EAST-WEST
Journal of **Economics and Business**
Vol. VIII – 2005, No 1&2 (137-156)

INDUSTRY LEVEL TECHNOLOGY GAPS AND COMPLEMENTARY KNOWLEDGE STOCKS AS DETERMINANTS OF INTRA-MNC KNOWLEDGE FLOWS

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Abstract

Pursuing a subsidiary level analysis, we this paper tests the 'technology gap' hypothesis in the context of intra-MNC knowledge flows. Furthermore, it introduces complementary knowledge stocks into the concept of absorptive capacity. A set of hypotheses is tested in a sample of 434 foreign subsidiaries based in Central and East Europe. We find partial support for the 'technology gap' hypothesis applied at industry level. Furthermore, subsidiaries'

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complementary knowledge stocks increase the probability for corresponding knowledge inflows from the foreign parent.

KEYWORDS: multinational corporations, foreign direct investment, technology transfer, productivity gap, absorptive capacity

JEL classification: F23, D83, O33

Introduction

It has been suggested that international productivity differentials can be explained mainly by patterns in international trade and foreign direct investment (Keller 2001). Thus, it can be argued that there is a link between FDI, technological flows, and productivity growth. Most of the empirical literature on the effects of FDI in transition or developing countries has focused solely on productivity or technological spillovers to domestic firms (see Stephan 2005 for an overview). However, there is a body of studies that has started to consider also the heterogeneity of multinational companies' operations as a factor explaining the variability of spillover effects (for example Todo and Miyamato 2002, Castanelli and Zanfei 2003, Marin and Bell 2004). Our study tries to make a contribution to the literature by examining two determinants of intra-MNC technology flows: the technology gap at industry level and complementary subsidiary knowledge stocks as a form of absorptive capacity.

There is a considerable body of literature concerned with external effects of FDI that has paid attention to the technology gap hypothesis (Blalock and Gertler 2004, Blomström and Wolff 1994, Castellani and Zanfei 2003, Imbriani and Reganti 1997, Kokko 1994, Kokko et al 1996 etc.), however, the evidence with regard to the impact on intra-MNC technology transfer is very limited (for example Gupta and Govindarajan 2000). The concept of absorptive capacity (Cohen and Levinthal 1989) has been widely applied, however, in addition to prior studies we introduce a complementary element to the concept of absorptive capacity i.e. we propose that the extent of knowledge inflows from the foreign parent company depends on the existence of a complementary knowledge stock latent in the subsidiary.

We test our hypothesis with a firm-level data that was collected simultaneously from 434 foreign invested firms in Poland, Hungary, Estonia, Slovakia and Slovenia in 2002-2003. This database unifies information on FDI from 38 different countries in North America, Asia, and Europe. The advantage of survey data is that it provides detailed information about individual subsidiary-headquarter relations and a range of potential channels for technology transfer. This kind of information is simply not available from the official registry data, other public sources, and existing surveys. It can be provided by case studies. However, the case study type of evidence has considerable limitations regarding the generalisation of findings, in particular if we are focusing on MNC heterogeneity issues. This data source is relatively large compared to similar studies in the international business literature (for example Taggert 1999, Anderson et al 2001, Harzing and Sorge 2003, Anderson et al 2005, Birkinshaw et al 2005).

We employ an ordered probit model to test our hypotheses and estimate the marginal effects of the respective determinants on internal technology transfer. In contrast to most FDI spillover studies, we approximate technology transfer by measuring knowledge flows directly and not indirectly via productivity. We proxy internal technology transfer by the importance of the foreign owner in three different areas of subsidiary competitiveness: R&D related activities, human capital formation, and quality control. We control for other observed firm-specific, industry-specific and unobserved host-country specific effects.

The study is organised in the following way. First, we give an overview of the theoretical literature and existing empirical evidence of technology transfer via FDI. Second, we elaborate our research hypotheses. Third, we briefly describe the data. Fourth, we introduce the econometric approach and discuss some methodological issues relating to the ordered probit technique. In the sixth section, we present the estimation results and check for robustness. In section seven, we place our findings in the context of prior theory and empirical evidence. The last section concludes by discussing limitations of our approach and maps out possible directions for future research.

