Does Absorptive Capacity Affect Who Benefits from International Technology Transfer?

Draft

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Abstract

This paper studies how absorptive capacity at country and at firm level affects international technology transfer in the 25 transition economies using data from the Business Environment and Enterprise Performance Survey. We use firm specific measure of access to foreign technology (foreign ownership, supplying MNEs and exporting) and measures of absorptive capacity (investment in R&D, provision of formal training and workforce education) which are closely related to the concept of absorptive capacity, less prone to measurement error and more informative from a policy perspective than productivity gap measures frequently used in previous studies. It also examines the impact of both firm and country level absorptive capacity on technology transfer. Our main 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 at country or firm level and access to foreign technology. We also find evidence that firms that have high levels of absorptive capacity, especially in terms of workforce education, are significantly more likely to be foreign-owned, to supply MNEs and to export.

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1. *Introduction*

Characteristics of firms and countries, such as absorptive capacity, are seen as important in affecting the firms' ability to assimilate new technologies. In this paper we study the role of absorptive capacity in facilitating international technology transfer through foreign ownership, supplying MNEs and exporting.

A large number of studies have examined whether absorptive capacity facilitates international technology transfer. Using aggregate data, Benhabib and Spiegel (1994), Griffith et al. (2003), Borensztein, Gregorio and Lee (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 have lead many to conclude that differences in country absorptive capacity affect the occurrence and the extent of international technology transfer. The review of the empirical evidence on international technology transfer on these channels suggests that, for several channels of international technology transfer such as FDI spillovers and learning by exporting, the empirical evidence is mixed. This same conclusion is drawn by existing surveys (Görg and Strobl, 2001; Görg and Greenaway, 2004; Greenaway and Kneller, 2007; Wagner, 2007). All these studies document cross country differences in the results. Görg and Greenaway (2004) 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; Wagner et al. 2007 for learning by exporting, and Konings

(2001), Nicolini and Resmini (2006), Damijan et al. (2003) for FDI). 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) find evidence of positive horizontal spillovers for domestic firms in Czech Republic, Poland, Romania and Slovakia and insignificant spillovers for domestic firms in Bulgaria, Estonia, Hungary, Latvia, Lithuania, and Slovenia. They also find evidence of spillovers through backward linkages in Czech Republic, Poland and Slovenia, but insignificant spillovers in the other countries. Their interpretation of these results 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 (Greenaway, Girma and Wakelin, 2001; Girma, 2005; Nicolini and Resmini, 2006; Girma and Gorg, 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 2, are again mixed and most of the studies on transition countries do not find supporting evidence for this hypothesis.

Motivated by these studies, and by our previous results that the effects of international technology transfer differ across groups of countries, we study how absorptive capacity affects technology transfer through foreign ownership, supplying MNEs and exporting. This study contributes to the literature in several ways.

First, we study how host 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 industries and therefore to be able 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 firm level measures of absorptive capacity affect technology transfer within a country.

Second, we use firm level measures of access to foreign technology developed abroad. 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 (Greenaway, Girma and Wakelin, 2001; Girma, 2005; Nicolini and Resmini, 2006; Girma and Gorg, 2007; Girma, et al, 2008) is more common. 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 of access to foreign technology, which reflect firms' access to foreign technology more precisely. In keeping with this literature however, the measures we use are: foreign ownership, supplying

MNEs and exporting. We focus on these channels because in the previous paper we found that these channels of international technology transfer are robustly associated with higher total factor productivity.

Thirdly, 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 (Greenaway, Girma and Wakelin, 2001; Girma, 2005; Nicolini and Resmini, 2006; Girma and Gorg, 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 which is reviewed in section 2.1. They are also more similar to the measures used in the macro literature (Benhabib and Spiegel, 1994; Borenzstein et al. (1998), Griffith et al. (2003, 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 Gorg, 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, Gong and Gorg, (2009) and Damijan et al. (2009). Human capital, measured as share of skilled workers, was used by

Koymen and Sayek (2009), and the provision of formal training was used by Girma, Gong and Gorg (2009).

We start our study by testing whether a country's absorptive capacity affects technology transfer at firm level. Our main results show that internalisation and absorptive capacity measures are associated with higher productivity, but there is no evidence of an interaction effect between absorptive capacity and internalisation. One possible explanation for the fact that the interaction between host country characteristics and internalisation is insignificant is that there is large heterogeneity with regard to absorptive capacity 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.

We then test whether firm's absorptive capacity affects technology transfer at the firm level. Again, our main results show that internalisation and absorptive capacity measures are associated with higher productivity, but there is no evidence of an interaction effect between absorptive capacity and internalisation.

There are several possible explanations for these findings. First, it is possible that the firms that have access to foreign technology do not need absorptive capacity to implement this technology because technology transfer is facilitated by the foreign MNEs, not by the actions of the domestically owned supplier. Second, it is possible that MNEs and foreign partners make sure that their future suppliers or affiliates have the necessary absorptive capacity before transferring technology to them. We test this hypothesis and we find supporting evidence that firms that have high levels of absorptive capacity, especially in terms of workforce education, are significantly more likely to be foreign-owned, to supply MNEs and to export.

The paper is organised as follows. The following section reviews the economic theory and the empirical evidence from country and firm level studies on how absorptive capacity affects technology transfer. Section 3 describes the data used in this study. Section 4 describes the empirical methodology used. Section 5 presents the results of the empirical analysis and the discussion of these results.

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 2.2, and from studies using firm level data, in section 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. We will conclude by summarising the main findings that emerge from these studies, limitations of these studies and our contribution.

2.1 Absorptive capacity and International Technology Diffusion

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. (2003) 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 and follow new technological developments, to evaluate them and to adopt the ones which are suitable (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:

$$\left[\ln A_T\left(H_t\right) - \ln A_0\left(H_t\right)\right]_i = \alpha_0 + \alpha_1 H_i + \alpha_2 H_i \left[\frac{Y_{\max} - Y_i}{Y_i}\right]$$

In this equation, *A* stands for productivity, *H* stands for human capital and *Y* stands for output. 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 that country, which represents the ability of the country to innovate, and an interaction term between human capital and the technological gap between the country and the most productive country, which represents the diffusion of technologies from abroad facilitated by human capital.

Griffith, Van Reenen and Redding (2004) extend Benhabib and Spiegel (1994) 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. In their model, 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) idea that R&D plays an important role in creating new knowledge, but also in absorbing technology developed by others. The productivity growth of country i and industry j is given by:

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

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 specific 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 (Keller, 2004). 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 and on an interaction term between FDI and human capital of the country, which represents the absorptive capacity of the country:

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

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.

2.2 Country Level Studies on Absorptive Capacity and Technology Transfer

Keller (1994) suggested that absorptive capacity was an important factor which led to differences between countries in their ability to assimilate foreign technology. Recently, 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. Benhabib and Spiegel (1994) measure human capital as 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, Van Reenen and Redding (2003) 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). R&D intensity is measured as R&D expenditure divided by output. In their study, they also allow human capital to play a similar role to R&D. 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 the role of human capital. The average total contribution of human capital varies between 0.28% for the US and 0.56% for Finland. The contribution of human capital to productivity growth due to technology transfer varies across countries and it is largest in countries further away from technology frontier.

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, Redding and Van Reenen (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, measured as the ratio of R&D to output, and human capital, measured as 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 small and less R&D intensive OECD countries. It is argued that for smaller, less R&D intensive countries, R&D might play a more important role in absorbing technology from abroad than in the creation of new technology. The results for the sample of the less R&D intensive countries sample confirm this hypothesis. 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.

Borensztein, Gregorio and Lee (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 is such 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 an ambiguous effect on economic growth, but this effect is positive when the host country has the necessary human capital.

A large number of empirical studies have adopted a similar specification to Borenszstein 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 Borenzstein et al. (1999). Their study differs from Borenzstein et al. (1998) in two aspects. First, Xu (2000) uses a different measure of technology transfer through FDI. Xu (2000) 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 (2000) 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 (2000) 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 Borenzstein *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 Borenzstein *et al.* (1998), but below the threshold found by Xu (2000). The author argues that Borenzstein *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 the 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 Borenzstein, 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 actually had higher human capital levels than the minimum threshold found by Borenzstein et al. (1998), and above this minimum threshold the absorptive capacity of the host country does not play a significant role in technology diffusion through FDI. In most transition countries, the level of human capital was very high at the beginning of the transition, but declined afterwards, mainly due to diminishing public financial support while the economic growth rates increased. Finally, they argue that at the beginning of the transition period human capital was excessively specialised and the occupational structure of human capital 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 trade and an interaction term between trade openness and human capital. They test these models using data for 83 developed and developing countries between 1960 and 1989. They measure openness to trade as 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 that human capital has a direct negative impact on total factor productivity. The magnitude of coefficients is such 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 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 machinery imports, 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. Most of these studies adopt a specification in which the productivity of a country depends on the technology developed in the country, foreign technology and an interaction between foreign technology and absorptive capacity. The most frequently used measure of absorptive capacity is human capital, although a few studies (Griffith et al., 2003; Kneller, 2005) also use investment in R&D. The measures used for foreign technology are either the productivity gap between the given country and the most productive country, or a specific channel of international technology transfer channel (FDI, importing or exporting). Taken as a whole, the empirical evidence from studies that use aggregate data suggests that human capital and conducting R&D facilitate adoption of foreign technology.

2.3 Empirical studies on absorptive capacity at the firm level

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 sectors 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 their required, or they may purchase only basic inputs with little technological content. In this case, the potential of technology transfer to local firms is limited (Javorcik, 2008). 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:

$$\Delta ln(TFP)_{it} = \alpha_1 \Delta ForeignTechnology_{it-1} + \alpha_2 ForeignTechnology_{it-1} * AbsorptiveCapacity_{it-1} + \alpha_3 AbsorptiveCapacity_{it-1} + \gamma X_{it-1} + e_i$$

In this specification the total factor productivity growth of firm *i* is regressed on a measure of access to foreign technology at time *t* and an interaction between foreign technology and absorptive capacity of the firm 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 characteristics of the firm and sector and allow the effect of the foreign technology to depend on absorptive capacity in a non linear way.

