	0.306
	(0.089)	(0.078)	(0.076)	(0.070)		
Labour	0.653**	0.160**	0.945**	0.292**	3690	0.269
	(0.084)	(0.075)	(0.076)	(0.064)		
Capital	0.785**	0.204**	0.913**	0.431**	3690	0.320
	(0.105)	(0.084)	(0.078)	(0.070)		
Sales/employee	0.205**	0.190**	0.113**	0.152**	3690	0.615
	(0.041)	(0.035)	(0.026)	(0.024)		
Value added/empl.	0.207**	0.176**	0.123**	0.138**	3690	0.603
	(0.041)	(0.033)	(0.025)	(0.023)		
Capital /employee	0.132*	0.044	-0.032	0.139**	3690	0.360
	(0.073)	(0.060)	(0.053)	(0.041)		
Tertiary education	0.068**	0.042**	0.050**	0.034**	3648	0.255
	(0.015)	(0.013)	(0.013)	(0.010)		
R&D activities	0.079**	0.057**	0.154**	0.066**	3275	0.191
	(0.025)	(0.020)	(0.021)	(0.014)		

Source: BEEPS 2002, 2005.

The results show that there are large size premia associated with all the measures of international engagement in terms of sales, value added, employment and capital. Among firms engaged in international activities, exporters are the largest in terms of sales, value added, employment and capital. Plants that supply MNEs have the largest productivity premia as measured by sales per employee and value added per employee. The results for capital intensity are mixed. All four international activities

are also associated with a higher proportion of employees with tertiary education and a higher probability of conducting R&D activities.

These patterns are in line with those documented by the previous literature for exporters as compared to non exporters, for foreign owned as compared to domestic firms, importers and non importers. The findings for MNEs suppliers show that they share many of the characteristics of the firms engaged in international trade and of foreign affiliates.

To summarise, we find preliminary evidence that firms engaged in international activities have higher productivity, but also that they are significantly larger, pay higher wages, have a better educated labour force and are more likely to invest in R&D. In the next section, we test more formally whether engaging in these international activities is associated with higher total factor productivity, by controlling for other characteristics which themselves are correlated with productivity.

3.4 Empirical Strategy

The central hypothesis is that having access to technology developed abroad has a positive impact on a firm's total factor productivity *ceteris paribus*. Define FT_i as the vector of our measures of access to this foreign technology, specifically:

$FT_i = (\text{Foreign ownership, FDI in the sector, MNEs Supplier, Exporter, Importer})$

Each of these variables varies at the level of plant, *i*, with the exception of FDI in the sector, which varies at the level of industry-country level. Then, assuming that the production function is Cobb-Douglass, we have:

$$\ln(VA)_{ijct} = \alpha_{ijc} + \beta_K K_{ijct} + \beta_L L_{ijct} + \beta_{FT} FT_{ijct} + \beta_X X_{ijct} + u_{ijct} \qquad (3.1)$$

VA_i is value added of plant i and it is calculated a total sales minus the cost of material inputs and purchased components and services and energy and fuel. K_i is the capital of plant i and it is measured as the replacement value of the physical production assets owned and used by the firm (land, buildings and equipment). L_i is measured as the number of full time employees. The sales, capital and the costs with material inputs and energy are expressed in current USD. In the robustness checks we relax the assumption that the production function is Cobb-Douglass and also that the assumptions that the coefficients of production inputs are the same across countries and sectors.

The FT_i variables are potentially correlated. However, the correlation matrix reported in Table 3.16, shows that although many of these variables are correlated with each other, the magnitude of the correlation coefficients is not large. The largest correlation is between exporting and importing (0.29). This shows that although many firms tend to participate in several of these activities simultaneously, we would still be able to examine the effects of different channels.

To isolate the effect of FT_i on TFP, we also control for a number of other firm characteristics that may affect firm productivity, denoted X_i. We assume that the productivity of firms depends also on internal sources of knowledge as well as access to foreign technology, so we also control for firms' human capital, R&D activities and age. X_i also includes controls for product market competition. Given the possible effects of FDI on productivity through its impact on market structure (Wang and Blomström, 1992; Aitken and Harrison, 1999) discussed above, many studies on FDI spillovers control for competition in product market to isolate the

effect of FDI on productivity through technology transfer (among other, Javorcik, 2004a; Haskel, Pereira and Slaugher, 2007; Blalock and Gertler, 2008). We control for product market competition using dummy variables for low elasticity of demand, medium elasticity of demand and high elasticity of demand. The definitions and summary statistics for all variables are reported Table 3.14 and in Table 3.15, respectively. Most studies on FDI spillovers and on other channels of international technology transfer control include region fixed effects to control for characteristics of the region, for instance infrastructure, which might affect firm productivity. We do not have information on the region in which the firms are located within a country, but we have information on whether the firms are located in capital city and the size of the city. The size categories of the city/town are explained in Table 3.14 in the annexes. X_i also include sector and country of the firm which control for sector specific and country specific effects on the total factor productivity of the firms.

All the regressions are estimated using clustered standard errors for the plants in the same industry and country. Moulton (1990) showed that in the case of regressions performed on micro units, like firms, but including aggregate variables, if there is a correlation in the disturbance terms of individual units that share a common aggregate variable, the standard errors from OLS estimation can be biased downwards. Therefore, the standard errors in the regressions estimated are clustered for all observations that belong to the same country and industry.

Most of the specifications will be estimated using the BEEPS 2005 wave. Given that in this case we have only one cross section we will not be able to include firm fixed effects.

Using the panel component of the sample we will estimate this specification also using fixed effects estimation, which has the advantage that it allows us to control for firm unobserved characteristics, on the sample of firms that appears in 2002 and 2005 waves. It is important to control for these characteristics given the existing evidence on selection of most productive firms in participating in the international activities considered. In this case the OLS estimates suffer from omitted variable bias. Fixed effects estimation can be used to mitigate this problem if the selection into participating in international activities is caused by fixed differences between firms. To address the problem of time varying firm characteristics which might be correlated with the participation in international activities one could use instrumental variables or dynamic GMM models. Our data does not contain any instruments that are both important determinants of participation in international activities and are not correlated with the error term in the productivity equation. The limited time dimension of our data does not allow us to use dynamic GMM model, which require a long lag structure. For the same reason we cannot use the methods developed by Olley and Pakes (1996) or Levinsohn and Petrin (2003) to account for endogeneity of inputs.

3.5 Estimation Results

3.5.1 Baseline Results

Table 3.8 shows the results of estimating equation (3.1). Column (1) presents the results for estimating equation (3.1) including only production inputs and sector and country fixed effects. Columns (2) to (5) include a vector of control X_i for the firm's age, R&D expenditure, human capital, state ownership and product market competition. Column (3) reports the results of a translog production function.

Column (4) reports the results of equation in which we allow the coefficients of production inputs to differ across countries and column (5) reports the results of the same specification in which we allow the coefficients to differ across sectors.

Table 3.8 Baseline results (BEEPS 2005 sample)

Dependent variable Ln(VA)	OLS	OLS	Translog	Country specific coefficients	Sector specific coefficients
	(1)	(2)	(3)	(4)	(5)
Foreign ownership	0.170***	0.117***	0.119***	0.114***	0.123***
	(0.041)	(0.042)	(0.042)	(0.043)	(0.043)
FDI in the sector	0.006	-0.030	-0.025	-0.025	-0.043
	(0.067)	(0.070)	(0.070)	(0.071)	(0.068)
MNEs supplier	0.166***	0.136***	0.132***	0.123***	0.137***
	(0.029)	(0.031)	(0.030)	(0.029)	(0.030)
Exporter	0.101***	0.088***	0.087***	0.091***	0.095***
	(0.027)	(0.028)	(0.028)	(0.029)	(0.029)
Importer	0.110***	0.074***	0.075***	0.070***	0.077***
	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)
Capital[13]	0.142***	0.145***	0.147***		
	(0.011)	(0.011)	(0.011)		
Labour[14]	0.886***	0.881***	0.883***		
	(0.011)	(0.014)	(0.015)		
Sector FE	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes
Other firm characteristics	no	yes	yes	yes	yes
Obs.	3690	3222	3222	3222	3222
R^2	0.897	0.899	0.899	0.902	0.901

Notes: *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results from column (1) show that the coefficients of foreign ownership, supplying MNEs, exporting and importing are positive and significant, suggesting that foreign owned firms and firms that participate in these activities are more productive. These results are consistent with the hypothesis that foreign ownership, backward linkages, exporting and importing are important channels of international

[13] For the translog production function we report the output capital elasticity at the mean values of the inputs, which is calculated as:
$e_k = \beta_k + 2\beta_{kk}k + \beta_{kl}l$

[14] For the translog production function we report the output labour elasticity at the mean values of the inputs, which is calculated as:
$e_l = \beta l + 2\beta_{ll}l + \beta_{kl}k$

technology diffusion. The coefficient of the share of foreign firms in the same industry and country is statistically insignificant, consistent with previous studies that found insignificant horizontal spillovers from FDI in transition and developing countries.

The results in column (2) show that these findings are robust to controlling for other firm characteristics like firm's age, R&D expenditure, human capital and product market competition. However, the magnitude of the coefficients is reduced by the inclusion of these characteristics which suggest that part of the productivity premia of globally engaged firms is due to having a better skilled workforce and to conducting R&D activities. The specification in column (2) is our baseline specification. The results based on this specification suggest that foreign ownership, supplying MNEs, importing and exporting are all associated with higher total factor productivity. Our point estimates in the baseline specification suggest that supplying MNEs is associated with the highest TFP premium (14.5%), followed by foreign ownership with (12.5%), then by exporting (9%) and then by importing (7.7%). However, the differences between different channels are not statistically significant and thus, we cannot reject the hypothesis that these channels are equally important. Our measure of horizontal spillovers is smaller and never statistically significant. The results for the other control variables suggest that firms that employ a higher share of employees with tertiary educations and conduct R&D activities are more productive. Age, state ownership, product market competition do not have a significant impact on total factor productivity.

Column (3) reports the results of a translog production function which is less restrictive than the Cobb Douglass specification. The translog production function

estimated is a version of equation (3.1) which also includes quadratic terms of the production inputs and an interaction term of the production inputs. The results show that the coefficients of foreign ownership, supplying MNEs, exporting and importing remain positive and significant and the coefficients have a similar magnitude to those obtained from our baseline estimation. The coefficients of horizontal spillovers from FDI are statistically insignificant as in the previous specifications. To summarise, the results from the translog specification show that the results for technology transfer through foreign ownership, supplying MNEs, exporting and importing are robust to the use of a more flexible functional form for the production function.

Equation (3.1) assumes that the coefficients of the production inputs are the same across countries and across sectors. We tested these assumptions and the results are reported in Table 3.9.

Table 3.9 Differences in the coefficients of production inputs across countries and sectors

	p-value
Differences in the coefficients of K across countries (F test)	0.000
Differences in the coefficients of L across countries (F test)	0.000
Differences in the coefficients of K across sectors (F test)	0.102
Differences in the coefficients of L across sectors (F test)	0.000

The results show that the hypotheses that the coefficients of production inputs do not differ across countries and sectors were rejected. We are not able to allow the coefficients of production inputs to vary by country and by industry due to the relatively small sample of firms in the same sector and country, but we allow the coefficients to vary by country and then by sector. Column (4) presents the results of the estimation of the Cobb Douglas production function with country specific coefficients for capital and labour. The results of this specification shows that the coefficients of the variables that control for foreign ownership, supplying MNEs,

export and import status remain positive and significant, and that the magnitude of the coefficients is similar to the baseline specification. In column (5) we report the results of the estimation of the Cobb Douglas production function with sector specific coefficients for capital and labour. The results are in line with our previous results. We are therefore confident that the restrictions imposed by equation (3.1) with regard to the variation of production function across countries and sectors do not significantly affect our main results.

3.5.2 Extensions and Robustness Checks

- **Sample of Domestic Firms**

Several studies found that FDI spillovers affect differently domestic firms and foreign firms. For instance, Aitken and Harrison (1999) found that FDI spillovers have a positive impact on other foreign firms, but a negative impact on domestic firms in Venezuela. Similar effects of horizontal FDI were found by Javorcik and Spatareanu (2008) in Romania, Konings (2001) in Bulgaria and Romania, and by Djankov and Hoekman (2000) in Czech Republic. In addition, it is possible that MNEs may source inputs in the host country not from local firms but from other MNEs that operate in the same country Javorcik (2008). In this case, the positive effect of supplying MNEs on productivity might be driven by benefits of scales due to increased sales of foreign affiliates to other foreign affiliates rather than technology transfer through backward linkages to local suppliers.

It is also important to notice that the fact that BEEPS used a quota for foreign firms may introduce sample bias. Therefore, it is important to examine whether our results hold for the sample of domestic firms.

In view of these considerations, we repeat the estimations for the sample of domestic firms.

The results are reported in Table 3.10.

Table 3.10 Baseline results for domestic firms (BEEPS 2005 sample)

Dependent variable Ln(VA)	OLS	OLS	Translog	Country specific coefficients	Sector specific coefficients
FDI in the sector	0.035	-0.026	-0.028	-0.036	-0.046
	(0.072)	(0.077)	(0.077)	(0.079)	(0.076)
MNEs supplier	0.157***	0.131***	0.128***	0.120***	0.130***
	(0.032)	(0.034)	(0.034)	(0.032)	(0.033)
Exporter	0.121***	0.103***	0.103***	0.106***	0.111***
	(0.029)	(0.031)	(0.031)	(0.031)	(0.032)
Importer	0.107***	0.078***	0.079***	0.077***	0.082***
	(0.024)	(0.025)	(0.025)	(0.025)	(0.025)
Capital	0.140***	0.147***	0.149***		
	(0.011)	(0.012)	(0.011)		
Labour	0.887***	0.880***	0.882***		
	(0.011)	(0.015)	(0.015)		
Sector FE	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes
Other firm characteristics	no	yes	yes	yes	yes
Obs.	3287	2890	2890	2890	2890
R^2	0.893	0.894	0.895	0.897	0.896

Notes: *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results for the sample of domestic firms, reported in Table 3.10, are very similar to those for the whole sample. They show that domestically owned firms that supply MNEs, export or import are more productive than domestically owned firms that do not engage in these activities. Thus, we conclude that our baseline results for supplying MNEs, exporting and importing are not driven by positive effects of engaging in these activities for foreign affiliates.

➢ Intensity of Global Engagement

Several studies have suggested that intensity of participation in international activities matters for technology transfer[15]. For instance, Javorcik (2004b) argues and presents evidence that MNEs tend to transfer more advanced technologies to majority owned foreign affiliates than to minority owned foreign affiliates because of fear of technology leakage. Djankov and Hoekman (2000) also found evidence that majority owned foreign affiliates are more productive than minority owned affiliates.

Castellani (2002) and Girma *et al.* (2004) argue that export intensity is an important determinant of learning by exporting and therefore it should affect productivity. Castellani (2002) argues that higher export intensity is an indicator or the firm's commitment to its foreign operations. If firms need to invest resources in order to benefit from learning by exporting, firms that export a higher share of their output have more incentive to undertake these investments. Castellani (2002) also argues that low export intensity may signal an occasional exporter. In line with this hypothesis, he found that for a sample of Italian manufacturing firms that firms that have export intensity experienced significantly higher productivity growth. Girma *et al.* (2004) interpret export intensity as the amount of experience in foreign markets and they argue that learning by exporting increases with this experience. They found that for a sample of UK manufacturing firms the rate of productivity growth is related to increases in the share of exports in total output for newly exporting firms. These findings are consistent with higher benefits from learning by exporting for

[15] Intensity of participation in international activities could also refer to a firm pursuing several types of international activities simultaneously, which is sometime called complex integration strategies. This has been studied by Tomiura (2007) who found that productivity levels vary across different choices of integration strategies and that firms which are involved in FDI, exporting and outsourcing are more productive than firms involved in only one of these activities.

firms that export a large share of their output. Similar arguments apply for suppliers of MNEs.

In view of these arguments, and in the light of Figure 3.1 and Figure 3.2, we sub-divide plants into a series of bands which represent the intensity of their involvement in international activities. Table 3.11 reports the results of the estimation of these specifications.

With regard to foreign ownership the results show that firms with a foreign share of the capital between 50% and 90% and firms with a foreign share of capital larger than 90% are significantly more productive than domestic firms. The coefficients of the minority foreign owned affiliates are positive, but statistically insignificant. It is possible that these coefficients are poorly determined due to the small number of firms that are minority owned (only 2% of the sample). In fact, we cannot reject the hypothesis that minority foreign owned affiliates are as productive as majority owned foreign affiliates.

Table 3.11 Does technology transfer vary with intensity of global engagement? (BEEPS 2005 sample)

Dependent var. Ln(VA)	All firms		Domestic firms	
	(1)	(2)	(3)	(4)
Foreign share 10-50%	0.103	0.045		
	(0.073)	(0.080)		
Foreign share 50-90%	0.189***	0.123**		
	(0.059)	(0.057)		
Foreign share >90%	0.187***	0.147***		
	(0.050)	(0.056)		
Supplies MNEs<10%	0.056	0.001	0.013	-0.038
	(0.062)	(0.061)	(0.063)	(0.066)
Supplies MNEs 10-50%	0.198***	0.173***	0.188***	0.176***
	(0.035)	(0.038)	(0.036)	(0.040)
Suppliers MNEs>50%	0.130***	0.113**	0.158***	0.119**
	(0.046)	(0.047)	(0.054)	(0.056)
Exports<10%	0.094**	0.105**	0.101**	0.101**
	(0.042)	(0.046)	(0.042)	(0.047)
Exports 10-50%	0.136***	0.113***	0.151***	0.128***
	(0.032)	(0.034)	(0.035)	(0.038)
Exports >50%	0.034	0.019	0.060	0.036
	(0.039)	(0.044)	(0.044)	(0.051)
Imports <10%	0.067	0.075	0.063	0.079
	(0.059)	(0.066)	(0.062)	(0.068)
Imports 10-50%	0.093***	0.057*	0.091***	0.058**
	(0.028)	(0.030)	(0.026)	(0.029)
Imports >50%	0.125***	0.083***	0.124***	0.091***
	(0.027)	(0.027)	(0.028)	(0.028)
Sector FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Other firm characteristics	no	yes	no	yes
Obs.	3690	3222	3287	2890
R^2	0.897	0.900	0.894	0.895

Notes: *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

Firms that sell more than 10% of their output to MNEs are more productive than domestic firms and firms that sell less than 10% of their output to MNEs. Firms that sell less than 10% to MNEs are not significantly different from firms that do not supply MNEs. Firms that sell a large share of their output to MNEs may have more incentives to introduce changes in technology, quality or business practices required by MNEs. In addition, MNEs may also have stronger incentive to assist them in making the changes required in order to lower the costs or improve the quality of

their inputs. It is possible that small share of sales to MNEs reflects the fact that these local firms do not produce the specialised inputs required by MNEs and MNEs source from them only basic inputs and therefore the potential for technology transfer is limited. Taken together, these results, suggest that firms that supply a large share of their output to MNEs benefit more from these linkages.

The results suggest that the firms that export less than 50% of their output are significantly more productive than domestic firms. Firms that export more than 50% are not significantly different than non exporters and they are significantly less productive than firms that export less than 50%. This is in contrast with the hypothesis that export intensity could be interpreted as experience in foreign markets and therefore should be an important determinant of learning by exporting and also with the findings of Castellani (2002) and Girma *et al.* (2004). Figure 3.2 shows that actually there are a large number of firms which export more than 50% of their output in our sample. These results could be due to the fact that most of the firms which export more than 50% of their output specialise in low technology goods. In the data, most of the firms that export more 50% in the sample operate in the textiles, apparel and footwear, whole sale and retail trade and basic metals and metal products sectors which are indeed low technology sectors.

The results for importing suggest that firms that import more than 50% of their material inputs are the most productive, followed by firms that import between 10% and 50% of their material inputs, and then by those that import less than 10% of their material inputs. The firms that import less than 10% of their output are not significantly different from the firms that do not import any material inputs.

However, the coefficients are positive and large in magnitude and we cannot reject the hypothesis that firms that import less than 10% are as productive as those that import more than 10% of their material inputs. It is possible that these coefficients are poorly determined due to the small number of importers that import less 10% of their inputs, only 3% of our sample.

In conclusion, the results suggest that intensity of global engagement matters especially for MNEs suppliers. Supplying a larger share of output to MNEs is associated with higher productivity. We find similar evidence for foreign ownership, and importing, but due to fact that some of the coefficients are poorly determined it is difficult to draw a conclusion for these activities. Overall, for these activities, the evidence supports the hypothesis that intensity of participation in international activities is associated with higher productivity. For exporting we find higher export intensity is not associated with a higher productivity, although this would appear to be because export intensive firms are clustered in low technology sectors.

- **Different Categories of Firms**

In this section we study whether the effect of international technology transfer channels differs for large and small firms, old or new firms, firms in industry sectors and service sectors, and firms in CEE countries and in CIS countries.

Large firms may be more able to benefit from international technology transfer for several reasons. They have more resources (financial, human) to introduce new technology. They may have the necessary scale in case new technology requires a certain scale. They also may be more able to compete with foreign firms and therefore they are more likely to benefit from horizontal FDI spillovers. However, it

is also possible that they already use technology similar to foreign firms and they do not benefit as much from interactions with these firms as firms which have more to learn. We separate the sample into small and large firms and define a firm as small if it has less than 50 employees and large if it has at least 50 employees. This is commonly used classification. It was used for instance by Aitken and Harrison (1999) and Nicolini and Resmini (2010).

We also study whether the effect of international technology transfer differs for old and new firms. Older firms are former state-owned enterprises, which have inherited old technologies and organizational structures and may find it more difficult to adapt to changes in technology. We considered a firm is new if it was established after 1990, the beginning of the transition period, and old if it was established before 1990.

We also study whether these effects differ across sectors. We distinguish between the industrial sectors (mining, manufacturing and construction) and service sectors (transport, storage and communication, trade, real estate, renting and business services, hotels and restaurants and others services). Most of the existing studies focus on manufacturing sector. However, given the services account for a large and rising share of GDP in transition countries, it is important to study whether the hypothesis of international technology transfer holds also for plants in the service sectors.

It has been argued that the level of development of the country can affect international technology transfer (Aitken and Harrison, 1999; Görg and Strob, 2001;

Görg and Greenaway, 2004). In the case of transition countries it has been argued that the institutions and the progress with the transition towards market economy affect technology transfer through FDI (Gordnichenko *et al.*, 2007; Nicolini and Resmini, 2010; Djankov and Murrell, 2002). We will separate the sample into countries in Central and Eastern Europe (CEE), which includes also Baltic countries and the Balkans, and CIS, which includes countries in the former Soviet Union except the Baltic countries. Overall, the countries in CEE have made more progress in the transition process and have better institutions and higher GDP per capita than countries in CIS. The results from these estimations are reported in Table 3.12.

Table 3.12 Does technology transfer vary with size, age, sector, country? (BEEPS 2005 sample)

Dependent variable Ln(VA)	Small	Large	New	Old	Industry	Services	CEE	CIS
Foreign ownership	0.117*	0.062	0.103**	0.167	0.097*	0.109*	0.117**	0.131**
	(0.061)	(0.057)	(0.044)	(0.108)	(0.050)	(0.063)	(0.054)	(0.065)
FDI in the sector	-0.067	0.120	-0.050	0.000	0.044	-0.196	-0.015	-0.233
	(0.081)	(0.111)	(0.079)	(0.147)	(0.070)	(0.139)	(0.081)	(0.157)
MNEs supplier	0.137***	0.132***	0.128***	0.166***	0.126***	0.148***	0.116***	0.151*
	(0.039)	(0.048)	(0.034)	(0.053)	(0.039)	(0.043)	(0.030)	(0.078)
Exporter	0.131***	0.018	0.079***	0.064	-0.007	0.223***	0.104***	0.067
	(0.036)	(0.051)	(0.027)	(0.055)	(0.038)	(0.041)	(0.031)	(0.072)
Importer	0.071**	0.103**	0.096***	0.067	0.097***	0.039	0.056*	0.109**
	(0.029)	(0.047)	(0.033)	(0.050)	(0.037)	(0.031)	(0.029)	(0.044)
Capital	0.151***	0.130***	0.148***	0.135***	0.167***	0.126***	0.135***	0.163***
	(0.013)	(0.017)	(0.012)	(0.022)	(0.018)	(0.013)	(0.012)	(0.023)
Labour	0.879***	0.882***	0.881***	0.886***	0.835***	0.929***	0.905***	0.836***
	(0.021)	(0.030)	(0.016)	(0.026)	(0.020)	(0.016)	(0.015)	(0.025)
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes	yes	yes
Other firm characteristics	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	2338	884	2517	705	1726	1496	2371	851
R^2	0.775	0.858	0.876	0.935	0.912	0.888	0.909	0.855

Notes: *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results show that foreign ownership is associated with higher productivity in all subgroups of firms, but for large firms and for firms created before 1990 the coefficient is not statistically significant. In the case of large firms, it is possible that large domestic firms use similar technology to foreign owned firms or exporters. Aitken and Harrison (1999) found similar results for large firms in Venezuela. In the case of old firms the coefficient is large and positive, but not significant at usual levels of significance.

Supplying MNEs is positive and statistically significant for all size, age, sector and country group categories considered and the magnitude of coefficient is similar across these categories. Foreign presence in the sector has an insignificant effect on all categories of firms.

Exporting is associated with higher productivity only for small firms, new firms, firms in service sectors and firms in CEE countries. It is possible that large domestic firms are similar to exporters in terms of technology and therefore the differences in productivity are not significant.

Importing is associated with higher productivity for all firms except older firms and firms in service sectors. It is possible that for the later due to the nature of services using imports that embody new technology is not such an important source of productivity improvement as for manufacturing firms.

In conclusion, we find that the results of different channels vary across subgroups, except for supplying MNEs which is associated with higher productivity for all

categories of firms concerned. Foreign ownership and importing are associated with higher productivity for most of subgroups, but the impact of exporting varies considerably.

- **Results for 2002 Wave and for Pooled Sample**

In this section, we will present the estimations for the BEEPS 2002 and 2005 and the pooled sample of the two waves. We want to examine whether we find similar results for the 2002 wave and most importantly, using the sample of firms that appears in both surveys to study whether our results are robust to controlling for firm unobserved characteristics.

There are some differences in the questionnaires used in the BEEPS 2002 wave and 2005 wave. The most important difference is that the 2002 wave did not collect data on the costs of material intermediate inputs used and energy; therefore, in these regressions we will use sales as dependent variable instead of value added. In addition, a large number of plants did not answer the question regarding R&D expenditures (more than 70%). In order to increase the number of observations, we excluded this variable from the specification.

The modified specification is:

$$\ln(Sales)_{ijct} = \alpha_{ijc} + \beta_K K_{ijct} + \beta_L L_{ijct} + \beta_{FT} FT_{ijct} + \beta_X X_{ijct} + u_{ijct} \qquad (3.2)$$

FT_i represents access to foreign technology and our measures of access to foreign technology are: foreign ownership, FDI in the sector, supplying MNEs, exporting and importing, like in the main specification. X_i represents other firm characteristics: share of employees with tertiary education, controls for product market competition, state ownership, firm age, industry, country and location fixed effects. In the

estimation of this specification on the pooled 2002-2005 sample, we also include time dummies. The definitions of all these variables are in

Table 3.14 and summary statistics on these variables for 2002 and 2005 are in Table 3.15.

Using the panel component we will estimate this specification also using fixed effects estimation. Fixed effects estimation has the advantage that it allows us to control for firm unobserved characteristics. This is important given the existing evidence that MNEs tend to acquire the most productive firms (Djankov and Hoekman, 2000), and that the most productive firms become MNEs suppliers (Javorcik and Spatareanu, 2009), exporters (Kneller and Greenaway, 2007) and importers (Kasahara and Lapham, 2008; Altomonte and Bekes, 2009). In this case the OLS estimates suffer from omitted variable bias. However, the panel component is limited because only 483 firms were surveyed in both years, provided data on all the variables in specification (3.2). Given that balanced panel sample is much reduced compared to the original sample, will also estimate equation (3.2) on this sample using pooled OLS to examine whether results the results differ from the results for the whole sample. The standard errors in estimations using pooled sample are clustered at the level of the firm. The results are reported in Table 3.13.

Table 3.13 Results for the 2002 and the pooled 2002 & 2005 samples

Dependent variable Ln(Sales)	BEEPS 2002	BEEPS 2005	BEEPS 2002 & 2005	BEEPS (balanced panel 2002 & 2005)	BEEPS (balanced panel 2002 & 2005)
	OLS	OLS	Pooled OLS	Pooled OLS	FE
Foreign ownership	0.115**	0.113***	0.120***	0.118	-0.142
	(0.054)	(0.039)	(0.033)	(0.088)	(0.184)
FDI in the sector	0.095	0.002	0.070	0.077	0.043
	(0.088)	(0.065)	(0.056)	(0.110)	(0.143)
MNEs supplier	0.132***	0.155***	0.150***	0.092	0.103
	(0.042)	(0.035)	(0.027)	(0.063)	(0.090)
Exporter	0.093**	0.081***	0.092***	0.137**	0.097
	(0.039)	(0.027)	(0.023)	(0.061)	(0.100)
Importer	0.077***	0.099***	0.093***	0.081	0.017
	(0.030)	(0.025)	(0.020)	(0.050)	(0.073)
Capital	0.181***	0.164***	0.163***	0.118***	0.054**
	(0.015)	(0.012)	(0.009)	(0.018)	(0.023)
Labour	0.819***	0.883***	0.861***	0.867***	0.869***
	(0.014)	(0.013)	(0.010)	(0.025)	(0.060)
Sector FE	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes
Other firm characteristics	yes	yes	yes	yes	yes
Obs.	2846	3630	6476	966	966
R^2	0.843	0.897	0.870	0.879	0.954

Notes: *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses for the 2002 and 2005 samples, for the pooled samples they are clustered at firm level.

In column (1) we report the result of estimation equation (3.2) on BEEPS 2002 sample. The results show that the coefficients of the variables that control for foreign ownership, supplying MNEs, importing and exporting are all positive and statistically significant and that their magnitude is similar to the results obtained for the BEEPS 2005 sample. The coefficient of foreign presence in the industry of the firm is all the time insignificant, in line with our previous results. For comparison, in column (2) we report the results of estimating equation (3.2) on BEEPS 2005 sample. The results are very similar both qualitatively and quantitatively. We can conclude that the results for the 2002 wave confirm the previous findings for foreign ownership, supplying MNEs and exporting. In column (3) we report the results for

the pooled sample estimated using pooled OLS. The results are very similar to the results for each of the two samples.

In column (4), we report the results for the balanced panel sample which will be used in the fixed effects estimation. The results are similar to the whole sample, but smaller in magnitude and statistically insignificant. This suggests that the change in the sample affects the results.

In column (5) we report the results of fixed effects estimation on the balanced panel sample. The coefficient of foreign ownership is negative and statistically insignificant. The coefficients of foreign presence in the sector, supplying MNEs located in the same country, exporting and importing are positive, but statistically insignificant. One possible explanation for these results is limited variation over time in participation in international activities. We only have two observations for each firm and there is limited variation over time in participation in international activities. Using FE estimation in short panels tends to magnify the impact of error in variables, which can bias the results towards zero (Wooldridge, 2010). In addition, as mentioned above, the panel component of the dataset is very limited and the results from the OLS estimation reported in column (4) show that the change in sample affects the results.