Literature review

Technology Transfer via Foreign Direct Investment (FDI)

Technology can be broadly defined as managerial practices, production methods, and other tacit and codified know-how by which a firm transforms capital, labour, and materials into a product (Blalock and Gertler 2004). According to the international business literature, MNCs possess some form of firm specific advantage such as a product, a production process, reputation, or other intangible assets that allow firms to exploit other markets (Coase 1937, Dunning 1977 and 1981). Therefore, it is generally assumed that internationalising firms operate at a higher technological level compared to companies in the host economy. Hence, multinationals potentially act as conduits of technology transfer to their affiliates and other domestic firms. Blomström and Kokko (2002) differentiate between internal effects of inward FDI which refers to direct technology transfer between MNC and foreign subsidiary and external effects. External effects run from the foreign subsidiary to other domestic enterprises (spillover effects). These effects potentially run to domestic firms within the same sector or vertically along the supply chain. However, any spillover effect requires prior internal technology transfer from the foreign parent/MNC network to the local subsidiary.

For Central and East Europe as well as from other emerging economies there is substantial evidence that internal effects are more frequent compared to any external effects (Blomström and Sjöholm 1999, Aitken and Harrison 1999, Alverez et al 2002, Blalock 2001, Damijan et al 2003, Stephan 2005 etc.). In CEE transition economies internal effects are not only consistently more often positive but also larger in magnitude compared to any 'spillover' effects from FDI (Damijan et al 2003, Jindra 2005). This could simply indicate that multinationals effectively transfer technology and limit unwanted technology leakages. Thus, subsidiaries benefit from the transfer of a firm-specific advantage that allows them to operate at a higher technological level compared to other domestic firms. Existing empirical studies on technological transfer via FDI almost exclusively focused on external effects. As a result, we know that internal technology transfer is an important and real world phenomenon; however, we are not able to illustrate how it takes place. Therefore, this report focuses on a selected range of determinants of intra-MNC knowledge flows.

Technology gap vs. technology accumulation hypothesis

Findlay (1978) argues that given a certain minimum of economic development, regions or countries with a large initial technological gap are more likely to benefit from spillovers compared to advanced regions. In contrast to the 'technology gap hypothesis', it has been argued that the spillover potential increases, the lower the technological gap (Cantwell 1989) or technological distance. Kokko et al (1996) argue that for moderate technology gaps foreign technologies are useful to local firms and local firms possess the skills needed to apply or learn from foreign technologies. On the contrary, large gaps may signal that foreign technologies are too different from local ones, so that local firms remain unable to learn, or that local firms are too weak to be able to learn. This has been labelled as 'technological accumulation hypothesis' (Cantewell 1989). Criscuolo and Rajneesh (2002) propose a dynamic model where in a catching-up growth phase FDI and trade are the most important sources of knowledge accumulation, whereas, in countries closer to the technological frontier knowledge creation is facilitated by outward FDI, joint ventures and strategic alliances of domestic firms.

In the literature concerned the impact of the technology gap has almost exclusively been scrutinised by studies focusing on technology spillover from FDI to domestic firms. Here the gap is measured as the difference between the domestic firm’s labour productivity and the average labour productivity in foreign firms. Kokko (1994), using cross-section industry level data for Mexico, finds that a large technology gap per se does not appear to hinder technology spillovers on average. Kokko et al (1996), using a cross-section of firm-level data for Uruguay and Imbriani and Reganti (1997) for the Italian manufacturing sector, find evidence for spillovers only in firms with a low difference between the domestic firm’s productivity level and the industry frontier productivity level. In contrast, Castellani and Zanfei (2003) for selected EU-15 countries, Blomström and Wolff (1994) for Mexico as well as Blalock and Gertler (2004) for Indonesian firms, find evidence in support of the technology gap hypothesis. Thus, at the aggregate level there seems to be no clear-cut evidence. To date there is very limited evidence as to what extent the technology gap impacts on internal technology transfer in MNCs. A notable exception is the study of Gupta and Govindarajan (2000). They approximate the technology gap in terms of GDP per capita income differentials between home and host economies and tested the impact on knowledge inflows to the focal subsidiary. They find higher inflows for subsidiaries located in countries with lower levels of economic advancement relative to the FDI home country. Thus, this seems to support the technology gap hypothesis. However, most studies dealing with technology spillovers find that the extent technology transfer differs according to the industry or sector (Evenett and Voicu 2002, Castellani and Zanfei 2003). Therefore, in contrast to Gupta and Govindarajan (2000) we prefer to use a detailed industry level measure for labour productivity gaps rather than a country level measures.

Closely related to the technology gap hypothesis is the concept of absorptive capacity which can be defined as the firm’s ability to recognise valuable new knowledge, integrate it into the firm and use it productively (Cohen and Levinthal 1989, Lane and Lubatkin 1998). Cohen and Levinthal (1989) argue that R&D stimulates innovation but also increases a firm’s absorptive capacity. It develops the firm’s ability to identify, assimilate, and exploit outside knowledge, which is likely to increase the incident of technology diffusion. Keller (1996) and Borensztein et al (1998) propose that absorptive capacity is a function of technology accumulation and human capital in local firms. Additionally, the firm’s organisational structure and combinative capabilities contribute to a firm’s absorptive capacity (Van den Bosch et al 1999). Blalock and Gertler (2004) refer more generally to ‘firm capabilities’, which embrace absorptive capacity and human capital.