Several measures of absorptive capacity have been used, including the productivity gap, investment in R&D and human capital. 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:

$$Absorptive\ capacity_{it-1} = ln(TFP_{it-1}) / max\ ln(TFP_{jt-1})$$

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), Nicolini and Resmini (2006), Girma and Gorg (2007), Girma, Gorg and Pisu (2008), 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 Gorg, 2007). Finally, productivity gap measures are not very helpful for policy because they do not explain why the productivity gap is large or small in the first place or what can be done to reduce it.

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 non linear way. Local firms need to possess a minimum level of technology 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 technology capacity are very similar to foreign owned firms and therefore the potential for spillovers is limited. The author 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 Gorg (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 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 through competition. 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 are contrast with the results of Girma (2005). However, the studies differ in the several respects. Girma and Gorg (2005) use a sample of firms in electronics and engineering sectors, while Girma (2005) uses a sample of all manufacturing firms. In addition, Girma (2005) distinguishes between FDI in the same region and FDI outside the region. Girma and Gorg (2007) do not distinguish between FDI inside the region and FDI outside the region. The papers also differ with regard to econometric methods used and the control variables included. The different results of the two studies might be due to these differences.

Nicolini and Resmini (2006) 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 1995 – 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 the firms with a productivity level above the average productivity in the industry benefit from both horizontal and vertical spillovers, and firms with productivity below the industry average are affected negatively by the presence of foreign firms in the same sector and in downstream or upstream sectors.

Girma, Gorg 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 from exporting foreign owned firms to domestic exporters, 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 mention several possible explanations for this result. Export oriented MNEs may operate in *"enclave"* sectors with limited linkages with local firms. If these MNEs 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.

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, Jefferson and Jinchang (2005) and Girma, Gong and Gorg (2009), among others.

Kinoshita (2000) studies the effects of R&D in facilitating technology transfer to local firms through foreign ownership and intra industry spillovers using a panel of manufacturing firms in the Czech Republic during the period 1995 -1998. Kinoshita (2000) estimates a model in which total factor productivity growth depends on R&D, foreign ownership and foreign presence in the sector and an interaction between R&D and foreign ownership and R&D and foreign presence 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 author finds that 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 absorptive capacity of the affiliate helps absorb technology from its 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 and vertical spillovers using a panel of manufacturing firms in 10 transition countries in the period 1995-1999. They find that investment in R&D facilitates technology transfer through horizontal spillovers only in two countries (Slovakia and Hungary), and it actually hinders horizontal spillovers in Estonia and Latvia and in all the remaining countries its effect is insignificant. With regard to spillovers through backward linkages, the authors find that the interaction between absorptive capacity and foreign presence in downstream industries is insignificant for all countries with the exception of Romania and Slovenia, where it is negative. Damijan et al (2003) suggest that their mixed results might be due to the poor data on R&D at firm level.

Hu, Jefferson and Jinchang (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, purchase of technology 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 thus facilitates the adoption of technology purchased from foreign firms.

Girma, Gorg and Gong (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. Aghion et al (2005) argues that this will stimulate firms close to the frontier to innovate and in the same time will discourage firms which are far from the technological frontier from investing 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 own 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.

Koymen and Sayek (2009) study the effect of human capital on the 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 of the firm as the share of skilled workers in total workers. They define skilled employees as management and high level technical personnel. They study the effect of the interaction of the human capital and the presence of foreign firms in the same industry and in downstream and upstream industries on the level of total factor productivity and on the growth of total factor productivity. They find that human capital has a negative effect on spillovers through backward linkages and that there are positive spillovers though backward linkages only for domestic firms with a skilled employees share smaller than 12%. Their explanation for this result is that domestic suppliers with higher levels of human capital may charge higher prices for the inputs they produce. In this case, MNEs might find it more cost effective to source their inputs from less expensive domestic suppliers with low levels of human capital and transfer to these suppliers technology and supervise their production. This way, domestic suppliers of MNEs with low levels of technology benefit from a direct technology transfer from MNEs. They also find that the horizontal FDI spillovers and forward FDI spillovers on the TFP level of domestic firms are not affected by the human capital level of these firms.

In conclusion, there is a large literature that examines empirically how absorptive capacity at the firm level affects international technology transfer. Most of these studies adopt a specification in which productivity or productivity growth of a firm depends on its absorptive capacity, on foreign technology and an interaction term between foreign technology and absorptive capacity. In this specification a positive and significant coefficient of the interaction term is interpreted as evidence consistent with the hypothesis that absorptive capacity facilitates international technology transfer. The most frequently used measure of absorptive capacity is productivity gap between the firm and the most productive firm in the industry, although there are a few studies that use R&D investment, training and human capital (measured as share of skilled workers). The measures used for foreign technology are either FDI in the sector, or FDI in the upstream or downstream sectors. The results of these studies are mixed. Most of the studies that used productivity gap measures found results consistent with the hypothesis that absorptive capacity has a positive effect on technology transfer through FDI spillovers. The results from the studies that used measures like R&D or human capital as measures of absorptive capacity are very mixed: Girma, Gorg and Gong

(2009) and Hu et al. (2005) found a positive effect for firms in China and Kinoshita (2000) found a positive effect for firms in Czech Republic, Damijan et al (2003) found different results for different transition countries and Koymen and Sayek (2009) found a negative effect on backward linkages and a insignificant effect for horizontal spillovers for Turkish firms.

2.4 Conclusions and contribution

The most recent studies suggest that productivity is affected by the creation of new technology inside the firm or country, by technology transfer from abroad that occurs independently of the absorptive capacity and on the technology transfer which is facilitated by absorptive capacity. Empirical evidence from both country and firm level suggest all these three factors are important.

Empirical evidence suggests that the country's absorptive capacity affects international technology transfer, but also that the firm's absorptive capacity affects international technology transfer within a country. Therefore, in this study we will examine the effects of both country and firm level absorptive capacity on international technology transfer.

The studies have used various measures of absorptive capacity. Economic theory suggests R&D and human capital as measures of absorptive capacity and most of the macro level studies found evidence that human capital and R&D facilitate the absorption of technology developed abroad. However, most of firm level studies used measures such as the productivity gap, mainly due to data limitations, but also a few studies used measures such as investment in R&D or human capital. The results of these studies have been mixed. We can improve on the firm level literature by using measures of absorptive capacity which are closely related to the concept of absorptive capacity and to the measures used in macro literature: R&D investment, training and education of the workforce. These measures are also less prone to measurement error than total factor productivity gap (Girma and Gorg, 2007) and are more informative from a policy perspective.

Previous studies also used various measures of absorptive capacity. The studies using aggregate data use measures such as the productivity gap between countries, but also inward FDI, exports and imports of machinery and equipment. The firm level literature has focused on foreign ownership and horizontal and vertical FDI spillovers. The horizontal and vertical FDI spillovers measures are measured at industry or regional level and do not identify the firms that benefit from technology transfer. We improve on the literature by using firm level measures of foreign technology, which reflect firm access to foreign technology through foreign ownership, supplying MNEs and exporting.

Table 1 Studies using aggregate data on absorptive capacity and technology transfer

Study	Sample	Absorptive capacity	Foreign technology	Effect of Absorptive Capacity on Technology Transfer
Benhabib and Spiegel (1994)	Cross section of 78 developed and developing countries 1965 -1985	Human capital (educational attainment of labour force)	Productivity gap between the country and the leading country	Positive and significant. More important for developing countries than for developed countries.
Griffith, Van Reenan and Redding (2003)	Panel of manufacturing industries in 12 OECD countries 1974-1990	R&D expenditure/sales Human capital (percentage of total population that attained tertiary education)	Productivity gap between the country and the leading country	Positive and significant for both R&D and human capital. More important for the countries further from the technology frontier.
Kneller (2005)	Panel of manufacturing industries in 12 OECD countries 1972-1992	R&D expenditure/sales Human capital (years of schooling in the population aged 25 or older)	Productivity of the leading country	Positive and significant for human capital. Positive, but insignificant for R&D, except for small and less R&D intensive countries.
Borenztein, Gregorio and Lee (1998)	Panel of 69 developing countries 1970-1989	Human capital (the average male secondary school attainment in the population over 25 years old)	FDI inflows from OECD countries to developing countries in the sample	Positive and significant
Xu (2000)	Panel of 40 countries (20 developed and 20 developing countries) 1966 - 1994	Human capital (the average male secondary school attainment in the population over 25 years old)	MNEs affiliates spending on royalties and license fees as a share of foreign affiliates' value added multiplied by the share of MNE affiliates' value added in the host country GDP	Positive and significant
Campos and Kinoshita (2002)	Panel of 25 transition countries 1990-1998	Human capital	FDI	Insignificant
Miller and Upadhyay (2000)	Panel of 83 developed and developing countries 1960 - 1989	Human capital (the average number of years of schooling for adult population)	Ratio of exports to GDP.	Positive and significant
Mayer (2001)	Cross section of 53 developing countries 1970-1990	Human capital (the average number of years of schooling in population aged 15 or above)	Average ratio of imports of machinery and equipment to GDP	Positive and significant

