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Foreign Direct Investment, Spillovers and Absorptive Capacity: Evidence from Quantile Regressions

by

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Foreign direct investment, spillovers and absorptive capacity:
Evidence from quantile regressions

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Abstract:

This paper focuses on the role of absorptive capacity in determining whether or not domestic firms benefit from productivity spillovers from FDI using establishment level data for the UK. We allow for different effects of FDI on establishments located at different quantiles of the productivity distribution by using conditional quantile regression. Overall, while there is some heterogeneity in results across sectors and quantiles, our findings clearly suggest that absorptive capacity matters for productivity spillover benefits. We find evidence for a u-shaped relationship between productivity growth and FDI interacted with absorptive capacity. We also analyse in some detail the impact of changes in absorptive capacity on establishments' ability to benefit from spillovers.

Keywords: foreign direct investment, absorptive capacity, productivity spillovers, quantile regressions

JEL-Classification: F21, F23

Non Technical Summary

Many governments around the globe actively attempt to attract multinational companies (MNCs) to locate in their country using substantial fiscal and financial incentives. One of the main rationales for these policy interventions is the belief that domestic firms can benefit from the presence of foreign multinationals through productivity spillovers. Hence, domestic firms may improve their productivity if there are positive externalities emanating from multinationals.

Recent surveys of the literature conclude that there does not appear to be much evidence that there are aggregate benefits which accrue to all types of domestic firms equally. Rather, it appears that conditions in the host country seem crucial for whether or not there are positive spillovers. In particular, the absorptive capacity of domestic firms, that is their ability to utilise spillovers from multinationals to improve their productivity, has been found to be an important determinant for whether or not domestic firms benefit from foreign direct investment (FDI).

The aim of this paper is to focus in detail on the role of establishments' absorptive capacity in determining the magnitude of possible benefits from FDI. To this end we calculate absorptive capacity as the gap in total factor productivity (TFP) between the domestic establishment and the "industry leader" and allow for a non-linear relationship between FDI and absorptive capacity. We then investigate how changes in absorptive capacity may determine the benefits to domestic firms from productivity spillovers, holding FDI constant. This is an important issue from a policy point of view, as policy may be more easily targeted at improving levels of absorptive capacity than at fine tuning the level or growth inward FDI. A further contribution of our paper is that we allow for different effects of FDI on TFP at different quantiles of the productivity distribution. This allows us to take better account of the large and persistent heterogeneity in productivity dynamics across establishments. We present a detailed analysis of the role of absorptive capacity for FDI spillovers using data for the UK.

Our results indicate that absorptive capacity is important in determining whether or not domestic establishments benefit from FDI spillovers. We find a u-shape relationship between productivity growth and spillovers from FDI interacted with absorptive capacity. We determine the exact turning points for the quadratic relationship and evaluate the marginal effects of changes in absorptive capacity on productivity holding FDI constant.

Nicht technische Zusammenfassung

Viele Regierungen in der ganzen Welt versuchen aktiv, multinationale Unternehmen (MNU) ins Land zu holen, und bieten dabei erhebliche steuerliche und finanzielle Anreize. Einer der Hauptgründe für diese politischen Eingriffe ist die Überzeugung, dass die inländischen Firmen durch Spill-over-Effekte bei der Produktivität von der Präsenz multinationaler ausländischer Unternehmen profitieren können. Wenn zum Beispiel positive externe Effekte von den multinationalen Unternehmen ausgehen, könnten die inländischen Firmen ihre Produktivität steigern.

Nach den jüngsten Veröffentlichungen zu urteilen, scheint nicht viel darauf hinzudeuten, dass es einen gesamtwirtschaftlichen Nutzen gibt, der allen Arten von inländischen Unternehmen gleichermaßen zugute kommt. Es ist wohl vielmehr so, dass die Bedingungen im Gastgeberland einen entscheidenden Einfluss darauf haben, ob es positive Spill-over-Effekte gibt oder nicht. Insbesondere die Absorptionskapazität der inländischen Firmen, d. h. ihre Fähigkeit, von multinationalen Unternehmen ausgehende Spill-over-Effekte zur Steigerung ihrer Produktivität zu nutzen, erwies sich als wichtiger Punkt bei der Frage, ob inländische Firmen von ausländischen Direktinvestitionen (ADI) profitieren können oder nicht.