3.6 Conclusions

In this chapter we study the relative importance of foreign ownership, intraindustry productivity spillovers from FDI, FDI spillovers through backward linkages, exporting and importing as channels of international technology transfer in 26 transition economies in Central and Eastern Europe using data from BEEPS 2002

and 2005. We examine the main channels of international technology transfer and we use firm-specific measures for foreign ownership, FDI spillovers through backward linkages, exporting and importing.

To study whether there is evidence of technology transfer through international activities, we test whether engaging in these international activities is associated with higher total factor productivity. Following other empirical studies on this topic, we begin our analysis by estimating a Cobb Douglass production function augmented with variables that for access to foreign technology through foreign ownership of the firm, participation in importing, exporting, supplying MNEs, the foreign presence in the industry of the firm and country and other plant characteristics that might affect productivity.

The results suggest that foreign ownership, supplying MNEs, exporting and importing are associated with higher firm productivity. We find no evidence of intraindustry FDI spillovers. These results are consistent with the hypotheses of technology transfer through foreign ownership and relationships with foreign customers (either MNEs located in the same countries or foreign firms located abroad) and importing material inputs. With regard to the relative importance of different channels of international technology transfer, we cannot reject the hypothesis that these channels are equally important.

Our results are robust to controlling for firm internal knowledge (human capital and R&D), using translog production function, allowing the coefficients to differ across countries and sectors and restricting the sample to the sample of domestic firms. We

also obtain similar results, especially for supplying MNEs, for large and small firms, old and new firms, firms in industrial sectors an firms operating in service sectors and for firms in CEE countries and in CIS countries and for the 2002 wave and for 2005 wave. However, we are not able to establish causality. This might be due to the fact that the panel element in our dataset is very limited.

An additional finding is that intensity of global engagement matters especially for supplying MNEs. Supplying a larger share of output to MNEs is associated with higher productivity. We find similar evidence for foreign ownership, and importing, but due to fact that some of the coefficients are poorly determined it is difficult to draw a conclusion for these activities. For exporting we find higher export intensity is not associated with a higher productivity.

In conclusion, our results are consistent with the hypotheses of technology transfer through foreign ownership, supplying MNEs, exporting and importing material inputs, but there is also evidence of selection of the best performing firms in participating in international activities.

Appendices to Chapter 3

Table 3.14 Variable definitions

Variable Name	Definition
Foreign owned	A dummy variable that takes the value 1 if more than 10% of the firm's capital is owned by foreign investors and 0 otherwise.
Foreign presence in the sector	The share of employment accounted for by foreign plants in total employment in the sector and country to which the plant belongs.
MNEs supplier	A dummy variable that takes the value 1 if the firm sells part of its output to MNEs located in the same country and 0 otherwise.
Exporter	A dummy variable that takes the value 1 if the firm exports part of its output (directly or indirectly) and 0 otherwise.
Importer	A dummy variable that takes the value 1 if the firm imports part of its material inputs (directly and indirectly) and 0 otherwise.
Value added	Total sales minus costs with material inputs and purchased components and services and costs with energy and fuel.
Capital	Replacement value of the physical production assets like land, buildings and equipment.
Labour	Number of full time employees.
Human capital	Share of the number of employees with at least secondary education or the share of employees with tertiary education.
R&D	A dummy variable that takes the value 1 if the firm had positive expenditure on R&D and 0 otherwise.
Age	The year of the survey minus the year when the firm was established.
State ownership	A dummy variable that takes the value 1 if more than 50% of the capital of the firm is owned by the state and 0 otherwise.
Elasticity of demand dummies	Dummy variables that indicate the hypothetical reaction of the firm's customers if the firm increased the price of its main product by 10% and the firm's competitors maintained their current prices.
Location Size dummies	Dummy variables which indicate whether the firm is located in the capital city, a city with more than 1 million inhabitants, a city with between 250.000 and 1million inhabitants, a city with between 50.000 and 250.000, a town with less than 50.000 inhabitants.

Table 3.15 Descriptive statistics

	2002			2005		
Indicator	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Productivity						
Sales	2880	2170.24	9035.99	3690	3573.02	15096.09
Value Added					1679.08	6673.40
Labour	2880	138.09	462.50	3690	86.37	231.40
Capital	2880	949.01	5185.12	3690	1277.26	5254.44
International Activities						
Foreign affiliates	2880	0.16	0.36	3690	0.11	0.31
FDI in the sector	2880	0.23	0.24	3690	0.23	0.21
MNEs suppliers	2880	0.16	0.37	3690	0.16	0.37
Exporters	2880	0.29	0.45	3690	0.29	0.45
Importers	2880	0.59	0.49	3690	0.55	0.50
Other firm characteristics						
Tertiary education	2849	0.32	0.30	3648	0.24	0.27
R&D activities				3275	0.18	0.38
Age	2880	14.95	18.87	3685	17.19	19.14
State ownership	2880	0.14	0.35	3690	0.07	0.260
Inelastic demand	2876	0.19	0.39	3677	0.20	0.40
Low elasticity of demand	2876	0.31	0.46	3677	0.30	0.46
Medium elasticity of demand	2876	0.20	0.40	3677	0.20	0.40
High elasticity of demand	2876	0.30	0.46	3677	0.30	0.46

Source: BEEPS 2002, 2005. Notes: All monetary values are in thousands USD.

Table 3.16 Correlation Matrix

	Foreign ownership	FDI in the sector	MNEs supplier	Exporter	Importer
Foreign ownership	1.000				
FDI in the sector	0.181	1.000			
	0.000				
MNEs supplier	0.126	0.055	1.000		
	0.000	0.001			
Exporter	0.231	0.062	0.192	1.000	
	0.000	0.000	0.000		
Importer	0.178	0.015	0.186	0.293	1.000
	0.000	0.377	0.000	0.000	

Source: BEEPS 2005

Chapter 4 Does Absorptive Capacity Affect Who Benefits from International Technology Transfer?

4.1 Introduction

International technology transfer is not an automatic consequence of access to foreign technology, but it depends on firm and country characteristics. A major determinant of successful international technology transfer is absorptive capacity, which is the ability of firms to assimilate and exploit knowledge developed outside the firm (Keller, 2004, 2009).

A large number of studies have examined whether absorptive capacity facilitates international technology transfer. Using aggregate data, Benhabib and Spiegel (1994), Griffith *et al.* (2004), Borensztein *et al.* (1998), and Xu (2000) found empirical evidence consistent with the hypotheses that absorptive capacity plays an important role in facilitating international technology transfer. In addition, the mixed results of various firm level studies on international technology transfer through FDI spillovers, reviewed in the previous chapter, suggest that differences in country absorptive capacity affect the occurrence and the extent of international technology transfer. Existing surveys on FDI spillovers like (Görg and Strobl, 2001; Görg and Greenaway, 2004; Crespo and Fontoura, 2007; Meyer and Sinani, 2009) and on learning by exporting (Greenaway and Kneller, 2007; Wagner, 2007) also document cross country differences in the results and suggest that likely sources of these inconsistencies are empirical methodologies used and differences in country characteristics such as absorptive capacity.

A small number of micro-econometric studies have attempted to deal with the issue of differences in methodology by examining technology transfer through FDI or learning by exporting in a cross country setting using a common methodology. Examples here include Mayer and Ottaviano (2007) and Wagner *et al.* (2007) for learning by exporting; and Konings (2001), Damijan *et al.* (2003) and Nicolini and Resmini (2010) for technology transfer through FDI spillovers. However, a limitation of these studies has been that they are forced to rely on different data sources for each country, and therefore the question of whether the data are fully comparable remains unanswered. They instead estimate separate regressions for each country. All these studies found that the occurrence and magnitude of technology transfer differs across countries. For instance, Damijan *et al.* (2003) study the horizontal spillovers in eight transition countries and find evidence of positive horizontal spillovers for domestic firms only in Romania and negative spillovers in Czech Republic and Poland and insignificant spillovers for domestic firms in Bulgaria, Estonia, Hungary, Slovakia and Slovenia. A possible explanation for these different results for different countries is that host country characteristics affect the occurrence of productivity spillovers. Unfortunately, the data restrictions prevent them from attempting to identify which characteristics of the host country make the environment more conducive for technology diffusion in one country than in another.

Another strand of the literature that is related to our study is the empirical literature on the impact of firms' absorptive capacity on international technology transfer within a country. There is a large literature on this topic (Kinoshita, 2000; Damijan *et al.*, 2003; Sinani and Meyer, 2004; Girma, 2005; Nicolini and Resmini, 2010;

Girma and Görg, 2007; Girma *et al.*, 2008, among others). These studies assume that all the firms in a sector or industry have equal access to the technology of the foreign firms present in the industry or sector, but the ability of the firms to benefit from this technology depends on their absorptive capacity. The findings of these studies, which are summarised in Table 4.2 are again mixed and most of the studies on transition countries do not find supporting evidence for this hypothesis.

Motivated by these mixed findings studies, we study how absorptive capacity affects technology transfer through foreign ownership, supplying MNEs, exporting and importing. This study contributes to the literature in several ways.

First, we study how country characteristics and firm characteristics affect technology transfer at the firm level. This differs from the existing literature which examines how absorptive capacity facilitates technology transfer either at country level or at firm level within a country. Unlike previous firm level studies that use data from different sources for each country, we use data that is drawn from a common source and is therefore directly comparable across countries. This allows us to pool the data across countries and to attempt to model how country characteristics affect technology transfer and to test it empirically using a common methodology. We also recognise that within a country firms might differ in their absorptive capacity and we also examine how firms' absorptive capacity affects technology transfer within a country.

Second, we use firm level measures of access to foreign technology. This contrasts with most of the existing empirical literature where the use of sector level measures,

such as the extent of foreign presence in a sector (Girma, 2005; Nicolini and Resmini, 2010; Girma and Görg, 2007; Girma *et al.*, 2008). By relating these aggregate measures to firm productivity, these studies assume that all the firms in the sector have equal access to the technology of the foreign firms present in the same sector and country. Our dataset allows us to use firm level measures which capture firms' access to foreign technology more precisely. The measures we use are: foreign ownership, supplying MNEs, exporting and importing. We focus on these channels because in Chapter 3 we found that these channels of international technology transfer are robustly associated with higher total factor productivity.

Third, the measures of absorptive capacity used in this study are more precise and more closely related to the concept of absorptive capacity than the measures frequently used in other firm level studies on this topic. The measures of absorptive capacity we use are: investment in R&D, provision of formal training and workforce education. Compared with the total factor productivity gap, which is the most frequently used measure of absorptive capacity in firm level studies (Girma, 2005; Nicolini and Resmini, 2010; Girma and Görg, 2007; Girma *et al.*, 2008, among others), our measures of absorptive capacity have several advantages. Our measures of absorptive capacity are closely related to the concept of absorptive capacity as it is defined in the theoretical literature (Nelson and Phelps, 1966; Cohen and Levinthal, 1989). They are also more similar to the measures used in the macro literature (Benhabib and Spiegel, 1994; Borensztein *et al.*, 1998; Griffith *et al.*, 2004; Kneller, 2005). They are also less prone to measurement error than total factor productivity gap measures, because the total factor productivity gap may be affected by temporary shocks that do not affect the absorptive capacity of the firm (Girma and

Görg, 2007). Finally, productivity gap measures are not very informative for policy because they do not explain why the productivity gap is large or small in the first place and what can be done to reduce it. Measures of R&D investment, provision of training and education are more informative from a policy point of view because policies can be targeted to support these activities. Only a few firm level studies have used similar measures. R&D investment was used by Kinoshita, (2000), Damijan *et al.* (2003), Girma *et al.* (2009). Different measures of human capital were used by Sinani and Meyer (2004), Gorodnichenko *et al.* (2007), Köymen and Sayek (2010), and the provision of formal training was used by Girma *et al.* (2009).

We start our study by testing whether a country's absorptive capacity affects technology transfer at the firm level. Our main results show that country absorptive capacity is associated with higher firm productivity, but there is no evidence of an interaction effect between absorptive capacity and participation in international activities. One possible explanation for this result is that there is large heterogeneity with regard to absorptive capacity at firm level within countries. For instance, even in a country that has overall low absorptive capacity, there are firms which invest in R&D, offer formal training for employees and hire highly educated workers and, therefore, have high absorptive capacity. Therefore, we also test whether individual firms' absorptive capacity affects technology transfer at the firm level. Again, our main results show that absorptive capacity measures are associated with higher firm productivity, but there is no evidence of an interaction effect between absorptive capacity and participation in international activities.

There are several possible explanations for these findings. It is possible that all firms that have access to foreign technology benefit from it, or that technology transfer is facilitated by the foreign parent firms or foreign customers or suppliers and not by the actions of the domestically owned firms, or that only firms with the necessary absorptive capacity select into participation in international activities.

The chapter is organised as follows. Section 4.2 reviews the economic theory and the empirical evidence from country and firm level studies on how absorptive capacity affects technology transfer. Section 4.3 describes the data used in this study. Section 4.4 describes the empirical methodology used. Section 4.5 presents the results of the empirical analysis on the effect of country absorptive capacity and firm absorptive capacity on technology transfer. Section 4.6 concludes.

4.2 Literature Review

In this section we discuss the concept of absorptive capacity and how it affects adoption of foreign technology according to the theoretical literature and empirical evidence on this topic. There is a very large literature on this topic; in this literature review, we focus only on those aspects which are most relevant for our empirical research. First, we look at the theoretical literature which focuses on the concept of absorptive capacity, on the effect of absorptive capacity on international technology transfer and on how this effect has been modelled. Then, we examine the empirical evidence on this topic from studies using aggregate data, in section 4.2.2, and from studies using firm level data, in section 4.2.3. In the review of the empirical literature, we focus on the measures of absorptive capacity and foreign technology used by previous studies, whether these measures correspond to those suggested by theoretical literature, and the main findings of these studies.

4.2.1 Review of Theoretical Literature

The term absorptive capacity was first introduced by Cohen and Levinthal (1989) who defined it as *"the ability to identify, assimilate, and exploit knowledge from the environment"*. They argue that this ability is important for adopting new products and processes used outside the firm and to make use of the available scientific research.

Cohen and Levinthal (1989) and Griffith *et al.* (2004) argued that a firm develops its absorptive capacity by conducting in house R&D activities. They argue that by actively engaging in R&D in a particular field, a firm acquires tacit knowledge of that field and this allows the firm to understand and assimilate knowledge created by others. Nelson and Phelps (1966) argue that human capital plays a similar role. They argue that education and training enable people to understand new technological developments, evaluate them, and adopt the ones which are suitable for them (Nelson and Phelps, 1966). Nelson and Phelps developed a theoretical model in which human capital affects technology transfer. In their model, productivity growth depends on the gap between the technology used in practice and the theoretical level of technology, which is exogenous, and on human capital, which affects the speed of technology adoption.

Neither Cohen and Levithal (1989), nor Nelson and Phelps (1966) examined the effect of absorptive capacity on international technology transfer. However, given the importance of absorptive capacity for the adoption of new technology, it has been argued that absorptive capacity should also be important for adoption of technologies created abroad. Building on Nelson and Phelps' (1966) model, Benhabib and Spiegel

(1994) develop a model that focuses on international technology diffusion which is affected by human capital. In their model, countries do not catch up to a technological level that is determined by the level of theoretical knowledge, but to the technology of the leading country. Human capital affects total factor productivity growth in two ways. First, similar to Nelson and Phelps' model, human capital increases the adoption of technology developed abroad. Secondly, human capital has a direct effect on productivity growth through its effect on the creation of new technology, in the spirit of Romer's (1990) model of endogenous growth. The productivity growth of country *i* is given by:

$$\left[\log A_T(H_t) - \log A_{T-1}(H_t)\right]_i = \alpha_0 + \alpha_1 H_i + \alpha_2 H_i \left[\frac{Y_{\max} - Y_i}{Y_i}\right]$$

In this equation, A stands for productivity, H stands for human capital and Y stands for output in country i at time t. H_i is measured as the average logarithm of human capital over the period. Y_{max} represents the output of the most productive country and $(Y_{max} - Y_i)/Y_i$ represents the productivity gap between the most productive country and country i. Thus, in this model, productivity growth of a country depends on the level of human capital in the country, which represents its ability to innovate, and an interaction term between human capital and the technological gap between the country and the most productive country in the world, which represents the diffusion of technologies from abroad facilitated by human capital.

Griffith *et al.* (2004) extend Benhabib and Spiegel model along several lines. In their model total factor productivity growth depends on the creation of new technology, on technology transfer from the country with frontier technology (facilitated by absorptive capacity) and on technology transfer from the country with

frontier technology that occurs independently of the absorptive capacity of the receiving country. This technology transfer term is given by the gap between the productivity of the country in the given industry and the productivity of the most productive country in that industry. The creation of new technology and the absorption of technology from abroad are determined by the investment in R&D in accordance with Cohen and Levinthal (1989). Thus, in their model productivity growth of country *i* and industry *j* is given by:

$$\Delta \ln A_{ijt} = \alpha_1 \left(\frac{R}{Y}\right)_{ijt-1} + \alpha_2 \left(\frac{R}{Y}\right)_{ijt-1} * \ln\left(\frac{A_F}{A_i}\right)_{jt-1} + \alpha_3 \ln\left(\frac{A_F}{A_i}\right)_{jt-1} + \gamma_X X_{ijt-1}$$

In this equation, A_{ijt} denotes productivity in country *i* and industry *j* at time *t*. *R* stands for investment in R&D, *Y* is the output and *X* represents other factors that affect productivity growth. The first term, is the R&D intensity in the given country and industry and it determines the creation of new technology in the country *i* and industry *j*. A_F represents the highest productivity in industry *j* in any country and A_F/A_i represents the productivity gap between the most productive country and country *i* in industry *j*. The second term is an interaction term between the productivity gap between the most productive country and country *i* in industry *j* and R&D intensity and it represents international technology transfer facilitated by absorptive capacity. The third term is the gap between the productivity of the country in the given industry and the productivity of the most productive country in that industry and it represents technology transfer that occurs independently of absorptive capacity.

The studies reviewed so far model technology transfer as a function of foreign technology, but do not specify a mechanism through which international technology

transfer occurs. Recently, the literature on international technology transfer has emphasised the importance of channels though which international technology transfer takes place. This literature identified two main channels: FDI (Markusen, 2002) and international trade (Grossman and Helpman, 1990; Coe and Helpman, 1995). Following insights from this literature, several studies examined how absorptive capacity affects international technology diffusion through specific channels like FDI, exporting or importing.

Borensztein, Gregorio and Lee (1998) adopt a model in the spirit of Benhabib and Spiegel (1994), but focus on technology transfer from developed to developing countries through a specific channel – FDI. In their model productivity growth in a country depends on inward FDI, which represents foreign technology, on human capital (H) and on an interaction term between FDI and human capital of the country, which represents the absorptive capacity of the country:

$$g = \alpha_0 + \alpha_1 H + \alpha_2 FDI * H + \alpha_3 FDI + \gamma_X X$$

Several studies have adopted similar models, but focused on different channels of international technology transfer. For instance, Miller and Upadhyay (2000) focused on exporting and Mayer (2001) focuses on imports of machinery and equipment as channels of international technology transfer.

All the models reviewed above assume that technology transfer increases with absorptive capacity. Although this hypothesis is studied frequently in both theoretical and empirical literature on international technology transfer, there is also an alternative hypothesis that international technology transfer increases with the technology gap between local and foreign firms. This hypothesis was proposed by

Findlay (1978). According to this hypothesis new technology needs to be demonstrated in a local context in order to be effectively adopted by local firms. MNEs in backward regions or countries expose local firms to new technology and this enables local firms to imitate the technology. Technology transfer from MNEs to local firms increases with the technological gap between the domestic firms and MNEs because a large technology gap implies many opportunities for domestic firms to increase their productivity by imitating MNEs. In this model the technology growth rate in the backward region is a function of the technology gap between developed region and the backward region and also of the openness of the backward region to FDI. However, Findlay (1978) also suggests that the gap cannot be too large because if it is too large local firms would not be able to imitate MNEs.

4.2.2 Review of Country and Industry Level Studies

Several studies have examined empirically how country absorptive capacity affects the adoption of technology developed abroad.

Benhabib and Spiegel (1994) test their model on a sample of 78 developed and developing countries between 1965 and 1985. They estimate a specification which follows their theoretical model described in the previous section. Their measure of human capital is the average years of schooling in the labour force, taken from Kyriacou (1991). Their measure of international technology diffusion facilitated by human capital is the difference between the output of the leading country and the output of the domestic country interacted with the human capital of the domestic country. They find evidence consistent with the hypothesis that human capital plays an important role in facilitating technology transfer from abroad. The magnitude of the impact is large and economically significant. They find that 1% increase in the

average level of human capital is associated with between 12.1% and 16.7% increases in per capita GDP growth over the twenty years period. They also analyse whether this effect is due to the contribution of human capital to the creation of new technology or to its contribution in absorbing technology developed abroad. They find that, for the whole sample, human capital contributes to productivity growth mainly through its contribution to technology adoption. They also test whether the contribution of human capital to technology adoption and to innovation differs across countries. They argue that, in developing countries, human capital contributes to productivity growth mainly through technology adoption, while in developed countries mainly through its contribution to the creation of new technology. To test this hypothesis, they separate the sample into developed and developing countries and estimate the equation separately for the two samples. Consistent with their hypothesis, they find that in the least developed countries, human capital contributes to productivity growth mainly through its effect on technology adoption, while the developed countries human capital contributes to productivity growth mainly through its contribution to innovation.

Griffith *et al.* (2004) test their theoretical model, using a panel of manufacturing industries from 12 OECD countries covering the period 1974 to 1990. Following their theoretical model, they estimate a specification in which total factor productivity growth depends on creation of technology (investment in R&D), technology transfer that occurs independently of absorptive capacity (technology gap in that industry) and international technology transfer facilitated by absorptive capacity (an interaction term between the technology gap in that industry and R&D). In addition, in their model, human capital plays a similar role to R&D. R&D

intensity is measured as R&D expenditure divided by output and human capital is measured as the percentage of total population with tertiary education, from Barro and Lee (1994). They find that R&D and human capital affect productivity growth through creation of new technology but also through facilitating technology transfer from abroad. They find that a 1% increase in R&D stock is associated with between 0.69% and 1.05% productivity growth per year. The percentage share of technology transfer in R&D contribution varies across countries between 14% in US and 54% in Finland. They find that, for countries closer to technology frontier, most of R&D's contribution to productivity growth is due to its contribution to innovation. In countries further from the technology frontier most of the R&D's contribution to productivity growth is due to technology transfer. They find similar evidence for human capital.

Kneller (2005) examines how technology transfer is affected by absorptive capacity (measured by human capital and R&D) in a panel of manufacturing industries in 12 OECD countries which covers the period 1972 to 1992. Unlike the Griffith *et al.* (2004) model, this study focuses on the level of total factor productivity. In this model, total factor productivity level depends on the creation of new technology, measured by previous investments in R&D, the level of frontier technology, and on the interaction between frontier technology and the domestic absorptive capacity and the interaction between frontier technology and distance. The measures of absorptive capacity used in this study are R&D (the ratio of R&D to output), and human capital (the average years of schooling in population over 25 years old, from the Barro and Lee (2000) dataset). The study finds evidence that human capital facilitates diffusion of foreign technology. With regard to R&D, Kneller (2005) finds that R&D plays an

important role in innovation but it plays a role in facilitating technology adoption only in for the sample of small and less R&D intensive OECD countries. It is argued that this result is due to the fact that in smaller, less R&D intensive countries, R&D might play a more important role in absorbing technology from abroad than in creating new technology. To assess the contribution of human capital to productivity growth, Kneller (2005) reports the ratio of the productivity of a country to the productivity of the US, which is the leading country in most industries, and an estimate of this ratio if the human capital of the given country was increased to the level of human capital in the US. This effect varies across countries between 1% in Canada to 9% in Italy. The results show that for the countries where the level of human capital is close to the US the effect is small, while for countries where the level of human capital is low the effect is large. This suggests that absorptive capacity plays a more important role in countries further from the technology frontier than for countries closer to the technology frontier.

Borensztein *et al.* (1998) test their model of technology transfer from developed to developing countries through a specific channel – FDI – on a sample of 69 developing countries over the period 1970 to 1989. Following their model, they estimate an equation in which GDP per capita growth of a country depends on FDI inflows, which represents foreign technology, and on an interaction term between FDI and human capital of the country, which represents the absorptive capacity of the country, and a set of other variables that affect economic growth. FDI is measured as FDI inflows from OECD countries to the countries included in the sample. They focus only on FDI from OECD countries because they argue that these FDI flows are more likely to bring new technology to the developing countries.

Human capital is measured as the average secondary education schooling in the male population aged over 25 in the initial year, again taken from the Barro and Lee (1994) dataset. The estimated coefficient on FDI is negative, but statistically insignificant, but the coefficient of the interaction term is positive and statistically significant. The magnitude of the coefficients implies that only countries that have a level of human capital above 0.52 years of secondary school attainment in the population over 25 years benefit from FDI. In their sample, 46 countries out of 69 had a level of human capital above this threshold during the period of time considered. To illustrate the magnitude of the effect of FDI on economic growth, they calculate the effect of an increase in the FDI to GDP ratio by one standard deviation for a country with the average human capital stock (0.91). This increase in the FDI to GDP ratio (0.005%) would result in a 0.3% higher growth rate per year for a country with the average level of human capital. In conclusion, they find that FDI has a positive effect on economic growth, only when the host country has the necessary human capital.

A large number of empirical studies have adopted a similar specification to Borensztein *et al.* (1998) to study the effect of absorptive capacity on international technology transfer. In these models, productivity (or productivity growth) depends on foreign technology (measured as inward FDI, imports or exports), on countries' absorptive capacity and on an interaction between the absorptive capacity and foreign technology.

Xu (2000) studies the effect of technological transfer from US multinationals to their foreign affiliates in a sample of 40 countries, of which 20 are developed and 20 are

developing countries, between 1966 and 1994. They adopt a model that is similar to Borensztein *et al.* (1999). Their study differs from Borensztein *et al.* (1998) in two aspects. First, Xu uses a different measure of technology transfer through FDI. Xu distinguishes between benefits for the host country from the presence of MNEs due to technology transfer and other benefits, for instance productivity gains resulting from the effects of FDI on market structure. Xu measures the presence of foreign affiliates in a country as the ratio between the MNE affiliates' valued added and the host country GDP. The measure for technology transfer is the spending of MNEs affiliates on royalties and license fees as a share the host country GDP. Secondly, instead of including an interaction term between the technology transfer measure and human capital, Xu estimates the equation for different samples selected according to different thresholds of human capital. Human capital is measured as the average male secondary school attainment in the population over 25 years old. This study finds that technology transfer through FDI has a positive impact on productivity growth only in countries that have accumulated a minimum stock of human capital. The magnitude of the coefficient of the technology transfer through FDI and the magnitude of the coefficient of the interaction between this variable and human capital are such that the minimum level of human capital above which a country benefits from technology transfer is 1.9 years of secondary school attainment in the population over 25 years old. This threshold is higher than 0.52 years of secondary school attainment in the population over 25 years which was the threshold found by Borensztein *et al.* (1998). The author finds that most of developing countries in the sample have a level of human capital above the threshold found by Borensztein *et al.* (1998), but below the threshold found by Xu (2000). The author argues that Borensztein *et al.* (1998) actually estimate the benefits from the presence of MNEs,

which may include other benefits than technology transfer, for instance productivity gains due to the effects of the MNEs on market structure. According to this interpretation developing countries benefit from the presence of MNEs, but not from technology transfer. In support of this hypothesis, Xu (2000) presents evidence that for his sample of developing countries there is a positive and significant relationship between the presence of MNEs and productivity growth, but not between technology transfer and productivity growth.

Campos and Kinoshita (2002) study the effect of FDI on economic growth in 25 transition countries between 1990 and 1998 using a model similar to the one used by Borensztein, Gregorio and Lee (1998). They find that FDI has a positive and significant effect on growth in transition economies, but this effect does not depend on the host country's human capital level. In addition, they find that, in many specifications, human capital appears to have a negative and significant sign. They suggest several explanations for these findings. All the transition economies during the period studied had human capital levels above the minimum threshold found by Borenszstein *et al.* (1998), and they argue that above this minimum threshold the absorptive capacity of the host country may not play a significant role in technology diffusion. In most transition countries, the level of human capital was very high at the beginning of the transition, but declined slightly between 1990 and 1998, mainly due to diminishing public financial support, while the economic growth rates increased. In addition, it is possible that at the beginning of the transition period human capital was excessively specialised and its occupational structure was not well suited for market economy.

Miller and Upadhyay (2000) develop a model in which total factor productivity depends on human capital, openness to international trade and an interaction term between openness to international trade and human capital. They test this model using data for 83 developed and developing countries between 1960 and 1989. Their measure of openness to international trade is the ratio of exports to GDP. Human capital is measured as the average number of years of schooling for the adult population from Barro and Lee (1994). Their results show that trade openness and the interaction between trade openness and human capital have a positive and significant effect on total factor productivity growth, suggesting that countries benefit from technology transfer through trade and that countries with higher human capital benefit more than others from this technology transfer. The point estimates suggest that an increase by 1% in the level of human capital of a country would increase the absorption of technology transferred through trade by 4%. However, they find the coefficient of human capital is negative. The magnitude of coefficients of human capital and of the interaction term implies that the total impact of human capital on total factor productivity is negative for low levels of openness, but positive for open economies. They find that the threshold openness above which human capital has a positive impact is 11%. Their explanation for this result is that for low levels of openness human capital is underutilised.

Mayer (2001) studies the role of human capital in facilitating technology transfer through imports of machinery and equipment in 53 developing countries between 1970 and 1990. This study adopts a model in which total factor productivity depends on technology transferred through imports of machinery and equipment, the stock of human capital, and technology transferred facilitated by the absorptive capacity of

the country, represented by an interaction term between these two variables. Human capital is measured as the average number of years of schooling in population aged 15 or above. Technology transfer through imports of machinery and equipment is measured as average ratio of imports of machinery and equipment to the GDP. Mayer (2001) finds a positive and statistically significant impact of the interaction term between human capital and imports of machinery, suggesting that human capital plays an important role in assimilating foreign technology. Another result of the study is that when the interaction term between imports of machinery and human capital is included, the direct effect of human capital is not statistically significant. Mayer (2001) interprets these results as evidence that human capital in developing countries affects productivity mainly through its impact on the adoption of new technology.

In conclusion, there is a large literature that examines empirically how absorptive capacity affects international technology transfer at country and industry level. Taken as a whole, the empirical evidence from studies that use aggregate data suggests that human capital and conducting R&D play important roles in increasing the ability to adopt technology developed abroad.

4.2.3 Review of Firm Level Studies

Even within one country, not all firms are able to assimilate new technology and the firm's absorptive capacity is considered an important factor in determining this ability. Firm level studies can also document in greater detail the mechanism through which absorptive capacity affects technology transfer.

There are a number of reasons why absorptive capacity at the firm level should matter for technology transfer though FDI spillovers and international trade. In the case of horizontal spillovers, absorptive capacity is important because, although all firms in the sector are exposed to new technology, new products or new marketing techniques introduced by MNEs, firms that possess higher absorptive capacity are more able to imitate and adopt them. In order to benefit from backward spillovers, domestic firms have to be able to produce inputs that meet the MNEs' standards in terms of quality, costs and delivery on time. The firms that are more technologically advanced are more able to make the necessary improvements to meet these standards. MNEs might decide not to purchase inputs from local firms that do not have the capacity to produce the inputs with the characteristics they require, or they may purchase only basic inputs with little technological content (Javorcik, 2008). In this case, the potential of technology transfer to local firms is limited. Finally, firms' ability to learn by exporting may also depend on their absorptive capacity. Interactions with foreign competitors and customers provide information on new products and technology that allows exporters to reduce costs and to improve quality (Greenaway and Kneller, 2007). Firms with higher absorptive capacity are more able to recognize, evaluate information and to implement the necessary adjustments.