Table 2 Firm level studies on absorptive capacity and technology transfer

Study	**Sample**	**Absorptive capacity**	**Foreign technology**	**Effect of Absorptive Capacity on Technology Transfer**
Girma (2005)	Manufacturing firms in UK 1989-1999	Technological gap	Foreign presence in the same industry and the same region Foreign presence in the same industry, but outside the region of the firm	Positive, but nonlinear effect.
Girma and Gorg (2007)	Engineering and electronics firms in UK 1980-1992	Technology gap	Foreign presence in the same industry	Positive, but nonlinear effect.
Girma, Gorg and Pisu (2008)	Manufacturing firms in UK 1992-1999	Technology gap	Foreign presence in the same industry Foreign presence in downstream industry Foreign presence in upstream industry	Positive, for horizontal and vertical spillovers, but depends on the export orientation of the domestic and foreign firms
Nicolini and Resmini (2006)	Manufacturing firms in Bulgaria, Poland and Romania 1995-2003	A dummy variable that takes the value 1 if the firm TFP is lower than the average TFP in the industry and 0 otherwise	Foreign presence in the same industry Foreign presence in downstream industry Foreign presence in upstream industry	Positive. Only firms with TFP equal or above the average benefit from FDI spillovers
Kinoshita (2001)	Manufacturing firms in Czech Republic 1995-1998	R&D expenditures/sales	Foreign ownership Foreign presence in the same sector	Insignificant effect on technology transfer from MNEs parent Positive effect on technology transfer from foreign firms in the same sector
Damijan *et al.* (2003)	Manfacturing firms in 10 transition countries 1995-1999	R&D expenditures/sales	Foreign presence in the same industry Foreign presence in downstream industry Foreign presence in upstream industry	Horizontal spillovers Positive (Hungary and Slovakia), negative (Estonia and Latvia), insignificant in the other countries Backward spillovers Negative (Romania and Slovenia), insignificant in the other countries. Forward spillovers Negative (Latvia and Romania) and insignificant in the other countries.
Hu, Jefferson and Jinchang (2005)	Manufacturing firms in China 1995-1999	R&D expenditures/sales	Firm expenditure on patent licensing fees and payments for blueprint technology from foreign firms	Positive

Girma, Gorg, Gong (2009)	State owned manufacturing firms in China 1999-2005	R&D expenditures/sales Training expenditure/sales	Foreign presence in the same sector	Positive
Koymen and Sayek (2009)	Manufacturing firms in Turkey 1990-2001	Share of skilled employees	Foreign presence in the same industry Foreign presence in downstream industry Foreign presence in upstream industry	Horizontal spillovers Insignificant Backward spillovers Negative Forward spillovers Insignificant

3. *Data Description*

This section describes indicators of absorptive capacity and examines how these characteristics differ across countries and firms.

3.1 Absorptive Capacity Indicators

We will use three measures of absorptive capacity: tertiary education, investment in R&D and provision of formal training. As discussed in section 2, the theoretical literature suggests that these activities facilitate the ability to follow, evaluate and implement new technology. These indicators capture different aspects of absorptive capacity. Education increases the ability of people to understand, evaluate and implement new knowledge (Nelson and Phelps, 1966). It is frequently used as a measure of absorptive capacity in studies that used aggregate data (Benhabib and Spiegel, 1994; Borezstein 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, especially secondary and vocational 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, Gong and Gorg (2009). Our third measure of absorptive capacity is R&D activity, which facilitates understanding and assimilation of knowledge created by others. Investment in R&D was used as a measure of absorptive capacity in a few industry levels studies (Griffith et al., 2003; Kneller, 2005) and in several micro level studies Kinoshita (2000), Damijan et al. (2003), Hu, Jefferson and Jinchang (2005), Girma, Gong and Gorg (2009).

The variable R&D is based on the question q58b in the 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. 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.

The training variable is based on a question q71 in the questionnaire: “Does your firm offer any 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. 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. If the firm did not answer to the question regarding any of the three categories it was considered that the answer is missing.

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.

Similar indicators have been used in previous studies that used BEEPS or WBES datasets. The indicator for education capital was used in previous studies, for instance by

Gorodnichenko et al., (2007, and 2008) and by Almeida and Fernandes (2008). A similar indicator for R&D activities was used by Almeida and Fernandes (2008) and by Gorodnichenko et al. (2008) and a similar indicator for training was used by Almeida and Fernandes (2008).

3.2 Descriptive Statistics

We begin our data analysis by looking at descriptive statistics of the absorptive capacity variables. Table 3 reports the descriptive statistics for these indicators for the whole sample and for the sample of firms used in the empirical analysis. The sample used in the empirical analysis is smaller because observations with missing values or unrealistic values for sales, capital, material inputs and other firm characteristics were excluded.

Table 3 Descriptive Statistics for absorptive capacity measures

	Full sample			*Regression sample*		
Variable	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Education	8585	0.276	(0.291)	3648	0.242	(0.270)
Training	8005	0.427	(0.495)	3444	0.482	(0.499)
R&D	8748	0.091	(0.287)	3690	0.156	(0.363)

Source: BEEPS 2005. The sample used in the empirical analysis is smaller because observations with missing values or unrealistic values for sales, capital, material inputs and other firm characteristics were excluded.

Table 3 shows that almost 9% of the firms invested in R&D, more than 40% of firms provided formal training to their employees and the average share of workforce with university degree in the firms in the sample is 28%.

To put these values into perspective, we will compare the absorptive capacity of firms in transition economies to other countries. For this comparison we use the data from the WBES survey for 2005 and 2006 which provides comparable data for other developing countries and several OECD countries. The OECD countries included are the four cohesion countries (Greece, Ireland, Portugal and Spain) and Germany. For this comparison, we will use the full sample. Table 4 reports the absorptive capacity indicators for the transition, for developing, and the OECD countries covered by WBES.

Table 4 Absorptive capacity indicators

	Transition countries	Developing countries	OECD countries
Education	0.276	0.110	0.195
Training	0.427	0.451	0.406
R&D	0.091	0.133	0.136

Source: WBES 2005, 2006.

Table 4 shows that, on average, firms in transition economies have better educated labour force than other developing countries and even than the OECD countries included in the WBES. This is consistent with the fact that workforce in transition countries is well educated compared to other countries at similar income levels, due a history of the large public spending on education and high enrolment rates (World Bank, 2001; Commander and Kollo, 2008). The share of firms that provides training to their employees in countries in transition is similar to the share of firms that provides training to their employees in developing and in OECD countries. With regard to investment in R&D, it can be noticed that a lower share of firms invest in R&D in transition economies than in other developing countries and in the OECD countries included in the sample. In conclusion, workforce in countries in transition is well educated, and a large share of firms provides training to their employees, but only a relatively small share of firms invests in R&D.

Are these indicators correlated? This is important because we wish to measure the extent to which each indicator affects the degree of technology transfer. The correlation matrix of these indicators is reported in Table 5.

Table 5 Correlation matrix: firm absorptive capacity

	Education	Training	R&D
Education	1.000		
Training	0.039	1.000	
	(0.001)		
R&D	-0.026	0.170	1.000
	(0.013)	(0.000)	

Source: BEEPS 2005

The correlation matrix shows that although the correlation between the variables is statistically significant the magnitude of the correlation is small. Education is positively correlated with training, but the magnitude of the correlation is less than 0.04. Education is negatively and significantly correlated with R&D, although the magnitude of the coefficient is small (less than 0.03). This negative correlation is driven by large manufacturing firms which are more likely to invest in R&D than small manufacturing firms and firms in service sectors, but employ a smaller share of workers with tertiary education compared with their total employment. The largest correlation is between investment in R&D and provision of training. The correlation between these indicators is 0.17 and it is statistically significant. This is consistent with the idea that to make use of 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.

Next, we examine how absorptive capacity measures vary across countries and within countries. To do this we look at the mean and the standard deviation between and within countries. Table 6 presents these statistics.

Table 6 Absorptive capacity between and within countries

	Mean	Std. Dev.	Obs.
Education			
overall	0.276	0.291	8585
between		0.094	25
within		0.276	343.4
Training			
overall	0.427	0.495	8005
between		0.147	25
within		0.479	320.2
R&D			
overall	0.091	0.287	8748
between		0.044	25
within		0.284	349.92

Source: BEEPS 2005

Table 6 reports the mean for each indicators and the overall, between and within standard deviations for our measures of absorptive capacity. The table suggests that the variation within countries is much larger than the variation between countries, but there is also considerable variation between countries. In our empirical analysis we will look at both country characteristics and firm level characteristics.

3.3 Differences in Absorptive Capacity across Countries

In this subsection we focus on the differences in absorptive capacity between countries. It is useful to study the differences between countries because there is also considerable variation between countries and because this allows us to compare our measures based on BEEPS 2005 with corresponding macro indicators from other sources.

- **Education**

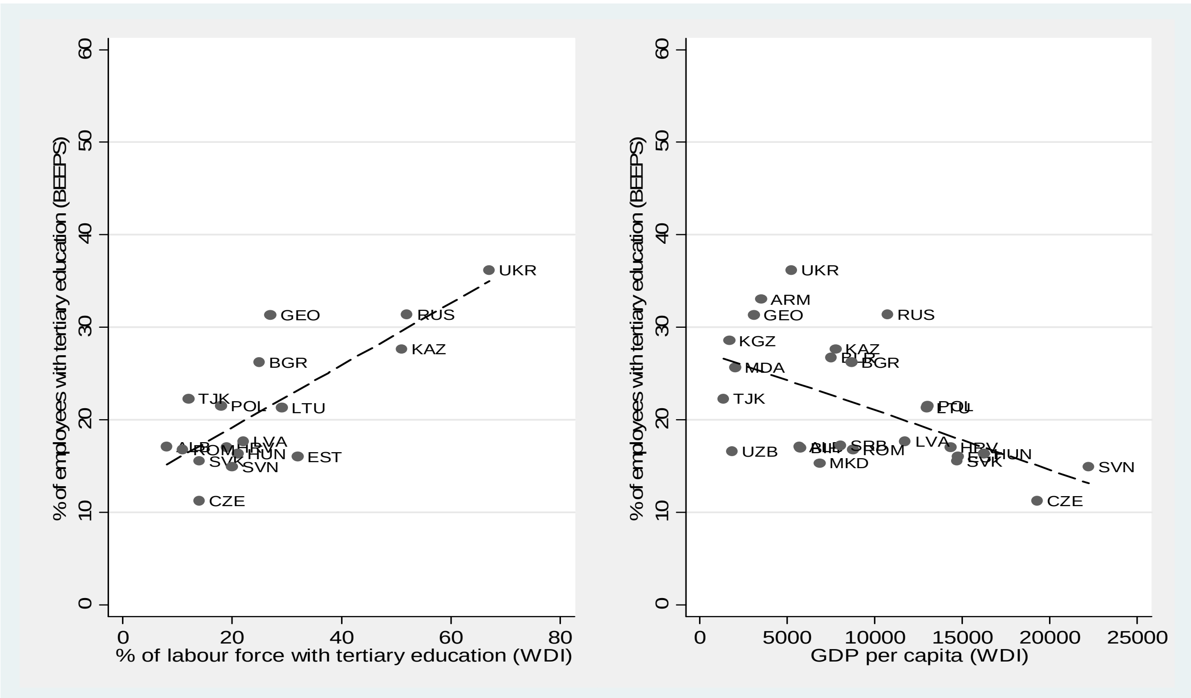
Education at country level is measured as share of employees with tertiary level education of total employees in the country. The average share of employees with university education in each country in the sample is presented in Table 21. Ukraine is the country with the largest share of workforce with tertiary education and the country with the lowest share of workforce with tertiary education is Czech Republic. It can be noticed that some countries have unusual 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 have very large shares of employees with tertiary education compared with their level of development and compared with the most developed countries in the region. The most developed countries in the region, like Czech Republic, Slovenia, Slovakia and Hungary, have comparatively low share of workforce with tertiary education.