Main economic studies measuring the impact of absorptive capacity use different but quite narrow proxies such as investment into intangible assets (Damijan and Knell 2003), R&D intensity (Kinoshita 2000, Kneller 2002, Barrios et al 2003), human capital endowment and training (Schoors and van d. Tool 2002, Todo and Miyamato 2002, Kneller 2002). Blalock and Gertler (2004) apply a comprehensive approach that proxies absorptive capacities by R&D, however, also control for human capital endowment as well as the gap between productivity levels of foreign firms. Investment into R&D and human capital endowment is found to have a positive impact on the extent of technology absorption (Kinoshita 2000¸ Schoors and van d. Tool 2002, Todo and Miyamato 2002, Kneller 2002). In the international business literature and in particular in studies applying a knowledge-based perspective, we find a more differentiated approach to the concept of absorptive capacity. These studies suggest in particular that intra-MNC knowledge inflows depend on the provision of training, managerial assistance (Lyles/Salk 1996, Steensma/Lyles 2000) as well as specific human resource practices that support knowledge transfer (Cyr/Schneider 1996, Minbaeva 2005).

These finding by and large underline the importance of human capital formation in addition to the R&D oriented indicators employed in economic studies. Thus, subsidiaries' R&D capabilities play an important role in stimulating absorptive capacities in subsidiaries. However, despite recent trends towards greater dispersion of activities related to industry-specific core technologies (Cantwell and Santangelo 1999), MNCs mostly apply more standard and mature technology in foreign affiliates and undertake basic R&D activities at home or in other highly industrialised countries (Kvinge 2004). Therefore, we restrict absorptive capacities in subsidiaries based in transition countries not only to the ability to perform R&D. It can be argued that absorptive capacity exists in form of a firm-specific mix of skills. These skills in turn crucially depend on human capital formation. Hence, various forms of training and human resources practices by the local firm to increase absorptive capacity.

Building the hypotheses

Due to an outdated capital stock and due to the lack of competition, firms in former planned economies were to some extent technologically backward and urgently needed restructuring, and hence, could take advantage of technology transfer via inward FDI to narrow the technology gap. The literature review showed conflicting evidence regarding the impact of the technology gap on knowledge flows. Therefore, the direction of the effect can run both ways. If we assume that subsidiaries with a large technology gap are further from the international technology frontier benefit more from internal technology transfer ('technology gap' hypothesis), we can hypothesise:

H (1) The size of technology gap is positively associated with the extent of internal technology transfer to the subsidiary.

If we assume that subsidiaries closer to the international technology frontier benefit more from internal technology transfer ('technology accumulation' hypothesis). Large productivity gaps probably limit the scope and intensity of technology transfer. Therefore, we would hypothesise:

H (2) The size of technology gap is negatively associated with the extent of internal technology transfer to the subsidiary.

Drawing from the concept of 'absorptive capacity' we can argue that internal technology transfer is not an automatic consequence of the presence of foreign parents' knowledge stock. In addition to prior studies we introduce a complementary element to the concept of absorptive capacity i.e. we propose that the extent of knowledge inflows from the foreign parent company depends on the existence of a complementary knowledge stock in the subsidiary. For example, a foreign parent is more likely to transfer R&D related knowledge under the condition that the local subsidiary has command of complementary R&D related knowledge, this in turn allows a more effective integration of new external R&D related knowledge into the production process. A similar effect could be expected for other areas relevant to absorptive capacity such as training and human resources practices. Therefore, we hypothesise

H (3) The extent of intra-MNC knowledge inflows depends positively on complementary knowledge stock in the subsidiary.

However, we could also assume that knowledge inflows to the subsidiary from the MNC network are particularly high, in a situation where the subsidiary has no complementary knowledge, and is therefore, dependent on foreign parent transfers. Thus, we could hypothesise:

H (4) The extent of intra-MNC knowledge inflows depends negatively on complementary knowledge stock in the subsidiary.

Data and variables

To verify our research hypotheses, firm-level data was collected simultaneously in Poland, Hungary, Estonia, Slovakia, and Slovenia in 2002-2003 using the same structured instrument. The advantage of the survey data is that it provides detailed information about individual subsidiary-headquarter relations. This kind of data is simply not available from the official registry data or other public sources and existing surveys. In the course of interviews, company presidents and CEOs of foreign-invested firms provided information on measurable company characteristics and managers' assessment of their decision-making independence. The questionnaires were translated into local languages and back translated back into English. Highly qualified local experts conducted the fieldwork.