A large number of studies have examined empirically how firms' absorptive capacity affects technology transfer through various channels. These studies adopt a specification similar to the ones used in the macroeconomic literature, and assume that a firm's productivity, or productivity growth, depends on its access to foreign technology, on its absorptive capacity and the interaction between the absorptive

capacity and its access to foreign technology. The studies generally estimate variants of the following specification, used by Girma *et al.* (2008):

$$\ln(TFP)_{ijt} = \beta_{FT} FT_{jt} + \beta_{AC} FT_{jt} * AC_{ijt} + \gamma_X X_{ijt} + u_{it}$$

In this specification the total factor productivity of firm *i* at time *t* is regressed on a measure of access to foreign technology at time *t* and an interaction between foreign technology and other control variables. A positive and significant coefficient of the variable that measures the interaction between foreign presence in the sector of the firm and the absorptive capacity of the firm is interpreted as evidence consistent with the hypothesis that absorptive capacity facilitates technology transfer. Most of the specifications include controls for other firm characteristics and allow absorptive capacity to affect technology transfer in a nonlinear way.

Several measures of absorptive capacity have been used. One of the most commonly-used measures for the absorptive capacity of a firm is the difference between the initial level of technology of the firm and the best practice technology in the industry at time *t*:

$$AC_{ijt} = TFP_{ijt} / TFP_{\max jt}$$

This measure shows how far behind the best practice in the industry is the technology of a given firm. Variants of this measure have been used by, Girma (2005), Girma and Görg (2007), Girma, Görg and Pisu (2008), Nicolini and Resmini (2010) among others. Despite being one of the most frequently used measure of absorptive capacity in firm level studies, it has several disadvantages. This measure is not related to the concept of absorptive capacity as it is defined in the theoretical literature or the measures used in the macro literature. It is also prone to measurement error because the total factor productivity gap between a firm and

productivity frontier may be affected by temporary shocks that do not affect at the same time the absorptive capacity of the firm (Girma and Görg, 2007). Finally, productivity gap measures are not very informative for policy because they do not explain why the productivity gap is large or small in the first place and what can be done to reduce it. Next, we will review some of these empirical studies, which are most relevant for our analysis.

Girma (2005) studies whether the absorptive capacity of local firms is important in determining whether local firms benefit or not from presence of foreign owned firms in the same region and sector using panel of UK firms in manufacturing sectors covering the period 1989 to 1999. The author finds evidence that higher absorptive capacity increases spillovers from foreign firms in the same sector and region for FDI and that the effect of the FDI spillovers depends on the absorptive capacity in a nonlinear way. Local firms need to possess a minimum level of technological capacity in order to benefit from FDI spillovers, and above a certain higher level of absorptive capacity, FDI spillovers become less important. His interpretation of the results is that firms below a certain level of technology capacity are not able to benefit from spillovers through demonstration and imitation, but are hurt by competition from foreign firms. Domestic firms with a high level of absorptive capacity are very similar to foreign owned firms and therefore the potential for spillovers is limited. This interpretation is line with the technology gap hypothesis proposed by Findlay (1978). Girma finds that for the sample that includes all sectors the minimum absorptive capacity required to benefit from FDI is 48.7% and that the threshold above which spillovers benefits from FDI start diminishing is 72.6%. The author finds that a large share of the firms in the sample (68.8% - 83.4%) has

absorptive capacity between the two thresholds and, thus, benefits from FDI in the same industry and region.

Girma and Görg (2007) study the impact of absorptive capacity on horizontal FDI spillovers in a panel of UK firms in the electronics and engineering sectors during the period 1980-1992. They find evidence that absorptive capacity is important in determining whether or not a firm benefits from horizontal FDI spillovers. They find that, for a given level of FDI presence in the sector, an increase in the absorptive capacity of the local firms will first reduce the benefits from FDI, but above a certain threshold it will increase the firm's benefits from FDI. They explain their result as it follows. At low levels of technological capacity firms are not able to benefit from FDI spillovers but they are also not in direct competition with MNEs and therefore they are not affected by the presence of FDI in the same industry. Local firms with a higher productivity but still below a certain threshold are not able to benefit from technology spillovers, but are affected negatively by competition from MNEs. Finally, firms above a certain threshold are able to benefit from technology spillovers from MNEs and to compete successfully against MNEs. The effect of foreign presence in the sector on these firms is positive. They find that for both sectors the critical value of absorptive capacity above which firms benefit from foreign presence is around 60% of the productivity of the industry leader and they find that more 50% of the firms in their sample have an absorptive capacity below this level. Their results contrast with the results of Girma (2005), but the two studies differ in the manufacturing sectors covered and in the specification and econometric methods used.

Girma, Görg and Pisu (2008) study horizontal and vertical productivity spillovers from FDI using a panel of UK manufacturing firms from 1992 to 1999. They find evidence on horizontal productivity spillovers and that these spillovers increase with the absorptive capacity of the local firms. However, they find that spillovers depend on the export orientation of the MNEs and of the local firms. They find that there are no productivity spillovers from domestic market oriented FDI to local firms and no productivity spillovers from export market oriented FDI for non-exporters. With regard to backward linkages, they find that there are spillovers from domestic oriented FDI to exporting or non exporting local firms and that these spillovers are increasing with absorptive capacity of the local firm. However, they find that export oriented FDI has a negative impact on local firms in upstream industries and they find no evidence that absorptive capacity affects these spillovers. They present several possible explanations for this result. If export oriented MNEs have limited linkages with local firms in upstream industries and they captured the market share from domestic firms that had linkages with local firms, than the entrance of MNEs results in negative spillovers for the domestic firms in upstream industries (Rodriguez Clare, 1996). Negative spillovers may also be the result of higher bargaining power of MNEs than their local suppliers. However, the authors are unable to test these hypotheses due to data limitations.

Nicolini and Resmini (2010) study the effect of absorptive capacity on horizontal and vertical spillovers in Bulgaria, Poland and Romania. They use a panel of firms in manufacturing industries, which covers the period 1998 – 2003. Their measure of the productivity gap is a dummy variable that takes the value 1 if the total productivity of the firm is below the average productivity in the industry of the firm and zero

otherwise. They find that in all three countries only the firms with a productivity level above the average productivity in the industry benefit from both horizontal and vertical spillovers.

Another measure of absorptive capacity of the firm is the firm's investment in R&D. By conducting R&D, firms not only create new technology but also develop their capacity to identify, evaluate and assimilate knowledge from outside the firm (Cohen and Levinthal 1989). This proxy was used by Kinoshita (2000), Damijan *et al.* (2003), Hu *et al.* (2005) and Girma *et al.* (2009), among others.

Kinoshita (2000) studies the effects of R&D in facilitating technology transfer through foreign ownership and FDI intra industry spillovers using a panel of manufacturing firms in the Czech Republic during the period 1995 -1998. Kinoshita estimates a model in which total factor productivity growth depends on R&D, foreign ownership and FDI in the sector and an interaction between R&D and foreign ownership and R&D and FDI in the sector. Kinoshita (2000) finds that, on average, foreign owned firms are not more productive than domestic firms and that there are no spillovers from FDI in the sector. However, the interaction between foreign presence in the sector and firm investment in R&D is positive and significant, which suggest that spillovers increase with the absorptive capacity of the local firms. The author also tests whether R&D helps absorb technology from MNE parent, but finds no empirical evidence in support of this hypothesis.

Damijan *et al.* (2003) study the effects of R&D in facilitating technology transfer to local firms through horizontal FDI spillovers and international trade using a panel of

manufacturing firms in eight transition countries in the period 1994-1998. They find that investment in R&D facilitates technology transfer through horizontal FDI spillovers only in Romania, and it actually hinders horizontal spillovers in Czech Republic and Poland and in all the remaining countries its effect is insignificant. The authors also find that the interaction term between firm R&D and exports is negative in Czech Republic and it is insignificant for all the other countries and the interaction term between R&D and imports is positive in Czech Republic, but insignificant for all the other countries.

Hu *et al.* (2005) study how investment in R&D facilitates technology transfer using a panel of Chinese firms in manufacturing sectors covering the period 1995 to 1999. They define technology transfer as the expenditure of the firm on the disembodied technology purchased from foreign firms such as patent licensing fees and payments for blueprints of technology. They estimate a production function in which the firm's technology depends on its investment in R&D, foreign technology purchased from outside the firm and an interaction term between firm's R&D and technology purchased. They find evidence consistent with the hypothesis that R&D enhances a firm's absorptive capacity and facilitates the adoption of technology purchased from foreign firms.

Girma *et al.* (2009) examine empirically the role of absorptive capacity of local firms in facilitating technology transfer though horizontal FDI spillovers. They use a panel of state owned Chinese firms in manufacturing industries covering the period 1999 to 2005. Their study differs from previously reviewed studies because instead of focusing on the impact of productivity they study firm innovation, measured as the

share of output involving new products. They use two measures of absorptive capacity: R&D intensity and training provided for the firm's employees. They expect that foreign presence in the industry might affect the innovation of the domestic firms because some of the technology of MNEs will leak to local firms, through worker movement or imitation. In addition, the entry of foreign firms will lead to an increase in the competition in the industry and that could stimulate firms invest more in innovation. They find that inward FDI in the sector has a negative impact on the innovation of the state owned firms on average, but firms that invest in R&D and those that provide training for their employees benefit from inward FDI in the sector. These results are consistent with the hypothesis that the absorptive capacity facilitates technology transfer.

Another measure of absorptive capacity of the firm is human capital, measured in terms of share of nonproduction employees or share of employees with a certain level of education. Variants of these measures were used by Sinani and Meier (2004), Gorodnichenko *et al.* (2007), Köymen and Sayek (2010), among others.

Sinani and Meyer (2004) study the effect of various firm characteristics, including firms' human capital, on the horizontal spillovers from FDI on manufacturing firms in Estonia between 1994 and 1999. Their measure of human capital is the average costs with labour calculated as the total cost with labour divided by the number of employees. They find that human capital has a positive direct effect on firms' productivity growth, but that the interaction term between human capital and FDI presence in the sector of the firms is negative for the overall sample of domestic

firms. They also find that this interaction term is negative or insignificant for most of subsamples of domestic firms defined based on size, ownership and export status.

Gorodnichenko *et al.* (2007) study how education of firms' employees affects technology transfer from horizontal and vertical FDI spillovers for firms in 17 transition economies using BEEPS dataset. Their measure of human capital is the share of employees with tertiary education in total employees. They use industry measures of horizontal, downstream and upstream spillovers, but also firm level measures of vertical spillovers. Their results show that for the overall sample of domestic firms has a positive direct effect on total factor productivity growth, but the interaction term between different measures of FDI spillovers and human capital are statistically insignificant. They also consider several subsamples defined based of firm size, sector of activity and age of the firm and find similar results for most of subsamples.

Köymen and Sayek (2010) study the effect of human capital on the ability of firms to benefit from horizontal and vertical spillovers from FDI using a panel of Turkish firms in manufacturing industries which covers the period 1990-2001. They measure human capital as the share of management and high and medium level technical personnel in total employees. They find that human capital affects the ability of firms to benefit from horizontal FDI spillovers. Their estimations indicate that only firms which have a share of skilled employees above 9% are able to benefit from horizontal spillovers. In their sample, more than 75 % of the firms have a share of skilled employees above 9% and therefore are able to benefit from horizontal spillovers. For firms below this threshold the effect of FDI in the same sector is

statistically insignificant. They also find that firms in their sample benefit from FDI spillovers through backward linkages and that the effect of spillovers through backward linkages does not depend on the firms' human capital.

To summarise, a large number of studies examined the role of absorptive capacity in facilitating the transfer of technology created abroad at firm level and they found ambiguous results. Most of the studies measure absorptive capacity as the technological gap between the firm the most productive firm in the industry and these studies found that absorptive capacity a nonlinear effect on technology transfer through FDI spillovers. However, these measures of absorptive capacity present several disadvantages: they are not related to the concept of absorptive capacity as it was defined in theoretical literature and the measures used in country level studies, they are more prone to measurement errors and they are not very informative for economic policy. Recently, several studies used firm investment in R&D and human capital as measures of firm absorptive capacity, which address the problems mentioned above. These studies, especially those on firms in ECA, have found insignificant or even negative results for the effect on absorptive capacity on technology transfer through FDI or international trade.

We address some of the issues in previous studies by examining the effect of several measures of firm and country level absorptive capacity which are closely related to the concept of absorptive capacity, by using firm level measures of access to foreign technology and by studying firms in a large number of transition economies in ECA.

Table 4.1 Studies on the effect of country absorptive capacity on transfer of foreign technology

Study	Sample	Absorptive capacity	Foreign technology	Effect of Absorptive Capacity on Technology Transfer
Benhabib and Spiegel (1994)	78 developed and developing countries 1965 -1985	Human capital (average years of schooling)	Technological gap between a country and the leader	+
Griffith *et al.* (2004)	12 manufacturing industries in OECD countries 1974-1990	R&D Human capital (share of population with tertiary education)	Technological gap between a country and the leader in the industry	+ R&D + Human capital.
Kneller (2005)	12 manufacturing industries in OECD countries 1972-1992	R&D Human capital (average years of schooling)	Technological gap between a country and the leader in the industry	+ Human capital ? R&D
Borensztein *et al.* (1998)	69 developing countries 1970-1989	Human capital (average male secondary school attainment)	FDI from OECD countries	+
Xu (2000)	40 developed and developing countries 1966 - 1994	Human capital (average male secondary school attainment)	Technology transfer spending of MNE affiliates/host country GDP	+
Campos and Kinoshita (2002)	25 transition countries in ECA 1990-1998	Human capital (basic education enrolment ratio)	FDI	?
Miller and Upadhyay (2000)	83 developed and developing countries 1960 - 1989	Human capital (average years of schooling)	Exports/GDP.	+
Mayer (2001)	53 developing countries 1970-1990	Human capital (average years of schooling)	Imports of machinery and equipment/GDP	+

Table 4.2 Studies on the effect of firm absorptive capacity on transfer of foreign technology

Study	Sample	Absorptive capacity	Foreign technology	Effect of Absorptive Capacity on Technology Transfer
Girma (2005)	Manufacturing firms in UK 1989-1999	Technological gap between a firm and the leader in the industry	Horizontal FDI spillovers	Nonlinear effect
Girma and Görg (2007)	Engineering and electronics firms in UK 1980-1992	Technological gap between a firm and the leader in the industry	Horizontal FDI spillovers	Nonlinear effect
Girma *et al.* (2008)	Manufacturing firms in UK 1992-1999	Technological gap between a firm and the leader in the industry	Horizontal FDI spillovers Backward FDI spillovers Forward FDI spillovers	+ Horizontal FDI spillovers + Backward FDI spillovers + Forward FDI spillovers The effects depend on the export orientation of domestic and foreign firms.
Nicolini and Resmini (2010)	Manufacturing firms in Bulgaria, Poland and Romania 1995-2003	Technological gap between a firm and the average in the industry	Horizontal FDI spillovers Backward FDI spillovers Forward FDI spillovers	+ Horizontal FDI spillovers + Backward FDI spillovers + Forward FDI spillovers
Kinoshita (2000)	Manufacturing firms in Czech Republic 1995-1998	R&D	Foreign ownership Horizontal FDI spillovers	? Foreign ownership. + Horizontal spillovers.
Damijan *et al.* (2003)	Manfacturing firms in 8 CEECs 1994-1998	R&D	Horizontal FDI spillovers Exports/sales Imports/sales	Horizontal spillovers: + ROM, - CZE, POL, ? other countries Exports: - CZE, ? other countries Imports: + CZE, ? other countries

Hu *et al.* (2005)	Manufacturing firms in China 1995-1999	R&D	Expenditure on patent licensing fees foreign firms	+
Girma *et al.* (2009)	Manufacturing firms in China 1999-2005	R&D Training	Horizontal FDI spillovers	+ R&D +Training
Sinani and Meier (2004)	Manufacturing firms in Estonia 1994-1999	Average costs with labour	Horizontal FDI spillovers	-
Gorodnichenko *et al.* (2007)	Manufacturing and service firms in 17 transition economies	Share of employees with tertiary education.	Horizontal FDI spillovers Backward FDI spillovers, Forward FDI spillovers, Share of output sold to MNEs	?
Köymen and Sayek (2010)	Manufacturing firms in Turkey 1990-2001	Share of skilled employees	Horizontal FDI spillovers Backward FDI spillovers Forward FDI spillovers	+ Horizontal spillovers ? Backward spillovers ? Forward spillovers

4.3 Data Description

This section describes the data used and the indicators of absorptive capacity and examines how these characteristics differ across countries and firms. The data used in this chapter comes from BEEPS 2005 conducted by the World Bank and the EBRD, as described in Chapter 2. We use mainly the 2005 wave because in 2002 wave almost 70% of the firms did not answer the questions about investment in R&D, which is one of the main measures of absorptive capacity. We use the same sample as in the previous chapter.

We use four channels of international technology transfer as measures of firms' access to technology transfer. These channels are once again: foreign ownership, supplying MNEs, exporting and importing. We focus on these channels because in the previous chapter we found that only these channels are robustly associated with higher productivity, and, therefore, consistent with technology transfer hypothesis. These measures as well as the other variables related used in this chapter are the same as those defined in Chapter 3 and are described in Table 3.14 and Table 3.15. In this section we will focus on the measures of absorptive capacity at firm and country level.

4.3.1 Definition of Absorptive Capacity Indicators

We will use three measures of absorptive capacity: tertiary education, provision of formal training and investment in R&D. As discussed in section 4.2, the theoretical literature suggests that these activities facilitate the ability to understand, evaluate and implement new knowledge. These indicators capture different aspects of absorptive capacity. Education is frequently used as a measure of absorptive capacity

in studies that used aggregate data (Benhabib and Spiegel, 1994; Borensztein *et al.* 1998; Griffith *et al.* 2004; Kneller, 2005). However, in the case of transition countries, it has been argued that some of the skills acquired through education, during the central planning may not be adequate for the needs of a market economy (World Bank, 2001). According to World Bank (2001) this is due to a strong emphasis on narrow specialisations which were no longer required under the market economy and the lack of focus on general knowledge and skills, which led to low adaptability of workers. Firms can address the problem of shortage of appropriate skills of the labour force by providing training. Therefore, we also use the provision of formal training in the enterprise as a measure of absorptive capacity. A similar measure was used by Girma *et al.* (2009). Our third measure of absorptive capacity is R&D activity. Investment in R&D was used as a measure of absorptive capacity in several industry levels studies (Griffith *et al.*, 2004; Kneller, 2005) and in several micro level studies Kinoshita (2000), Damijan *et al.* (2003), Hu *et al.* (2005), Girma *et al.* (2009).

The education variable is based on question q69a4 in the survey. It asks: "What percentage of the workforce at your firm has education levels up to (....) some university education or higher?". Education is defined as the share of employees with some university education or higher. A similar indicator for workforce education was used in previous studies (Gorodnichenko *et al.*, 2007, 2008; Almeida and Fernandes, 2008). Country level measure of the workforce education is also based on the same question. It is defined as the share of employees with tertiary education of the total number of employees in the firms in the given country.

The training variable is based on a question q71 in BEEPS 2005 questionnaire: "Does your firm offer formal training to your employees? If yes, what percentage of employees in each category received training over the last 12 months?". If the firm answered that it did offer training to employees in any of the three categories (skilled workers, unskilled workers, non production workers), the variable training takes the value 1. A similar indicator for training was used by Almeida and Fernandes (2008). It the firm answered no in all three categories or in some categories it answered no and in the other categories it did not answer, the variable training takes value 0. Country level measure of training is constructed based on this question and it is defined as the share of firms that provide training to their employees in the given country.

The variable R&D is based on the question q58b in BEEPS 2005 questionnaire. This question asks: "Could you please tell me how much did your firm spend in 2004 on each of the following: ... Research and Development (including the wages and salaries of R&D personnel, R&D materials, R&D related education and R&D related training costs)". R&D is defined as a dummy variable that takes the value 1 if the firm had positive expenditure on R&D in 2004 and 0 otherwise. A similar indicator for R&D activities was used by Almeida and Fernandes (2008) and by Gorodnichenko *et al.* (2008). If the firms did not answer this question, it was considered that they spent 0 on R&D. We made this imputation because without it, it appeared that an implausibly large share of firms invests in R&D in less economically developed countries. Country level measure of R&D is based on this question and it is defined as the share of firms that invest in R&D in the given country.

4.3.2 Description of Absorptive Capacity Indicators

In this section we will describe the main indicators of absorptive capacity. We begin our data analysis by looking at descriptive statistics of absorptive capacity indicators. Table 4.3 reports the descriptive statistics for these indicators for the whole sample and for the sample of firms used in the empirical analysis.

The summary statistics regarding firm absorptive capacity show that in the average firm 28% of employees have tertiary education; more than 42% of firms provided formal training to their employees and almost 9% of the firms invested in R&D. Comparing the whole sample with the sample used in the regressions, it can be noticed that the firms in the regression sample have on average a less educated workforce, but are more likely to invest in training and R&D. The values of these indicators differ for the regression sample due to the country composition of the regression sample. In this sample, as explained in Chapter 2 several former Soviet Union countries are underrepresented and these countries tend to have higher share of employees with tertiary education and a smaller share of firms that invest in training and R&D, as shown in Figure 4.1.

Overall, these statistics suggest that an important share of firms has high absorptive capacity especially with regard to measures of human capital. This is in line with existing evidence of high human capital stocks in transition economies in ECA.

Table 4.3 Descriptive statistics for absorptive capacity indicators

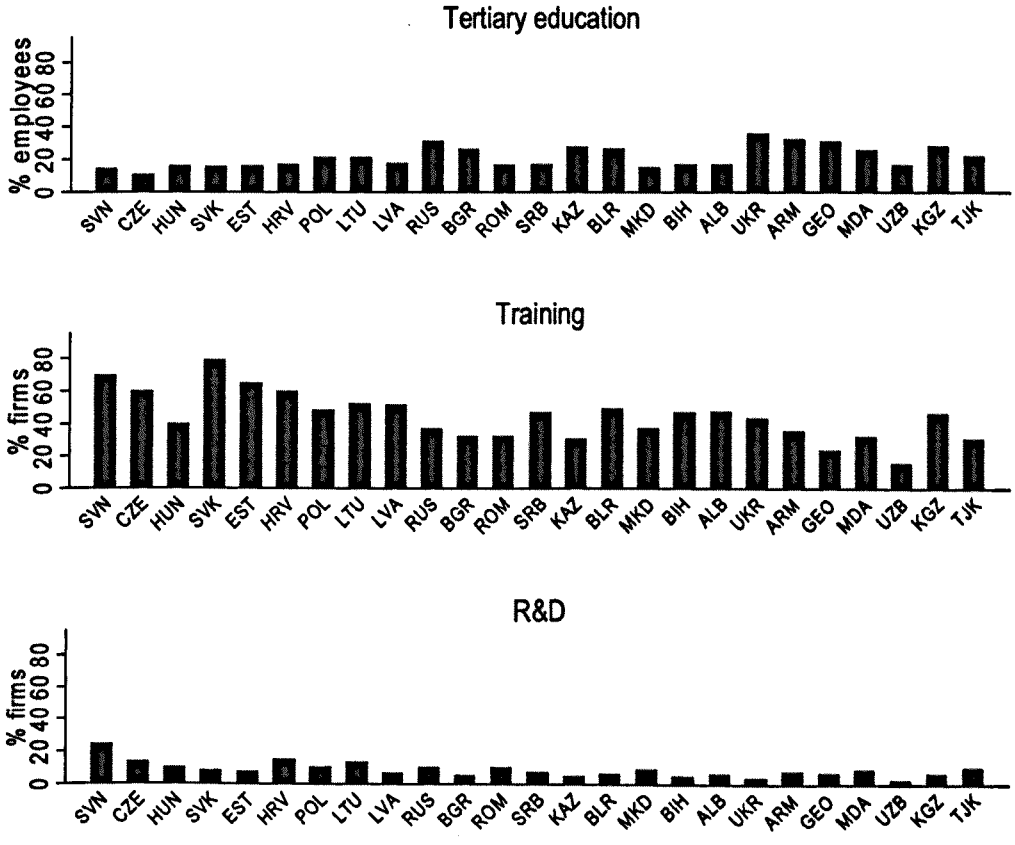
	Definition	All sample			Regression sample		
		Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
	Firm absorptive capacity						
Education	Share of employees with tertiary education in the firm.	8931	0.282	(0. 293)	3648	0.242	(0.270)
Training	A dummy variable that takes the value 1 if the firm formal training to employees in the previous year and 0 otherwise.	8298	0.418	(0.493)	3444	0.483	(0.499)
R&D	A dummy variable that takes the value 1 if the firm invested R&D in the previous year and 0 otherwise.	9098	0.087	(0.282)	3690	0.157	(0.364)
	Country absorptive capacity						
Education	Share of employees with tertiary education in the country.	9098	0.234	(0.081)	3690	0.213	(0.068)
Training	Share of firms in the country that provided formal training in the previous year.	9098	0.419	(0.134)	3444	0.456	(0.121)
R&D	Share of firms in the country that invested in R&D in the previous year.	9098	0.087	(0.041)	3690	0.098	(0.038)

Source: BEEPS 2005

The value for country level education measure differs from the corresponding firm level measure because this measure is weighted by employment. It is also important to notice that the standard deviation in the case of country absorptive capacity is much smaller than in case of firm level absorptive capacity. This suggests that the variation within countries is much larger than the variation between countries, but there is also considerable variation between countries.

Figure 4.1 illustrates how the three country absorptive capacity measures considered differ across 25 transition countries.

Figure 4.1 Absorptive capacity: differences across countries



Sources: BEEPS 2005

Figure 4.1 show that most of the countries have a high share of employees with tertiary education, but there are also important differences between countries. It

appears that in most countries in Central and Eastern Europe the share of employees with tertiary education is lower than in countries in former Soviet Union. It can be noticed that some countries have unusually high values for this indicator compared with their level of development and with the most developed countries in the sample. For instance, countries like Armenia and Georgia are among the countries that have the largest shares of employees with tertiary education. Also, the most developed countries in the region, like Czech Republic and Slovenia, have comparatively low share of workforce with tertiary education.

The figure also shows that in Central and Eastern Europe countries a higher share of firms invest in training and in R&D than in CIS countries. However, in most countries a large share of firms provides formal training to their employees, but with the exception of Slovenia few firms invest in R&D.

Are these indicators correlated between them and are they correlated with measures related to participation in international activities? This is important for several reasons. First, if measures of participation in foreign activities are correlated with measures of absorptive capacity, this might create multicollinearity problems for our estimation of their direct and indirect effects on productivity. Secondly, if our different measures of absorptive capacity are correlated, then it would be difficult to separate the effects of different measures of absorptive capacity on technology transfer. Similarly, if the measures of access to foreign technology are correlated it would be difficult to separate the effects of different channels of international technology transfer. The correlation matrix of these indicators is reported in Table 4.4.

Table 4.4 Correlation Matrix

	Foreign	MNEs Supplier	Exporter	Importer	Education (firm)	Training (firm)	R&D (firm)	Education (country)	Training (country)	R&D (country)
Foreign	1.000									
MNEs Supplier	0.126	1.000								
	(0.000)									
Exporter	0.231	0.192	1.000							
	(0.000)	(0.000)								
Importer	0.178	0.186	0.293	1.000						
	(0.000)	(0.000)	(0.000)							
Education	0.127	0.066	0.064	0.089	1.000					
(firm)	(0.000)	(0.000)	(0.000)	(0.000)						
Training	0.108	0.133	0.191	0.191	0.039	1.000				
(firm)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)					
R&D	0.119	0.110	0.243	0.155	-0.015	0.170	1.000			
(firm)	(0.000)	(0.000)	(0.000)	(0.000)	(0.363)	(0.000)				
Education	-0.008	-0.043	-0.113	-0.005	0.204	-0.126	-0.038	1.000		
(country)	(0.636)	(0.010)	(0.000)	(0.745)	(0.000)	(0.000)	(0.021)			
Training	-0.018	0.033	0.135	0.140	-0.106	0.269	0.084		1.000	
(country)	(0.096)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
R&D	-0.048	0.014	0.086	-0.027	-0.116	0.152	0.100	-0.489	0.577	1.000
(country)	(0.004)	(0.410)	(0.000)	(0.106)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Source: BEEPS 2005

The correlation matrix shows several interesting patterns. The measures of access to foreign technology are positively and significantly correlated, but the magnitude of the coefficients is small. The largest correlation is between exporting and importing (0.29). This shows that although many firms tend to participate in several of these activities simultaneously, we would still be able to examine the effects of different channels.

Most of the measures of firm level absorptive capacity are not significantly correlated. Only R&D is significantly correlated with training. This is consistent with the idea that to create new knowledge firms need to upgrade the skills of their employees. These correlations suggest that these three indicators of absorptive capacity reflect different aspects of absorptive capacity and it is important to study the effect of all these measures in the empirical analysis.

Most of the country level measures of absorptive capacity are strongly and significantly correlated. The correlations between education and training and education and R&D are negative and significant and large in magnitude (-0.37 for training and -0.49 for R&D). A possible explanation is that these negative correlations are due to other country characteristics which affect negatively investment in R&D and in personnel training, but are positively correlated with education. As shown in Figure 4.1 countries in former Soviet Union have higher share of employees with tertiary education than countries in CEE. However, these countries have progressed less in their transition to market economy and have, on average, less favourable investment climate, which might affect firms' investments in R&D and training. The share of firms that invests in R&D in a country and the

share of firms that invest in personnel training are both strongly and positively correlated.

All measures of firm level absorptive capacity are positively and significantly correlated with measures of access to foreign technology. However, the magnitude of the coefficients is not large. The largest is between firm investment in R&D and exporting and it is (0.24).

The workforce education in a country appears to be negatively correlated with all international activities and these correlations are significant for supplying MNEs and for exporting. Again, these correlations may be driven by the CIS countries which have higher shares of employees with tertiary education than CEE countries, but have made less progress with transition, especially with the liberalisation of international trade and FDI, and overall have less favourable investment climate, which might affect firms' ability to participate in these international activities. The correlations between the other country level absorptive capacity measures and participation in internationals activities are mostly insignificant, except for exporting which is positively correlated with the share of firms that invest in training and in R&D.

Next, we compare our country level measures of absorptive capacity based on BEEPS with related macro indicators from World Bank Development Indicators. We do this because the descriptive statistics in the previous section suggest some unexpected patterns. The values of some country absorptive capacity measures, especially education, appear to be very different from what would be expected based

on these countries level of development. In addition, our country level indicator of workforce education is negatively and significantly correlated with investment in R&D and training as well as participation in international activities, especially exporting. Therefore, we will compare our measures of absorptive capacity with corresponding indicators at macro level.

i. Education

The average share of employees with university education in each country in the sample is presented in Table 4.15 (column 1), in the annexes to this chapter. In our sample, Ukraine is the country with the largest share of workforce with tertiary education (0.36) and the country with the lowest share of workforce with tertiary education is Czech Republic (0.11).