In diesem Diskussionspapier soll eingehend untersucht werden, inwieweit die Absorptionskapazität von Unternehmen das Ausmaß des aus ADI zu ziehenden Nutzens beeinflusst. Zu diesem Zweck berechnen wir die Absorptionskapazität als Differenz der Faktorproduktivität (TFP) zwischen der inländischen Firma und dem „Branchenmarktführer“ und gehen dabei von einer nichtlinearen Beziehung zwischen den ADI und der Absorptionskapazität aus. Danach untersuchen wir, wie der Nutzen, den inländische Unternehmen aus Spill-over-Effekten auf die Produktivität ziehen, von der Absorptionskapazität beeinflusst wird. Dies ist eine wichtige politische Frage, da eine Verbesserung der Absorptionskapazität leichter angestrebt werden könnte als eine Feinsteuerung der Höhe oder des Wachstums der zufließenden Direktinvestitionen. Außerdem werden in unserem Papier die unterschiedlichen Auswirkungen der ADI auf die TFP bei einzelnen Quantilen der Produktivitätsverteilung untersucht. Dadurch können wir die große und permanente Heterogenität der Produktivitäts-dynamik zwischen den Unternehmen besser berücksichtigen. Wir präsentieren eine detaillierte Analyse der Auswirkungen der Absorptionskapazität auf die Spill-over-Effekte von ADI anhand von Daten für Großbritannien.

Unsere Ergebnisse zeigen, dass die Absorptionskapazität bei der Frage, ob inländische Firmen von Spill-over-Effekten bei ADI profitieren oder nicht, eine wichtige Rolle spielt. Wir stellen eine u-förmige Relation zwischen Produktivitätswachstum und Spill-over-Effekten aus ADI in Abhängigkeit von der Absorptionskapazität fest. Wir bestimmen die genauen Wendepunkte für die quadratische Relation und ermitteln die marginalen Auswirkungen von Änderungen der Absorptionskapazität auf die Produktivität bei konstanten ADI.

Contents

Lists of Tables and Figures

Foreign direct investment, spillovers and absorptive capacity: Evidence from quantile regressions [*]

1 Introduction

Many governments around the globe actively attempt to attract multinational companies (MNCs) to locate in their country using substantial fiscal and financial incentives. For example, the British Government provided an estimated $30,000 and $50,000 per employee to attract Samsung and Siemens respectively to the North East of England in the late 1990s (Girma et al., 2001). Across the Atlantic, the government of Alabama paid the equivalent of $150,000 per employee to Mercedes for locating its new plant in the state in 1994 (Head, 1998). Some countries also provide tax incentives. For example, Ireland offers a corporate tax rate of 12.5 percent to all manufacturing firms locating in the country.

One of the main rationales for these policy interventions is the belief that domestic firms can benefit from the presence of foreign multinationals through productivity spillovers. Hence, domestic firms may improve their productivity if there are positive externalities emanating from multinationals, although domestic firms may be affected adversely if competition with multinationals reduces output for domestic firms and, thus, leads to reductions in productivity (see Aitken and Harrison, 1999).

Recent surveys of the literature conclude that there does not appear to be much evidence that there are aggregate benefits which accrue to all types of domestic firms equally (see Görg and Greenaway, 2004 and Blomström and Kokko, 1998). Rather, it appears that conditions in the host country seem crucial for whether or not there are positive spillovers. In particular, the absorptive capacity of domestic firms, that is their ability to utilise spillovers from multinationals to improve their productivity, has been

[*] Remarks: The authors are grateful to the ONS Business Data Linking Project for providing access to the ARD database. Thanks are due to David Greenaway, Steve Redding, Beata Smarzynska Javorcik, Eric Strobl, Dieter Urban and participants at the Kiel Workshop on Multinationals and International Integration, the RES conference in Warwick, a NUPI/TIK workshop in Oslo and a seminar at IIIS Dublin for helpful comments. Financial support from the European Commission (Grant Nos. HPSE-CT-1999-00017 and SERD-2002-00077) and the Leverhulme Trust (Grant No. F114/BF) is gratefully acknowledged.