The highest proportion of the foreign-invested firms in our sample is from Poland (35.3%), followed by subsidiaries from Hungary (19,6%), Slovakia (18%), Slovenia (15.7%), and Estonia (11.5%). In terms of the industry breakdown, the biggest share in the total sample is in electrical and optical equipment industry (17%), followed by metals and metal products (14%), food, beverages and tobacco (10%), non-metal mineral products (9%), chemicals and man-made fibres (8%), rubber and plastic products (7%), clothing and textiles (7%). The distribution of the firms by size is well balanced. However, Slovenian firms are significantly smaller and Hungarian firms significantly larger than the sample average. A comparison of manufacturing sectors shows a significantly higher than average number of employees per company only in food, beverages and tobacco, and in transport equipment industries. In all other manufacturing sectors there are no statistically significant differences in the number of employees. Poland is strongest represented both in terms of the number of firms and average employment which is in line with the high share of FDI in Poland in the total stock of manufacturing FDI in CEE. The Slovenian sample is moderately overrepresented and Hungary slightly underrepresented. In addition, representativeness could also be evaluated comparing the number of firms included in the sample with the total number of firms with foreign investors in individual countries. From that point of view, sample firms represent about 4.9% of all foreign-invested firms in the analyzed countries. The highest share (23.8%) is in Slovenia, followed by Estonia with 12.4%, Poland with 3.5% and Hungary with 2.1%. A standard test of non-response bias indicated no significant differences between respondents and non-respondents on variables such as country and industry distributions, number of employees, etc.

Econometric approach

The estimation technique

We use an ordered probit model for our estimations. Following McKelvey and Zavoina (1975), Wooldridge (2002), and Greene (2003)2 ordered probit models should be applied if the dependent variables are categorically scaled. Ordinary least square (OLS) regression analysis interprets distances between two responses as being identical for all responses. However, ordinal data give information about a ranking of different outcomes, where distances are not necessarily identical or unknown. If we employed binary probit or multinomial logit/probit models, we would only account for nominal scale and would therefore ignore the information given by the ranking.

Therefore, we build the model as follows:

$$y^* = x'\beta + \varepsilon \qquad (1)$$

Where y* is the unobserved endogenous variable, β is the parameter vector and ε is the error term. As with binary probit regression models, the real y is unobserved. That is because the answers given are only given in some discrete value that best fits to the real y of the person interviewed. Therefore, we only observe whether an answer falls into a particular category or not. This is given by the responses:

$$\begin{aligned} &y = 0 \text{ if } y^* \leq 0, \\ &y = 1 \text{ if } 0 < \mathrm{y}^* \leq \mu_1, \\ &\vdots \\ &y = J \text{ if } \mu_{J-1} \leq y^* \end{aligned} \qquad (2)$$

Where μ are the unknown parameter to be estimated with β . These are also termed as cut off or limit points.

Greene (2003) argues that a sufficient assumption is that the distribution is known and continuous as for all Maximum Likelihood Estimations. However, in probit models it s also assumed that ε is normally distributed with mean equal to zero and variance equal to unity.

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[2] *We use Greene's notation throughout the paper if not stated otherwise..*

Thus, we get 3:

$$\begin{aligned}
&\Pr(y=0 \mid x) = \Phi(-x'\beta), \\
&\Pr(y=1 \mid x) = \Phi(\mu_1 - x'\beta) - \Phi(-x'\beta), \\
&\vdots \\
&\Pr(y=J \mid x) = 1 - \Phi(\mu_{J-1} - x'\beta)
\end{aligned} \tag{3}$$

Where $\Phi(-x'\beta)$ measures the estimated probability of $y=0$ conditional on x and $\Phi(\mu_1 - x'\beta) - \Phi(-x'\beta)$ measures the estimated probability of $y=1$ conditional on x etc.

Interpretation of estimation coefficients

For interpreting the effects of the exogenous variables on the endogenous, one has two possibilities. First it is possible to calculate the cut off point or limit points for the likelihood of a particular ranked event. If we take the example of three response possibilities, we get:

$$\begin{aligned}
&\Pr(y=0) = \Pr(y^* < cut1) \\
&\Pr(y=1) = \Pr(cut1 < y^* < cut2) \\
&\Pr(y=2) = \Pr(cut2 < y^*)
\end{aligned} \tag{4}$$

Lies the coefficient of a significant exogenous variable below cut1, then this variable has an effect on the probability that event 0 will take place. Lies the probability y* between cut1 and cut2 then the variable impacts on the probability that event 1 takes place. Lies the probability y* above cut2 then the variable impacts on the probability that event 2 takes place. One can interpret the coefficients for all events, however, following Greene (2003) one only can infer the direction of the effect from the sign of the coefficient for y=0 and y=J (lower and upper end of ranking). For all y between 0 and J the direction of the effect is ambiguous.