We compare the average share of workforce with tertiary education calculated from BEEPS with the share of labour force with tertiary education in total labour force at country level from World Development Indicators (WDI)[16] compiled by World Bank for the year 2004. For countries for which this data is not available for 2004, we use data from 2003 or the most recent year available. The share of labour force with tertiary education from (WDI) is reported in Table 4.15 (column 2), in the annexes to this chapter. For some countries, like Armenia, the WDI does not provide this information at all.

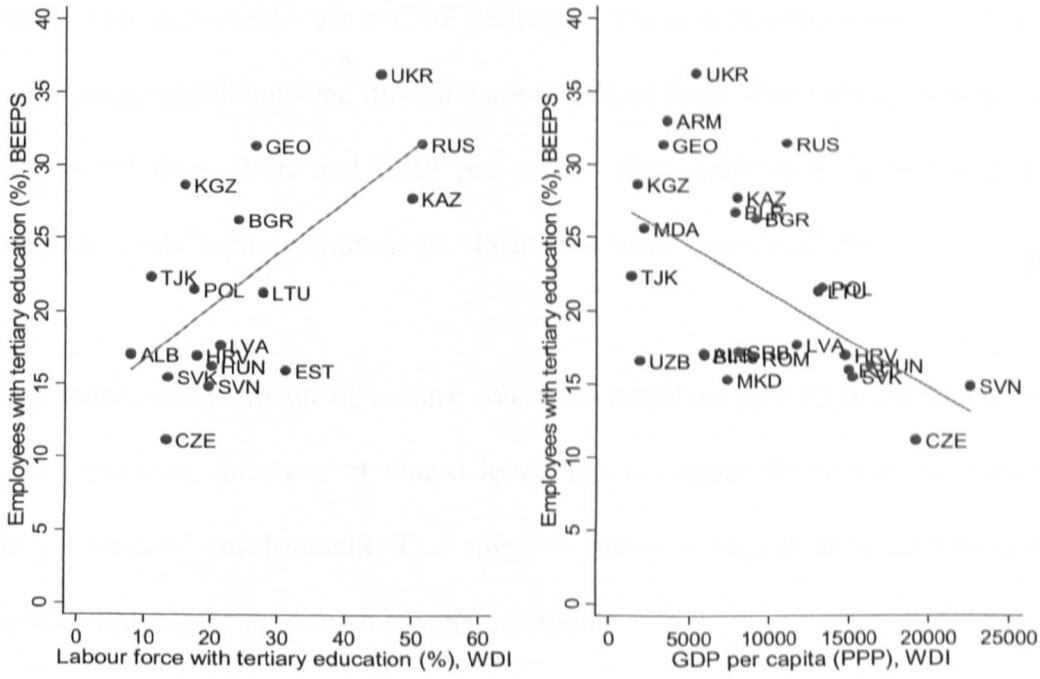
It is important to notice that the indicator from WDI and the indicator calculated from BEEPS differ in their content. The indicator of tertiary education based on BEEPS is only representative of the labour force employed in the private sector in

[16] An alternative measure of human capital is population educational attainment from Barro and Lee dataset, which was used in many empirical studies on absorptive capacity, but that dataset does not provide information on most of the former Soviet Union and former Yugoslavia countries.

the sectors covered by the BEEPS 2005. The percentage of labour force with tertiary education from WDI includes the whole labour force, including labour force in sectors not covered by BEEPS. However, we expect a positive relationship between the two indicators. We also compare these indicators with the general level of development measured as GDP per capita in 2004 measured in PPP from WDI, also reported in Table 4.15. We also expect a positive relationship between these two indicators because human capital is an important determinant of economic growth and thus in the long term also of GDP per capita.

Figure 4.2 presents the relationship between the tertiary education indicator from BEEPS and tertiary education indicator from WDI in the left panel and the relationship between tertiary education indicator from BEEPS and GDP per capita in the right panel.

Figure 4.2 BEEPS and WDI indicators of education and GDP per capita



Sources: BEEPS 2005, World Bank Development Indicators 2002, 2003, 2004, 2005.

The left panel of Figure 4.2 shows that, as expected, there is a positive relationship between the BEEPS measure of tertiary education and the corresponding indicator from WDI. The correlation coefficient between the two indicators is 0.67 and it is statistically significant at 1% significance level. However, the right panel shows that there is a *negative* correlation between the share of workforce with tertiary education (measured from BEEPS) and the GDP per capita. The correlation coefficient between these two indicators is 0.54 and is statistically significant at 1% significance level. As education contributes to the development of human capital, we would expect it to be positively correlated with the level of development of the country. This negative relationship between level of development and education suggests that labour force education is correlated with other host country characteristics which have a negative effect on economic development. It can be seen from Figure 4.2 that this negative relationship is mainly driven by countries in CIS, which have higher shares of employees with tertiary education than countries in Central and Eastern Europe, but have lower levels of GDP per capita. We also examined whether there is a similar relationship between the indicator of labour force with tertiary education at country level from WDI and GDP per capita. This correlation is also negative, although it is smaller in magnitude (0.11) and statistically insignificant.

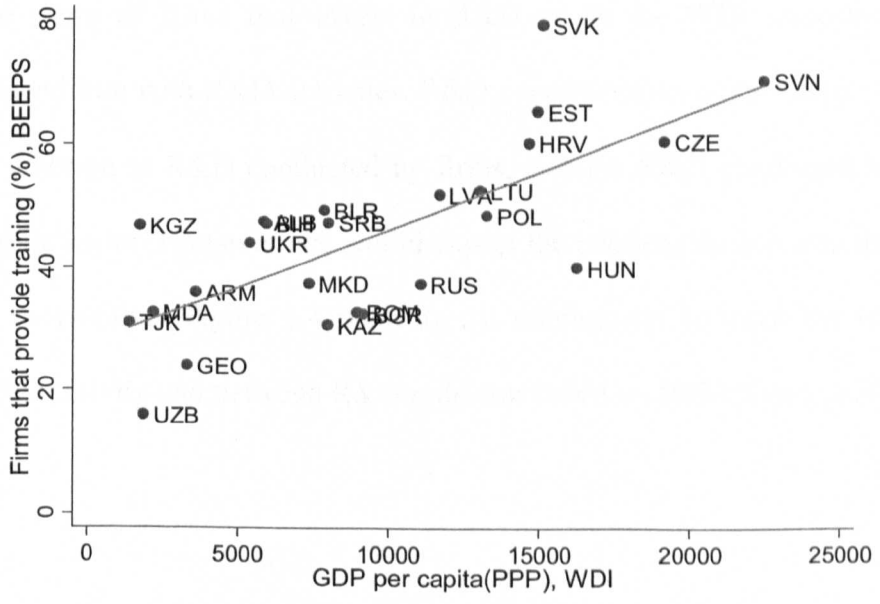
In conclusion, our indicator of tertiary education based on BEEPS is correlated with the corresponding indicator at macro level, but is negatively correlated with the country's level of development. This suggests that it is important to control in our empirical analysis for other country characteristics.

ii. Training

In our sample, the country with the largest share of firms that provide formal training to their employees is Slovakia (almost 70% of firms provide training to their employees) and the country with lowest share of firms that provide formal training to their employees is Uzbekistan, where only 16% of firms do this. The shares of firms that provide training in each country in the sample are reported in Table 4.15 (column 3).

We cannot compare our indicator for training with any corresponding indicator from macroeconomic sources, but we compare it with the level of development of the country. As training also contributes to the development of human capital, we would expect it to be correlated with the level of development of the country. Figure 4.3 presents the relation between the share of firms that provide training to their employees and the level of development of the country (measured as PPP GDP per capita).

Figure 4.3 BEEPS indicator of training and GDP per capita



Sources: BEEPS 2005, Word Bank Development Indicators 2004

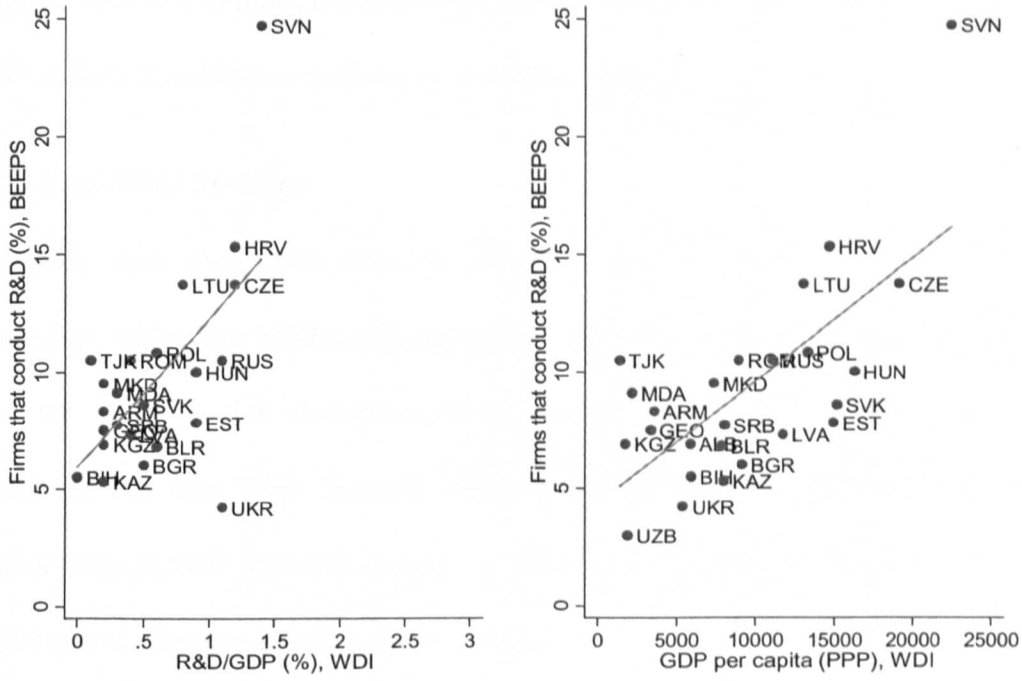
The graphic shows that the share of firms that invest in training their employees in the country and the PPP GDP per capita are highly correlated. The correlation coefficient between the two indicators is 0.73 and it is significant at 1%, which suggests that the provision of training captures an important aspect of human capital.

iii. R&D

R&D at country level is measured as the share of firms in the country of the firm that invests in R&D. The values of this indicator for each country are reported in Table 4.15 shows that there is large variation in share of firms that invests in R&D across countries. The country with the largest share of firms that invest in R&D is Slovenia, where almost 25% of firms invest in R&D and the country with the lowest share of firms that invest in R&D is Uzbekistan, where only 3% of firms invest in R&D.

We compare our indicator of investment in R&D with the expenditure on R&D as a percentage of GDP from World Bank Development Indicators. It is important to notice that there are differences between the two indicators. Our indicator represents the share of firms that invest in R&D while the WDI indicator represents the expenditure with R&D activities. R&D expenditure as a percentage of GDP includes in addition to R&D conducted by firms, also the R&D conducted by institutions in public sector. However, we would expect the relationship between the two indicators to be positive. Figure 4.4 presents the relationship between the two indicators of R&D activity and between R&D indicator based on BEEPS and GDP per capita.

Figure 4.4 BEEPS and WDI indicators of R&D and GDP per capita



Sources: BEEPS 2005, World Bank Development Indicators 2004

Figure 4.4 shows that there is a positive relationship between the R&D indicator based on BEEPS and R&D investment as a share of GDP. The correlation coefficient between the two indicators is 0.61 and it is statistically significant at 1% significance level. The figure also shows that there is a positive relationship between the share of firms that invest in R&D in a country and PPP GDP per capita. The correlation coefficient between these two indicators is 0.69 and it is significant at 1% significance level. The figure also shows that Slovenia is an outlier and has a larger share of firms that invest in R&D than it would be expected based on its ratio of R&D investment to GDP and on its level of GDP per capita.

In conclusion, indicators of country characteristics based on BEEPS are correlated with the corresponding indicators at macro level, although for individual countries they might differ and also with the level of development of the country as measured

by GDP per capita, with the exception of the indicator of university education. This suggests that they capture the important aspects of human capital and investment in R&D and are suitable as measures of absorptive capacity.

4.4 Empirical Strategy

We study how absorptive capacity affects technology transfer through foreign ownership, supplying MNEs and exporting. We will consider several hypotheses. First, we study whether absorptive capacity at the country level affects technology transfer at the firm level. Second, recognising that within a country firms differ considerably in their absorptive capacity, we also examine how firm level measures of absorptive capacity affect technology transfer.

4.4.1 Effects of Country Absorptive Capacity

Our first hypothesis, based on the literature reviewed, is that there is an interaction effect between the absorptive capacity at country level and having access to foreign technology. We assume, following the literature reviewed in section 4.2, that firm productivity is affected by three key factors: absorptive capacity, technology transfer from abroad that occurs independently of the absorptive capacity and technology transfer which is facilitated by absorptive capacity:

$$\ln(VA)_{ijct} = \alpha_{ijc} + \beta_K K_{ijct} + \beta_L L_{ijct} + \beta_{FT} FT_{ijct} + \beta_{FTAC} FT_{ijct} * AC_{ct} + \beta_{AC} AC_{ct} + \\ + \beta_X X_{ijct} + u_{ijct} \quad (4.1)$$

VA_{ijc} represents value added of firm i in industry j and country c. FT_{ijc} represents access of a firm to foreign technology. Our measures of foreign technology are: foreign ownership, supplying MNEs, exporting and importing. These measures were described in Chapter 3. AC_c is a measure of absorptive capacity of country c. Our

measures of absorptive capacity are: R&D, training and education and were described in section 4.3.

A positive and significant coefficient of the interaction term is interpreted as evidence consistent with the hypothesis that absorptive capacity at the country level facilitates technology transfer. In addition, we also expect that firms that engage in international activities to be more productive than those that do not. Given that we have only a cross section of firms and that we include country fixed effects we cannot examine the direct effect of country level absorptive capacity on productivity. For the same reason we cannot include firm fixed effects, except for the sample based on the panel component of the data set.

We start with a specification that includes only our main variables of interest: foreign technology and an interaction between the two and controls for production inputs (capital and labour), country and sector fixed effects. We estimate separates equation for each channel of international technology transfer and each measure of absorptive capacity. To isolate better the effect of the interaction terms between absorptive capacity and access to foreign technology on productivity, we will systematically add controls for firm characteristics that may affect firm productivity. Recognising that firms have access to foreign technology through different channels, we estimate a specification that includes all measures of participation in international activities. Similarly, recognising our measures of absorptive capacity reflect different types of skills, we include all measures of absorptive capacity. Then, we will add controls for other firm characteristics that may affect productivity: the age of the

firm, state ownership, and product market competition and location size. All these variables are defined and described in

Table 3.14 and Table 3.15 in annexes to Chapter 3.

4.4.2 Effects of Firm Absorptive Capacity

Recognising that within a country firms differ in their absorptive capacity, we also examine how firm level measures of absorptive capacity affect technology transfer. Our main hypothesis is that firm level absorptive capacity facilitates technology transfer. Again, in line with the literature reviewed in section 4.2, we assume that firm productivity is affected by three key factors: creation of new technology inside the firm (given by absorptive capacity), by technology transfer from abroad that occurs independently of the absorptive capacity (given by access to foreign technology through different international activities) and on the technology transfer which is facilitated by absorptive capacity (given by the interaction term between the two). We estimate the following equation:

$$\ln(VA)_{ijct} = \alpha_{ijc} + \beta_K K_{ijct} + \beta_L L_{ijct} + \beta_{FT} FT_{ijct} + \beta_{AC} AC_{ijct} + \beta_{FTAC} FT_{ijct} * AC_{ijct} + \beta_X X_{ijct} + u_{ijc} \quad (4.2)$$

AC_{ijc} is a measure of absorptive capacity at firm level. We use three measures of absorptive capacity: R&D, training and education and they were described in section 4.3. The other variables are defined as in section 4.3.2.

Our main hypothesis is that there is an interactive effect between absorptive capacity and access to foreign technology. If this hypothesis is true we expect that the coefficient of the interaction term will be positive and significant. In addition, we expect the coefficient of foreign technology to be positive and significant, based on

our previous results. We also expect that R&D, training and education of labour force to contribute to the creation of technology inside the firm and therefore to have a positive direct effect on firm total factor productivity. Given that we have only one cross section of firms we cannot include firm fixed effects, except for the sample based on the panel component of the data set.

We follow the same empirical strategy as for country level absorptive capacity. First, we start with a specification that includes only our main variables of interest: foreign technology, absorptive capacity and an interaction between the two and basic controls production inputs (capital and labour), sector and country fixed effects. We estimate a separate equation for each channel of international technology transfer and each measure of absorptive capacity. We interpret these results as preliminary evidence regarding our hypothesis that absorptive capacity facilitates technology transfer. Then, we will systematically add controls for other firm characteristics that may affect productivity: all measures of participation in international activities, all measures of absorptive capacity, age of the firm, state ownership, and product market competition and location size. All the variables are defined and described in

Table 3.14 and Table 3.15 in annexes to Chapter 3.

4.5 Estimation Results

4.5.1 Effects of Country Absorptive Capacity

Tables below present the results of estimating equation (4.1). In all specifications, the dependent variable is value added and all include controls for capital and labour.

Table 4.5 Effect of country education on foreign technology transfer

	Foreign technology measure:			
Dependent variable ln(VA)	Foreign ownership	Supplying MNEs	Exporting	Importing
Foreign technology	0.205*	0.101	0.183**	0.103
	(0.114)	(0.104)	(0.079)	(0.069)
Foreign technology *Education	0.117	0.556	-0.096	0.272
	(0.493)	(0.516)	(0.360)	(0.309)
Sector FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Obs.	3690	3690	3690	3690
R^2	0.894	0.895	0.894	0.894

Notes: All equations include controls for labour and capital.*, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

Table 4.6 Effect of country provision of training on foreign technology transfer

	Foreign technology measure:			
Dependent variable ln(VA)	Foreign ownership	Supplying MNEs	Exporting	Importing
Foreign technology	0.231	0.361***	0.141	0.131*
	(0.150)	(0.122)	(0.102)	(0.075)
Foreign technology *Training	-0.002	-0.312	0.048	0.068
	(0.314)	(0.248)	(0.201)	(0.158)
Sector FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Obs.	3690	3690	3690	3690
R^2	0.894	0.895	0.894	0.894

Notes: All equations include controls for labour and capital.*, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

Table 4.7 Effect of country R&D on foreign technology transfer

	Foreign technology measure:			
Dependent variable ln(VA)	Foreign ownership	Supplying MNEs	Exporting	Importing
Foreign technology	0.203*	0.214**	0.073	0.142**
	(0.105)	(0.086)	(0.069)	(0.056)
Foreign technology *R&D	0.299	0.027	0.917	0.202
	(1.031)	(0.755)	(0.592)	(0.518)
Sector FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Obs.	3690	3690	3690	3690
R^2	0.894	0.894	0.894	0.894

Notes: All equations include controls for labour and capital.*, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results in Table 4.5 through Table 4.7 show that all interaction terms between investment in R&D, provision of training and education at country level and access

to foreign technology are statistically insignificant. This suggests that absorptive capacity does not play an important role in facilitating the transfer of foreign technology through these channels. The coefficients of variables that control for participation in international activities are positive and statistically significant in most cases. Given that we have only a cross section of firms and that we included country fixed effects we cannot examine the direct effect of country level absorptive capacity on labour productivity. Overall, our interpretation of these results is that there is no preliminary evidence that the absorptive capacity at country level facilitates technology transfer.

Next, we add controls for other firm characteristics that may affect productivity. We start by including all channels of international technology transfer. In the first three columns of Table 4.8 we use only one measure of absorptive capacity: education (column 1), training (column 2) and R&D investment (column 3). In column (4) we use all measures of absorptive capacity. In column (5) we also include controls for other firm characteristics which may affect productivity: the age of the firm, state ownership, product market competition, and location size. In all specifications the dependent variable is value added and they all include controls for capital and labour and country and sector fixed effects.

Table 4.8 Effect of country absorptive capacity on foreign technology transfer

Dependent Variable Ln(VA)	Education	Training	R&D	All AC measures	All AC measures
	(1)	(2)	(3)	(4)	(5)
Foreign	0.149	0.174	0.167	0.133	0.105
	(0.119)	(0.158)	(0.105)	(0.269)	(0.272)
Supplier	0.062	0.329***	0.174**	0.184	0.158
	(0.101)	(0.121)	(0.086)	(0.203)	(0.205)
Exporter	0.151*	0.075	0.008	0.066	0.108
	(0.081)	(0.101)	(0.068)	(0.183)	(0.181)
Importer	0.048	0.071	0.136**	-0.054	-0.117
	(0.070)	(0.076)	(0.056)	(0.145)	(0.150)
Foreign*Education	0.098			0.088	0.068
	(0.518)			(0.602)	(0.611)
Supplier*Education	0.498			0.272	0.395
	(0.504)			(0.530)	(0.583)
Exporter*Education	-0.233			0.024	-0.097
	(0.355)			(0.424)	(0.420)
Importer*Education	0.281			0.342	0.401
	(0.307)			(0.360)	(0.368)
Foreign*Training		-0.009		0.005	-0.086
		(0.326)		(0.353)	(0.370)
Supplier*Training		-0.355		-0.339	-0.381
		(0.245)		(0.272)	(0.267)
Exporter*Training		0.058		-0.157	-0.214
		(0.203)		(0.235)	(0.229)
Importer*Training		0.085		0.198	0.208
		(0.163)		(0.195)	(0.205)
Foreign*R&D			0.038	0.158	0.463
			(1.019)	(1.137)	(1.181)
Supplier*R&D			-0.081	0.730	0.731
			(0.755)	(0.843)	(0.825)
Exporter*R&D			0.953	0.973	0.925
			(0.601)	(0.728)	(0.708)
Importer*R&D			-0.286	-0.134	0.119
			(0.524)	(0.632)	(0.653)
Sector FE	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes
Other firm characteristics	no	no	no	no	yes
Obs.	3690	3690	3690	3690	3630
R^2	0.897	0.897	0.897	0.898	0.899

Notes: All specifications include controls for capital and labour. Specification (5) also includes controls for age, importing and licensing, product market competition and location. *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results show that none of interaction terms between participation in international activities and absorptive capacity are statistically significant. Overall, they confirm

the results of our preliminary findings. They suggest that contrary to our hypothesis we find no evidence that absorptive capacity at country level plays an important role in facilitates technology transfer.

To address possible measurement errors in our absorptive capacity measures, we estimate equation (4.1) using data on the share labour force with tertiary education from the World Bank Development Indicators as a measure of human capital. The World Bank Development Indicators dataset does not provide data on all the countries in our sample and therefore we have fewer observations than in our previous regressions. The results are reported in Table 4.9.

Table 4.9 The effect of country education (WDI indicator) on foreign technology transfer

Dependent variable Ln (VA)	
Foreign owned	0.153***
	(0.049)
MNEs supplier	0.134***
	(0.028)
Exporter	0.064**
	(0.031)
Importer	0.088***
	(0.027)
Foreign owned*Education WDI	-0.001
	(0.001)
MNEs supplier*Education WDI	-0.001
	(0.001)
Exporter*Education WDI	0.001
	(0.000)
Importer*Education WDI	0.000
	(0.001)
Sector FE	yes
Country FE	yes
Other firm characteristics	yes
Obs.	2979
R^2	0.904

Notes: The specification includes controls for capital and labour.
*, ** and *** indicate significance at 10%, 5% and 1%, respectively.
Standard errors clustered by country and industry are in parentheses.

The results confirm our previous results. We find that all interaction terms between country absorptive capacity and participation in international activities are statistically insignificant. All the coefficients of variables that control for participation in international activities are positive and statistically significant.

In conclusion, we found no evidence that absorptive capacity of the country facilitates international technology transfer through foreign ownership, supplying MNEs or exporting. These results are in line with the results of Campos and Kinoshita (2002), who also found that country level absorptive capacity measured as human capital does not affect the impact of FDI in transition economies. One possible explanation for the result that the interaction between host country characteristics and access to foreign technology is insignificant is that there is large heterogeneity with regard to absorptive capacity within countries. For instance, even in a country that has low levels of absorptive capacity overall, there are firms which invest in R&D, formal training for employees and have highly educated labour force and therefore they have high absorptive capacity. In fact the descriptive statistics presented in section 4.3.2 demonstrate there is more variation in the absorptive capacity of firms within countries than between countries. We examine this hypothesis in the next section.

4.5.2 Effects of Firm Absorptive Capacity

Next, we examine whether firm level absorptive capacity facilitates technology transfer. Tables below show the results of estimating the equation (4.2). In all specifications the dependent variable is value added and they all include controls for capital and labour, country and sector fixed effects.

Table 4.10 Effects of firm workforce education on foreign technology transfer

	Foreign technology measure:			
Dependent variable ln(VA)	Foreign ownership	Supplying MNEs	Exporting	Importing
Foreign technology	0.128**	0.175***	0.082**	0.115***
	(0.050)	(0.044)	(0.036)	(0.031)
Foreign technology *Education	0.183	0.053	0.184**	0.092
	(0.118)	(0.109)	(0.089)	(0.081)
Education	0.319***	0.335***	0.291***	0.290***
	(0.051)	(0.053)	(0.059)	(0.066)
Sector FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Obs.	3648	3648	3648	3648
R^2	0.895	0.896	0.895	0.895

Notes: All equations include controls for labour and capital.*, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

Table 4.11 Effects of firm provision of training on foreign technology transfer

	Foreign technology measure:			
Dependent variable ln(VA)	Foreign ownership	Supplying MNEs	Exporting	Importing
Foreign technology	0.146**	0.260***	0.171***	0.145***
	(0.058)	(0.051)	(0.039)	(0.033)
Foreign technology *Training	0.127*	-0.076	-0.048	0.004
	(0.069)	(0.062)	(0.046)	(0.048)
Training	0.076***	0.092***	0.105***	0.076*
	(0.025)	(0.026)	(0.030)	(0.041)
Sector FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Obs.	3444	3444	3444	3444
R^2	0.895	0.894	0.895	0.895

Notes: All equations include controls for labour and capital.*, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

Table 4.12 Effects of firm R&D on foreign technology transfer

	Foreign technology measure:			
Dependent variable ln(VA)	Foreign ownership	Supplying MNEs	Exporting	Importing
Foreign technology	0.227***	0.231***	0.167***	0.155***
	(0.044)	(0.030)	(0.030)	(0.024)
Foreign technology *R&D	-0.011	-0.111**	-0.083	-0.025
	(0.077)	(0.056)	(0.057)	(0.061)
R&D	0.185***	0.203***	0.214***	0.190***
	(0.042)	(0.040)	(0.051)	(0.056)
Sector FE	yes	yes	yes	yes
Country FE	yes	yes	yes	yes
Obs.	3690	3690	3690	3690
R^2	0.895	0.896	0.895	0.895

Notes: All equations include controls for labour and capital.*, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

Again it remains the case that in most specifications the coefficients of interaction terms between the employees' education, investing in R&D, providing training and participating in international activities are statistically insignificant. Only the interaction term between exporting and share of employees with tertiary education in the firm and the interaction term between foreign ownership and provision of training are statistically significant. Given that we do not have any reason to expect the significance of these coefficients above any of the others we included, we conclude that, contrary to our hypothesis, we find little evidence that firm's absorptive capacity facilitates technology transfer through foreign ownership, supplying MNEs, exporting and importing.

As expected, the results show that the coefficients of most of our measures of participation in international activities are positive and significant. Foreign ownership is associated with between 13% and 25% higher total factor productivity, supplying MNEs is associated with between 18% and 29% higher total factor productivity, exporting is associated with between 8% and 18% higher total factor productivity and importing is associated with between 12% and 16% higher total factor productivity.

Also, the results show that the coefficients of most of our measures of absorptive capacity are positive and significant. The results suggest that increasing the share of workforce with university education by one standard deviation is associated with an increase the firm total factor productivity between 8% and 10%. The coefficients in Table 4.11 imply that providing formal training is associated with between 7.6% and 10% higher total factor productivity. The results in Table 4.12 suggest that

conducting R&D activities is associated with between 20% and 24% higher total factor productivity.

In conclusion, we find little evidence that there is an interaction between investing in the absorptive capacity of the firm and access to foreign technology. However, we do find evidence consistent with a direct effect of absorptive capacity on total factor productivity.

Next, we add controls for other firm characteristics that may affect productivity. The results are reported in Table 4.13. In the first three columns we use only one measure of absorptive capacity: education (column 1), training (column 2) and R&D investment (column 3). In column (4) we use all measures of absorptive capacity. In column (5) we also include controls for other firm characteristics which may affect productivity: the age of the firm, state ownership, product market competition, dummies for location size.

Table 4.13 Effects of firm absorptive capacity on foreign technology transfer

Dependent variable ln(VA)	Education	Training	R&D	All AC Measures	All AC Measures
	(1)	(2)	(3)	(4)	(5)
Foreign owned	0.101*	0.077	0.156***	0.003	-0.012
	(0.052)	(0.059)	(0.044)	(0.072)	(0.071)
MNEs supplier	0.156***	0.224***	0.179***	0.201***	0.193***
	(0.044)	(0.050)	(0.030)	(0.062)	(0.063)
Exporter	0.042	0.119***	0.104***	0.082*	0.083*
	(0.034)	(0.038)	(0.029)	(0.043)	(0.042)
Importer	0.092***	0.102***	0.104***	0.076**	0.069*
	(0.029)	(0.033)	(0.024)	(0.036)	(0.036)
Education	0.218***			0.219***	0.202***
	(0.069)			(0.068)	(0.066)
Foreign *Education	0.124			0.126	0.131
	(0.119)			(0.134)	(0.134)
Supplier*Education	-0.032			0.066	0.060
	(0.108)			(0.126)	(0.128)
Exporter*Education	0.156*			0.071	0.074
	(0.084)			(0.094)	(0.099)
Importer*Education	0.020			0.045	0.033
	(0.075)			(0.079)	(0.080)
Training		0.082*		0.066	0.066
		(0.042)		(0.042)	(0.042)
Foreign *Training		0.155**		0.129*	0.120
		(0.071)		(0.075)	(0.074)
Supplier*Training		-0.087		-0.079	-0.076
		(0.061)		(0.064)	(0.063)
Exporter*Training		-0.056		-0.051	-0.050
		(0.048)		(0.048)	(0.048)
Importer*Training		-0.007		-0.002	-0.001
		(0.050)		(0.050)	(0.049)
R&D			0.203***	0.168***	0.166***
			(0.063)	(0.063)	(0.063)
Foreign*R&D			0.046	0.080	0.083
			(0.078)	(0.082)	(0.082)
Supplier*R&D			-0.089	-0.093	-0.082
			(0.056)	(0.061)	(0.063)
Exporter*R&D			-0.063	-0.050	-0.050
			(0.057)	(0.060)	(0.061)
Importer*R&D			-0.009	-0.001	0.004
			(0.063)	(0.067)	(0.066)
Country FE	yes	yes	yes	yes	yes
Industry FE	yes	yes	yes	yes	yes
Other firm ch.	no	no	no	no	yes
Obs.	3648	3444	3690	3411	3393
R^2	0.897	0.898	0.898	0.899	0.899

Notes: All specifications include controls for capital and labour. *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results show that most of the interaction effects between measures related to firm absorptive capacity and participation in international activities are statistically insignificant.