Given that for the values of the workforce education indicator for these countries appear to be very different from what would be expected based on their level of development it is useful to compare these indicators based on BEEPS 2005 to macro indicators from other sources. 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) 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. For some countries, like Armenia, the WDI does not provide this information at all. We could also compare our indicator with the indicators from Barro and Lee dataset, which was 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.

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 the sectors covered by the BEEPS. The percentage of labour force with tertiary education from WDI includes the whole labour force; including labour force that works in public sector or in one of the sectors not covered by BEEPS. However, we expect a positive relationship between the two indicators because in a country with more educated labour force we would expect that the share of employees with tertiary education in an average firm to be higher. We also compare these indicators with the general level of development measured as GDP per capita in 2004 measured in PPP from WDI.

Figure 1 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 capital in the right panel.

Figure 1 Tertiary Education: BEEPS indicator and WDI indicators of education and development



The left panel of Figure 1 shows that, as expected, there is a positive relationship between the BEEPS measure of tertiary education and the corresponding indicator from WDI. The correlation between the two indicators is 0.78 and it is statistically significant at 1%. The right panel shows that there is a *negative* relationship between the share of workforce with tertiary education and the level of development of the countries studied. The correlation between the two variables is 0.54 and it is statistically significant at 1%. This finding is unexpected; therefore, we also examined whether there is a similar relationship between the indicator of labour force with tertiary education at country level from WDI and level of development. The correlation between the tertiary education indicator from WDI and the level of development is negative, but it is smaller in magnitude and it is not statistically significant. A possible explanation of this negative relationship is that labour force education is correlated with other host country characteristics which have a negative effect on economic development.

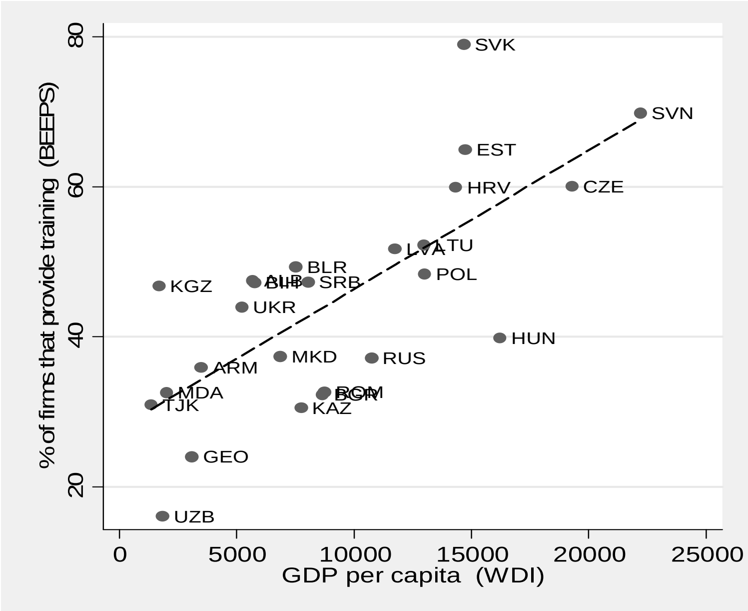
In conclusion, indicator of tertiary education based on BEEPS is correlated with the corresponding indicator at macro level, although for individual countries they might differ. The indicator for education displays a negative correlation with country's level of development and there is a similar relation between the corresponding indicator of tertiary education from WDI and the level of development.

- **Training**

Training at country level is measured as the share of firms in the country that provide training to employees. The share of firms that provide training in each country in the sample is reported in Table 21. The country with the largest share of firms that provide formal training to their employees is Slovakia (almost 80% of firms provide training to their employees), followed by Slovenia (almost 70%). The country with lowest share of firms that provide formal training to their employees is Uzbekistan, where only 16% of firms do this.

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 2 presents the relation between the share of firms that provide training to their employees and the level of development of the country (measured as GDP per capita).

Figure 2 Training: BEEPS indicator and WDI indicator of development



The graphic shows that the share of firms that invest in training their employees in the country and the level of development are highly correlated. The correlation 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.

- **Investment in 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 21 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 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 3 presents the relationship between the two indicators of R&D activity and between R&D indicator based on BEEPS and GDP per capita.

Figure 3 Investment in R&D: BEEPS indicator and WDI indicators of R&D and development

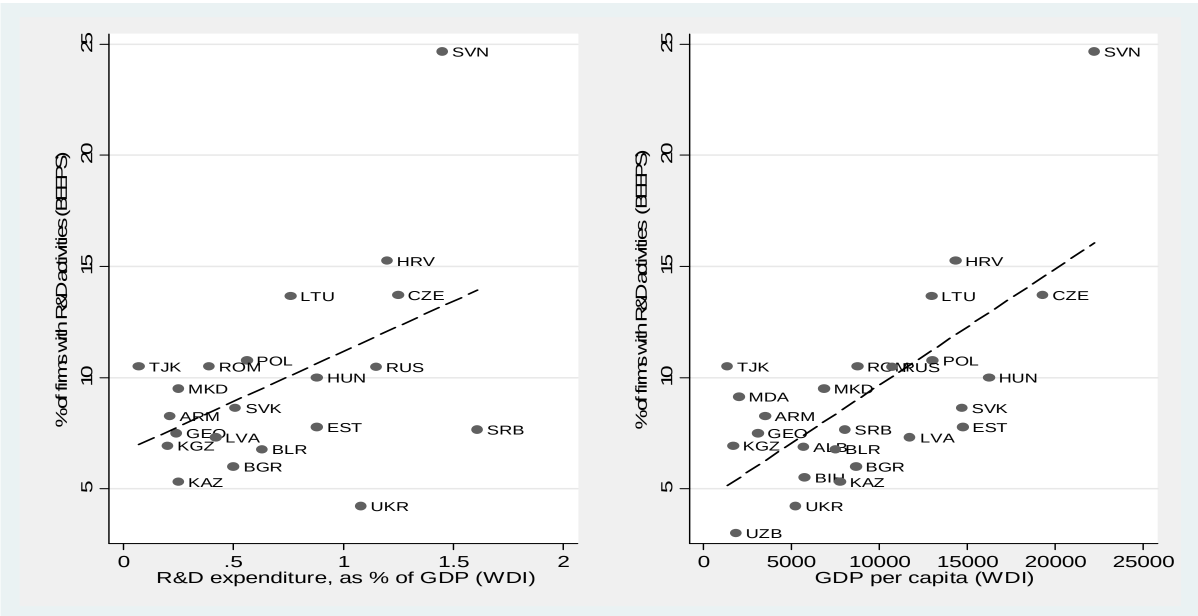


Figure 3 shows that there is a positive relationship between the two indicators of R&D activity. The correlation between the two is 0.46 and it is statistically significant at 5%. It also shows that there is a positive relationship between the share of firms that invest in R&D in a country and general level of development of the country. The correlation between the two indicators is 0.69 and it is significant at 1%. The figure also shows that Slovenia is an outlier and has a larger share of firm that invest in R&D than it would be expected based on the share of R&D in its GDP or on its 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. Also most of the indicators of country characteristics based on BEEPS are correlated with the level of development of the country as measured by GDP per capita in PPP, with the exception of the indicator of university education.

Are these country characteristics correlated? The correlation matrix of the country level indicators calculated based on BEEPS is presented in Table 7.

Table 7 Correlation Matrix

	Education	Training	R&D	GDP per capita
Education	1.000			
Training	-0.299	1.000		
	(0.147)			
R&D	-0.435	0.499	1.000	
	(0.026)	(0.011)		
GDP per capita	-0.534	0.727	0.698	1.000
	(0.005)	(0.000)	(0.000)	

Source: BEEPS 2005, GDP per capita from World Bank.

The correlation matrix suggests several surprising patterns regarding workforce education. Workforce education is negatively and significantly correlated with investment in R&D and with GDP per capita. We expected a positive correlation because conducting R&D activities requires a well educated labour force. A possible explanation is that this negative correlation is due to other country characteristics which affect negatively investment in R&D and economic development, like for instance corruption, and are positively correlated with education. In addition, education is negatively correlated with training, although the correlation is not statistically significant. R&D and provision of training are positively correlated and the correlation is statistically significant and they are also positively correlated with GDP per capita.

We compare this correlation matrix with the correlation matrix for host country characteristics using aggregate data from other sources. This correlation matrix is presented in Table 8.

Table 8 Correlation matrix using aggregate data

	Education	R&D/GDP	GDP per capita
Education	1.000		
R&D/GDP	0.189	1.000	
	(0.483)		
GDP per capita	-0.216	0.651	1.000
	(0.406)	(0.001)	

Sources: World Bank Development Indicators

The main difference between the two tables is that Table 8 shows that there is a positive, although statistically insignificant, relationship between R&D investment and tertiary education while Table 7 show a negative relationship between the two indicators. A possible explanation for this difference is that R&D indicator from World Bank Development Indicators measures the expenditure with R&D as a percentage of GDP and it is different from the R&D indicator from BEEPS which measure the share of firms that invest in R&D.