Second, because we cannot interpret the coefficients as marginal effects in probit estimations, we cannot yet infer from the information the direction and strength of the effect on the probability of a particular event. Therefore, we calculate the marginal effects for the different exogenous variables. Following Greene (2003) we compute the first differences in the following way:

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[3] *Greene (2003) unlike Wooldridge (2002) models includes a constant term that equals the first cut off point. However, we follow Wooldridge (2002) in our rules of interpretation i.e. we model without a constant term.*

$$\frac{\partial \Pr(y=0|x)}{\partial x} = -\phi(x'\beta)\beta,$$
$$\frac{\partial \Pr(y=1|x)}{\partial x} = [\phi(x'\beta) - \phi(\mu - (x'\beta)]\beta, \qquad (5)$$
$$\frac{\partial \Pr(y=2|x)}{\partial x} = \phi(\mu - (x'\beta)]\beta$$

From this would follow if the exogenous variable increases by one unit, the probability for the endogenous variable to fall into a certain group rises by this marginal influence (measured in percentages). In case the exogenous variable is a dummy variable, a discrete change from zero to unity, implies that the probability for the endogenous observation falling into a certain category rises by this marginal influence. Dealing with ordinal probit each answer category builds its one equation, we therefore have to estimate the marginal effects of five equations per model. Because we deal with a restriction within the marginal effects that one of the possible outcomes will occur, the probabilities have to add up to unity and marginal effects sum up to zero. For convenience we present and interpret in our study only the marginal effects of the probability that the response is zero i.e. the response category "not important".

For the below estimations we use the same specification:

(1) $P(y=0) = Cdum_i + Size_i + Age_i + Tgap_i + Acap_i$

where *Cdum* represents a country dummy for Estonia, Hungary, Slovakia, and Slovenia respectively capturing any unobserved country level effects. Poland is used as control group representing the country with most observations. *Size* is measured as the logarithm of the number of employees. *Age* is measured as the logarithm of the total number of full years between the firm's foundation and 2002. *Tgap* approximated the size of the technology gap. It is calculated for each subsidiary as the gap between labour productivity levels at the industry level in the host economy, benchmarked with the respective labour productivity levels in the US as a proxy for the international technology frontier. We use data from 2002 and calculate the labour productivity as value added (converted from current prices into US$) per employee (full time equivalent).[4] We do not include any industry dummies, as they would be highly correlated with our *Tgap* variable. *Acap* measures absorptive capacity in terms of complementary knowledge stocks either patents, licenses, and R&D; people and training; or

[4] *Data for USA: O'Mahony and van Ark (2003), 60-Industry Database, Groningen Growth and Development Centre, http://www.ggdc.net/, updated from October 2005; CEE countries: National Statistical Offices, National Banks, WIIW Database.*

quality control depending on the respective dependent variable. We estimate model specification (1) for three different proxies of knowledge transfer. Foreign invested firms indicated the importance of the foreign owner as a source for the following individual areas of competitiveness of the local firm:

(1.1) Patents, licences, and R&D activities;

(1.2) People and training;

(1.3) Quality control assistance.

The answers were given on a 5-point Likert scale ranging from 0 to 5 (with 0 = not important, 1 = little important, 3 = important, 4 = very important, and 5 = extremely important). The variable on patents, licences, and R&D proxies the internal transfer of intangible assets and codified knowledge. People and training relates to knowledge transfer via the formation of human capital, which then is employed in the production process of the local firm. The last dependent variable is understood to approximate the transfer of specific knowledge, skills, and management techniques related to quality control. We decided to estimate our models for all three dependent variables in order to test whether the three proxies where differently affected by the exogenous variables or not.