The coefficients of participation in different international activities are mostly positive and significant, except for foreign ownership which becomes insignificant in the specifications in which we include all measures of absorptive capacity. Based on the results of the most comprehensive model reported in column (5) in Table 4.13, supplying MNEs is associated is 20% higher total factor productivity and exporting is associated with 9% higher total factor productivity and importing is associated with 7% higher total factor productivity. Foreign owned firms are not significantly different from domestic firms when we control for all measures of absorptive capacity and interactions between absorptive capacity and participation in international activities and other firm characteristics.

The direct effects of the investing in R&D and workforce education are positive and statistically significant in most specifications. Based on the results in column (5), investing in R&D is associated with 17% higher total factor productivity and increasing the share of employees with tertiary education by one standard deviation is associated with 6% higher total factor productivity. Provision of formal training becomes statistically insignificant in the specifications in which we control for all measures of firm absorptive capacity.

We estimate a variant of the equation (4.2) in which we control for unobserved fixed firm characteristics that might be correlated with both productivity and participation

in international activities. It is important to control for these characteristics given the existing evidence on selection of most productive firms in participating in the international activities considered. Fixed effects estimation addresses this problem if the selection into participating in international activities is caused by fixed differences between firms. In addition, we use past absorptive capacity of the firm instead of the present absorptive capacity. Being exposed to foreign technology might itself affect absorptive capacity by creating incentives for firms to invest more in absorptive capacity. Therefore, we control for past absorptive capacity.

Another way of controlling for unobserved firm characteristics is to include the lagged dependent variable as an explanatory variable. Including the lagged dependent variable is a way of controlling for these unobserved firm characteristics if firm characteristics which determined firm performance in the past are also relevant for current firm performance.

For estimating these specifications, we use the panel component of the survey. As mentioned in Chapter 3, the BEEPS 2002 differs in several ways from the BEEPS 2005. The most important differences are that BEEPS 2002 does not provide information on material inputs and energy and that more than 70% of firms did not answer the question related to investment in R&D. Therefore, we will use sales instead of value added as dependent variable and we will study only the effects of past absorptive capacity measures related to workforce education and provision of training. Due to the small number of observations in the panel component we will use a single measure of participation in international activities instead of four

different channels[17]. The results from all these specifications are reported in Table 4.14. In column (1) we report the equation (4.2) in which we use past absorptive capacity instead of present absorptive capacity. In column (2) we report the results of the FE estimation. In column (3) we report the results of the lagged dependent variable estimation. All the estimations are based on the panel component.

Table 4.14 Effects of firm past absorptive capacity on foreign technology ransfer

Dependent variable Ln(Sales)	OLS	FE	Lagged Dependent Variable
	(1)	(2)	(3)
Sales 2002			0.129***
			(0.029)
Capital	0.151***	0.048**	0.124***
	(0.027)	(0.024)	(0.027)
Labour	0.902***	0.864***	0.816***
	(0.033)	(0.060)	(0.038)
International Activities	0.223**	0.095	0.214*
	(0.113)	(0.150)	(0.111)
Education 2002	0.424**		0.426**
	(0.187)		(0.183)
International Activities*Education 2002	-0.005	0.069	-0.020
	(0.216)	(0.266)	(0.211)
Training 2002	0.202*		0.192*
	(0.104)		(0.102)
International Activities*Training 2002	-0.091	-0.076	-0.116
	(0.124)	(0.157)	(0.122)
Country FE	yes	yes	yes
Sector FE	yes	yes	yes
Other firm characteristics	yes	yes	yes
Obs.	460	920	460
R^2	0.909	0.953	0.913

Notes: *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results in column (1) show that both interaction terms between past absorptive capacity and participation in international activities are statistically insignificant, but the coefficients of the past measures of absorptive capacity and the coefficient of

[17] International Activities is a dummy variable that takes the value 1 if the firm is engaged in at least one of the international activities considered (foreign ownership, supplying MNEs, exporting and importing) and 0 otherwise.

participation in international activities are positive and statistically significant. These results confirm the results reported in Table 4.13.

The results from FE estimation, reported in column (2), also show that interaction terms between absorptive capacity and participation in international activities are statistically insignificant. They suggest that firms, which had a higher absorptive capacity before being exposed to foreign technology, do not benefit more from this exposure than firms with lower absorptive capacity. The coefficient of participation in international activities is positive, but statistically insignificant, which is in line with the results for the separate international activities obtained in FE estimation in Table 3.13 in Chapter 3.

In column (3) we report the results of the specification which includes lagged dependent variable as an explanatory variable. The coefficient of the lagged sales is positive and statistically significant, which suggests that some firm characteristics which determined firm performance in the past are also relevant determinants of firm performance in the present. The magnitude of the coefficient is not large, but it is important to notice that the lag is three years and that the period 2002-2005 was a period of dramatic change in the economies of most transition economies in ECA. The results for the interaction terms between past workforce education and provision of training and participation in international activities, are statistically insignificant in line with the previous results.

Overall, our robustness checks confirm our main result that there is no evidence of an interaction effect between absorptive capacity and participation in international

activities. This suggests again that absorptive capacity does not play an important role in facilitating technology transfer through these activities.

These results are similar to those found elsewhere in the literature on transition economies in ECA. As discussed in the literature review, the results of the empirical studies that used similar measures of absorptive capacity and focused on transition economies are also mixed. Kinoshita (2000) finds that investment in R&D has no impact on technology transfer through foreign ownership. Damijan *et al.* (2003) find that investment in R&D facilitates technology transfer through horizontal FDI spillovers only in Romania, and that it facilitates technology transfer though imports only in Czech Republic and in all the other transition countries studied the effect is either insignificant or negative. Sinani and Meyer (2004) also found no evidence of human capital interaction with FDI spillovers, except for the large firms in Estonia. Gorodnichenko *et al.* (2007) found no evidence that share of employees with tertiary education facilitates technology transfer through supplying MNEs, importing or exporting in 17 transition countries. Köymen and Sayek (2010) find that the human capital has no effect on spillovers through backward linkages.

There are several possible explanations for these findings. First, it is possible that all firms are able to benefit from interactions with foreign firms, regardless of their absorptive capacity. Second, it is possible that the technology transfer is facilitated by the assistance provided by the foreign parent firms, customers or suppliers, not by the actions of the domestic firms. There is much anecdotal and survey evidence regarding the assistance provided by MNEs to their foreign affiliates and local suppliers (UNCTAD, 2001; Javorcik, 2008). For instance, Javorcik (2008) reports

that 40% of the Czech firms that supply MNEs benefit from some kind of assistance from their customers. Personnel training, quality inspections and assistance with the organisation of production lines are among the most common forms of assistance. Third, it is possible that MNEs and foreign partners make sure that their future suppliers or affiliates have the necessary absorptive capacity before signing any contracts and transferring technology to them. This is consistent with the large literature on firms' selection into exporting (Melitz, 2003; Greenaway and Kneller, 2007) and importing (Kasahara and Lapham, 2008), supplying MNEs (Javorcik and Spatareanu, 2009) and acquisition of better performing firms or firms with better skilled workforces by MNEs (Djankov and Hoekman, 2000; Damijan *et al.* 2003).

4.6 Conclusions

The ability to assimilate foreign technology differs across countries and also across firms within a country. The existing empirical evidence on the effect of FDI and international trade on domestic firms suggest that not all countries and not all firms within a country are able to benefit from international technology transfer. Absorptive capacity was suggested as an important factor affecting this ability.

In this chapter, we study how absorptive capacity at country and at firm level affects technology transfer through foreign ownership, supplying MNEs and exporting in 25 transition countries in ECA. Our main contribution to the literature is the use of measures of absorptive capacity (investment in R&D, provision of formal training and workforce education) which are precise, closely related to the theoretical concept of absorptive capacity and are informative for policy. Another important contribution is studying how country absorptive capacity and firm absorptive capacity affect technology transfer at firm level. This differs from the existing literature which

examines whether absorptive capacity facilitates technology transfer either at country level or at firm level within a country. We also use firm specific measures for access to foreign technology (foreign ownership, supplying MNEs, exporting and importing) which reflect better the firms' access to foreign technology than the industry level measures frequently used in other studies on this topic.

Our main results suggest that access to foreign technology and absorptive capacity at firm level are associated with higher productivity, but, contrary to our hypothesis, there is no evidence of an interaction effect between absorptive capacity at country or firm level and access to foreign technology. These results are in line with previous studies on transition economies in ECA region. They suggest that firms are able to benefit from foreign technology regardless of their absorptive capacity, or that the firms with the necessary absorptive capacity select into participating in international activities. It is also possible that other firm or country characteristics, for instance related to business environment and financial development, play a more important role than absorptive capacity in facilitating technology transfer.

Appendices to Chapter 4

Table 4.15 Absorptive capacity: differences across countries

Country	*Tertiary Education (BEEPS)*	*Tertiary Education (WDI)*	*Training (BEEPS)*	*R&D (BEEPS)*	*R&D /GDP (WDI)*	*GDP per capita in PPP (WDI)*
Albania	0.171	0.079[a]	0.475	0.069		5862.819
Armenia	0.330		0.359	0.083	0.002	3601.351
Belarus	0.267		0.493	0.068	0.006	7882.199
Bosnia Herzegovina	0.170		0.472	0.055	0.000	5934.770
Bulgaria	0.262	0.241	0.323	0.060	0.005	9172.388
Croatia	0.170	0.178[b]	0.599	0.153	0.012	14709.579
Czech Rep	0.112	0.132	0.601	0.137	0.012	19189.702
Estonia	0.160	0.311[b]	0.649	0.078	0.009	14990.162
Georgia	0.313	0.266	0.240	0.075	0.002	3327.088
Hungary	0.163	0.200	0.398	0.100	0.009	16286.280
Kazakhstan	0.277	0.500	0.305	0.053	0.002	8000.692
Kyrgyz Republic	0.286	0.160	0.468	0.069	0.002	1748.001
Latvia	0.177	0.213	0.517	0.073	0.004	11725.556
Lithuania	0.213	0.277	0.523	0.137	0.008	13085.492
Macedonia	0.153		0.374	0.095	0.002	7365.985
Moldova	0.256		0.325	0.091	0.003	2191.798
Poland	0.215	0.174	0.483	0.108	0.006	13297.143
Romania	0.168	0.101[b]	0.326	0.105	0.004	8963.668
Russian Federation	0.314	0.515	0.372	0.105	0.011	11088.161
Serbia and Montenegro	0.172		0.473	0.077	0.003	8039.562
Slovakia	0.155	0.134	0.790	0.086	0.005	15166.372
Slovenia	0.149	0.196	0.698	0.247	0.014	22526.784
Tajikistan	0.223	0.109	0.309	0.105	0.001	1404.996
Ukraine	0.362	0.452[c]	0.439	0.042	0.011	5396.917
Uzbekistan	0.166		0.160	0.030		1891.941

Source: BEEPS 2005, WDI 2002, 2003, 2004, 2005.
Notes: The WDI indicators are from 2004, except: [a]2002, [b]2003, [c]2005.

Chapter 5 International Integration of Firms and Demand for Skills

5.1 Introduction

Over the last decades, many countries have experienced increases in wage inequality between skilled workers and unskilled workers, despite increases in the supply of skilled labour, which implies an increase in the relative demand for skilled labour. The literature suggests that globalisation is one of the mechanisms driving the increasing demand for skilled labour.

The main mechanisms through which globalisation can affect the relative demand for skills in developing countries are: transfer of skilled biased technology change through trade and FDI (Acemoglu, 1998, Keller, 2004), specialisation according to comparative advantage in goods/activities intensive in unskilled labour, outsourcing of activities or goods which are relatively unskilled labour intensive from perspective of a developed country but relatively skilled labour intensive from the perspective of a developing country (Feenstra and Hanson, 1996) and adoption of skill intensive technology in order to improve competitiveness in international markets (Yeaple, 2005; Bustos, 2005; Verhoogen, 2008). Adoption of skilled biased technological change through trade and FDI, outsourcing of more skilled intensive goods from developed countries and adoption of more skill intensive technology in order to become more competitive in international markets have a positive effect on the relative demand for skilled labour. On the other hand, specialisation in goods intensive in unskilled labour according to the Heckscher-Ohlin (HO) model has a negative effect on the relative demand for skilled labour. The overall effect is ambiguous; it depends on which of the two effects prevails.

The theoretical literature does not indicate which kind of workforce skills are affected by globalisation. Most previous empirical studies have focused on the share of nonproduction employees. However, employees within these two categories may differ considerably with regard to their formal education, vocational qualifications, training and work experience, which are exactly the characteristics which are important to capture skill level and which are informative for policy. Recently, several studies have found evidence of a relationship between globalisation and workforce education (Commander and Kollo, 2008; Fajnzylber and Fernandes, 2009; Almeida, 2010) and provision of training (Tan and Batra, 1996; Tan *et al.*, 2007).

In this chapter, we study empirically how participation in international activities affects firms' demand for skilled labour and the ways in which firms adjust to changes in demand for skilled labour in 26 transition economies in ECA region using the BEEPS 2002 and2005 waves. This research contributes to the literature in several ways.

First, we study two related ways in which firms respond to changes in the demand for skills: changing the share of labour with the required skills in total employment and training their employees. While there are many empirical studies that examine the impact of globalisation on the share of skilled labour (Harrison and Hanson, 1999; Pavcnik, 2003; Commander and Kollo, 2008; Fajnzylber and Fernandes, 2009; Almeida, 2010), there is little evidence on the impact of globalisation on provision of training (see however Tan and Batra, 1996, Tan *et al.*, 2007). The data we use allows us to study several measures of skilled labour and provision of training: share of employees with tertiary education, share of nonproduction employees, share of

skilled production employees, provision of formal training, provision of formal training to nonproduction employees and provision of training to production employees.

Second, we use several measures of international integration: foreign ownership, exporting, importing and supplying MNEs. The effect of foreign ownership, exporting and importing on demand for skilled labour upgrading has been extensively studied before, for instance by Harrison and Hanson (1999), Pavcnik (2003), Commander and Kollo (2008), Almeida (2010) and Fajnzylber and Fernandes (2009). Many of the mechanisms though which FDI and international trade affect demand for skilled labour can also apply to supplying MNEs, but the effect of supplying MNEs on skill upgrading has not been examined in the previous studies.

Thirdly, we use several empirical methods to study the effect of globalisation on firms' demand for skills. First, using the cross sectional dimension of our data, we study whether firms that participate in international activities employ a more skilled workforce and whether they are more likely to provide formal training to their employees. We do this by comparing firms that participate in international economic activities to purely domestic firms that operate in the same country and industry after controlling for other firm characteristics. Then, using the panel dimension of our survey, we will test whether the relationship between skill upgrading and international integration is robust to controlling for unobserved fixed firm characteristics. Most of the existing studies (with the exception of Pavcnik, 2003) do not control for firm unobserved characteristics, mainly due to data limitations, but

controlling for these characteristics is important because they may affect both the participation in international activities and the demand for skilled labour and thus their omission might lead to biased estimates. Finally, we will also explore information on firms starting, continuing and stopping to participate in international activities during the periods studied to examine whether firms upgrade the skills of their workforce after starting to participate in international activities or whether firms with better skilled workforce select into participation in international activities.

The transition economies in ECA provide an interesting setting for studying the effects of globalisation on demand for skilled labour. These countries lag behind developed countries in terms of technology, but unlike many developing countries, they have a highly educated labour force (World Bank 1996, 2001, 2004). A highly educated workforce makes it easier for internationally integrated firms to introduce advanced, skill biased technology. This suggest that skill biased technological change may play an important role. Despite high educational attainment, exports of goods intensive in unskilled labour, like textiles and furniture, represent a large share of manufacturing exports of many transition economies (World Bank, 2005). In addition, several studies on determinants of FDI found that an important determinant of FDI in these countries is low wage costs (Bevan and Estrin, 2004; Carstensen and Toubal, 2004). This suggests that specialisation in goods intensive in unskilled labour according to HO model might be an important determinant of demand of skilled labour. Finally, the proximity of these countries to EU market (at least those located in Europe) and their access to EU market through a variety to trade agreements means that outsourcing of more skilled intensive goods from developed

countries and adoption of more skilled intensive technology in order to become more competitive in international export markets could also play important roles.

From a policy perspective, these questions are very relevant for transition countries in the ECA in view of the increasing wage inequality and of the emerging problem of skill shortages. Since the beginning of the transition process, the returns to education, especially university education, increased in all the transition economies in the region (Svejnar, 1999; Fleischer *et al.*, 2005), despite increases in the supply of skilled labour during this period (World Development Indicators, 2010). Recently, skill shortages emerged as an important problem in several transition economies, as documented by Rutkowski (2007) for the EU10 countries, by Tan *et al.* (2007) for Russia and by Commander and Kollo (2008) for Hungary, Romania and Russia. These studies argue that at least some of the skills acquired through education during central planning and also during the transition before the education system was reformed do not correspond to the skills required by employers in a market economy. Simultaneously, the exposure of these countries to international trade and FDI has increased considerably since the beginning of transition and it has been suggested that this exposure is an important factor influencing changes in demand for skills.

Our main results suggest that firms engaged in international activities have a better educated labour force and are more likely to train their production and nonproduction employees than domestic firms. However, this happens because firms with better skilled workforces and with formal training programmes select into participating in international activities, and not because these firms upgrade the skills of their workforces after starting to participate in international activities.

The chapter is structured as follows. In section 5.2 we review the main theoretical and empirical studies related on to our study. Section 5.3 presents the data used in this study. Section 5.4 presents the empirical strategy. Section 5.5 presents the main estimation results and robustness checks. Section 5.6 concludes and discusses the main findings.

5.2 Literature Review

5.2.1 Review of Theoretical Literature

The theoretical literature proposes several mechanisms through which globalisation can affect the relative demand for skilled labour.

Skill biased technology change (SBTC) is regarded as the main explanation of the changes in relative demand for skilled labour in developed economies since 1970s. According to this explanation, technologies introduced during this period, like computers and automation technologies, are complementary to skilled labour, and firms that adopted these technologies increased their relative demand of skilled labour. According to Acemoglu (1998), SBTC has taken place in developed countries since 1970s because the increase in the supply for skilled labour in developed countries lowered the relative cost of adopting skill intensive technology. A large number of studies, including Berman *et al.* (1994), Doms *et al.* (1997), Autor *et al.* (1998) and Berman *et al.* (1998), provide empirical evidence that SBTC explains an important part of the increase in the relative demand for skilled labour in developed countries, on the basis of finding strong positive association between the use of ICT, R&D investment or other technology measures and increases in the wage share of nonproduction employees.

SBTC is also regarded as an important explanation of increases in the demand for skilled labour in developing and transition countries. In these countries, SBTC takes place mainly through the technology transfer from developed countries. International trade and FDI play important roles as channels through which skilled biased technology is transferred to developing and transition countries (Keller, 2004). This technology transferred from developed countries is likely to be skill biased because it is created to be complementary to skilled labour, which is abundant in developed countries (Acemoglu, 1998). This suggests that firms which are globally engaged though trade or FDI use a more skill intensive technology than domestic firms and therefore they employ a more skilled workforce.

Another mechanism through which globalisation can affect the demand for skilled labour is specialisation according to comparative advantage. The HO trade model assumes that developed countries are abundant in skilled labour and developing countries are abundant in unskilled labour. In the HO model trade between developed and developing countries leads to specialisation in skill intensive goods in developed countries and specialisation in unskilled labour intensive goods in developing countries. The specialisation in unskilled labour intensive goods in developing countries results in a decrease in the relative demand for skilled labour in these countries. This model implies that exporters in developing countries specialise in goods or stages of production which are intensive in unskilled labour (in which they have a comparative advantage over producers in developed countries due to lower labour costs). Similarly, importers buy from abroad intermediate inputs which are intensive in skilled labour, and concentrate on stages of production which are more intensive in unskilled labour. FDI can play a similar role, especially vertical

FDI, motivated by low labour costs in developing countries. In this case, the parent MNEs perform the activities intensive in skilled labour and the foreign affiliates specialise in activities intensive in unskilled labour. Similarly, MNEs might decide to purchase only basic inputs with little technological content from their local suppliers.

A third mechanism through which globalisation can lead to a rise in the relative demand for skilled labour is the outsourcing of activities by multinationals from developed countries to developing countries. Feenstra and Hanson (1997) propose a model in which firms in developed countries outsource to developing countries activities which are relatively unskilled labour intensive from the perspective of a developed country but relatively skilled labour intensive from the perspective of a developing country. As a result, outsourcing leads to increases in the relative demand for skilled labour in both developed and developing countries. In line with the predictions of this model, Feenstra and Hanson (1996) show that outsourcing, measured as a share of imported intermediated inputs in the total purchase of intermediate inputs, contributed substantially to increases in the wage bill share of nonproduction employees in US manufacturing between 1979 and 1990. Feenstra and Hanson (1997) show that the increase in relative wages of skilled workers between 1975 and 1988 in Mexico was associated with FDI inflows in the region. Zhu and Trefler (2005) propose a similar model in which the rise in the demand for skilled labour in developed and developing countries is caused by the movement of the production of the least skill intensive goods in developed countries to developing countries. These goods are more skill intensive than the goods already produced in the developing countries. This movement of the production of less skill intensive

goods from developed to developing countries raises the demand for skilled labour in both developed and developing countries. This mechanism suggests that firms which are internationally integrated produce more skill intensive goods or perform more skill intensive stages of production than domestic firms and, therefore, have a better skilled workforce.

Globalisation can also affect the technology choices of firms. Yeaple (2005) and Bustos (2005) propose models in which firms choose between two technologies. One technology is skilled labour intensive and has a high fixed cost, but allows the firms to achieve low marginal cost. The other technology is less skill-intensive, has a lower fixed cost, but involves higher marginal costs. In these models, an increase in export opportunities raises the incentives to adopt the skill intensive technology, which leads to skill upgrading. Verhoogen (2008) proposes a similar model, but focuses on quality upgrading in developing countries. In his model, firms also choose between two technologies: one that is skill intensive and produces high quality goods and one that that is less skill intensive and produces lower quality goods. Quality is more important for export markets in developed countries than for domestic markets. Therefore, increases in exports to developed countries lead to increases in the incentives to adopt the skill intensive technology which produces high quality goods and, thus, to skill upgrading. These models imply that firms that are internationally integrated use a more skill intensive technology than domestic firms that allows them to achieve lower marginal costs or higher quality than domestic firms. Because this technology is more skill intensive, their workforce should be better skilled than the workforce of domestic firms. These models focus on international trade but they can be relevant for FDI, especially vertical FDI and for

suppliers of MNEs located in the same country because they face similar requirements in terms of prices and quality from their customers.

The studies reviewed so far assume that firms meet these changes in demand by hiring employees with the needed skills from outside the firm, which leads to a rising share of skilled labour in employment and the wage bill. However, firms can also accommodate the increasing demand for skills by training their existing employees. All the mechanisms reviewed above may result in training of employees rather than hiring employees from outside the firm. Training employees may be even preferable to hiring skilled employees if the firm needs skills which employees in the local labour market do not have. This is likely to be the case for internationally integrated firms in developing countries. These firms adopt technology created to complement labour skills available in developed countries, which might differ from the labour skills available in developing countries. There are several studies on FDI spillovers which discuss how foreign affiliates provide training to their employees in order to enable them to use the technology of parent MNEs (Blomström and Kokko, 1998; Fosfuri *et al.*, 2001; Görg *et al.*, 2007). MNE suppliers or exporters, who adopt new technology in order to adapt to requirements of their customers, and importers, who use inputs that embody new technology, may need to train their employees for similar reasons.

Overall, the theoretical literature suggests that in developing countries the effect of globalisation on the demand for skilled labour is the result of two opposite effects: a positive effect due to skilled biased technological change facilitated by trade and FDI, outsourcing and adoption of new technology in order to become more

competitive in international markets, and a negative effect due to specialisation in goods intensive in unskilled labour. The overall effect is ambiguous and requires empirical evidence. The literature also suggests that the changes in the demand for skilled labour can be met by either hiring skilled employees from outside the firm or by training existing employees.

5.2.2 Review of Related Empirical Studies

In this section we discuss the empirical studies on transition and developing countries which are most relevant for our investigation. This research is closely related to two strands of literature: studies on the relationship between international integration of firms and the share of skilled labour in total employment or wage bill and studies on the relationship between firms' participation in international activities and provision of training.

Most studies on this topic focus on two mechanisms though which globalisation affects demand for skilled labour: specialisation in goods intensive in unskilled labour and skill biased technology change. The empirical approach used in these studies is to compare the use of skilled labour in firms that are involved in international activities and domestic firms, after controlling for other firm characteristics. Studies on provision of training use a similar approach. To do this they estimate variants of the following reduced form equation:

$$Skill_{it} = \beta_I I_{it} + \beta_T T_{it} + \beta_X X_{it} + \mu_i + u_{it}$$

In this equation, $Skill_{it}$ is a measure of workforce skills in firm i at time t. The most commonly used measure is the share of nonproduction workers in employment, but several studies also used share of employees with tertiary education (Commander

and Kollo, 2008; Fajnzylber and Fernandes, 2009; Almeida, 2010), and measures of the provision of training (Tan and Batra, 1996, Tan *et al.*, 2007).

I_{it} is a measure of international integration of the firm, T_{it} is a measure of firm technology and X_{it} represents other firm characteristics that affect the demand for skills. Adoption of new technology is likely to increase demand for skills if the technology is skilled biased. If this technology also reduces production cost or improves the quality of products than it may also increase the probability of participation in international activities. Therefore, not including controls for technology might lead to overestimating the effect of the participation in international activities on demand for skills. However, if participating in international activities leads to adoption on new skill intensive technology, as in models proposed by Yeaple (2005) and Bustos (2005), then controlling for technology adoption would bias down the coefficients of international activities.

μ_i are fixed firm unobserved characteristics. It is important to control for these characteristics because the participation in international activities could be correlated with unobserved plant characteristics that also affect workforce skills. For instance, it is likely that managerial ability affects both the skills of the workforce and participation in international activities. If these fixed firm unobserved characteristics are correlated with participation in international activities, then the estimated coefficient of participation in international activities is affected by omitted variable bias. However, many empirical studies are not able to control for these characteristics due to data limitations.

A positive relationship between participation in international activities and the share of skilled labour is interpreted as evidence that the positive effect of skill biased technology transfer outweighs the negative effect of specialisation in goods intensive in unskilled labour. A negative or an insignificant relationship between participation in international activities and the share of skilled labour is interpreted as evidence that the positive effect of skill biased technology transfer is offset by the negative effect of specialisation in goods intensive in unskilled labour.

One of the first firm level studies on this topic in a developing country is Harrison and Hanson (1999). They use a sample of manufacturing firms in Mexico which covers the period 1984-1990 to study how foreign ownership, exporting and importing material inputs affect the demand for nonproduction labour. Their measures of skilled labour are the shares of nonproduction employees in employment and in the wage bill. They find that foreign ownership, exporting and importing are associated with higher relative wages for nonproduction workers and, more relevant for our study, higher relative employment of nonproduction workers.

Pavcnik (2003) studies how the use of imported material inputs, foreign patents and foreign technical assistance affects the relative wages and employment of nonproduction employees. She uses a panel of Chilean manufacturing firms which covers the period 1979-1986. One of the main contributions of this study is that it examines whether the effect of the use of foreign technology on demand for skilled labour is robust to controlling for fixed firm unobserved characteristics. Pavcnik (2003) argues that firms with certain unobserved characteristics may be correlated with both the use of foreign technology and the share of skilled labour in the firm.

She finds that all measure of foreign technology are positively associated with the share of nonproduction workers in wage bill and employment, but that this effect becomes insignificant when she controls for fixed firm unobserved characteristics.

Recently, several studies examined the relationship between globalisation and firm demand for skilled labour using data similar to the BEEPS surveys. These studies have the advantage of using measures of skilled labour based on workforce education which reflect better the workforce skills than the production/nonproduction employees distinction used in previous studies. In addition, because these surveys provide comparable data for several countries, studies based on them can examine whether this effect differs across countries.

Commander and Kollo (2008) study the relationship between the international integration of firms and technology adoption on demand of skilled labour changes in three transition economies (Hungary, Romania and Russia). They use data from an EBRD survey similar to BEEPS. Their measures of skilled labour are the shares of labour with different levels of education and different occupation categories in employment. Their measures of international integration are starting a joint venture with foreign partners and exporting. They find that, in Hungary and Romania measures of international integration and adoption of new technology have different effects. In these countries, measures of international integration are positively associated with different measures of unskilled workers and negatively or insignificantly associated with measures of skilled workers. Measures of technology adoption are associated with different measures of skilled employees and negatively associated with measures of unskilled employees. For Russia, most of the results are

insignificant, which the authors argue that is due to the limited progress with the transition process. Taken together, these results show that firms in these transition countries are affected by both skill biased technology change and specialisation in goods intensive in unskilled labour.

Fajnzylber and Fernandes (2009) study the effect of foreign ownership, importing and exporting on the demand of skilled labour in a cross section of manufacturing firms in Brazil and China. They use data from World Bank Enterprise Survey (WBES), which is a survey similar to BEEPS. Their measures of workforce skills are: share of nonproduction workers (managerial, professional and other nonproduction employees) in total employment and in the wage bill, share of management and professional workers in total employment and in the wage bill and the share of workers with some university education in total employment and in the wage bill. In Brazil, Fajnzylber and Fernandes find that foreign ownership and importing are associated with a higher share of employees with high education and nonproduction employees, which they interpret as evidence of diffusion of skill biased technology through these channels. For China, they find that importing and exporting are associated with lower demand for skilled labour and that foreign ownership has an insignificant effect on the demand for skilled labour. They argue that these results are due to specialisation of Chinese firms in goods intensive in unskilled labour, which outweighs the effect of skill biased technology change. The authors also use instrumental variables to control for the endogeneity of participation in exporting, importing and FDI. Their instruments are within country, industry-region average of the international activities considered, industry level tariffs, import penetration rates and for China industry-region share of firms that have been

restructured into shareholding. The results from the instrumental variable estimations confirm their initial results.

Almeida (2010) studies the relationship between participation in international activities and demand for skilled labour in a cross section of manufacturing firms from eight countries in East Asia at different stages of development. Her data also comes from WBES. Two measures of skilled labour are used in this study: the share of employees with more than secondary education and the share of nonproduction employees (managerial, professional and other nonproduction employees). Almeida finds that while foreign ownership is associated with a higher demand for skilled labour, while exporting is associated with lower demand for skilled labour. She argues that the negative results for exporting a due to specialisation in goods intensive in unskilled labour, which is abundant in the countries studied.

There are also several studies on the effect of participation in international activities on provision of formal training. Tan *et al.* (2007) study the determinants of the probability of provision of training in a cross section of Russian firms using the Russia Competitiveness and Investment Climate Survey. They estimate a probit model in which the probability of a firm providing formal training to its employees depends on measures of international integration (exporting and foreign ownership) and technology measures and other control variables. They find that firms that export are more likely to train their employees, but they do not find similar evidence for foreign ownership. They interpret these results as evidence of exporting firms adapting the skills of the employees to the change in technology and change in the quality of goods produced in order to meet the standards of foreign buyers.

Tan and Batra (1996) also study the determinants of provision of training and international activities in Columbia, Indonesia, Malaysia, Mexico, Taiwan and China. They estimate a probit model in which the probability that a firm provides training depends on measures of international integration (exporting and foreign ownership), measures of technology and firm characteristics. They estimate this model on a cross section of manufacturing firms in Columbia, Indonesia, Malaysia, Mexico, Taiwan and China. They find a positive relationship between provision of training and exporting (in all countries except Malaysia) and foreign ownership (although this relationship is not robust to inclusion of several other firm characteristics).