found to be an important determinant for whether or not domestic firms benefit from foreign direct investment (FDI).[1]

The aim of this paper is to focus in detail on the role of establishments' absorptive capacity in determining the magnitude of possible benefits from FDI. To this end we calculate absorptive capacity as the gap in total factor productivity (TFP) between the domestic establishment and the "industry leader" and allow for a non-linear relationship between FDI and absorptive capacity. We then investigate how changes in absorptive capacity may determine the benefits to domestic firms from productivity spillovers, holding FDI constant. This is an important issue from a policy point of view, as policy may be more easily targeted at improving levels of absorptive capacity (through, for example, training or R&D programmes) than at fine tuning the level or growth of inward FDI.

A further contribution of our paper is that we allow for different effects of FDI on TFP at different quantiles of the productivity distribution. While standard least squares estimates the mean of the dependent variable conditional on the covariates we use the quantile regression estimator to estimate the effect of the covariates on different quantiles of the productivity distribution. This allows us to take better account of the large and persistent heterogeneity in productivity dynamics across establishments.[2]

We present a detailed analysis of the role of absorptive capacity for FDI spillovers using data for the UK.[3] Our results indicate that absorptive capacity is important in determining whether or not domestic establishments benefit from FDI spillovers. We find a u-shape relationship between productivity growth and spillovers from FDI interacted with absorptive capacity. We determine the exact turning points for the quadratic relationship and evaluate the marginal effects of changes in absorptive capacity on productivity holding FDI constant.

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1 Keller (2001) also discusses the role of absorptive capacity for successful technology diffusion.

2 To the best of our knowledge, there has been only one previous application of quantile regression in the literature on productivity spillovers. Dimelis and Louri (2002) apply this technique to analyse spillovers from FDI for a sample of Greek manufacturing firms using cross-sectional data. They do not allow for an impact of domestic firm's absorptive capacity, however. Also, they only analyse the effect of FDI on domestic labour productivity while we look at total factor productivity.

3 While much of the literature on productivity spillovers has focused on developing countries, the literature on developed countries has grown substantially in the very recent past. In particular, there have been a number of recent studies on the UK (for example, Driffield, 2001, Girma et al., 2001,

The remainder of the paper is structured as follows. Section 2 presents a brief review of the literature on the role of absorptive capacity for FDI spillovers. Section 3 outlines the econometric methodology and discusses the advantages of using quantile regression in the context of our paper. Section 4 discusses the dataset and some summary statistics while Section 5 presents the empirical results. Finally, Section 6 concludes.

2 The role of absorptive capacity

In an early theoretical paper, Findlay (1978) emphasised the importance of relative backwardness for the speed of adoption of new technologies and spillover benefits from multinationals. Findlay's model suggests that the greater the technological distance between the (less advanced) host and (advanced) home country, the greater the available opportunities to exploit in the former and the more rapidly new technology is adopted. Hence, the potential for positive spillovers is higher the larger the technology gap between host and home. More recently, however, this view has changed. For example, Glass and Saggi (1998) also see a role for technological distance between the host and home country, however, they see the technology gap as indicating absorptive capacity of host country firms, i.e., their ability to absorb and utilise the knowledge that spills over from multinationals. The larger the gap, the less likely are host country firms to have the human capital and technological know-how to benefit from the technology transferred by the multinationals and, hence, the lower is the potential for spillover benefits.

There have been a number of empirical studies examining this issue. Kokko (1994) advances the idea that spillovers depend on the complexity of the technology transferred by multinationals, and the technology gap (that is, the difference in labour productivity) between domestic firms and MNCs. Using cross-section industry level data for Mexico he finds no evidence for spillovers in industries where multinationals use highly complex technologies (as proxied by either large payments on patents or high capital intensity). A large technology gap *per se* does not appear to hinder technology

Girma and Wakelin, 2001, Haskel et al., 2002). None of the studies analyses the role of absorptive capacity in such detail as done in this paper.

spillovers on average, although industries with large technology gaps and a high foreign presence experience lower spillovers than other industries.[4]