Estimation results

Main exogenous variables

The results of estimating (1.1) show that productivity differentials between industries in the home and host economies have a significant effect on the importance of the foreign parent as a source for patents, licences, and R&D. Here, a larger productivity gap has a negative impact on the probability that the foreign owner is not an important source. Hence, a large productivity gap triggers the foreign parent to be important as a source of intangible and codified knowledge. However, the marginal effect is relatively low compared to other exogenous variables. In contrast a technology gap variable does not seem to have a statistically significant impact on knowledge inflows in the areas of human capital formation (1.2) and quality control (1.3). From this estimation result we can infer that R&D related knowledge inflows are higher in industries that show a higher gap in terms of labour productivity compared to the international technology frontier. In our sample of five CEE countries in petroleum (NACE 23), chemicals and man made fibres (NACE 24) the technology gap is largest. Whereas, in rather low-tech industries such as food, beverages, tobacco (NACE 17-18) or textiles and leather (NACE 19) labour productivity gaps are lowest (see Appendix Chart 1). It follows that there are considerable differences in R&D related knowledge inflows into MNC subsidiaries across industries. Thus, hypothesis (1) that the size of technology gap is positively associated with the extent of internal technology transfer to the subsidiary can be supported with respect to R&D related knowledge but not however, not for human capital or quality control related knowledge inflows. On the other hand, hypothesis (2) that the size of technology gap is negatively associated with the extent of internal technology transfer to the subsidiary cannot be confirmed.

At the same time, the absorptive capacity proxies show a significant negative impact on the probability that the foreign owner company is not an important source of knowledge inflows. Thus, complementary knowledge stock increases absorptive capacity and seems to facilitate higher inflows of external knowledge. In case of estimation (1.1) the marginal effect of subsidiaries' R&D related knowledge stock is 15 times larger than the effect of the technology gap. The size of the respective marginal effects for human capital and quality control related knowledge stock is even larger. Judging from this we cannot reject hypothesis (3) that the extent of intra-MNC knowledge inflows depends positively on complementary knowledge stock in the subsidiary. Consequently we are able to reject hypothesis (4) that predicted a negative impact of absorptive capacity approximated by complementary subsidiary knowledge stocks.

Country-specific effects

Across all estimations, we found significant unobserved host-country-effects using Poland as point of reference. However, the pattern differs depending on the regressant in question. In the case of the importance of the foreign parent for patents, licences and R&D (1.1) we found for subsidiaries based in Estonia a higher probability that they did not benefit from this type of internal technology transfer. This is most likely to be linked to the industrial compositions of FDI into Estonia, which rather tends to be skewed towards low and medium low-tech industries. For human capital formation as dependent variable (1.2), we find that subsidiaries based in Estonia, Hungary, and Slovenia showed a higher probability to indicate that the foreign parent was not important as a supplying source. A possible explanation could be that Hungarian, Slovenian, and Slovakian foreign invested firms have a comparatively higher level of human capital in comparison to Polish and Estonian firms. On the other hand, it might also be partially explained by the fact that the dominating types of activities require higher levels of involvement of the foreign investor for building human capital. With regard to the importance of the foreign investor as a source of quality control (1.3), we again find significantly higher probability for Hungarian enterprises not to benefit from such knowledge inflows in comparison to the Polish group. The opposite is the case for the Slovakian foreign affiliates. It is possible that in Slovakian firms the share of total sales going to the foreign parent is comparatively high. Subsequently, quality standards and compatibility requirements might explain the relatively strong emphasis on quality control related knowledge inflows.

Firm specific effects

We also controlled for firm-specific effects by considering the foreign invested firms' size and age. However, both variables have no significant impact on any type of knowledge inflow. That is somehow surprising particularly in the case of the size.

Goodness of fit and robustness

Following White (1982) given that the assumptions of consistency and asymptotic normality hold, we are able to perform a Wald-Test (1943) to evaluate whether the model as such is significant. Before using the Wald-Test one has to make sure that the model is correctly specified. The results show significant p-values for each estimations (see appendix Table 1). We also present the Pseudo-R^2, but as long as one deals with non-linear models, the Pseudo-R^2 does not provide information on the percentage of explained variance to total variance. As not being bounded by zero and unity, the value of the Pseudo-R^2 can be interpreted as absolute value only. Judging from the estimation (1.2) shows the highest value followed by (1.3) and (1.1). We also indicate the Schwartz information criteria. The lower the value, the better the model explains the underlying data. Judging from this again estimation (1.2) explains the underlying data best followed by model (1.1), and (1.3).