In conclusion, the indicators of absorptive capacity used in this study and based on BEEPS are correlated with the corresponding indicators at macro level, although for individual countries they might differ. The countries included in this study differ considerably in their absorptive capacity, as well as other country characteristics, but there is larger variation within countries with regard to absorptive capacity than between them.

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 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. Finally, we examine whether investment in R&D, training and employees education facilitates firms' participation in supplying MNEs, exporting and becoming foreign owned.

4.1 Host country characteristics

We start our empirical analysis by examining whether the absorptive capacity of the country facilitates technology transfer at the firm level. 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 2, that firm productivity is affected by three key factors: creation of new technology inside the firm, by technology transfer from abroad that occurs independently of the absorptive capacity and on the technology transfer which is facilitated by absorptive capacity:

$$lnLP_i = \alpha_0 + \alpha_1 ForeignTech_i + \alpha_2 AbsorptiveCapacity_c + \alpha_3 ForeignTech_i * AbsorptiveCapacity_c + \gamma X_i + u_i \quad (1)$$

LP_i represents the labour productivity of firm *i*. $ForeignTech_i$ represents access of a firm to foreign technology. We will use three channels of international technology transfer as measures of firms' access to technology transfer. These channels are: foreign ownership, supplying MNEs and exporting. We focus on these measures because in the previous paper we found that these channels are robustly associated with higher productivity, and, therefore, consistent with technology transfer hypothesis. $AbsorptiveCapacity_c$ is a measure of absorptive capacity of country *c*. We use three measures of absorptive capacity: R&D,

training and education. R&D at country level is measured as the share of firms in the country of the firm that invests in R&D. Training at country level is measured as the share of firms in the country of the firm that provides training to employees. Education at country level is measured as the share of employees with tertiary level education of total employees in the country of the firm.

A positive and significant coefficient on 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 are more productive than those that do not. We also expect the absorptive capacity of the country to be positively associated with the productivity of the firm, through its effect on technology creation. However, given that we have only a cross section of firms we cannot separate the direct effect of absorptive capacity at country level from other host country characteristics, thus we cannot interpret the coefficient of this variable as the direct effect of the country's absorptive capacity on the productivity of the firms in the given country. A similar methodology was used in firm level studies on the role of absorptive capacity in facilitating technology transfer though horizontal and vertical FDI spillovers, for instance, by Kinoshita (2000) or Damijan et al. (2003).

We estimate a separate equation for each channel of international technology transfer and each measure of absorptive capacity. In addition, recognizing that firms have access to foreign technology through different channels, we estimate a specification that includes all measures of participation in international activities. We estimate the equations with and without country fixed effects. As a robustness check we will also estimate the equation (1) using indicators of human capital and R&D from WDI as measures of absorptive capacity.

4.2 Firm level characteristics

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, we assume that firm productivity is affected by three key factors: creation of new technology inside the firm, by technology transfer from abroad that occurs independently of the absorptive capacity and on the technology transfer which is facilitated by absorptive capacity. To study this hypothesis we examine the productivity premia associated with engaging in international activities, investing in absorptive capacity and the productivity premia associated with investing in absorptive capacity and engaging in international activities. We estimate the following equation:

$$lnLP_i = \alpha_0 + \alpha_1 ForeignTech_i + \alpha_2 AbsorptiveCapacity_i + \alpha_3 ForeignTechn_i * AbsorptiveCapacity_i + \gamma X_i + u_i \qquad (2)$$

LP_i represents the labour productivity of firm *i*. $ForeignTech_i$ represents access to foreign technology of firm *i.* We use three channels of international technology transfer as measures of firms' access to technology transfer. These channels are once again: foreign ownership, supplying MNEs and exporting. These channels were defined in section 3. $AbsorptiveCapacity_c$ is a measure of absorptive capacity at firm level. We use three measures of absorptive capacity: R&D, training and education. All the three measures were defined in section 3.

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 have a positive and significant effect on firm productivity.

We estimate a separate equation for each channel of international technology transfer and each measure of absorptive capacity. In addition, recognizing that firms have access to foreign technology through different channels, we estimate a specification that includes all measures of participation in international activities. We estimate the equations with and without country fixed effects. We will also estimate whether past absorptive capacity facilitates technology transfer. We will also estimate the effect of the interaction between absorptive capacity and access to foreign technology on total factor productivity. To isolate the of the interaction terms between absorptive capacity and access to foreign technology on total factor productivity, we control for a number of other firm characteristics that may affect firm productivity: the age of the firm, other channels of international technology transfer (importing and licensing), product market competition, includes industry fixed effects and country fixed effects, dummies for capital city and city size to proxy the effects of regional characteristics. All the variables are defined in Table 20.

4.3 Absorptive capacity and participation into international activities

We will also test whether there firms that with higher level of absorptive capacity are more likely to be foreign owned, suppliers to MNEs or exporters. It is possible that MNEs and foreign partners make sure that their future suppliers or affiliates have the necessary absorptive capacity before transferring technology to them. If this happens than higher absorptive capacity should increase the probability of participation in international activities. Also in this case we will not observe and interactive effect between international activities and absorptive capacity on firm productivity.

To test whether firms with higher absorptive capacity select into participation in international activities, we follow the methodology used by Bernard and Jensen (2004) to study factors that increase the probability of exporting. We assume that firm i in country c and industry j participates in international activities if the present value of the expected profit is positive.

$$Y_i = \begin{cases} 1 & \text{if} \quad \pi^*_i > 0 \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

Y_i are dummy variables that take the value 1 if the firm is foreign owned, supplies MNEs or exports and 0 otherwise. π^*_i is the expected profit. We do not observe π^*_i , but we observe whether the firm is foreign owned, supplies MNEs, exports or not. We assume that π^*_i depends on the three measures of absorptive capacity (education of workforce, provision of training and R&D investment) and other firm characteristics. X_i represents the vector of other firm characteristics:

$$\pi_i^* = \beta_0 + \beta_1 Education_i + \beta_2 Training_i + \beta_3 RD_i + \gamma X_i + u_i \tag{4}$$

X_i represents the vector of other firm characteristics: performance (productivity and size), labour quality (wage, share of skilled workers), ownership structure, and product introduction. We also include industry and country fixed effects. We estimated this equation using a probit model.

These estimates could be affected by simultaneity problem. Simultaneity problem arises when firms that start exporting also undergo substantial changes in the employment composition, size, and wages, among other aspects as it was documented by Bernard and Jensen (1995) and Bernard and Jensen (1999). To avoid this problem Bernard and Jensen (2004) lag all independent variables by one year. Due to data limitations we need to make several changes to this methodology. First, for most of the variables of interest we only have information for 2004. Therefore, we first estimate the equation using all the variables for year

2004 and excluding variables that control for past participation in international activities by the firms. For the education variable we also have information on share of labour force with tertiary education 3 years ago. In addition, we have data on several control variables (the labour and labour productivity, introduction of new products) three years ago. Therefore, we also estimate the specifications using only one measures of absorptive capacity – education - to check whether past absorptive capacity is correlated with present participation in international activities.

5. *Estimation Results*

5.1 Country Absorptive Capacity

Tables 9 to 11 present the results of estimating Equation (1) including country and sector fixed effects.

Table 9: The effect of educational attainment in the country and foreign technology on labour productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Education	-7.046***	-6.979***	-6.657***	-6.651***				
	(0.582)	(0.595)	(0.599)	(0.608)				
Foreign	0.355*			0.147	0.353**			0.262*
	(0.144)			(0.148)	(0.117)			(0.120)
Foreign* Education	-0.453			0.032	-0.237			-0.149
	(0.619)			(0.645)	(0.503)			(0.524)
Supplier		0.436*		0.304*		0.149		0.071
		(0.170)		(0.171)		(0.134)		(0.138)
Supplier* Education		-0.421		-0.053		0.578		0.711
		(0.865)		(0.869)		(0.702)		(0.729)
Exporter			0.498***	0.425***			0.265**	0.217**
			(0.119)	(0.122)			(0.081)	(0.082)
Exporter *Education			-1.070*	-1.030			-0.259	-0.342
			(0.543)	(0.545)			(0.389)	(0.391)
Country FE	no	no	no	no	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	3690	3690	3690	3690	3690	3690	3690	3690
R^2	0.322	0.332	0.330	0.345	0.600	0.601	0.599	0.611

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

Table 10: The effect of training in the country and foreign technology on labour productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Training	3.735***	3.727***	3.725***	3.783***				
	(0.292)	(0.283)	(0.306)	(0.305)				
Foreign	0.324*			0.199	0.213			0.170
	(0.186)			(0.192)	(0.149)			(0.152)
Foreign* Training	-0.026			0.020	0.200			0.136
	(0.379)			(0.393)	(0.308)			(0.314)
Supplier		0.504**		0.433*		0.288*		0.260*
		(0.192)		(0.195)		(0.148)		(0.157)
Supplier* Training		-0.308		-0.280		-0.042		-0.091
		(0.359)		(0.369)		(0.282)		(0.302)
Exporter			0.477**	0.389*			0.203*	0.151
			(0.167)	(0.172)			(0.109)	(0.109)
Exporter *Training			-0.428	-0.400			0.018	-0.012
			(0.340)	(0.356)			(0.215)	(0.218)
Country FE	no	no	no	no	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	3690	3690	3690	3690	3690	3690	3690	3690
R^2	0.287	0.296	0.292	0.310	0.600	0.600	0.599	0.611