Kokko et al. (1996) hypothesise that domestic firms can only benefit if the technology gap between the multinational and the domestic firm is not too wide so that domestic firms can absorb the knowledge available from the multinational. Thus domestic firms using very backward production technology and low skilled workers may be unable to learn from multinationals. Using a cross-section of firm-level data for Uruguay, Kokko et al. find evidence for productivity spillovers to domestic firms with moderate technology gaps, (measured as the difference between the firm's labour productivity and the average labour productivity in foreign firms) but not for firms which use considerably lower levels of technology.[5]

Girma et al. (2001) use firm-level panel data to examine productivity spillovers in UK manufacturing. They find evidence for spillovers to firms with a low difference between the firm's productivity level and the industry frontier productivity level (termed "technology gap"). Firms with a technology gap of 10 per cent or less appear to increase productivity with increasing foreign presence in the industry, while firms with higher gaps seem to suffer reductions in productivity.

These papers define absorptive capacity as a technology gap defined in terms of productivity differentials between foreign and domestic firms. This is motivated by the idea that domestic firms with productivity levels similar to multinationals' may also be more capable of absorbing the transferred technology. Other definitions of absorptive capacity have been put forward, however. For example, Kinoshita (2001) finds evidence for positive spillovers from FDI to local firms that are R&D intensive in her analysis of firm level panel data for the Czech Republic. She interprets firms' R&D intensity as a measure of absorptive capacity.[6] Barrios and Strobl (2002) also take R&D active domestic firms as having absorptive capacity. Furthermore, they argue that

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4 Kokko (1994) argues that these industries show many of the characteristics of being "enclaves" where multinationals have little interaction with domestic firms and, hence, there is little scope for spillovers.

5 By contrast, Sjöholm (1999) finds that, in cross-sectional data for Indonesian manufacturing firms, productivity spillovers from foreign to domestic firms are larger the larger the technology gap (also defined in terms of differences in labour productivity) between those groups of firms and the higher the degree of competition in the industry.

6 Somewhat related, Görg and Strobl (2003) distinguish positive effects from FDI on domestic plants in high vs low tech industries, and find that only plants in the former industries benefit.

exporting firms are more exposed to competition on foreign markets and may, therefore, be likely to have higher levels of technology, and thus absorptive capacity, than non-exporters. In their empirical analysis, using firm level panel data for Spain, they find that, indeed, exporters benefit more from FDI spillovers, but that there is no apparent absorptive capacity effect for R&D active firms relative to those that are not R&D active.

3 Econometric model and estimation technique

3.1 Modelling productivity spillovers from FDI

Empirical studies on productivity spillovers commonly regress firm level productivity on a number of covariates, including foreign presence in the industry. This implies the constraint that all firms benefit equally from spillovers, *ceteris paribus*. In this paper we allow the spillover effect to vary across plants according to their level of absorptive capacity (ABC). Our assumption is that plants with higher levels of ABC (lower technology gaps vis-à-vis the industry leader) are able to reap greater benefits from foreign direct investment, as they have the necessary technological ability to assimilate the knowledge available from foreign multinationals.[7]

Specifically, to investigate the role of absorptive capacity we estimate the impact of FDI spillovers on productivity via the following total factor productivity (TFP) growth equation,

$$\Delta TFP_{it} = \beta' X_{it-1} + \gamma(ABC)\Delta FDI_{jt} + D_{rt} + \varepsilon_{it} \tag{1}$$

which forms the basis for our empirical work.[8] Here *i, j r* and *t* index establishment, four-digit industries, regions and time periods respectively. *X* is a vector of variables hypothesised to impact on plant level TFP growth trajectories, namely plant

[7] We are cautious to point out, however, that TFP is of course only a noisy measure of the technological level of the plant, as there may, for instance, be temporary shocks that affect TFP but do not at the same time change a plants technological capability. If anything, this should cause estimated spillover effects to be downward biased.

[8] We utilise a TFP growth rather than levels equation as this purges any establishment specific time invariant effects that impact on TFP in levels.

age and a measure of four-digit industry concentration (Herfindhal index).[9] *FDI* is a vector that captures foreign presence in the firm's four-digit industry; as is common in the literature (see Görg and Strobl, 2001) it is calculated as the proportion of employment in the industry accounted for by foreign multinationals.[10] *D* denotes full sets of regional and time dummies and ε is a random error term. The use of regional dummies helps mitigate concerns that, within a sector, the regional location of FDI might be correlated with factors that also affect plants' productivity.