The interpretation of the above outlined estimations of coefficients, marginal effects, as well as test statistics rely on the assumption that the residuals are homoscedastic normally distributed. According to Greene (2003) heteroscedasticity consistent estimation models exist only for multinomial logit and multinomial probit purposes. Therefore, we are not able to estimate a heteroscedasticity consistent model. However, we try to assess whether we have to deal at all with a heteroscedasticity problem. First, we choose a descriptive approach, where we plot the standardised predicted values against the variance of the non-standardised residuals for each specifications estimate. The analysis shows no deviations from linearity, which would imply that our parameter estimators are consistent so far. Second, we examine the biases of the covariance matrix by using a bootstrap technique (Green 2003). In fact we find that the estimators and corresponding bootstrap estimators do not differ much in the parameter estimates. Consequently, we consider the parameters are estimated consistent. In Probit techniques the probability function has to be the normal distribution function. However, as we are dealing with a relatively small size of a micro-data set, the assumption of normal distributed error terms seems somewhat heroic. We use probability-probability plots of the ε -vector to assess normal distribution of residuals. The plots show that the assumption of normally distributed error terms seems to hold.

Discussion

For CEE, traditional economic studies concerned with the technology related effects of FDI have focused almost exclusively on spillover effects whereas the empirical evidence on internal technology transfer to MNC subsidiaries, based in CEE, is fairly limited (see Jindra 2005 for an overview). This study makes a contribution to fill this gap. Thereby, we test the ‘technology gap’ and develop and empirically test a ‘complementary knowledge stock’ hypothesis.

So far the evidence on the impact of the technology gap on intra-MNC knowledge flows has been very limited. Despite a rich literature on technology gaps and spillover effects from FDI, to our knowledge this is the first study to focus explicitly on the ‘technology gap’ hypothesis (Findley 1978) vs. the ‘technology accumulation’ hypothesis (Cantwell 1989) in the context of knowledge flows within the MNC. Furthermore, we go beyond the study by Gupta and Govindarajan (2000) by assessing the impact of the technology gap at industry level. Our results suggest that a large gap in labour productivity is positively associated with R&D related knowledge inflows i.e. mostly codified knowledge and explicit knowledge. From that point of view, there are substantial differences as to what extent foreign affiliates in particular industries actually benefit from R&D related knowledge inflows. So here subsidiaries in industries further away from the international technology frontier have a higher probability of knowledge inflows. However, the technology gap seems to have no statistical impact on internal technology transfer proxied by human capital formation or specific skills such as quality control. Hence, our evidence lends partial support to the ‘technology gap’ hypothesis in line with evidence from FDI spillover studies such as Blomström and Wolff (1994), Casteallani and Zanfei (2003), Blalock and Gertler (2004) as well as Gupta and Govindarajan (2000). However, the results also indicate that we have to be aware of industry differences when choosing a proxy for knowledge transfer in large firm-level studies. As our results indicate choosing an R&D related proxy introduces a bias towards particular high-tech industries. On the other hand, we find strong support for the concept complementary knowledge stocks for all three across all here different types of knowledge inflows. In other words, the higher the subsidiaries complementary knowledge stock (for example R&D), the higher the R&D related knowledge inflows from the foreign owner company. We would argue that this adds a new element, namely complementarity, to the absorptive capacity concept as suggested by (Cohen and Levinthal, Lane and Lubatkin 1998). This finding is in line with the argument that absorptive capacity is a function of technology accumulation and human capital formation (similar to Borenzstein et al 1998). Our evidence also supports also the argument that knowledge transfer (intra MNC and external effects) is not an automatic process (Kinoshita 2000) it rather depends rather on the extent to which *subsidiaries* are engaged into local knowledge enhancing activities (Todo and Miyamato 2002, Marin and Bell 2004).

Limitations and Future Research

There are several caveats to the research presented in this study. First, we use cross-sectional data that does not allow us to analyse the dynamics of intra-MNC knowledge transfer. Second, the representativeness of our data varies to a considerable extent across the countries in the sample. Thus, the number of observations is limited but fairly high in comparison to similar firm-level data studies in the international business literature (for example Taggert 1999, Anderson et al 2001, Harzing and Sorge 2003, Anderson et al 2005, Birkinshaw et al 2005). Moreover, the country composition of the data set has been limited to EU membership applicants at the time. On the one hand, this generates a certain homogeneity regarding the institutional background, on the other hand, limits the results in their generalisation for the Central and East European context as such. Third, the applied ordered probit model is superior to binary probit models, because we capture the full range of ordered information correctly. On the other hand, and this is the case for all probit models, we are not able to test the efficiency and consistency of the parameter estimators beyond reasonable doubt.

Future research on technology transfer should extend the comparative approach by including a broader set of CEE transition countries, emerging economies from the South-East Asian, and South American area, and put the results into the perspective of developed economies such as Japan, USA, and the EU-15 countries. This research should increasingly employ time series data in order to make some reliable conclusion regarding the dynamics of internal technology transfer. This study adopted a view on FDI as augmenting technology.