There are also several studies that examine the effect of other factors on the provision of training, but include measures of global engagement, like exporting or foreign ownership, as control variables and find a positive relation between provision of training and global engagement (Almeida and Aterido, 2008; 2010).

There is also survey evidence on the link between training and foreign ownership and supplying MNEs in transition countries. Djankov and Hoekman (1999) in their study of FDI productivity spillovers in the Czech Republic show that 60% of the firms that are majority foreign owned and 47% of the firms that are minority foreign owned provided training to their employees, compared with only 18% of domestic firms. Deardorff and Djankov (2000) provide survey evidence that in a sample of manufacturing firms in the Czech Republic, 62% of the firms that are subcontractors of foreign firms provide training to their employees compared to only 27% of firms that are not subcontractors of foreign firms. Javorcik (2008), Javorcik and

Spatareanu (2009) and Vacek (2010) present survey evidence that personnel training is one of the most common types of assistance received by MNEs suppliers from MNEs in the Czech Republic. However, Javorcik (2008) also finds employees' training is one of the most common measures undertaken by Czech firms in order to become a MNEs supplier.

In conclusion, previous empirical studies on the effect of globalisation on the employment of skilled labour in transition and developing countries found mixed results. Overall, these studies suggest that the results might depend on the measures of labour skills used, on controlling for firm fixed unobserved characteristics and on the country characteristics, especially level of development. In view of these conclusions, we examine the effect of globalisation on several measures of labour skills related to employees' education, occupation and training, we use several empirical methods, which allow us to study causal effects, and we study these effects in countries at different levels of development.

Table 5.1 Studies on participation in international activities and demand for skilled labour in developing and transition countries

Study	Country/Period	Labour Skills	International Activities	Results
Harrison and Harris (1999)	Mexico (1984-1990)	Nonproduction employees	Foreign ownership Exporting Importing	+ all measures of international activities
Pavcnik (2000)	Chile (1979-1986)	Nonproduction employees	Foreign technical assistance, foreign patents, importing	? all measures of international activities after controlling for fixed firm characteristics
Commander and Kollo (2008)	Hungary, Romania, Russia (1997-2000)	Primary, vocational and secondary education. Unskilled production, skilled production and nonproduction employees	Foreign Ownership Exporting	Hungary Foreign Ownership: +primary, -vocational, ?secondary + unskilled production,- skilled production,? nonproduction Exporting: + primary education,? vocational, ? secondary ?unskilled production, +skilled production, - nonproduction Romania Foreign ownership: ? primary, + vocational, - secondary. -unskilled production, +skilled production,? nonproduction. Exporting:+ primary, ?vocational,- secondary. +unskilled production, - skilled production, ? nonproduction Russia Foreign ownership:-primary, +vocational,-secondary ? unskilled production, ? skilled production, + nonproduction
Fajnzylber and Fernandes (2009)	Brazil (2003) and China (2001)	Tertiary education Nonproduction employees	Foreign ownership Exporting Importing	Brazil:+ foreign ownership,+ importing, ? exporting China ? foreign ownership,- importing, - exporting

Almeida (2010)	8 countries in East Asia (2002-2005)	Tertiary education Nonproduction employees	Foreign ownership Exporting	+ foreign ownership, - exporting.
Tan *et al.* (2007)	Russia (2005)	Formal training	Foreign ownership Exporting	? foreign ownership, + exporting
Batra and Tan (1996)	8 developing countries (1986-1995)	Formal training	Foreign ownership Exporting	+ foreign ownership in Malaysia and Taiwan. + exporting in Colombia, Mexico, Indonesia (only for unskilled workers) and Taiwan.
Almeida and Aterido (2008)	66 developing countries (2002, 2005)	Formal training	Foreign ownership Exporting	+ foreign ownership, + exporting
Almeida and Aterido (2010)	99 developing countries (2002-2007)	Formal training	Openness (foreign ownership or exporting)	+

5.3 Data Description

In this section we will present the data used in the empirical analysis, describe the main variables related to labour force skill and firms' international integration, and present some preliminary evidence in support of our main hypothesis. The data used in the empirical analyses comes from plant level dataset BEEPS 2002 and 2005 and it is described in Chapter 2.

The number of observations that can be use in the empirical analysis is smaller than the number of observations reported in the Chapter 2 because some firms did not respond to all the questions relevant for this analysis. Table 5.2 presents the number of observations for each of the cross section and panel samples used in the empirical analysis. The panel sample includes only firms that provide data for the main variables of interest in both years.

Table 5.2 Sample description

	2002	2005	2002-2005
All	6153	9098	1025
Country	6153	9098	1025
Sector	6153	9098	1025
Size	6122	9097	1024
Foreign ownership	5739	9097	921
Exporting	5709	9084	915
Importing	5380	8848	830
Supplying MNEs	5190	8583	777
Education	4291	8445	644
Non production workers	5125	8491	759
Skilled prod workers	4488	7508	597
Training	5190	8583	777
Training nonproduction workers	4684	6355	485
Training production workers	5080	8384	739

Source: BEEPS 2002 & 2005

The table shows that the samples are reduced considerably when we exclude observations that have missing values for international activities and basic control

variables. In the lower part of this table we show the number of observations for each of the cross-section and panels for which we also have information on the measures of workforce skills and on the international activities and basic control variables. These are the samples used in the baseline specifications in the empirical analysis.

5.3.1 Workforce Skills

We will use several measures for workforce skills: share of employees with university education, share of nonproduction employees, share of skilled production employees and provision of formal training, provision of formal training for nonproduction employees and provision of training for nonproduction employees.

Our measure of tertiary education is the share of employees with some university education or higher in total employees.

The share of nonproduction employees is the share of managers, professionals, and other nonproduction employees (like administration, sales) in total employment. This measure is frequently used in studies on this topic. The BEEPS 2002 and 2005 dataset contains information on the number of production and nonproduction permanent full time employees and the total number of permanent full time employees, based on which we calculate the share of nonproduction employees.

The share of skilled production employees in total production employees is based on the number of permanent, full time skilled production employees and the number of total permanent full time production employees in the BEEPS dataset. The exact question about skilled production workers is: "how many permanent, full time employees were skilled production workers?"The surveys did not include a

definition of skilled production workers and from the question it is not clear whether skilled production workers refers only to workers that have a formal qualification suitable for their occupation, like for instance vocational training, or also to other workers. Since the question refers to occupational categories and it distinguishes between skilled and unskilled workers, we consider that it refers to workers that are employed as skilled production workers and therefore have acquired some skills relevant for their jobs, but we do not make any assumptions about their formal education.

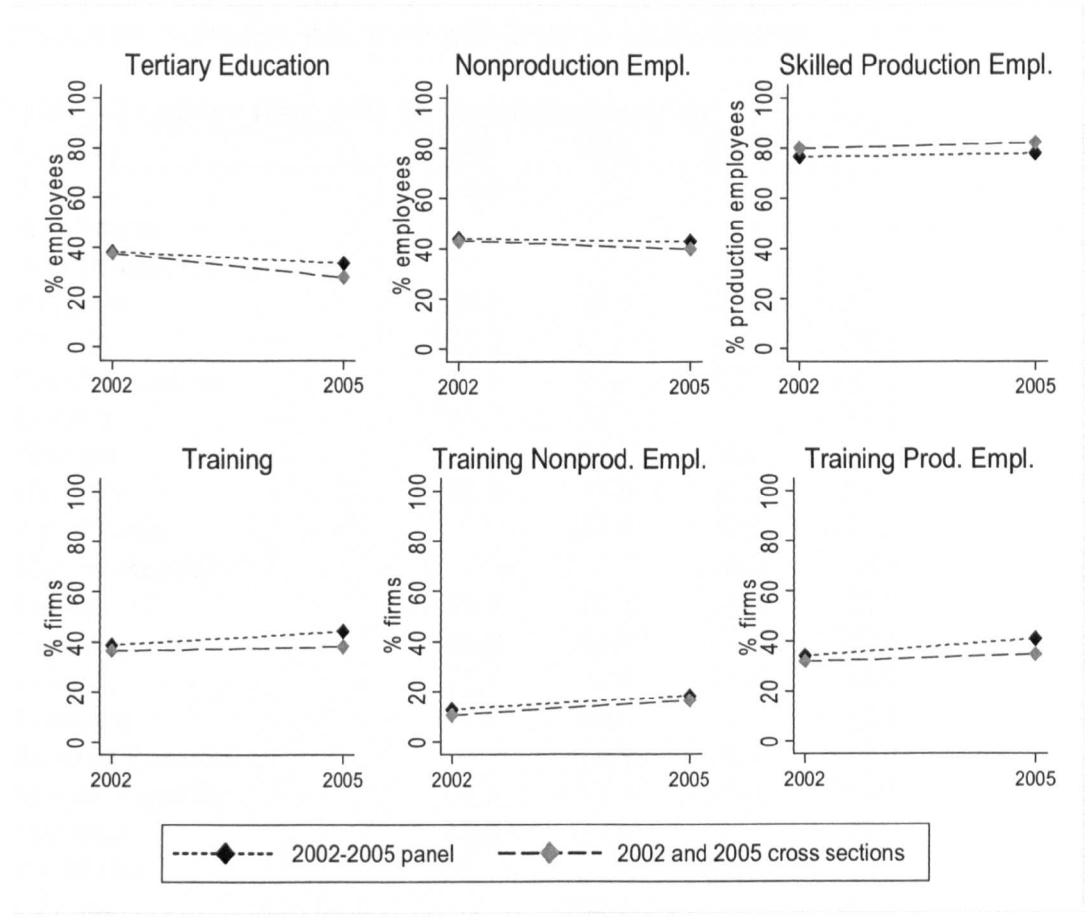
Firms were also asked whether or not the firm offers formal training to their employees and the percentage of employees in each occupational category that received training over the last 12 months. The exact question is: "Did this establishment have formal training programs for its permanent, full-time employees?". From this question, it is unclear exactly what type of training is offered by the firm and whether it leads to formal qualification or not. Since the question refers to training offered by the firm we assume that it leads to the acquisition of skills relevant for the employees' job. Other studies that used this dataset interpreted the question the same way (Almeida and Aterido, 2008, 2010).

Firms were also asked to indicate the percentage of employees in each occupational category that received training. Not all the firms that answered the question on whether or not they provided training indicated the shares of production or nonproduction workers that received formal training. Therefore, there are more observations for the variable training than for the variables training of production employees and training of nonproduction employees. There were also cases of firms

that answered that they provide training but indicated that shares of production and nonproduction workers that received training are both 0. In these cases, we considered that the answer to the question was mistaken and the firm did not provide training. There were also cases of firms that answered that they did not provide training and did not answer the questions about the shares of workers trained. In this case, I also considered that the shares are 0. Finally, there are some cases in which the firms answer that an unrealistically small share of workers received training. For instance, there was one firm that answered that 3% of its 12 nonproduction employees received training. In the EBRD description of the implementation of the survey (EBRD, 2010a), it was reported that several firms found it difficult to indicate the exact % of employees that received training, although they knew whether or not the firm had a training program. Therefore, we focus on the provision of training and on what type of employees (production or nonproduction employees) that received training and not on the intensity of training (the share of employees that received training).

We start by examining changes in labour skills over the period 2002-2005 to understand how the labour skills evolved over this period and whether there are differences between different samples used in the empirical analysis. The summary statistics for each measure of labour skills in each of the cross section and panels use in the study are reported in Table 5.19 in the annexes. Here, we will present the evolution of these measures graphically. Figure 5.1 presents the changes in labour skills over the period 2002-2005 using the 2002 and 2005 cross section and the 2002-2005 panel.

Figure 5.1 Labour skills between 2002 and 2005



Source: BEEPS 2002 & 2005

The 2002 and 2005 cross sections and also the balanced panel 2002-2005 show similar patterns for all three measures. The figures suggest that the average share of employees with tertiary education, the average share of nonproduction employees in total employees and the average share of skilled production workers *decreased* over the period 2002-2005. This pattern is surprising, especially because in most of the countries studied labour supply with tertiary education increased slightly over the period for most of the countries, as shown in Table 5.3 below, which reports the percentage of the labour force with tertiary education from WDI. However, it is important to mention that there are important differences between WDI indicator of labour force education in a country and our indicator. The WDI indicator refers to the whole labour force in the country, including labour employed in sectors excluded

in the survey, like of instance health, education, welfare, public administration, agriculture, electricity, gas, water and financial intermediation.

Table 5.3 Labour force with tertiary education (%)

Country	2001	2002	2004	2005
Albania	8.0	7.9		
Azerbaijan				
Bosnia and Herzegovina				
Bulgaria	23.3	23.0	24.1	24.1
Croatia	17.2			18.2
Czech Republic	11.6	12.5	13.2	13.7
Estonia	30.7	31.5		34.2
Georgia		27.2	26.6	
Hungary	16.5	18.6	20.0	20.2
Kazakhstan		47.4	50.0	
Kyrgyz Republic			16.0	2.4
Latvia	19.9	20.3	21.3	22.3
Lithuania	46.0	45.9	27.7	29.1
Poland	12.9	14.0	17.4	18.9
Romania	9.1	10.0		12.2
Russian Federation		24.8	51.5	50.4
Slovak Republic	11.5	11.5	13.4	15.2
Slovenia	16.6	17.0	19.6	20.9
Tajikistan			10.9	
Ukraine		66.1		45.2

Source: World Bank Development Indicators 2001, 2002, 2004, 2005.

A possible explanation for the evolution of the workforce skills over 2002-2005 period is the restructuring of firms. Most of the firms started the transition process overstaffed for the needs of a market economy and in order to become competitive they reduced redundant labour (World Bank, 1996). This process was prolonged and was ongoing during the period studied (Rutkowski, 2007). Finally, another possible explanation is that the data is not very precise. For instance, in the report of the implementation of the survey for 2002 in Bulgaria it is mentioned that due to the high level of unemployment in the country workers often perform duties below their education level. Managers did not care about their level of education and, therefore, they sometimes provided only rough estimates of the percentage of employees with tertiary education. There were no similar notes for any other country in the sample;

however, many countries were in a similar situation and it is possible that this problem existed also in other countries. EBRD (2007) found that one third of the employees in the transition countries work in jobs below their educational attainment and that this situation was more common in CIS countries. To address this potential problem, in our empirical analysis we will consider the robustness of our findings to the use of several measures of workforce skills.

The figure also shows that the share of firms that provided training to their employees increased from 2002 to 2005. It can be noticed that in all samples and in all years the share of firms that provides training to production workers is much higher than the share of firms that provides training to nonproduction workers. In terms of evolution over time, it can be noticed that the shares of firms that provided training to nonproduction and production workers increased during 2002-2005 period.

In conclusion, we find that the cross sections and the balanced panel show a similar evolution of our main indicators of workforce skills. All of them suggest that share of employees with tertiary education, the share of nonproduction employees and the share of skilled production employees decreased between 2002 and 2005. The share of firms that provides training to both production and nonproduction employees increases between 2002 and 2005.

5.3.2 International Activities

We use five measures of international activities. Four are the same measures used in the previous chapters: foreign ownership, supplying MNEs located in the same country, importing and exporting. These measures were defined in Chapter 3. We

also use a measure of international activities which indicates weather a firm participates in any of these international activities or not. Table 5.4 presents descriptive statistics for these variables for the two cross sections and the balanced panel. Each panel includes only firms that appear in all the years of the panel and provide data for all the main variables of interest.

Table 5.4 Participation in international activities

	Foreign ownership	Supplying MNEs	Exporting	Importing	Any International Activity
2002 wave	0.17	0.15	0.27	0.56	0.66
2005 wave	0.11	0.14	0.23	0.49	0.60
Panel 2002-2005					
2002	0.15	0.15	0.25	0.57	0.67
2005	0.12	0.14	0.23	0.50	0.60

Source: BEEPS 2002 & 2005

The 2002 and 2005 cross sections and also the balanced panel 2002-2005 show similar patterns for firms' international engagement. The table shows that the share of foreign owed firms decreased from 2002 to 2005. This could be due the use of different quotas for foreign owned firms in different waves of the survey. The BEEPS 2002 wave aimed to include 15% of foreign owned firms. However, due to the small universe of such firms in several countries, especially in smaller and less advanced in their transition countries and the quota was reduced to 10% and in some cases it was reduced even further. BEEPS 2005 aimed to include at least 10% of foreign owned firms, but in case this share was difficult to achieve the quota was reduced.

The 2002 and 2005 cross sections and also the 2002-2005 balanced panel show that the share of firms that supply MNEs located in the same country was 15% in 2002 and it remained almost unchanged in 2005.

Looking at the share of exporters in the three cross sections, it seems that the share of exporters in the sample decreased slightly from 2002 to 2005. Importing is the most common international activity undertaken by the firms in all samples and years. In all samples, almost half of the firms import part of their material inputs. The share of firms that imports material inputs decreased from 2002 to 2005.

In the last column we show the share of firms that participates in any of the four international activities considered. In all samples, large shares (more than 60%) of firms participated in some international activity. The table shows that the share of firms, more than half of the sample, that participated in some international activities decreased slightly from 2002 to 2005.

Next, we look at changes in participation in international activities. It is important to look at these changes because the estimation methods we use in our empirical analyses explore these changes to identify the effect of participation in international activities on skill upgrading. Table 5.5 presents the shares of firms that never participated in any international activities, participated continuously, started and quitted participating in such activities.

Table 5.5 Changes in participation in international activities

	Did not participate in 2005		Participated in 2005		Total
Foreign ownership	Firms	Share	Firms	Share	
Did not participate in 2002	645	0.83	15	0.02	660
Participated in 2002	39	0.05	78	0.10	117
Total					777
Supplying MNEs					
Did not participate in 2002	594	0.76	65	0.08	659
Participated in 2002	74	0.10	44	0.06	118
Total					777
Exporting					
Did not participate in 2002	540	0.69	41	0.05	581
Participated in 2002	55	0.07	141	0.18	196
Total					777
Importing					
Did not participate in 2002	252	0.32	84	0.11	336
Participated in 2002	133	0.17	308	0.40	441
Total					777
Any International Activities					
Did not participate in 2002	189	0.24	71	0.09	260
Participated in 2002	126	0.16	391	0.50	517
Total					777

Source: BEEPS 2002 & 2005

Table 5.5 shows that 93% of the firms did not change their ownership during 2002-2005 period: 83% of firms remained domestic owned for the whole period and 10% of firms remained foreign owned for the whole period. It also shows that there were more firms that changed ownership from foreign to domestic than from domestic to foreign. The small number of firms that changed ownership suggests that it may be difficult to identify the effect of changes in foreign ownership on skill upgrading.

A large share of firms (76%) never supplied MNEs located in the same country in 2002 and 2005. There is a large amount of entry into and, especially, exit from

supplying MNEs located in the same country. 10% of the firms that did not supply MNEs in 2002 started supplying MNEs in 2005 while 63% of the firms that supplied MNEs in 2002 stopped supplying them in 2005. Only 37% of the firms that supplied MNEs in 2002 continued to supply them in 2005. This suggests that supplying MNEs is often a short-lived activity.

The table shows 87% of the firms in the sample did not change their export status (69% of firms never exported and 18% exported continuously). Almost 93% of non-exporters in 2002 did not export in 2005 and almost 72% of exporters in 2002 continued to export in 2005. This is consistent with the previous findings in the literature that export status is highly serially correlated. There is also substantial switching in export status. 7% of non-exporters started exporting in 2005, while 28% of firms that exported in 2002 stopped exporting in 2005.

A large majority of non-importers (75%) at the beginning of the period did not import any inputs in 2005 and (almost 70%) of the importers continued to import their inputs in 2005. The degree of switching is considerable. 25% of firms that were not importers in 2002 used imported inputs in 2005 and 30% of the importers in 2002 stopped importing their intermediate inputs in 2005.

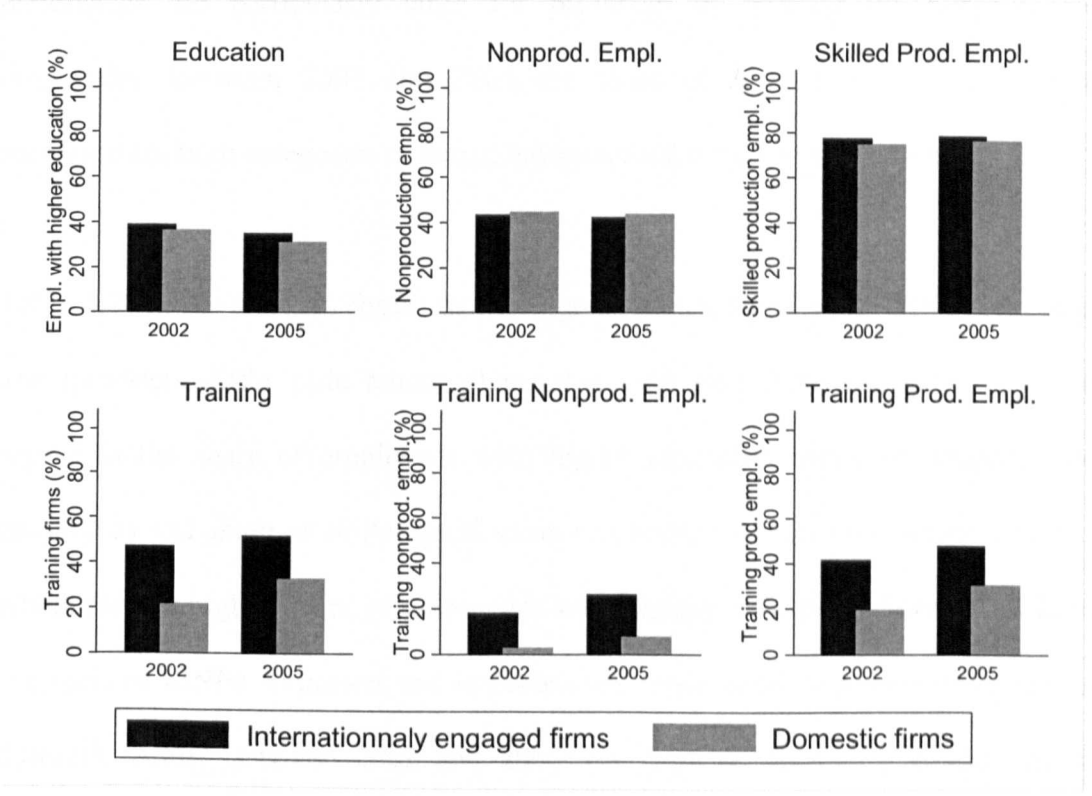
We also examine firms' participation in any international activities. More than 50% of firms participated continuously in some international activity during 2002-2005. Only 24% of firms did not participate in any international activity during this period. There are also high rates of entry and exit in participation in international activities. 27% of firms that were purely domestic in 2002 started participating in some

international activity in 2005 and 24% of the firms engaged in some international activity in 2002 stopped participating in 2005.

5.3.3 Workforce Skills and Participation in International Activities

In this section, we examine how workforce skills vary across firms which are involved in international activities. For expositional proposes, we will focus on the differences between firm that engaged in at least one of the international activities and those that do not participate in any international activities in the balanced panel sample for 2002-2005, which is the main sample used in the empirical analysis. Figure 5.2 shows the labour skills in domestic and internationally engaged firms.

Figure 5.2 Labour skills in internationally engaged firms and domestic firms



Source: BEEPS 2002 & 2005

The figure shows that differences between firms engaged in international activities and domestic firm with regard to the share of employee with tertiary education, share of nonproduction employees and share of skilled production employees are small.

These differences are statistically insignificant. Between 2002 and 2005, the share of employees with tertiary education decreased for both domestic and internationally engaged firms. The share of nonproduction employees and the share of skilled production employees changed very little between 2002 and 2005 for both categories of firms.

Compared to domestic firms, firms that participate in international activities are much more likely to provide formal training to both nonproduction and production employees. The differences between domestic and internationally engaged firms with regard to provision of training are large and statistically significant. These differences are particularly large for provision of training for nonproduction employees. Between 2002 and 2005 the share of firms that provides training increased for both categories of firms, but increased most for domestic firms.

Table 5.20 in the annexes shows that foreign affiliates, suppliers of MNEs, exporters and importers differ little among themselves and also from domestic firms with regard to the share of employees with higher education, share of nonproduction employees and share of skilled production employees, except that foreign affiliates, which have a higher share of employees with tertiary education. Foreign affiliates, suppliers of MNEs, exporters and importers are more likely to provide training than domestic firms. Between 2002 and 2005 the share of university employees, the shares of nonproduction employees and of skilled production employees decreased all firms involved in international activities and also for domestic firms. During this period, the shares of foreign affiliates, MNEs suppliers, exporters and importers that

provided training to nonproduction employees increased and the shares that provided training to production employees increased for all firms except MNEs suppliers.

In conclusion, this preliminary evidence shows that compared to domestic firms, firms that participate in international activities do not differ much in terms of workforce education and the shares of nonproduction employees and skilled production employees, but they do differ considerably in terms of provision of training. Firms engaged in international activities are more likely to provide formal training to their employees (both production and nonproduction employees) than purely domestic firms and these differences are large.

However, these simple correlations do not take into account the sector and the country in which firms operate. Participation in international activities and labour skills vary considerably across countries and sectors. Therefore, to examine the characteristics of globally engaged firms we estimate a regression of the labour skills measures on dummies controlling for participation in international activities and sector and country and year fixed effects. We use the balanced panel sample for 2002-2005.

Table 5.6 Preliminary evidence on labour skills and international integration (balanced panel 2002 & 2005, pooled OLS)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
International Activities	0.090*** (0.019)	0.033* (0.017)	0.020 (0.020)	0.187** (0.026)	0.147*** (0.024)	0.166** (0.027)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Obs.	1288	1526	1194	1554	970	1478
R^2	0.312	0.244	0.106	0.159	0.177	0.159

Notes: *, ** and*** indicate significance at 10%, 5% and 1%, respectively. Standard errors are clustered by firm.

The results of these estimations show that within sectors and countries firms engaged in international activities have a better educated workforce, a higher share of nonproduction employees (although the differences with regard to this measure of labour skills are small) and they are more likely to provide training to their production and nonproduction employees, but they do not employ more skilled production employees than purely domestic firms. The reason these results differ from the previous ones is that in these regressions we control for sector fixed effects. Firms in services sectors usually employ a larger share of nonproduction employees and of employees with university education than firms in manufacturing, mining and construction sectors, but they usually participate less in international activities like exporting and importing.

We conclude that preliminary evidence shows that firms that participate in international activities have a better skilled workforce according to all measures considered, except the share of skilled production workers.

5.4 Empirical Strategy

To study formally the relationship between labour skills and participation in international activities, we follow the methodology used in previous studies (reviewed in section 5.2.2). We estimate a specification in which measures of labour skills are regressed on measures of international integration, measures of technology and other firm characteristics:

$$Skill_{ijct} = \beta_I I_{ijct} + \beta_T T_{ijct} + \beta_X X_{ijct} + \mu_i + u_{ijct} \qquad (5.1)$$

i represents the firm and t represents the time in industry j and country c.

$Skill_{ijct}$ represents labour skills. The measures of skilled labour used are: share of employees with university education, share of nonproduction employees, share of

skilled production employees and provision of formal training, provision of formal training for nonproduction employees and provision of training for nonproduction employees. We use several measures of labour skills because the theory is not clear about which skills of the labour force are most relevant. For measures related to training we use dummy variables on whether the firm invest or not in training, for reasons explained in section 5.3. Similar measures for workforce skills where used by Commander and Kollo (2008), Almeida (2010), Fajnzylber and Fernandes (2009), Tan *et al.* (2007), among others.

I_{ijct} represents global integration of firms. The measures of international integration are: foreign ownership, supplying MNEs, exporting, importing and a dummy that indicates whether the firm participates in any of these international activities. A positive and significant coefficient β_I suggests that international integration is associated with higher demand for skilled labour.

T_{ijct} represents firm's technology. Adoption of new technology is likely to affect workforce skills if the technology is skilled biased and it may also increase the probability of the firm participating in international activities if using this technology reduces the cost or improves quality of the firms' products. Therefore, not including controls for technology might lead us to overestimate the effect of the participation in international activities on demand for skills. Technology is measured as a dummy variable that takes the value 1 if the firm introduced new products or upgraded its existing products in the previous three years. Similar controls for technology were used by Commander and Kollo (2008) and Almeida (2010). In our robustness checks

we will also include controls for the use of ICT and having an internationally recognised quality certificate. The definition of these variables is in Table 5.18[18].

X_{ijct} are other firm characteristics which may affect skill intensity and international integration. We will include controls for size, age, state ownership, year, country, sector and location size fixed effects to control for year, country, sector and location specific factors that influence the skill intensity of the firms. The definition of these variables is in Table 5.18. When the dependent variable is training of nonproduction employees or training of production employees we also include measures of workforce skills (share of employees with higher education and share of skilled production employees, respectively) in order to test whether training substitutes or complements these skills.

Equation (5.1) also includes firm fixed effects (μ_i), which capture fixed firm unobserved characteristics. It is important to control for these characteristics because the participation in international activities could be correlated with unobserved plant characteristics that also affect workforce skills. For instance, it is likely that managerial ability affects both the skills of the workforce and participation in international activities. Few studies on the relationship between globalisation and skill control for firm unobserved characteristics. However, the results of the studies that control for them suggest that these effects are important. Pavcnik (2003) finds that firms engaged in international activities have better skilled workforces, but that the effect of participation in international activities on skill upgrading becomes

[18] Another variable that has been commonly used to control for firms' technological efforts in similar studies is investment in R&D (Fajnzylber and Fernandes, 2009; Almeida, 2010). However, in the BEEPS 2002 wave only 30% of the firms answered the question regarding investment in R&D.

insignificant when she controls for fixed firm unobserved characteristics. Therefore, we consider that it is important to control for fixed firm unobserved characteristics.

This reduced forms specification compares the use of skilled labour for firms in the same country, region, and industry and with similar other characteristics but which differ in their participation in international activities. This reduced form specification is related to a specification derived from minimizing variable cost subject to an output constraint used by Berman et al. (1994, 1999) and Pavcnik (2003). The main differences between our specification and that one are that our dependent variable is skilled labour share in employment not in the wage bill that we do not include controls for capital intensity and for skilled wage premium. These changes are due to data availability. A similar model has been used in other studies on the effects of globalisation and technology on the skills of the workforce that used data similar to BEEPS (Commander and Kollo, 2008; Almeida, 2010; Fajnzylber and Fernandes, 2009).

We assume that the relationship between labour skills measures and participation in international activities and the other control variables can be expressed as a linear function, despite the fact that our dependent variables are shares and dummy variables, because this allows us to include firm fixed effects. The main problem with using linear probability model is that the predicted probability may lie outside the 0-1 interval (Wooldridge, 2010). Alternatively, we could use fixed effects logit. The main advantage of fixed effects logit over the linear probability model is that the predicted probability is contained in the unit interval, but it is not possible to

calculated marginal effects for this model (Wooldridge, 2010). Given advantages and disadvantages of these methods, we chose to use fixed effects linear probability[19].