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

Table 11: The effect of R&D investment in the country and foreign technology on labour productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D	10.482***	10.284***	10.682***	10.643***				
	(0.405)	(0.761)	(1.016)	(0.981)				
Foreign	0.182			0.039	0.210*			0.177
	(0.134)			(0.132)	(0.108)			(0.108)
Foreign* R&D	1.655			1.891	1.005			0.594
	(1.350)			(1.267)	(1.061)			(1.058)
Supplier		0.339**		0.250*		0.248*		0.209*
		(0.128)		(0.128)		(0.100)		(0.102)
Supplier* R&D		0.469		0.679		0.208		0.082
		(1.101)		(1.081)		(0.864)		(0.861)
Exporter			0.479***	0.420***			0.131*	0.072
			(0.088)	(0.090)			(0.071)	(0.071)
Exporter *R&D			-1.540*	-1.747*			0.812	0.744
			(0.811)	(0.820)			(0.587)	(0.593)
Country FE	no	no	no	no	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	3690	3690	3690	3690	3690	3690	3690	3690
R^2	0.254	0.263	0.263	0.282	0.600	0.600	0.599	0.611

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

The results show that the interaction terms between investment in R&D, provision of training and education at country level and access to foreign technology are statistically insignificant in all equations, which suggest that absorptive capacity does not play an important role in facilitating the transfer of foreign technology. The coefficients of variables that control for participation in international activities are positive and statistically significant in most of the equations. The coefficient of education at country level is negative and statistically significant suggesting a negative effect of education on labour productivity. However, as education may be correlated with other omitted country level variables we caution against a causal interpretation of these variables. As shown in section 3, education of labour force is negatively correlated with the level of development of the country and we cannot separate the effect of education from the effect of other country characteristics on labour productivity. Therefore, our interpretation of these results is that the share of workforce with tertiary education is correlated with host country characteristics which have a negative effect on labour productivity. The coefficients of investment in R&D and provision of training are positive and statistically significant, suggesting the labour productivity is associated with these country characteristics. However, for the reasons mentioned above we cannot interpret these results as evidence of a causal relationship.

As a robustness check we also estimate equation (1) using data on the education of the labour force from the World Bank Development Indicators as a measure of education at country level. World Bank Development Indicators does not provide data on all the countries in our sample and therefore the number of observation is different in our previous regressions. The results are reported in Table 12.

Table 12 The effect of educational attainment in the country and foreign technology on labour productivity (WDI data)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Education	-1.964***	-1.864***	-1.894***	-1.859***				
	(0.246)	(0.237)	(0.252)	(0.252)				
Foreign	0.392***			0.188	0.360***			0.250**
	(0.111)			(0.109)	(0.084)			(0.083)
Foreign* Education	-0.101			0.139	-0.034			0.112
	(0.319)			(0.319)	(0.241)			(0.237)
Supplier		0.505***		0.429***		0.353***		0.310***
		(0.109)		(0.108)		(0.063)		(0.062)
Supplier* Education		-0.540		-0.629		-0.437		-0.527*
		(0.364)		(0.370)		(0.250)		(0.248)
Exporter			0.419***	0.314***			0.235***	0.140*
			(0.089)	(0.087)			(0.058)	(0.056)
Exporter *Education			-0.140	-0.034			-0.068	0.027
			(0.295)	(0.295)			(0.245)	(0.249)
Country FE	no	no	no	no	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	2942	2942	2942	2942	2942	2942	2942	2942
R^2	0.220	0.229	0.237	0.256	0.584	0.582	0.581	0.595

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

The results are very similar to our previous results. We find no interaction effect between country level absorptive capacity and technology transfer and a high level of education is associated with lower labour productivity. Also, similar to the results reported in Table 9, participation in all international activities is associated with higher labour productivity and labour force education at country level is associated with lower labour productivity. We have also estimated several other variants of these equations, including one in which value added is the dependent variable and which includes controls for firm's capital, labour and other firm characteristics, and the results are very similar.

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 fact that the interaction between host country characteristics and internalisation is insignificant is that there is large heterogeneity with regard to absorptive capacity within countries. For instance, even in a country that have overall low absorptive capacity, 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 3.2 show that there is more variation in the absorptive capacity of firms within countries than between countries. We examine this hypothesis in the next section.

5.2 Firm Absorptive Capacity

Next, we examine whether firm level absorptive capacity facilitates technology transfer. Tables 13 to 15 show the results of estimating the equation (2).

Table 13 The effect of the education of firms' employees and foreign technology on labour productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Education	-0.351***	-0.331***	-0.395***	-0.475***	0.354***	0.387***	0.366***	0.319***
	(0.090)	(0.095)	(0.097)	(0.101)	(0.054)	(0.056)	(0.064)	(0.066)
Foreign	0.155*			0.028	0.213***			0.150**
	(0.084)			(0.080)	(0.052)			(0.053)
Foreign* Education	0.412*			0.365**	0.159			0.180
	(0.178)			(0.176)	(0.117)			(0.119)
Supplier		0.340***		0.305***		0.252***		0.235***
		(0.081)		(0.077)		(0.058)		(0.058)
Supplier* Education		0.222		0.047		-0.037		-0.134
		(0.181)		(0.177)		(0.133)		(0.131)
Exporter			0.335***	0.296***			0.176***	0.128***
			(0.063)	(0.062)			(0.035)	(0.034)
Exporter *Education			0.282*	0.205			0.033	0.017
			(0.137)	(0.138)			(0.093)	(0.087)
Country FE	no	no	no	no	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	3648	3648	3648	3648	3648	3648	3648	3648
R^2	0.096	0.109	0.119	0.137	0.606	0.606	0.605	0.615

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

Table 14 The effect of firm training and foreign technology on labour productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Training	0.274***	0.295***	0.278***	0.254***	0.122***	0.134***	0.144***	0.108***
	(0.043)	(0.047)	(0.050)	(0.053)	(0.026)	(0.025)	(0.029)	(0.029)
Foreign	0.125			-0.013	0.190**			0.122*
	(0.099)			(0.093)	(0.062)			(0.060)
Foreign* Training	0.170			0.208*	0.146*			0.162**
	(0.121)			(0.116)	(0.072)			(0.071)
Supplier		0.429***		0.370***		0.256***		0.220***
		(0.078)		(0.080)		(0.058)		(0.059)
Supplier* Training		-0.131		-0.129		-0.007		-0.014
		(0.102)		(0.101)		(0.063)		(0.063)
Exporter			0.376***	0.334***			0.204***	0.162***
			(0.064)	(0.063)			(0.040)	(0.040)
Exporter *Training			-0.064	-0.079			-0.033	-0.060
			(0.075)	(0.076)			(0.047)	(0.049)
Country FE	no	no	no	no	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	3444	3444	3444	3444	3444	3444	3444	3444
R^2	0.110	0.122	0.126	0.128	0.606	0.606	0.604	0.615

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

Table 15 The effect of firm R&D and foreign technology on labour productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D	0.282***	0.313***	0.190*	0.178*	0.219***	0.259***	0.244***	0.224***
	(0.061)	(0.066)	(0.079)	(0.087)	(0.045)	(0.042)	(0.059)	(0.062)
Foreign	0.226***			0.092	0.270***			0.194***
	(0.063)			(0.064)	(0.046)			(0.045)
Foreign* R&D	0.029			0.064	0.024			0.084
	(0.131)			(0.126)	(0.087)			(0.084)
Supplier		0.402***		0.338***		0.279***		0.232***
		(0.065)		(0.065)		(0.036)		(0.037)
Supplier* R&D		-0.164*		-0.142		-0.148**		-0.113
		(0.097)		(0.093)		(0.059)		(0.058)
Exporter			0.340***	0.279***			0.193***	0.133***
			(0.049)	(0.050)			(0.030)	(0.029)
Exporter *R&D			0.071	0.093			-0.073	-0.065
			(0.100)	(0.097)			(0.066)	(0.064)
Country FE	no	no	no	no	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Obs	3690	3690	3690	3690	3690	3690	3690	3690
R^2	0.102	0.116	0.120	0.128	0.606	0.607	0.604	0.615

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

As with the country-level results, the coefficients on the interaction terms between investing in R&D, providing training and participating in international activities are never statistically insignificant, with the exception of the interaction term between foreign ownership and workforce education and foreign ownership and provision of training. This suggests that, contrary to our hypothesis, we do not find evidence that firm's absorptive capacity plays an important role in facilitating technology transfer through foreign ownership, supplying MNEs or exporting.

As expected, most of the measures of access to foreign technology are positive and statistically significant. Based on the equations that include country fixed effects and controls for all international activities, foreign ownership is associated with between 13% and 20% higher labour productivity, supplying MNEs is associated use between 25% and 26% higher labour productivity and exporting is associated with exporting is associated with between 13 and 18% higher labour productivity.

The results in Table 13 show that when we do not control for country fixed effects, the share of workforce with tertiary education in the firm is negatively associated with productivity. Once we control for country fixed effects, the coefficient of education turns positive. This suggests that the share of workforce with tertiary education in the firm is correlated with other host country characteristics which have a negative effect on labour productivity. This is consistent with our previous finding that tertiary education at country level is negatively correlated with the level of development and with firm labour productivity. When we control for country specific characteristics by including fixed effects, education has a positive and significant effect on labour productivity. This effect is large and economically meaningful. Based on the results in column (8) in Table 13, increasing the share of workforce with university education by one standard deviation, is associated with an increase the firm labour productivity of 9.7 %.

Provision of formal training to employees is also associated with higher labour productivity. The coefficient is statistically significant and large in magnitude. The magnitude of the coefficients in column (8) in Table 14 imply that firms that provide training are around 11% more productive than firms that do not provide training. Controlling for country fixed effects, does not affect the sign or significance of the coefficients, but it reduces their magnitude from 28% in column (4) in Table 14 to 11% in column (8) in Table 14. This could be due to the correlation of training with host country characteristics that have a positive effect firms' labour productivity. This is in line with the findings in section 3 that the provision of training was highly correlated with investment in R&D, financial development and also with country GDP per capita. Investment in R&D is significantly associated with higher labour productivity. The results from the specification with country fixed effects and controls for all international activities reported in column (8) in Table 15 imply that firms that invest in R&D are 25% more productive than firms that do not conduct R&D.