However, according to the Criscuolo and Narula model (2002), over time we would expect that firms located in emerging economies start to develop their own international activities in from of outward FDI and strategic alliances. Already now, Russian, Chinese, and Mexican firms have started to acquire assets in the US and the EU. Local firms might also increasingly become targets of technology-seeking FDI. Future research should start to trace such changes carrying important theoretical implications with respect to international activities of the firm, organisational changes within multinationals, and the dynamics of international technology transfer. On the other hand, the FDI spillover research should test explicitly the impact of MNC heterogeneity on horizontal as well as vertical external effects for domestic enterprises.

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Appendix Chart 1:

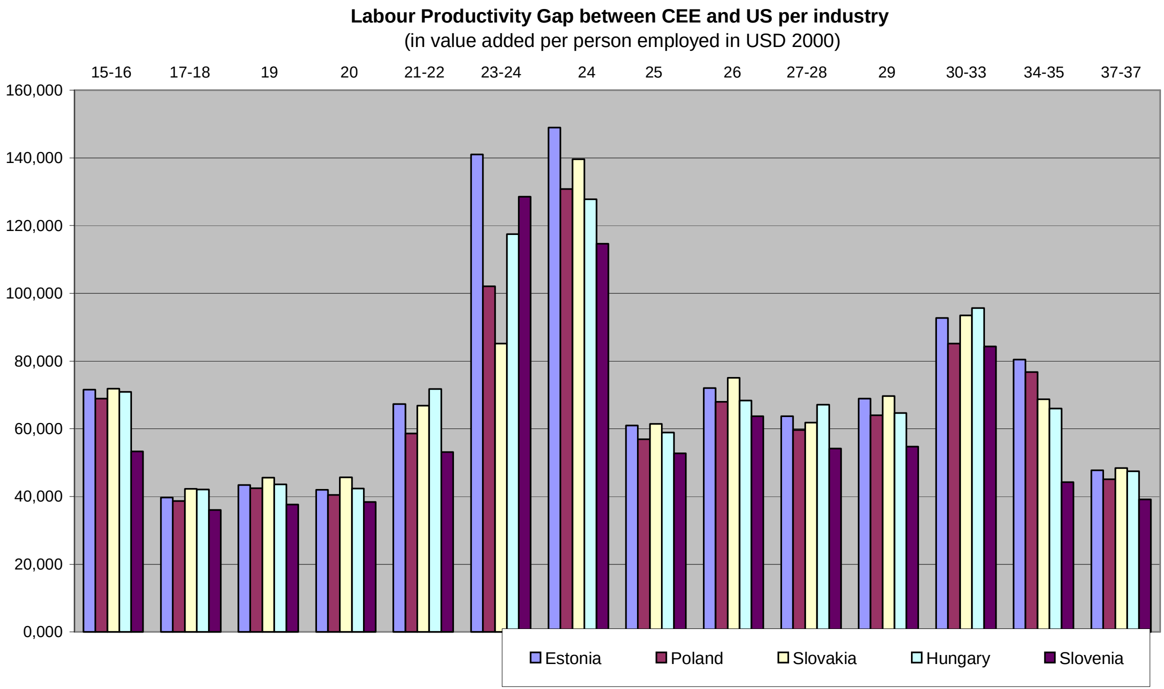

Table 1: Complete estimation results

Marginal effects for the probabailty that the MNC is not importnat as a source for:	Patents, leicences, R&D		Human Capital formation		Quality control	
	(1.1)		(1.2)		(1.2)	
Dummy for FDI host economy (Poland as control group)						
Estonia	0,154	**	0,103	*	0,003	
Hungary	0,063		0,214	***	0,148	***
Slovakia	-0,036		0,026		-0,069	**
Slovenia	-0,041		0,131	**	0,021	
Firm-specific effects						
Size (in number of employees)	0,006		0,009		0,004	
Age (in years sinec establishement)	-0,004		-0,012		-0,123	
Main exogenous variables						
Industry labour producitvity gap	-0,002	**	0,000		0,000	
Complimentary knwoledge stock	-0,037	***	-0,095	***	-0,075	***
cut_points						
LIMIT_1 (little important)	-0,180		0,210		0,391	
LIMIT_2 (important)	0,232		0,700		0,792	
LIMIT_3 (very important)	0,817		1,526		1,328	
LIMIT_4 (extremely important)	1,542		2,511		2,060	
N	360		367		370	
Wald-Statistic	27,980		50,870		39,970	
Prob(Wald-Statistik) (chi2)	0,001		0,000		0,000	
Schwarz Kriterium (bic)	1174,83		1155,11		1183,75	
Pseudo R-squared	0,029		0,0462		0,033	