Controlling for firm fixed characteristics is important for the reasons explained above; however using fixed effects (FE) also presents several disadvantages. One of the main disadvantages of using FE is that it imposes the restrictions that starting an international activity and exiting this activity have opposite effects of equal magnitude on demand for skills. In addition, using FE especially on a panel with short time dimension (our panel is 3 years) may exacerbate measurement errors, which can bias coefficients towards zero (Wooldridge, 2010). To address these problems, we will also estimate a specification which allows starting, continuing and quitting to participate in an international activity to have different effects on demand for skilled labour. This specification also allows us to examine whether firms with better skilled workforce select into participation in international activities. In this specification, we will use only the measure which indicates whether or not a firm participates in international activities because controlling for starting, continuing and stopping to participate in each of the four international activities may create multicollinearity problems. We will estimate the following specification:

$$Skill_{ijct} = \beta_1 StartI_{ijct} + \beta_2 ContI_{ijct} + \beta_3 ExitI_{ijct} + \beta_4 Year + \beta_5 StartI_{ijct} * Year + \\ + \beta_6 ContI_{ijct} * Year + \beta_7 ExitI_{ijct} * Year + \beta_T T_{ijct-1} + \beta_X X_{ijct-1} + u_{ijct} \quad (5.2)$$

$StartI_{it}$, $ContI_{it}$ and $ExitI_{it}$ represent dummy variables that indicate whether a firm started participating, participated continuously or stopped participating in international activities during 2002-2005, respectively. In this equation the

[19] As a robustness check we also estimated equation 5.1 using tobit and probit for the pooled samples 2002 and 2005 and the results obtained were very similar to those obtained in our linear probability models. These results are reported in Table 5.21, in the appendix to this chapter.

coefficients β_1 shows the differences in workforce skills in 2002 between the firms that started to participate in an international activity between 2002 and 2005 and firms that did not participate in the any international activity during this period. Similarly, coefficient β_2 shows the difference in the workforce skills in 2002 between firms that participated continuously in an international activity during the 2002-2005 and firms did not participate in any international activity during this period. If firms with better skilled workforces select into participating in international activities than coefficients β_1 and β_2 should be positive and significant. Interactions between these variables and year 2005 dummy indicate how the workforce skills of the given category of firms changed between 2002 and 2005 relative to 2002. The main coefficients of interest are β_5. If our hypothesis that firms upgrade the skills of their workforce after starting to participate in international activities is correct, then the coefficient β_5 should be positive and significant.

T_{it-1} represents firm technology at the beginning of the period. X_{it-1} represent the firm characteristics (we control for the same characteristics as in equation (5.1)) at the beginning of the period.

5.5 Estimation Results

5.5.1 Baseline Results

We start by estimating equation (5.1) on the balanced panel 2002-2005 using pooled OLS. The results for the main variables of interest are reported in Table 5.7

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Table 5.7 Labour skills and international integration (balanced panel 2002 & 2005, pooled OLS)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training nonprod. Empl.	Training Prod. Empl.
International	0.072***	0.041**	0.024	0.127***	0.097***	0.144***
Activities	(0.018)	(0.018)	(0.021)	(0.027)	(0.026)	(0.033)
Innovation	0.022	-0.001	-0.001	0.110***	0.071***	0.100***
	(0.016)	(0.017)	(0.020)	(0.027)	(0.026)	(0.032)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	1288	1518	1194	1547	800	1168
R^2	0.386	0.286	0.128	0.220	0.282	0.209

Notes.*, ** and*** indicate significance at 10%, 5% and 1%, respectively. Standard errors are clustered by firm.

These results show that participation in international activities is positively and statistically significantly associated with share of employees with tertiary education, share of nonproduction employees and all measures related to provision of training, but insignificantly associated with the share of skilled production employees. The magnitude of the coefficients implies that firms participating in international activities have 7.2 percentage points more employees with tertiary education and 4.2 percentage points more nonproduction employees. Participating in international activities increases the probability of providing formal training by almost 13 percentage points the probability of providing training to nonproduction employees by 10 percentage points and the probability of providing training to production employees by almost 14 percentage points.

Introduction of new products or upgrading existing products is insignificantly related to the share of employees with tertiary education, share of nonproduction employees and the share of skilled production employees, but it is positively and significantly associated with all measures related to provision of training.

However, these results show only an association between workforce skills and innovation and participation in international activities. There could be reverse causality from skills to innovation and international activity. This could happen if the firms with better skilled labour are more able to introduce new products/services or to upgrade the existing ones and because they have more competitive products they are more able to participate in international activities. We will address this by examining whether firms upgrade the skills of their employees after starting to participate in these activities or whether firms with better skilled labour select into these activities.

The share of employees with university education is positively and significantly associated with provision of training for nonproduction employees, which suggests that the training and education are complements rather than substitutes. The results also suggests that between 2002 and 2005 the share of employees with tertiary education decreased, the share of nonproduction employees and the share of skilled production employees did not change significantly and the likelihood that a firm provides training increased (this is consistent with the raw results presented in Figure 5.1). They also suggest that firms located in capital cities have a more highly skilled workforce according to all measures considered. The country dummies imply that firms in most CEE countries have a lower share of employees with tertiary education and nonproduction employees, but are more likely to provide training than firms in CIS countries.

Next, we study whether our results are robust to controlling for fixed firm unobserved characteristics. These results are reported in Table 5.8.

Table 5.8 Labour skills and international integration (balanced panel 2002 & 2005, Fixed Effects)

	Tertiary Education	Nonprod. Empl.	Skilled Prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
International	0.007	0.005	-0.018	0.075*	0.060	0.115**
Activities	(0.019)	(0.024)	(0.030)	(0.043)	(0.043)	(0.051)
Innovation	-0.026	-0.050**	0.019	0.059	0.048	-0.009
	(0.017)	(0.021)	(0.026)	(0.037)	(0.038)	(0.044)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	1288	1518	1194	1554	800	1168
R^2	0.861	0.753	0.676	0.667	0.738	0.673

Notes: *, ** and*** indicate significance at 10%, 5% and 1%, respectively.

The FE estimation results show that when we control for fixed firm unobserved characteristics, the effect of participation in international activities on share of employees with tertiary education and nonproduction employees and provision of training for nonproduction employees becomes insignificant. These results suggest that firms with better skilled workforces are more likely to select into participating in international activities, but they do not upgrade the skills of their workforce after becoming internationally integrated. We find similar results for introduction of new products/ upgrading of the existing products. These results are also in line with the results of similar studies, like Pavcnik (2003) and Doms *et al.* (1997). Another possible explanation for these results is limited variation over time in participation in international activities. However, the results for provision of training and for provision of training to production employees remain positive and statistically significant after controlling for firm unobserved characteristics.

Next we examine whether starting, continuing and quitting participating in an international activity have different effects on demand for skilled labour. We do this by estimating equation (5.2). The results are presented in Table 5.9.

Table 5.9 Labour skills and changes in participation in international activities (balanced panel 2002 & 2005)

	Tertiary Education	Nonprod. Empl	Skilled Prod Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
Start	0.054	0.000	0.013	0.087	0.010	0.102
	(0.040)	(0.039)	(0.047)	(0.063)	(0.069)	(0.075)
Start* Year	-0.006	0.039	-0.043	-0.028	0.018	-0.070
	(0.055)	(0.054)	(0.065)	(0.087)	(0.094)	(0.103)
Continue	0.092***	0.050*	0.026	0.195***	0.116**	0.194***
	(0.027)	(0.027)	(0.032)	(0.043)	(0.045)	(0.051)
Continue*Year	0.002	0.004	0.030	-0.078	-0.002	-0.073
	(0.035)	(0.035)	(0.042)	(0.055)	(0.058)	(0.066)
Exit	-0.049*	-0.026	-0.004	-0.053	-0.059	-0.001
	(0.029)	(0.030)	(0.036)	(0.047)	(0.052)	(0.057)
Exit*Year	-0.017	0.018	0.012	-0.167**	-0.087	-0.253***
	(0.046)	(0.045)	(0.055)	(0.072)	(0.078)	(0.087)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Other firm characteristics	yes	yes	yes	yes	yes	yes
Obs.	1288	1518	1194	1554	800	1168
R^2	0.374	0.285	0.129	0.224	0.289	0.221
Start*Year=-Exit*Year(p value)	0.780	0.478	0.755	0.134	0.624	0.038
Starter =Continue (p value)	0.301	0.178	0.757	0.068	0.102	0.188

Notes: All the estimations include controls for other firm characteristics and year, country, industry and location fixed effects.*, ** and*** indicate significance at 10%, 5% and 1%, respectively. Standard errors are clustered by firm.

The coefficients of interaction terms between the variables that control for starting to participate in international activities and year dummies are statistically insignificant in all specifications. These results suggest that firms that start participating in international activities do not upgrade the skills of their labour force after starting participating in international activities.

The results show that firms that participated continuously in international activities during 2002-2005 have a more highly skilled workforce than firms that never participate in international activities during this period. This is true for all measures of labour skills except share of skilled production employees. The coefficient of participating continuously in international activities is positive and significant for all measures of workforce skills, except skill production employees. The magnitude of the coefficients implies that firms that participated continuously in international activities have 9.2 percentage points more employees with tertiary education and 5 percentage points more nonproduction employees than firms that did not participate in international activities. Participating continuously in international activities increases the probability of providing formal training by almost 20 percentage points, the probability of providing training to nonproduction employees by more than 11 percentage points and the probability of providing training to production employees by almost 20 percentage points. These results are consistent with the hypothesis of selection of best firms into participation in international activities. The coefficient of the firms that will start participating in international activities between 2002 and 2005 is positive, but not statistically significant. The magnitudes of the coefficients in the specifications in which dependent variables are training and training of production employees are large. The test of the equality of the

coefficients of starting to participate in international activities and of participating continuously in such activities never rejects the hypothesis that the two coefficients are equal. It is possible that this coefficient is poorly determined. This is also suggestive of selection of firms with better skilled workforce in participating in international activities.

We also test whether the coefficients of starting to participate in international activities and quitting participating in such activities are equal in magnitude but have opposite signs. We find that we cannot reject this hypothesis and therefore the results of FE estimation are not biased due to imposing this restriction.

Taken together, the results of the pooled OLS, FE and DID estimations results suggest that firms engaged in international activities have a better educated labour force, a larger share of nonproduction employees and they are more likely to train their production and nonproduction employees than domestic firm. However, we find evidence that this happens because firms with a more highly skilled workforce select into participation in international activities and not because these firms upgrade the skills of their workforces after starting to participate in international activities.

5.5.2 Extensions and Robustness Checks

For different dependent variables we have different number of observations because not all the firms answered all the questions regarding their workforce skills. It is possible that our different results for different measures of workforce skills are driven by differences in samples. We repeat the estimations of equation (5.1) and (5.2) for the sample of firms that provided all information for all questions regarding

their workforce skills. This reduces the sample considerably to 556 observations. The results of these estimations are reported in Table 5.10, Table 5.11 and Table 5.12.

Table 5.10 Participation in international activities (balanced panel 2002 & 2005, sample with data on all measures of labour skills, pooled OLS)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod Empl.	Training Prod. Empl.
International	0.064***	0.024	0.025	0.172**	0.109***	0.157**
Activities	(0.025)	(0.023)	(0.033)	(0.038)	(0.033)	(0.036)
Innovation	0.017	0.033	-0.027	0.075**	0.040	0.078**
	(0.023)	(0.022)	(0.030)	(0.038)	(0.032)	(0.036)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	556	556	556	556	556	556
R^2	0.385	0.277	0.174	0.344	0.321	0.337

Notes: *, ** and*** indicate significance at 10%, 5% and 1%, respectively. Standard errors are clustered by firm.

Table 5.11 Participation in international activities (balanced panel 2002 & 2005, sample with data on all measures of labour skills, FE estimations)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
International	0.021	-0.019	0.004	0.135**	0.076	0.127**
Activities	(0.027)	(0.033)	(0.045)	(0.064)	(0.057)	(0.060)
Innovation	-0.014	-0.031	-0.004	-0.005	0.014	-0.049
	(0.024)	(0.030)	(0.042)	(0.059)	(0.052)	(0.056)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	556	556	556	556	556	556
R^2	0.870	0.756	0.719	0.732	0.736	0.748

Notes: *, ** and*** indicate significance at 10%, 5% and 1%, respectively.

Table 5.12 Labour skills and changes in participation in international activities (balanced panel 2002 & 2005, sample with data on all measures of labour skills)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
Starter	0.051	-0.002	0.016	0.079	-0.002	0.072
	(0.053)	(0.052)	(0.073)	(0.092)	(0.083)	(0.089)
Starter* Year2005	-0.061	-0.019	-0.048	-0.123	-0.046	-0.077
	(0.072)	(0.070)	(0.098)	(0.124)	(0.112)	(0.120)
Continue	0.097***	0.060*	0.003	0.228***	0.114**	0.180***
	(0.036)	(0.035)	(0.050)	(0.063)	(0.057)	(0.061)
Continue*Year2005	-0.035	-0.048	0.051	-0.101	-0.001	-0.054
	(0.046)	(0.045)	(0.063)	(0.079)	(0.072)	(0.077)
Exiter	-0.064	-0.028	-0.023	0.016	-0.078	0.073
	(0.043)	(0.042)	(0.058)	(0.074)	(0.067)	(0.072)
Exiter*Year2005	-0.066	-0.009	-0.004	-0.371***	-0.173*	-0.325***
	(0.062)	(0.060)	(0.085)	(0.107)	(0.097)	(0.104)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Other firm	yes	yes	yes	yes	yes	yes
Obs.	556	556	556	556	556	556
R^2	0.395	0.295	0.171	0.372	0.347	0.369

Notes: All the estimations include controls for other firm characteristics and year, country, industry and location fixed effects. *, ** and*** indicate significance at 10%, 5% and 1%, respectively. Standard errors are clustered by firm.

These results are similar to our previous results both qualitatively and quantitatively. Therefore, we conclude that the results obtained are not driven by differences in samples for different measures of skills.

We examine the effect of separate international activities (foreign ownership, supplying MNEs, exporting and importing) on demand for skills. The results are reported in Table 5.13 and Table 5.14.

Table 5.13 Foreign ownership, supplying MNEs, exporting and importing and labour skills (balanced panel 2002 & 2005, pooled OLS)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
Foreign	0.047*	0.009	-0.025	0.012	0.145***	-0.033
	(0.025)	(0.027)	(0.030)	(0.043)	0.048	(0.052)
MNEs	0.003	0.029	0.017	0.119**	0.025	0.164**
	(0.021)	(0.022)	(0.025)	(0.038)	0.043	(0.045)
Exporter	0.061***	0.083**	0.000	0.029	0.051	0.057
	(0.021)	(0.022)	(0.025)	(0.034)	0.040	(0.041)
Importer	0.041**	0.007	0.014	0.101**	0.096***	0.088**
	(0.017)	(0.018)	(0.020)	(0.028)	0.026	(0.033)
Innovation	0.018	-0.006	-0.001	0.103**	0.063**	0.093**
	(0.016)	(0.017)	(0.020)	(0.027)	0.026	(0.032)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	1288	1518	1194	1554	800	1168
R^2	0.391	0.294	0.128	0.227	0.307	0.218

Notes: *, ** and*** indicate significance at 10%, 5% and 1%, respectively. Standard errors are clustered by firm.

The results from the pooled OLS estimation reported in Table 5.13 show that foreign ownership, exporting and importing are associated with a higher share of employees with tertiary education. Only exporting is associated with a higher share of nonproduction employees. None of the international activities is associated with a higher share of skilled production employees. Supplying MNEs and importing are associated with higher likelihood of provision of formal training and of provision of

training to production employees. Only importing is associated with higher likelihood of provision of formal training to nonproduction employees.

Table 5.14 Foreign ownership, supplying MNEs, exporting and importing and labour skills (balanced panel 2002 & 2005, FE estimations)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
Foreign	0.022	-0.018	-0.041	-0.139*	-0.005	-0.147*
	(0.035)	(0.046)	(0.053)	(0.082)	0.082	(0.088)
MNEs	-0.037*	0.002	-0.001	0.102**	-0.050	0.149**
	(0.022)	(0.029)	(0.035)	(0.051)	0.051	(0.060)
Exporter	0.015	0.025	-0.034	0.068	0.085	0.109
	(0.026)	(0.035)	(0.040)	(0.061)	0.066	(0.068)
Importer	0.005	-0.004	-0.017	0.082**	0.083**	0.094*
	(0.018)	(0.023)	(0.028)	(0.040)	0.042	(0.048)
Innovation	-0.025	-0.051**	0.019	0.054	0.049	-0.021
	(0.017)	(0.021)	(0.027)	(0.037)	0.038	(0.044)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	1288	1518	1194	1554	800	1168
R^2	0.861	0.753	0.677	0.671	0.742	0.679

Notes: *, ** and*** indicate significance at 10%, 5% and 1%, respectively.

Table 5.14 reports the results of the FE estimation. These results show that the relationships between different international activities and labour skills become insignificant, when we control of firm fixed effects, except for the relationship between supplying MNEs and importing on different measures of training. Overall, the results are consistent with those from the baseline specifications, but they also show that different activities have different effects on demand of skilled labour.

We also test whether the inclusion of other technology measures affects the results. In our main specification we control for the introduction of new products/upgrading of the existing ones, which is in line with the theory and also with the measures used in previous empirical studies. However, previous studies also found that other measures of technology, like ICT (Autor *et al.* 1998; Almeida, 2010) or quality of

products (Commander and Kollo, 2008; Almeida, 2010) are associated with better skilled labour force. We estimate a variant of specification (5.1) which includes measures of the use of ICT and quality of products. Our measure of product quality is a dummy variable that indicates whether or not the firm has an internationally recognised quality certificate. Our measure of the use of ICT is a dummy that indicates whether or not the firm has an internet connection. The results of these estimations are reported in Table 5.15 and Table 5.16.

Table 5.15 Other measures of technology (balanced panel 2002 & 2005, pooled OLS)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
International	0.047**	0.026	0.024	0.090**	0.084***	0.103**
Activities	(0.019)	(0.018)	(0.021)	(0.027)	(0.027)	(0.032)
Innovation	0.011	-0.007	0.002	0.090**	0.062**	0.076**
	(0.016)	(0.017)	(0.020)	(0.027)	(0.026)	(0.032)
Quality	0.026	0.037*	-0.028	0.120**	0.095*	0.150**
certificate	(0.019)	(0.022)	(0.026)	(0.036)	(0.050)	(0.041)
ICT	0.103***	0.052***	-0.004	0.120**	0.024	0.132**
	(0.020)	(0.019)	(0.023)	(0.031)	(0.028)	(0.037)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	1282	1512	1190	1548	794	1164
R^2	0.404	0.291	0.130	0.236	0.287	0.231

Notes: *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors are clustered by firm.

Table 5.15 reports the results of pooled OLS estimation. The results from these estimations show that our main findings remain robust to controlling for the use of ICT and product quality. In addition, we find that, as expected, having an internationally recognised quality certificate is associated with a higher share of nonproduction employees and all measures related to the provision of training. The use of ICT is associated with a better educated labour force, a higher share of nonproduction employees and higher likelihood that the firm provides formal

training to its employees, especially production employees. Table 5.16 presents the results of the FE estimation and we find that the results of the FE estimation are in line with our previous results.

Table 5.16 Other measures of technology (balanced panel 2002 & 2005, FE)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
International	0.006	0.001	-0.015	0.071*	0.061	0.110**
Activities	(0.019)	(0.024)	(0.030)	(0.043)	(0.044)	(0.051)
Innovation	-0.026	-0.048**	0.019	0.058	0.048	-0.014
	(0.017)	(0.021)	(0.026)	(0.038)	(0.039)	(0.045)
Quality	0.013	0.009	-0.008	0.060	-0.009	0.104*
certificate	(0.023)	(0.031)	(0.037)	(0.055)	(0.054)	(0.063)
ICT	0.011	-0.005	-0.057	0.103*	0.008	0.127**
	(0.023)	(0.029)	(0.0350	(0.053)	(0.050)	(0.060)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	1282	1512	1190	1548	794	1164
R^2	0.861	0.754	0.680	0.668	0.738	0.676

Notes: *, ** and*** indicate significance at 10%, 5% and 1%, respectively.

We also estimate specification (5.1) separately for the firms in CEE countries and for the firms in CIS countries. Due to differences in development, progress with transition process, proximity to EU markets and integration in world economy, it is possible that the globalisation has different effects on the firms in the two groups of countries. The results for these estimations are reported in Table 5.17.

Table 5.17 Differences between CIS and CEE countries (balanced panel 2002 & 2005, pooled OLS and FE)

	Tertiary Education		Nonprod. Empl.		Skilled Prod. Empl.		Training		Training Nonprod. Empl.		Training Prod. Empl.	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE	OLS	FE	OLS	FE
CEE												
International	0.060**	0.010	0.046**	0.020	0.036	-0.024	0.110**	0.090	0.093**	0.041	0.130**	0.126**
Activities	(0.020)	(0.023)	(0.020)	(0.028)	(0.023)	(0.036)	(0.034)	(0.055)	(0.042)	(0.063)	(0.039)	(0.064)
Innovation	0.005	-0.046**	-0.007	-0.047*	0.001	0.038	0.088**	0.058	0.088**	0.132**	0.072*	-0.024
	(0.019)	(0.020)	(0.020)	(0.025)	(0.022)	(0.032)	(0.033)	(0.049)	(0.041)	(0.059)	(0.038)	(0.057)
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	836	836	1018	1018	826	826	1042	1042	480	480	804	804
R^2	0.370	0.857	0.263	0.757	0.180	0.666	0.196	0.631	0.318	0.753	0.189	0.644
CIS												
International	0.107**	0.008	0.038	-0.076	0.011	0.006	0.136**	0.046	0.122**	0.057	0.149**	0.079
Activities	(0.029)	(0.039)	(0.030)	(0.049)	(0.039)	(0.062)	(0.042)	(0.069)	(0.033)	(0.059)	(0.054)	(0.088)
Innovation	0.057**	0.019	0.004	-0.065*	-0.023	-0.022	0.163**	0.050	0.036	-0.051	0.188**	0.018
	(0.028)	(0.031)	(0.028)	(0.039)	(0.037)	(0.049)	(0.040)	(0.055)	(0.032)	(0.047)	(0.052)	(0.069)
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	452	452	500	500	368	368	512	512	320	320	364	364
R^2	0.369	0.858	0.315	0.755	0.118	0.723	0.287	0.754	0.241	0.701	0.292	0.771

Notes:*, ** and *** indicate significance at 10%, 5% and 1%, respectively.

We find that the results for the two groups are similar. In both groups of countries, firms that engage in international activities employ a higher share of employees with tertiary education and are more likely to provide training. In both groups of countries the effect of participation in international activities becomes insignificant when we control for fixed firm unobserved characteristics.

5.6 Conclusions

In this chapter we studied empirically how firms' participation in international activities affects their demand for skills and the ways in which firms meet this demand for skills in 26 transition countries. There is a large empirical and theoretical literature on this topic, but most of the studies found mixed results and many, due to data limitations, suffer from using measures of skilled labour which do not accurately reflect employees' skills and from not being able to address the problem of endogeneity of firms' participation in international activities. Recognizing that firms can respond in different ways to changes in demand for skilled labour we study several measures related to workforce education, occupational structure and provision of training. We also address the problem of the endogeneity of firms' participation in international activities in several ways.

To study the relationship between participation in international activities and demand for skilled labour, we, following the existing literature compare the use of skilled labour in firms that are involved in international activities and domestic firms, after controlling for other firm characteristics. Our main results suggest that firms engaged in international activities have a better skilled workforce in terms of employees' education, occupational structure and provision of training to both production and nonproduction employees than domestic firms, but in terms of skilled production

employees than domestic firms. Our results are robust to controlling for various measures of firm technology, firm size and other firm characteristics.

Then, using the panel dimension of our dataset, we test whether the relationship between skill upgrading and international integration is robust to controlling for unobserved firm characteristics. Our results indicate that when we control for fixed firm unobserved characteristics, the effect of international activities on most measures of skills becomes statistically insignificant. This suggests that firms with better skilled labour are more likely to select into participating in international activities, but they do not upgrade the skills of their workforce after becoming internationally integrated. The results are similar to the results of other studies on this topic that used panel data and controlled for fixed firm unobserved characteristics, like Pavcnik (2003) and Doms *et al.* (1997).

Finally, using information on firms starting, continuing and stopping to participate in international activities, we examine whether firms upgrade the skills of their employees after starting to participate in these activities or whether firms with better skilled labour select into these activities. The results from these estimations confirm our findings that firms do not upgrade their employees' skills after starting to participate in international activities and that firms with better skilled employees select into participation in international activities.

We also perform several robustness checks to control for differences in samples for different dependent variables, different measures of participation in international

activities, different measures of technology and by testing our hypothesis on different groups of countries. Overall our findings confirm our main results.

Taken together, our results suggest that firms engaged in international activities have a better skilled workforce in terms of employees' education, occupational structure and provision of personnel training within the firm. However, this happens because firms with better skilled workforces and with formal training programmes select into participating in international activities, and not because these firms upgrade the skills of their workforces after starting to participate in international activities.

Appendices to Chapter 5

Table 5.18 Variable definitions

Variable Name	*Definition*
Tertiary education	Share of permanent full time employees with tertiary education.
Non production employees	Share of permanent full time employees that are managers, professionals and other nonproduction workers.
Skilled production employees	Share of permanent full time production employees that are skilled production employees.
Training	A dummy variable that takes the value 1 if the firm provided formal training programs for permanent full time employees and 0 otherwise.
Training non production employees	A dummy variable that takes the value 1 if the firm provided formal training programs for permanent full time nonproduction employees and 0 otherwise.
Training production employees	A dummy variable that takes the value 1 if the firm provided formal training programs for permanent full time production employees and 0 otherwise.
Foreign	A dummy variable that takes the value 1 if more than 10% of the firm's capital is owned by foreign investors and 0 otherwise.
MNE supplier	A dummy variable that takes the value 1 if the firm sells part of its output to MNEs located in the same country and 0 otherwise.
Exporter	A dummy variable that takes the value 1 if the firm exports part of its output and 0 otherwise.
Importer	A dummy variable that takes the value 1 if the firm imports part of its material inputs and 0 otherwise.
International Activities	A dummy variable that takes the value 1 if the firm is foreign, or supplies MNEs located in the same country, or exports or imports and 0 if it is not involved in any of these activities.
Innovation	A dummy variable that takes the value 1 if the firm introduced a new product or upgraded an existing product over the previous 3 year and 0 otherwise.
ICT	A dummy variable that takes the value 1 if the firm has internet connection and 0 otherwise.
Quality certificate	A dummy variable that the value 1 if the firm has an internationally recognised certificate and 0 otherwise.
Size dummies	Dummy variables which indicate whether the firm is small (5 to 19 employees), medium (20 to 99 employees) or large (more than 99 employees).
Age	Age of the firm
State ownership	A dummy that takes value 1 if more than 50% of firm capital is owned by the state and 0 otherwise.
Location dummies	Dummy variables which indicate whether a firm is located in the capital city, a city with more than 1 million inhabitants, a city with between 250.000 and 1million inhabitants, a city with between 50.000 and 250.000 and a town with less than 50.000 inhabitants.

Table 5.19 Labour skills (summary statistics)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
Cross section 2002	0.38	0.43	0.80	0.37	0.11	0.32
Cross section 2005	0.28	0.40	0.82	0.38	0.16	0.35
2002-2005 panel						
2002	0.38	0.44	0.78	0.39	0.12	0.34
2005	0.30	0.43	0.78	0.44	0.18	0.41

Source: BEEPS 2002 & 2005

Table 5.20 Labour skills and international activities (summary statistics)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training Nonprod. Empl.	Training Prod. Empl.
Cross section 2002						
Domestic	0.34	0.44	0.79	0.25	0.05	0.22
Foreign	0.47	0.47	0.80	0.44	0.17	0.36
MNE supplier	0.43	0.46	0.82	0.54	0.21	0.48
Exporter	0.37	0.41	0.80	0.49	0.18	0.44
Importer	0.39	0.43	0.81	0.43	0.14	0.38
Cross section 2005						
Domestic	0.24	0.39	0.83	0.26	0.08	0.24
Foreign	0.37	0.43	0.79	0.53	0.33	0.48
MNE supplier	0.33	0.43	0.82	0.53	0.31	0.49
Exporter	0.30	0.38	0.81	0.55	0.33	0.51
Importer	0.30	0.40	0.82	0.47	0.25	0.43
Panel 2002-2005						
2002						
Domestic	0.36	0.45	0.75	0.22	0.03	0.19
Foreign	0.48	0.48	0.75	0.45	0.35	0.37
MNE supplier	0.39	0.44	0.76	0.64	0.33	0.58
Exporter	0.37	0.43	0.75	0.57	0.31	0.51
Importer	0.39	0.44	0.78	0.47	0.19	0.41
2005						
Domestic	0.31	0.44	0.77	0.33	0.08	0.30
Foreign	0.41	0.43	0.76	0.62	0.42	0.58
MNE supplier	0.39	0.48	0.81	0.58	0.35	0.53
Exporter	0.33	0.41	0.78	0.60	0.38	0.57
Importer	0.35	0.42	0.78	0.53	0.28	0.49

Source: BEEPS 2002 & 2005

Table 5.21 Labour skills and international integration (Pooled 2002 & 2005 sample, probit and tobit, marginal effects)

	Tertiary Education	Nonprod. Empl.	Skilled prod. Empl.	Training	Training nonprod. Empl.	Training Prod. Empl.
	Tobit	Tobit	Tobit	Probit	Probit	Probit
International	0.077***	0.043**	0.038	0.131***	0.111***	0.149***
Activities	(0.020)	(0.021)	(0.038)	(0.026)	(0.031)	(0.031)
Innovation	0.022	-0.005	-0.014	0.111***	0.096***	0.101***
	(0.017)	(0.020)	(0.034)	(0.025)	(0.029)	(0.030)
Sector FE	yes	yes	yes	yes	yes	yes
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Other ch.	yes	yes	yes	yes	yes	yes
Obs.	1288	1518	1194	1547	724	1161

Notes:*, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors are clustered by firm

Chapter 6 Conclusions

This dissertation contributes to the empirical literature on the effects of international technology transfer on firms' productivity and the demand for skilled labour in developing and transition countries. This study is motivated by the relevance of these topics for economic development of these countries, by the debate on wage-based inequality in these countries, and by the existing drawbacks of the literature. These drawbacks include: the measurement of the main variables of interest; partiality of evidence which focus only on one or several international technology transfer channels; and ambiguous results obtained by previous studies.

The dissertation provides empirical evidence on how participation in international activities affects firms' productivity, how it interacts with firms' absorptive capacity and how it affects the demand for skilled labour. The research focuses on the transition economies in Central and Eastern Europe and Central Asia. This group of countries is in some senses ideal for studying the effects of international technology transfer through international trade and FDI, because these countries lag behind developed countries in terms of technology, mainly due to isolation from the rest of the world during the central planning. Since the beginning of the transition their exposure to international trade and FDI increased significantly. They also have a highly educated labour force, and therefore they should, in principle, be able to assimilate advanced technology created in developed countries. Due to these specific characteristics of transition economies, international technology transfer could play an important role in increasing productivity and demand for skilled labour in these countries.

All the empirical analyses are based on the BEEPS 2002 and 2005 waves, which covers firms in 26 transition countries in ECA regions. This dataset is suitable for studying these topics because it contains firm specific measures of all the main international technology transfer channels and also a range of workforce skills, and other relevant firm characteristics. This allows us to use more precise, firm specific measures for these variables than previous studies. It also contains comparable information for 26 transition economies, which makes it possible to study these questions in a multicountry framework, and also comparable information for firms in manufacturing and in services, on which there is less research.