In conclusion, there is little evidence that there is an interaction between investing in the absorptive capacity of the firm and access to foreign technology. None of the interaction terms between absorptive capacity measures and exporting or supplying MNEs are positive and significant. However, we find evidence consistent with a direct effect of absorptive capacity on labour productivity.

As a robustness check we also estimate a variant of equation (2) using past absorptive capacity of the firm. This helps avoid the problem of simultaneity. This problem might arise if the most productive firms invest more in their absorptive capacity and attract better educated workers than less productive firms. In this case the measures of absorptive capacity in equation (2) would be endogenous.

The dataset does not provide information on the past investment in R&D or past provision of training and very few firms appear in both waves. However, the survey includes information on the education of the workforce three years ago. To test whether past investments in the development of the absorptive capacity facilitate the absorption of foreign technology we estimate equation (2) using the share of employees with tertiary education three years ago. The results are reported in Table 16.

Table 16: The combined effect of past absorptive capacity and foreign technology on labour productivity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Education 2001	-0.384***	-0.364***	-0.391***	-0.486***	0.342***	0.375***	0.371***	0.319***
	(0.088)	(0.093)	(0.094)	(0.099)	(0.054)	(0.055)	(0.062)	(0.064)
Foreign	0.136			0.003	0.201***			0.133**
	(0.084)			(0.079)	(0.053)			(0.053)
Foreign* Education 2001	0.488*			0.455**	0.201*			0.232**
	(0.194)			(0.187)	(0.119)			(0.118)
Supplier		0.348***		0.308***		0.254***		0.234***
		(0.077)		(0.073)		(0.057)		(0.057)
Supplier* Education 2001		0.211		0.049		-0.046		-0.142
		(0.169)		(0.164)		(0.131)		(0.126)
Exporter			0.368***	0.333***			0.196***	0.150***
			(0.064)	(0.063)			(0.035)	(0.033)
Exporter *Education 2001			0.188	0.101			-0.017	-0.036
			(0.142)	(0.141)			(0.095)	(0.088)
Country FE	no	no	no	no	yes	yes	yes	yes
Sector FE	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	3567	3567	3567	3567	3567	3567	3567	3567
R-squared	0.100	0.113	0.123	0.142	0.608	0.608	0.607	0.617

Notes: Dependent variable labour productivity. Education2001 is the share of workforce with tertiary education in 2001. *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results are very similar to results obtained for present values of education of workforce, reported in Table 13, both in qualitatively and in terms of magnitude. When we do not control for country fixed effects, it appears that the share of workforce with tertiary education three years ago is negatively associated with productivity. Our interpretation of these results is that the share of workforce with tertiary education is correlated with host country characteristics which have a negative effect on labour productivity. When we control for country characteristics by including country fixed effects, education of workforce in 2001 has a positive effect on labour productivity. The interaction term between participation in international activities and education of the workforce is insignificant in the regressions in which we control for country fixed effects with the exception of the interaction between foreign ownership and workforce education. This implies that the results reported in Table 13 were not due to simultaneity bias.

We also study the effect of absorptive capacity on total factor productivity. In this specification the dependent variable is value added and it includes controls for the capital of the firm. It is important to control for the capital of the firm because previous studies have shown that more capital intensive firms are more likely to participate in international activities and also more skill intensive and more productive. We have also estimated a specification that includes all channels of international technology transfer and all absorptive capacity measures. As mentioned in section 3 our absorptive capacity measures reflect different aspects of the absorptive capacity. The results are reported in Table 17.

Table 17 The combined effect of absorptive capacity and foreign technology on TFP

	(1)	(2)	(3)	(4)	(5)
Foreign owned	0.172***	0.094	0.110**	0.013	-0.008
	(0.044)	(0.058)	(0.052)	(0.071)	(0.071)
MNEs supplier	0.196***	0.240***	0.176***	0.215***	0.190***
	(0.030)	(0.051)	(0.044)	(0.061)	(0.062)
Exporter	0.124***	0.140***	0.059*	0.099**	0.082*
	(0.030)	(0.039)	(0.035)	(0.045)	(0.043)
R&D	0.209***			0.175***	0.167***
	(0.054)			(0.056)	(0.057)
Foreign owned*R&D	0.041			0.079	0.084
	(0.077)			(0.081)	(0.080)
MNEs supplier*R&D	-0.086			-0.088	-0.080
	(0.055)			(0.062)	(0.062)
Exporter*R&D	-0.072			-0.055	-0.047
	(0.056)			(0.058)	(0.059)
Training		0.090***		0.074**	0.067**
		(0.031)		(0.030)	(0.030)
Foreign owned*Training		0.151**		0.125*	0.121
		(0.070)		(0.074)	(0.073)
MNEs supplier*Training		-0.087		-0.077	-0.076
		(0.062)		(0.065)	(0.064)
Exporter*Training		-0.063		-0.054	-0.053
		(0.048)		(0.048)	(0.048)
Education			0.244***	0.259***	0.229***
			(0.059)	(0.062)	(0.060)
Foreign owned*Education			0.139	0.144	0.132
			(0.120)	(0.133)	(0.133)
MNEs supplier*Education			-0.049	0.050	0.065
			(0.108)	(0.125)	(0.126)
Exporter*Education			0.154*	0.069	0.081
			(0.086)	(0.095)	(0.097)
Country fixed effects	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes
Other firm characteristics	no	no	no	no	yes
Observations	3690	3444	3648	3411	3393
R-squared	0.897	0.897	0.897	0.898	0.899

Notes: Dependent variable is value added. All specifications include controls for capital and labour, which are not reported here. 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 the interaction effects between measures related to absorptive capacity and measures related to participation in international activities. The coefficients of international technology transfer are smaller in magnitude than in the equations that do not include controls for capital and foreign ownership is not statistically significant. Based on the results of the most comprehensive model reported in column (5) in Table 17, supplying MNEs is associated is 20% higher total factor productivity and exporting is associated with 8.5% higher total factor productivity. This suggests that part of the higher labour productivity premium was due to the use of more or better capital and material inputs. The direct effect of the investment in R&D, training and education are always positive and statistically significant. The magnitude of these coefficients is also smaller than in the specifications that do not control for capital of the firm. Based on the results in column (5), investing in R&D is associated with 18% higher labour productivity, providing training is associated with 7% higher labour productivity and increasing the share of employees with tertiary education is associated with 7% higher labour productivity. Comparing the specification that includes all measures of absorptive capacity with the specifications that include only one measure of absorptive capacity, it can be noticed that all the measures of absorptive capacity remain positive, statistically significant and the magnitude of their coefficients is only slightly affected. This suggests that R&D, training and education of workers reflect different, but relevant aspects of absorptive capacity.

In conclusion, our robustness checks confirm our main results that internalisation and absorptive capacity measures are associated with higher productivity, but there is no evidence of an interaction effect between absorptive capacity and internalisation.

As discussed in the literature review, the results of the empirical studies that used similar measures of absorptive capacity and focused on transition or developing economies are 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 spillovers only in two countries (Slovakia and Hungary), and it actually hinders horizontal spillovers in Estonia and Latvia and has an insignificant effect in the other transition countries. With regard to spillovers through backward linkages, the authors find that the interaction between absorptive capacity and foreign presence in downstream industries is insignificant for all countries with the exception of Romania and Slovenia, where it is negative. Koymen and Sayek (2009) find that the human capital has a negative effect on the spillovers through backward linkages and that the horizontal FDI spillovers and forward FDI spillovers on the TFP level of domestic firms are not affected by the human capital level of these firms. Hu, Jefferson and Jinchang (2005) find evidence consistent with the hypothesis that R&D enhances firm's absorptive capacity and thus facilitates the adoption of technology purchased through licensing agreements from foreign firms. Girma, Gorg and Gong (2009) find that Chinese firms that invest in own R&D and those that provide training for their employees benefit more from inward FDI in the sector than firms that do not.

It is important to notice that among these studies; only two of them use firm level measures of access to foreign technology. Kinoshita (2000) uses foreign ownership and finds no evidence that absorptive capacity facilitates technology transfer through this channel. Hu, Jefferson and Jinchang (2005) measures access to foreign technology as technology purchased through licensing agreements from foreign firms and they find evidence consistent with the hypothesis that R&D enhances firm's absorptive capacity and thus facilitates technology transfer.

There are several possible explanations for these findings. First, it is possible that the firms that have access to foreign technology do not need absorptive capacity to implement this technology. The technology transfer is facilitated by the foreign MNEs, not by the actions of the domestically owned supplier. For instance, MNEs might transfer to its supplier the blueprints for the products it buys together with instructions to implement those blueprints and therefore the supplier does not need any additional absorptive capacity to implement these measures. In addition, parent MNEs or customer MNEs might provide the necessary assistance to implement the new technology. There are many anecdotal and survey evidence to support this view (UNCTAD, 2000; 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.

Second, it is possible that MNEs and foreign partners make sure that their future suppliers or affiliates have the necessary absorptive capacity before transferring technology to them. This is consistent with the large literature on self-selection by firms into exporting (Melitz, 2003). There are also studies that found that better performing firms are more likely to be acquired by MNEs (Djankov and Hoekman, 2000) or more skilled intensive firms are more likely to be acquired by MNEs (Damijan, et al. 2003). Javorcik (2008) also provides anecdotal and survey evidence from Czech Republic and Latvia that before signing a contract MNEs perform audits on potential suppliers and require them to implement changes with regard to quality and on time delivery and acquire quality certifications. In the fallowing subsection we will examine this hypothesis.

5.3 Absorptive Capacity and Participation in International Activities

In this subsection, we examine whether investment in R&D, training and employees education increases the probability of firms' participation in supplying MNEs, exporting and becoming foreign affiliates. If the domestic firms are selected by their foreign partners to become affiliates or suppliers based on their absorptive capacity, then the firms selected will have the necessary absorptive capacity to implement the technology transferred.

As explained in section 4.3, we will start by estimating the equation that relates the contemporary measures of absorptive capacity to the probability of the firm being a MNEs supplier, exporter or foreign affiliate. Table 18 presents these results.

Table 18 Absorptive capacity and participation in international activities

	Foreign owned	MNEs Supplier	Exporter
R&D	0.002	0.027	0.067***
	(0.011)	(0.019)	(0.025)
Training	0.011	0.053***	0.010
	(0.010)	(0.016)	(0.016)
Education	0.120***	0.097***	0.275***
	(0.017)	(0.022)	(0.041)
Size	0.034***	0.013**	0.087***
	(0.003)	(0.005)	(0.008)
Labour Productivity	0.035***	0.050***	0.058***
	(0.007)	(0.010)	(0.016)
Wage	0.029***	0.044***	0.003
	(0.010)	(0.016)	(0.022)
New product	0.027***	0.028*	0.073***
	(0.010)	(0.016)	(0.018)
Foreign owned		0.052**	0.159***
		(0.022)	(0.034)
Sector FE	yes	yes	yes
Country FE	yes	yes	yes
Observations	3390	3402	3402
Log Likelihood	-945.878	-1288.104	-1489.442

Notes: Dependent variables are dummy variables for foreign ownership, supplying MNEs and exporting. The table reports the marginal effects (at the mean values) of the firm's propensity to engage in these activities. *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results show that the education of the workforce is positively and significantly correlated with supplying MNEs, exporting and being foreign owned. R&D investment is significantly associated with exporting, but not with supplying MNEs or being foreign owned. It is possible that in the case of foreign affiliates and MNEs suppliers R&D activity is concentrated in the parent MNEs. Training is significantly associated only with supplying

MNEs. This is line with Javorcik's (2008) finding that training is one the most common forms of assistance that MNEs provide to their local suppliers.

The results for the other variables are in line with the findings of previous studies on self selection into exporting. Large and productive firms are more likely to supply MNEs, export and be foreign owned. High average wage are also significantly associated with participation in international activities, with the exception of exporting. Also introducing a new product in the last three years is also significantly correlated with exporting and being foreign owned. Being foreign owned also increases the probability of supplying MNEs and exporting.

As explained in section 4.3, to avoid the simultaneity problem, we estimate the effect of the past absorptive capacity on participation in international activities. Due to data availability, we can only study the effect of workforce education on the participation in international activities. We estimate the effect of workforce education in 2001 on the participation in international activities in 2004. The other control variables are also lagged by three years. Table 19 presents the results of these estimations.

Table 19 Past Absorptive Capacity and Participation in International activities

	MNEs Supplier	Exporter	Foreign owned
Education 2001	0.154***	0.288***	0.124***
	(0.023)	(0.034)	(0.017)
Size 2001	0.025***	0.097***	0.035***
	(0.004)	(0.007)	(0.003)
Labour Productivity 2001	0.053***	0.061***	0.035***
	(0.009)	(0.011)	(0.006)
New product	0.042**	0.103***	0.030***
	(0.017)	(0.017)	(0.010)
Sector FE	yes	yes	yes
Country FE	yes	yes	yes
Obs.	3480	3480	3466
Log Likelihood	-1372.033	-1566.996	-986.131

Notes: Dependent variables are dummy variables for foreign ownership, supplying MNEs and exporting. The table reports the marginal effects (at the mean values) of the firm's propensity to engage in these activities. *, ** and *** indicate significance at 10%, 5% and 1%, respectively. Standard errors clustered by country and industry are in parentheses.

The results suggest that past absorptive capacity, measured as share of workforce with tertiary education, is positively and significantly correlated with supplying MNEs, exporting and foreign ownership. The magnitude of the effect on workforce education in 2001 on the participation in international activities in 2004 is similar to the effect reported for contemporary workforce education reported in Table 19. The results for the other variables are very similar to our previous results. This implies that the results reported in Table 18 were not the result of simultaneity bias. In other words, firms that had high levels of absorptive capacity, in terms of workforce education, are significantly more likely to become foreign affiliates, MNEs suppliers or exporters.

In conclusion, the evidence provided in this subsection shows that firms with higher absorptive capacity, especially the education of the workforce, are more likely to be foreign owned, MNEs suppliers or exporters. This is consistent with the hypothesis that foreign firms ensure that their local affiliates and suppliers have the necessary absorptive capacity before transferring technology to them and this can explain why we do not find evidence that the absorptive capacity facilitates technology transfer.

6. *Conclusions*

The ability to assimilate foreign technology differs across countries and also across firms within a country. Absorptive capacity was suggested as an important factor affecting this ability at country level and at firm level. In this paper, 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 Eastern Europe and former Soviet Union, using the Business Environment and Enterprise Performance Survey (BEEPS) 2005 and 2002 dataset. We contribute to the literature in several ways. First, our measures of access to foreign technology (foreign ownership, supplying MNEs and exporting) are firm specific.

These measures reflect better firms' access to foreign technology than the industry level measures used in most of the previous studies. Second, the measures of absorptive capacity used in this study (investment in R&D, provision of formal training and workforce education) present several advantages compared to the productivity gap measures, which are used in firm level studies. These measures of absorptive capacity are closely related to the concept of absorptive capacity and to the measures used in the macroeconomic literature. They are also less prone to measurement error than productivity gap measures. These measures are more informative from a policy perspective because policies can be targeted to support investment in R&D, training and education. Thirdly, we study 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.

Our main 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 at country or firm level and access to foreign technology. However, we find evidence that firms that have high levels of absorptive capacity, especially in terms of workforce education, are significantly more likely to be foreign-owned, to supply MNEs and to export.

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Annexes

Table 20 Variable definition

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
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
Education	Share of the employees with university education
Training	A dummy variable that takes the value 1 if the firm provided formal training to its employees in 2004 or 0 otherwise.
R&D	A dummy variable that takes the value 1 if the firm had positive expenditure on R&D in 2004 and 0 otherwise
Education (country level)	Share of employees with tertiary level education of total employees in the country
Training (country level)	Share of firms in the country that provide formal training.
R&D (country level)	Share of firms in the country that invest in R&D.
Access to external finance	A dummy variable that takes the value 1 if the firm finances its new investments through commercial banks or leasing arrangements.
Corruption	Share of sales spent on unofficial payments/gifts
Labour productivity	Sales per employee
Output	Total sales
Value Added	Total sales minus costs of intermediate inputs and energy
Capital	Replacement value of the physical production assets like land, buildings and equipment
Labour	Number of full time employees
Importing	A dummy variable that takes the value 1 if the firm imports part of its material inputs (directly and indirectly) and 0 otherwise
Licensing	A dummy variable that takes the value 1 if the firm acquired licensing contracts for new products over the previous three years and 0 otherwise
Age	The year of the survey minus the year when the firm was established
Inelastic demand	A dummy variable that takes the value 1 if the firm indicated that if it increased the price of its main product by 10% its customers would continue to buy the same quantities and 0 otherwise.
Low elasticity of demand	A dummy variable that takes the value 1 if the firm indicated that if it increased the price of its main product by 10% and the firm's competitors maintained their current prices its customers would decrease slightly the quantities they buy from the firm and 0 otherwise
Medium elasticity of demand	A dummy variable that takes the value 1 if the firm indicated that if it increased the price of its main product by 10% and the firm's competitors maintained their current prices its customers would buy much lower quantities they buy from the firm and 0 otherwise
High elastic of demand	A dummy variable that takes the value 1 if the firm indicated that if it increased the price of its main product by 10% and the firm's competitors maintained their current prices, its customers buy from the firms' competitors instead and 0 otherwise
Capital /Large city dummy	A dummy variable that takes the value 1 if the firm is located in capital city or a city with above one million inhabitants and 0 otherwise.
Wage	Total cost with labour force divided by the number of employees
New product	A dummy variable that takes the value 1 if the firm introduced a new product in the last 3 years and 0 otherwise

Table 21 Absorptive capacity: differences across countries

Country	*Education (BEEPS)*	*Education (WDI)*	*Training (BEEPS)*	*R&D (BEEPS)*	*R&D /GDP (WDI)*	*GDP per capita PPP (WDI)*
Albania	0.17	0.08	0.48	0.07		5680.41
Armenia	0.33		0.36	0.08	0.002	3488.58
Belarus	0.27		0.49	0.07	0.006	7522.06
Bosnia Herzegovina	0.17		0.47	0.06		5750.12
Bulgaria	0.26	0.24	0.32	0.06	0.005	8653.51
Croatia	0.17	0.18	0.60	0.15	0.012	14340.21
Czech Rep	0.11	0.13	0.60	0.14	0.013	19294.00
Estonia	0.16	0.31	0.65	0.08	0.009	14735.17
Georgia	0.31	0.27	0.24	0.08	0.002	3081.18
Hungary	0.16	0.20	0.40	0.10	0.009	16223.58
Kazakhstan	0.28	0.50	0.31	0.05	0.003	7750.17
Kyrgyz Republic	0.29		0.47	0.07	0.002	1693.27
Latvia	0.18	0.21	0.52	0.07	0.004	11739.96
Lithuania	0.21	0.28	0.52	0.14	0.008	12977.38
Macedonia	0.15		0.37	0.10	0.003	6848.56
Moldova	0.26		0.33	0.09	0.006	2003.29
Poland	0.22	0.17	0.48	0.11	0.004	13018.74
Romania	0.17	0.10	0.33	0.11	0.012	8737.25
Russian Federation	0.31	0.52	0.37	0.11	0.016	10746.32
Serbia and Montenegro	0.17		0.47	0.08	0.005	8040.55
Slovakia	0.16	0.13	0.79	0.09	0.015	14680.70
Slovenia	0.15	0.20	0.70	0.25	0.001	22211.92
Tajikistan	0.22	0.11	0.31	0.11	0.011	1361.00
Ukraine	0.36	0.66	0.44	0.04	0.006	5227.92
Uzbekistan	0.17		0.16	0.03	0.006	1832.70

Source: BEEPS 2005, WDI 2003, 2004.