Chapter 3 studies whether foreign ownership, supplying MNEs located in the same country, FDI horizontal spillovers, exporting and importing are conduits of technology transfer and their relative importance for firms in 26 transition economies. It adds to the literature by analyzing the impact of all main channels of international technology transfer simultaneously, unlike previous studies which focused only on one channel, and by providing evidence on their relative importance. We also recognise that access to foreign sources of technology will differ across firms within an industry and, therefore, we use firm-specific measures of global engagement for all channels of international technology transfer studied, except for horizontal FDI spillovers.

The main results suggest that foreign ownership, supplying MNEs and exporting and importing are robustly associated with higher firm productivity. These results are consistent with the hypotheses of technology transfer through foreign ownership, supplying MNEs and importing material inputs. The magnitude of the coefficients

suggests that there are large differences in total factor productivity between the domestic firms and firms engaged in international activities. These differences range between 8% for importers to 14% for firms that supply MNEs located in the same country. With regard to the relative importance of different channels of international technology transfer, we cannot reject the hypothesis that these channels are equally important. These results suggest that participating in international activities could play an important role in raising the productivity of the firms in transition economies in ECA.

Our results remain significant, especially for linkages through supplying MNEs, after controlling for firm internal knowledge (human capital and R&D), using translog production function, allowing the coefficients to differ across countries and sectors, restricting the sample to the sample of domestic firms, separating the sample into large and small firms, old and new firms, firms in industrial and in service sectors and for firms in CEE and in CIS countries. The results from the fixed effects estimation suggest that there is also some evidence that this association between participation in international activities and higher productivity might be due to selection of most productive firms into these activities. Despite not being able to establish causality, the results show that participation in international activities is strongly linked to firm productivity.

These findings highlight the importance of openness to trade and FDI for facilitating technology transfer and raising firm productivity in CEE and CIS countries. The results of this study suggest that countries which seek to encourage international technology transfer would benefit from reducing the remaining barriers to FDI and

international trade and increasing their attractiveness for FDI. The result that supplying MNEs is associated with higher productivity suggests that FDI not only provides direct benefits to the firms that receive FDI but also indirect benefits through backward linkages with local producers. This suggests that there could be benefits from supporting FDI projects that are more likely to establish linkages with local suppliers, as well establishing programs that help link MNEs with potential local suppliers and to develop further the existing linkages.

Since the beginning of the transition, most CEE and CIS countries removed or eased restrictions on FDI and trade, and many countries in the region began to actively encourage the inward FDI flows and participation in international trade. However, several countries in the region, like Belarus, Tajikistan and Uzbekistan, continue to maintain important restrictions on trade and FDI (World Bank, 2005). There are also countries which, despite openness, failed to attract FDI or successfully participate in international trade. Examples of such countries are CIS countries in Central Asia which do not have important natural resources, but also smaller countries in the Balkans, such as Albania, Bosnia Herzegovina and Macedonia, FYR (World Bank, 2005).

Chapter 4 extends the study on the channels of international technology transfer by examining how absorptive capacity affects international technology transfer. This chapter contributes to the large literature on this topic by studying both country and firm level absorptive capacity, by using measures of absorptive capacity which are precise and closely related to the theoretical concept of absorptive capacity and firm

specific measures of access to foreign technology (foreign ownership, supplying MNEs, exporting and importing).

Our main results show that absorptive capacity and participation in international activities are associated with higher productivity, but there is no evidence of an interaction effect between absorptive capacity and participation in international activities. Overall, these results are in line with previous studies on transition economies in ECA region (Kinoshita, 2000; Damijan *et al.* 2003; Sinai and Meyer, 2004; Gorodnichenko *et al.* 2007). They suggest that firms are able to benefit from foreign technology regardless of their absorptive capacity, or, alternatively, that firms with the necessary absorptive capacity select into participating in international activities.

From a policy perspective, the results that participation in international activities and firms' absorptive capacity are associated with higher productivity, even though there is no evidence of a significant interaction effect, suggests that it is important to facilitate firms participation in international activities and the development of firms' absorptive capacity.

These findings, especially the lack of evidence that absorptive capacity facilitates international technology diffusion, might be used to suggest that aspects of the business environment and financial development are more important for facilitating international technology diffusion in these countries than absorptive capacity. Meyer and Sinani (2009) in a meta-analysis of host country characteristics and occurrence and extent of horizontal FDI spillovers found that institutional development

influences FDI spillovers. To adopt new technology firms need to have incentives to improve their technology and also to be able to do so. A business environment that distorts the incentive of firms to invest in improving technology or in which firms do not have access to finance to undertake the necessary investments will hamper international technology diffusion. There is large heterogeneity between transition countries with regard to their business environment and business environment is less favourable in CIS countries and in particular in the countries in Central Asia (EBRD, 2010c). The same study also found that in all transition countries, firms consider access to finance an important obstacle to their growth and operation. All this suggests that these characteristics are important features of transition economies and they could play an important role in facilitating or hampering international technology diffusion in these countries. Considering the extent of support for such effects in our data, this might be considered a useful extension of the work contained in this thesis.

Chapter 5 studies how participation in international activities affects firms' demand for skilled labour and the ways in which firms respond to changes in demand for skilled labour. It contributes to the literature by studying different ways in which firms respond to changes in the demand for skilled labour (hiring employees from outside the firm or training existing employees), by studying several measures of international integration (foreign ownership, exporting, importing and supplying MNEs), one of which, supplying MNEs, has not been researched before, and using different empirical methods to study this relationship, including fixed effects and difference in difference.

Our results suggest that firms engaged in international activities have a better educated labour force, more nonproduction employees and they are more likely to train their employees than domestic firms. These differences are particularly large with regard to provision of training and share of employees with tertiary education. Firms participating in international activities have 7.2 percentage points more employees with tertiary education Participating in international activities increases the probability of providing formal training by almost 13 percentage points; it increases the probability of providing training to nonproduction employees by 10 percentage points and the probability of providing training to production employees by almost 14 percentage points. The differences with regard to the share of nonproduction employees are smaller and not very robust.

This relationship between engaging in international activities and provision of training and education is robust to controlling for various measures of firm technology, including the introduction of new products and upgrading of the existing ones, use of ICT and acquiring internationally recognised quality certificates, and also to other firms' characteristics. However, our estimations suggest this is driven by the selection of firms with better skilled workforces and with formal training programmes select into participating in international activities, and not by the firms upgrading the skills of their workforces after starting to participate in international activities.

The main policy implications of these results are that labour skills are very important for a successful reintegration into the world economy through firms' participation in international trade, FDI and supply linkages with MNEs and also for adoption of

new products, introduction of ICT and improving quality of the products. We study a range of measures of labour skills and we find that, along with the skills acquired through formal schooling, skills acquired though training within firms are also very important dimension of workforce skills, one which is related to participation in international activities, innovation and various measures of firm technology. This suggests that improving labour force education and also creating favourable conditions for firms to provide training to their employees, like improved access to external finance, can facilitate firms' participation in international activities and adoption of new technology.

The main limitation for all the three essays is the way we address the problem of endogeneity of firms' participation in international activities. Fixed effects method helps reduce this problem if the selection of the firms in participating in international activities is based on fixed unobserved characteristics. However, the panel component of the dataset is very limited. In addition, this method does not address the problem of time-varying firm characteristics which might be correlated with the participation in international activities. Therefore, an extension of this study would be to examine the main hypotheses in this study using an instrumental variable approach or a using a panel dataset with a longer time dimension. Using a longer time dimension, one could also investigate whether self-selection is a conscious process by which firms increase their productivity and upgrade the skills of their workforce with the purpose of starting to participate in international activities. Another way to deal with this problem is to find an exogenous shock in the trade liberalisation and examine how firm productivity and demand for skilled labour change in response to this shock. Of course, such natural experiments are difficult to

find. Another interesting way of addressing this problem and also to extend this study is to account directly for managerial ability. Many theoretical models assume that managerial ability is essentially a time invariant firm characteristic which leads to a permanent productivity advantage. Recently, significant progress has been made to measure management quality directly by examining the extent to which firms use best practices in areas such as monitoring, operation, setting targets and providing right incentives to employees (Bloom and Van Reenen, 2010; Bloom *et al.* , 2011). Bloom *et al.* (2011) show that management practices differ considerably across and within transition economies and that they are strongly linked to various measures of firm performance, including productivity, which suggest that they might be an important determinant of productivity. Including measures of the quality managerial practices directly in the analysis of productivity and demand for skilled labour addresses the problem of unobserved firm characteristics and it allows such characteristics to evolve over time. In addition, it would be interesting to examine the relationship between such measures and participation of firms in international activities.

Bibliography

Acemoglu, D. (1998) "Why Do New Technologies Complement Skills? Directed Technical Change and Wage Inequality," *Quarterly Journal of Economics*, vol. 113 (4): 1055-1089.

Acemoglu, D. (2002) "Technical Change, Inequality, and the Labor Market," *Journal of Economic Literature*, vol. 40 (1): 7-72.

Acemoglu, D. (2003) "Patterns of Skill Premia," *Review of Economic Studies*, vol. 70 (2): 199-230.

Aitken, B. J. and A. E. Harrison (1999). "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela", *American Economic Review*, vol. 89 (3): 605–18.

Almeida, R. (2010) "Openness and Technological Innovation in East Asia: Have They Increased the Demand for Skills?", Policy Research Working Paper 5272, World Bank.

Almeida, R. and R. Aterido (2008). "The Incentives to Invest in Job Training: Does Strict Labor Codes Influence this Decision?" Social Protection Discussion Paper 0832, World Bank.

Almeida, R. and R. Aterido (2010) "The Investment in Job Training: Why Are SMEs Lagging So Much Behind?" IZA Discussion Paper 4981, IZA.

Almeida, R. and A. M. Fernandes (2008), "Openness and Technological Innovations in Developing Countries: Evidence from Firm-Level Surveys," *Journal of Development Studies*, vol. 44 (5): 701-727.

Altomonte C. and G. Bekes (2009). "Trade Complexity and Productivity" IEHAS Discussion Papers 0914.

Amiti, M. and J. Konings (2007) "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia" *American Economic Review*, vol. 97 (5): 1611-1638.

Andersson, M., S. Johansson, and H. Lööf (2007). "Firm Performance and International Trade - Evidence from a Small Open Economy", Working Paper Series 99, CESIS.

David H. A., L. F. Katz and A. B. Krueger, (1998) "Computing Inequality: Have Computers Changed The Labor Market?," *Quarterly Journal of Economics*, vol. 113 (4): 1169-1213.

Barro, R. J. and J.-W. Lee (2000). International Data on Educational Attainment: Updates and Implications, CID Working Paper Series No. 42, Harvard.

Barro, R. J.and J.-W.Lee, (1994) "Sources of Economic Growth," Carnegie-Rochester Conference Series on Public Policy, vol. 40 (1): 1-46.

Berman E., J. Bound and Z. Griliches (1994), "Changes in the Demand for Skilled Labor within U.S. Manufacturing Industries: Evidence from the Annual Survey of Manufactures", *Quarterly Journal of Economics,* vol. 109 (2): 367-397.

Berman E., J. Bound and S. Machin (1998), "Implications of Skill-Biased Technological Change: International Evidence," *Quarterly Journal of Economics*, vol. 113 (4): 1245-1279.

Benhabib, J. and M. Spiegel (1994), "The Role of Human Capital in Economic Development Evidence from Aggregate Cross-Country Data," *Journal of Monetary Economics*, vol. 34 (2): 143-173.

Bernard, A.B., and J. B. Jensen (1995). "Exporters, Jobs, and Wages in U.S. Manufacturing: 1976–1987". Brookings Papers on Economic Activity. Microeconomics: 67–119.

Bernard, A. B. and J. B. Jensen (1999). "Exceptional Exporter Performance: Cause, Effect, or Both?", *Journal of International Economics*, vol. 47 (1): 1-25.

Bernard, A. B., J. B. Jensen and P. K. Schott (2005). "Importers, Exporters, and Multinationals: A Portrait of Firms in the U.S. that Trade Goods". NBER Working Papers 11404, National Bureau of Economic Research.

Bernard, A. and J. Wagner (1997), "Exports and Success in German Manufacturing," *Weltwirtschaftliches Archiv*, vol. 133 (1): 134-157.

Bevan, A. and S. Estrin (2004) "The Determinants of Foreign Direct Investment into European Transition Economies", *Journal of comparative economics*, vol.32 (4): 775-787.

Bloom, N., H. Schweiger and J. Van Reenen, (2011) "The Land that Lean Manufacturing Forgot? Management Practices in Transition Countries," NBER Working Papers 17231.

Bloom, N. and J. Van Reenen, (2010) "Why Do Management Practices Differ across Firms and Countries?," *Journal of Economic Perspectives*, vol. 24 (1): 203-224.

Blalock, G. and P. J. Gertler (2008). "Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers", *Journal of International Economics*, vol. 74 (2): 402-421.

Blomström, M. and A. Kokko (1998) "Multinational Corporations and Spillovers", *Journal of Economic Surveys*, vol. 12(3): 247-277.

Borensztein, E., J. De Gregorio and J-W. Lee (1998), "How does Foreign Direct Investment Affect Economic Growth?", *Journal of International Economics*, vol. 45 (1): 115-135.

Bustos, P. (2005) "The Impact of Trade Liberalization on Skill Upgrading Evidence from Argentina," Economics Working Papers 1189, Department of Economics and Business , Universitat Pompeu Fabra.

Castellani, D. (2002). "Export Behaviour and Productivity Growth: Evidence from Italian Manufacturing Firms," *Weltwirtschaftliches Archiv*, vol. 138 (4): 605-628.

Campos, N. F. and Y. Kinoshita (2002). "Foreign Direct Investment as Technology Transferred: Some Panel Evidence from the Transition Economies," *Manchester School*, vol. 70 (3): 398-419.

Carstensen, K. and F. Toubal (2004) "Foreign Direct Investment in Central and Eastern European Countries: a Dynamic Panel Analysis," *Journal of Comparative Economics*, vol. 32 (1): 3-22.

Chusseau, N., M. Dumont and J. Hellier (2008). "Explaining Rising Inequality: Skill-Based Technical Change and North-South Trade", *Journal of Economic Surveys*, vol. 22 (3): 409-457.

Commander, S. and J. Kollo (2008), "The Changing Demand for Skills: Evidence from the Transition", *Economics of Transition*, vol. 16 (2): 199-221.

Coe, D. T. and E. Helpman (1995). "International R&D Spillovers," *European Economic Review*, vol. 39 (5): 859-887.

Coe, D. T., E. Helpman, and A. W. Hoffmaister (1997). "North-South R&D Spillovers," *Economic Journal*, vol. 107(440): 134-149.

Cohen, W. M. and D. A. Levinthal (1989), "Innovation and Learning: the Two Faces of R&D?", *Economic Journal*, vol. 99 (397): 569-596.

Crespo, N. and M. P. Fontoura (2007) "Determinant Factors of FDI Spillovers - What Do We Really Know?," *World Development*, vol. 35(3): 410-425.

Crinò, R. (2009) "Offshoring, Multinationals, and Labour Market: A Review of the Empirical Literature", *Journal of Economic Surveys*, vol. 23 (2): 197-249.

Damijan, J. P., M. Knell, B. Majcen, and M. Rojec (2003). "The Role of FDI, R&D Accumulation and Trade in Transferring Technology to Transition Countries: Evidence from Firm Panel Data for Eight Transition Countries," *Economic Systems*, vol. 27 (2): 189-204.

Damijan, J., S. Polanec and J. Prasnikar (2007). "Self-selection, Export Market Heterogeneity and Productivity Improvements: Firm Level Evidence from Slovenia", *World Economy*, vol. 30: 135–155.

Deardorff, A. and S. Djankov (2000) , "Knowledge Transfer Under Subcontracting: Evidence from Czech Firms", *World Development,* vol.28 (10): 1837-1847.

Djankov, S. and B. M. Hoekman (2000). "Foreign Investment and Productivity Growth in Czech Enterprises," *World Bank Economic Review*, vol. 14 (1): 49-64.

De Loecker, J. (2007). "Do Exports Generate Higher Productivity? Evidence from Slovenia," *Journal of International Economics*, vol. 73 (1): 69-98.

Doms, M. E. and J. B. Jensen (1998). "Comparing Wages, Skills, and Productivity between Domestic and Foreign Owned Manufacturing Establishments in the United States". In: Baldwin, R., Lipsey, R., Richardson, J. (Eds.), Geography and Ownership as Bases for Economic Accounting. University of Chicago Press.

Doms, M., T. Dunne and K. R. Troske (1997) "Workers, Wages, and Technology", *Quarterly Journal of Economics*, vol. 112 (1): 253-290.

Driffield, N., M. Munday and A. Roberts, (2002) "Foreign Direct Investment, Transactions Linkages, and the Performance of the Domestic Sector" *International Journal of the Economics of Business*, vol. 9 (3): 335-351.

Dunning, J.H. (1993). Multinational Enterprises and the Global Economy. Addison-Wesley.

Ethier, W. J. (1982). "National and International Returns to Scale in the Modern Theory of International Trade," *American Economic Review*, vol. 72 (3): 389-405.

European Bank of Reconstruction and Development (2007) Transition Report 2007: People in Transition.

European Bank of Reconstruction and Development (2010a) Notes, Variable Labels and Value Labels for BEEPS panel dataset 2002-2009.

European Bank of Reconstruction and Development (2010b). The Business Environment and Enterprise Performance Survey (BEEPS) 2008-2009. A Report on Methodology and Observations.

European Bank of Reconstruction and Development (2010c) Transition Report 2010: Recovery and Reform.

Fajnzylber, P. and A. Fernandes (2009) "International Economic Activities and Skilled Labour Demand: Evidence from Brazil and China," *Applied Economics,* vol. 41: 563-577.

Feenstra, R. C and G. H. Hanson (1996). "Globalization, Outsourcing, and Wage Inequality," *American Economic Review*, vol. 86 (2): 240-245.

Feenstra, R. C. and G. H. Hanson (1997). "Foreign Direct Investment and Relative Wages: Evidence from Mexico's Maquiladoras," *Journal of International Economics*, vol. 42: 371-393.

Findlay, R. (1978) "

Findlay, R. (1978) "Relative Backwardness, Direct Foreign Investment, and the Transfer of Technology: A Simple Dynamic Model," *Quarterly Journal of Economics*, vol. 92(1), pp. 1-16.

Fleisher, B. M., K. Sabirianova and X. Wang (2005) "Returns to Skills and the Speed of Reforms: Evidence from Central and Eastern Europe, China, and Russia," *Journal of Comparative Economics*, vol. 33 (2): 351-370.

Fosfuri, A., M. Motta and T. Ronde (2001). "Foreign Direct Investment and Spillovers through Workers' Mobility," *Journal of International Economics*, vol. 53 (1): 205-222.

Girma, S. (2005) "Technology Transfer from Acquisition FDI and the Absorptive Capacity of Domestic Firms: An Empirical Investigation," *Oxford Bulletin of Economics and Statistics*, vol. 67 (3): 281-306.

Girma, S., D. Greenaway and R. Kneller (2004). "Does Exporting Increase Productivity? A Microeconometric Analysis of Matched Firms," *Review of International Economics*, vol. 12 (5): 855-866

Girma, S. and H. Görg (2007) "The Role of the Efficiency Gap for Spillovers from FDI: Evidence from the UK Electronics and Engineering Sectors," *Open Economies Review*, vol. 18 (2): 215-232.

Girma, S., H. Görg and M. Pisu (2008) "Exporting, Linkages and Productivity Spillovers from Foreign Direct Investment," *Canadian Journal of Economics*, vol. 41 (1): 320-340.

Girma, S., Y. Gong and H. Görg (2009) "What Determines Innovation Activity in Chinese State-owned Enterprises? The Role of Foreign Direct Investment", *World Development*, vol. 37 (4): 866-873.

Globerman, S., J. Ries, and I. Vertinsky (1994). "The Economic Performance of Foreign Affiliates in Canada", *Canadian Journal of Economics*, vol. 27: 143–156.

Goldberg, P. K. and N. Pavcnik (2007) "Distributional Effects of Globalization in Developing Countries" *Journal of Economic Literature*, vol. 45 (1): 39-82.

Görg, H. and E. Strobl (2001), "Multinational Companies and Productivity Spillovers: A Meta-Analysis", *Economic Journal*, vol. 111 (475): F723–F739.

Görg, H. and D. Greenaway (2004), "Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment?", *World Bank Research Observer*, vol. 19 (2): 171–197.

Görg, H., Strobl, E. and F. Walsh (2007) "Why Do Foreign-Owned Firms Pay More? The Role of On-the-Job Training," *Review of World Economics*, vol. 143 (3): 464-482.

Görodnichenko, Y, J. Svejnar and K. Terrell (2007), "When Does FDI Have Positive Spillovers? Evidence from 17 Emerging Market Economies," IZA Discussion Papers 3079, Institute for the Study of Labor (IZA).

Gorodnichenko, Y., J. Svejnar and K., Terrell, (2008) "Globalization and Innovation in Emerging Markets," IZA Discussion Papers 3299, Institute for the Study of Labor (IZA).

Greenaway D. and R. Kneller (2007) "Firm Heterogeneity, Exporting and Foreign Direct Investment", *Economic Journal*, vol. 117 (517): F134 – F161.

Griffith, R., S. Redding and J. Van Reenen (2004) "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries," *Review of Economics and Statistics*, vol. 86 (4): 883-895.

Grossman, G. M. and E. Helpman (1991) Innovation and Growth in Global Economy. Cambridge: MIT Press.

Hall, R. E and C. I. Jones (1999). "Why Do Some Countries Produce So Much More Output Per Worker Than Others?," *Quarterly Journal of Economics*, vol. 114 (1): 83-116.

Halpern, L. and B. Muraközy, (2007) "Does Distance Matter in Spillover?", *Economics of Transition*, vol. 15: 781-805.

Harrison, A. and G. Hanson (1999), "Who Gains from Trade Reform? Some Remaining Puzzles," *Journal of Development Economics*, vol. 59 (1): 125-154.

Haskel J. E., S. C. Pereira and M. J. Slaughter (2007) "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?," *Review of Economics and Statistics*, vol. 89 (3): 482-496.

Hu, A., G. H. Jefferson and Q. Jinchang (2005), "R&D and Technology Transfer: Firm-Level Evidence from Chinese Industry," *Review of Economics and Statistics*, vol. 87 (4): 780-786.

Javorcik, B. (2004a). "Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages", *American Economic Review*, vol. 94 (3): 605 - 627.

Javorcik, B. (2004b). "The Composition of Foreign Direct Investment and Protection of Intellectual Property Rights: Evidence from Transition Economies," *European Economic Review*, vol. 48 (1): 39-62.

Javorcik, B. (2008) "Can Survey Evidence Shed Light on Spillovers from Foreign Direct Investment?", *World Bank Research Observer*, vol. 23 (2): 139-159.

Javorcik, B. and M. Spatareanu (2008), "To Share or Not to Share: Does Local Participation Matter for Spillovers from Foreign Direct Investment?" *Journal of Development Economics*, vol. 85 (1-2): 194-217.

Javorcik, B. and M. Spatareanu (2009), "Tough Love: Do Czech Suppliers Learn from Their Relationships with Multinationals?" *Scandinavian Journal of Economies*, vol. 114 (4): 811-833.

Kasahara, H. and B. Lapham (2008), "Productivity and the Decision to Import and to Export: Theory and Evidence" CESifo Working Paper 2240.

Kasahara, H. and J. Rodrigue (2008). "Does the Use of Imported Intermediates Increase Productivity? Plant-level Evidence", *Journal of Development Economics*, vol. 87 (1): 106-118.

Keller, W. (2004). "International Technology Diffusion", *Journal of Economic Literature*, vol. 42 (3): 752-782.

Keller, W. (2009). "International Trade, Foreign Direct Investment, and Technology Spillovers", NBER Working Paper 15442.

Keller, W and S. R. Yeaple (2009) "Multinational Enterprises, International Trade, and Productivity Growth: Firm-Level Evidence from the United States" *Review of Economics and Statistics*, vol. 91 (4): 821-831.

Kinoshita, Y., (2000). "R&D and Technology Spillovers via FDI: Innovation and Absorptive Capacity". William Davidson Institute Working Paper Number 349, William Davidson Institute.

Kneller, R. (2005). "Frontier Technology, Absorptive Capacity and Distance," *Oxford Bulletin of Economics and Statistics*, vol.67 (1): 1-23.

Konings, J. (2001). "The Effects of Foreign Direct Investment on Domestic Firms: Evidence from Firm Level Panel Data in Emerging Economies", *Economics of Transition*, vol. 9 (3): 619–633.

Köymen, S. and S. Sayek (2010), "The Role of Human Capital in Productivity Spillovers from FDI: An Empirical Analysis on Turkish Manufacturing Firms" Bilkent University Discussion Paper No.10-03.

Kyriacou, G. A., (1991). "Level and Growth Effects of Human Capital: A Cross-Country Study of the Convergence Hypothesis", Working Papers 91-26, C.V. Starr Center for Applied Economics, New York University.

Levinsohn, J. and A. Petrin (2003) "Estimating Production Functions Using Inputs to Control for Unobservables." *Review of Economic Studies,* vol.70 (2): 317–341.

Markusen, J. R. (1989). "Trade in Producer Services and in Other Specialized Intermediate Inputs," *American Economic Review*, vol. 79 (1): 85-95.

Markusen, J. R. (2002). Multinational Firms and the Theory of International Trade, Cambridge: MIT Press.

Markusen, J. R. and A. J. Venables (1999). "Foreign Direct Investment as a Catalyst for Industrial Development," *European Economic Review*, vol. 43 (2): 335-356.

Mayer, J. (2001), "Technology Diffusion, Human Capital and Economic Growth in Developing Countries," UNCTAD Discussion Papers 154, United Nations Conference on Trade and Development.

Mayer T. and G. Ottaviano (2007) "The Happy Few: New Facts on the Internationalisation of European Firms", Bruegel-CEPR EFIM2007 Report, Bruegel Blueprint Series.

Melitz, M. J. (2003), "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica,* vol. 71 (6): 1695-1725.

Meyer, K. E. and E. Sinani (2009) "When and Where Does Foreign Direct Investment Generate Positive Spillovers", *Journal of International Business Studies*, vol. 40(7): 1075-1094.

Miller, S. M. and M. P. Upadhyay (2000) "The Effects of Openness, Trade Orientation, and Human Capital on Total Factor Productivity," *Journal of Development Economics*, vol. 63 (2): 399-423.

Moulton, R. (1990), "An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Unit," *Review of Economics and Statistics*, vol. 72 (2): 334-338.

Muûls, M. and M. Pisu (2009). "Imports and Exports at the Level of the Firm: Evidence from Belgium," *World Economy*, vol. 32(5): 692-734.

Nelson, R. and E. S. Phelps (1966) "Investment in Humans, Technological Diffusion and Economic Growth", *American Economic Review,* vol.56 (1/2): 69-75.

Nicolini, M. and L.Resmini (2010) "FDI Spillovers in New EU Member States," *Economics of Transition*, vol. 18 (3): 487-511.

Olley, S. G. and A. Pakes (1996). "The Dynamics of Productivity in the Telecommunications Equipment Industry." *Econometrica,* vol.64 (6): 1263–1297.

Pack, H. and K. Saggi (2001). "Vertical Technology Transfer via International Outsourcing," *Journal of Development Economics*, vol. 65 (2): 389-415.

Pavcnik, N., (2003). "What Explains Skill Upgrading in Less Developed Countries?," *Journal of Development Economics*, vol. 71 (2): 311-328.

Rutkowski, J. (2007) "From the Shortage of Jobs to the Shortage of Skilled Workers: Labor Markets in the EU New Member States", IZA Discussion Papers 320.

Saggi, K. (2002). "Trade, Foreign Direct Investment, and International Technology Transfer: A Survey," World Bank Research Observer, Oxford University Press, vol. 17 (2): 191-235.

Svejnar, J. (1999) "Labor Markets in the Transitional Central and East European Economies", in: O. Ashenfelter & D. Card (ed.), Handbook of Labor Economics, vol. 3: 2809-2857.

Synovate (2005). The Business Environment and Enterprise Performance Survey (BEEPS) 2005: A Brief Report on Observations, Experiences and Methodology from the Survey. Report prepared for the EBRD.

Synovate (2002). The Business Environment and Enterprise Performance Survey (BEEPS) 2002: A Brief Report on Observations, Experiences and Methodology from the Survey. Report prepared for the EBRD.

Tan, H. and G. Batra (1996) "Enterprise Training in Developing Countries: Overview of Incidence, Determinants and Productivity Outcomes", World Bank Private Sector Development Department Occasional Paper No.9, World Bank.

Tan, H., Y. Savchenko, V. Gimpelson, R. Kapelyushnikov, and A. Lukyanova (2007) "Skills Shortages and Training in Russian Enterprises," IZA Discussion Paper 2751.

Tomiura, E. (2007) "Foreign Outsourcing, Exporting, and FDI: A Productivity Comparison at the Firm Level", Journal of International Economics, vol. 72(1), pp. 113-127.

UNCTAD (2001) World Investment Report: Promoting Linkages, New York.

UNCTAD (2006) World Investment Report: FDI from Developing and Transition Economies: Implications for Development, New York.

USPTO (2008) Patents by Country, State, and Year - Utility Patents Report, US Patent and Trademark Office.

Vacek, P. (2010) "Panel Data Evidence on Productivity Spillovers from Foreign Direct Investment: Firm-Level Measures of Backward and Forward Linkages", IES Working Paper 19/2010.

Verhoogen, E. A. (2008) "Trade, Quality Upgrading, and Wage Inequality in the Mexican Manufacturing Sector", *Quarterly Journal of Economics*, vol. 123 (2): 489-530.

Wagner, J. (2007). Exports and Productivity: A Survey of the Evidence from Firm-Level Data", *World Economy*, vol. 30 (1): 60–82.

Wagner *et al.* (2007). "Exports and Productivity – Comparable Evidence for 14 Countries", GEP Working Paper 2007/41.

Wang, J. and M. Blomström (1992). "Foreign Investment and Technology Transfer: A Simple Model," *European Economic Review*, vol. 36 (1): 137-155.

Wooldridge J. (2010) Econometric Analysis of Cross Section and Panel Data, Cambridge MA: MIT Press.

World Bank (1996) From Plan to Market, World Development Report.

World Bank (2001) Hidden Challenges to Education Systems in Transition Economies, Washington, D.C.

World Bank (2004). World Development Indicators database, Washington, D. C.

World Bank (2005) From Disintegration to Reintegration: Eastern Europe and Former Soviet Union in International Trade, Washington, D.C.

World Bank (2010). World Development Indicators Database, Washington, D. C.

Xu, B. (2000), "Multinational Enterprises, Technology Diffusion, and Host Country Productivity Growth", *Journal of Development Economics*, vol. 62: 477-493.

Yeaple, S. R. (2005). "A Simple Model of Firm Heterogeneity, International Trade, and Wages", *Journal of International Economics*, vol. 65 (1): 1-20.

Yudaeva, K., K. Kozlov, N. Melentieva and N. Ponomareva (2003). "Does Foreign Ownership Matter? The Russian Experience", *Economics of Transition*, vol. 11 (3): 383-409.

Zhu, S. C. and D. Trefler (2005) "Trade and Inequality in Developing Countries: a General Equilibrium Analysis," *Journal of International Economics*, vol. 65 (1): 21-48.