If absorptive capacity matters for the pattern of FDI-induced TFP growth, the spillovers regression functions will not be identical across all domestic firms. For this reason the coefficient on the FDI vector in the above equations is explicitly made to depend on absorptive capacity (*ABC*), which is defined as

$$ABC_{it} = TFP_{it-1} \Big/ \max_{industry}(TFP_{jt-1}) \tag{2}$$

that is, establishment *i*'s TFP relative to the maximum TFP in the four digit sector (the "industry leader").[11] A high level of absorptive capacity is supposed to indicate technological congruity with industry leaders, which are predominantly foreign plants in the data.

In order to allow for possible non-linearities we allow the parameter capturing the degree of spillovers, γ, to be a quadratic function of the firm specific level of absorptive capacity,

$$\gamma = d_0 + d_1 ABC + d_2 ABC^2 \tag{3}$$

where the *d* are parameters to be estimated. Setting $d_2 = 0$ gives the linear model, which implies that the degree of spillovers either increases or decreases with absorptive

[9] Nickell (1996) argues that competition can affect total factor productivity growth. We calculate a Herfindahl index based on plant's market shares in terms of employment shares.

[10] Note that we neglect a regional dimension to spillovers and instead assume that spillovers dissipate through the whole of the industry, regardless of location. Girma and Wakelin (2001) focus on regional spillovers from FDI.

[11] As discussed above, other measures of absorptive capacity have been employed in the literature, such as R&D, export activity. Due to data availability we focus on the relative productivity measure. This measure may also be most appropriate as it determines the relative efficiency of the plant. Note also that, since we define absorptive capacity as a relative concept, i.e., each establishment's distance from

capacity monotonically. The quadratic specification is more flexible in that it allows the rate of FDI-induced productivity growth to vary with absorptive capacity. For example with $d_1 > 0$ and $d_2 < 0$, the initially positive impact of FDI on productivity will start to diminish once absorptive capacity gets past the critical level (or turning point) $ABC = -(d_1/2d_2)$.

3.2 Quantile regression

Recent empirical studies of firm-level productivity dynamics have established that there is large and persistent heterogeneity across firms even within narrowly defined industries, and that the amount of change in the productivity distribution is not trivial (see, e.g., Bartelsman and Doms, 2000). This has an important but previously unrecognised implication for productivity growth empirics: standard OLS or GMM techniques which concentrate on the conditional mean function of the dependent variable are unlikely to be adequate analytical tools. In the presence of heterogeneous productivity processes, it is more appropriate (and arguably more interesting) to examine the dynamics of productivity at different points of the distribution rather than "average" properties (i.e. conditional means).

To do this, we employ the quantile regression technique introduced by Koenker and Bassett (1978). Denoting the vector of regressors in equation (1) by *Z*, the quantile regression model can be written as

$$TFP_{it} = Z'_{it}\beta_\theta + \varepsilon_{\theta it}, \quad Quant_\theta(TFP_{it} \mid Z_{it}) = Z'_{it}\beta_\theta \tag{4}$$

where $Quant_\theta(TFP_{it} \mid Z_{it})$ denotes the conditional quantile of TFP. The distribution of the error term ε_θ is left unspecified, so the estimation method is essentially semiparametric.[12] The θ^{th} quantile regression, $0 < \theta < 1$, solves

$$\min_\beta \frac{1}{n}\left\{ \sum_{i,t:TFP \geq z'\beta} \theta \left| TFP_{it} - Z'_{it}\beta \right| + \sum_{i,t:TFP < z'\beta} (1-\theta) \left| TFP_{it} - Z'_{it}\beta \right| \right\}. \tag{5}$$

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the industry leader, this should not lead to problems if the industry leader is an extreme outlier or changes over time.

12 See Buchinsky (1998) for an overview of quantile regression models.

As one keeps increasing θ from 0 to 1, one can trace the entire conditional distribution of plant level productivity, conditional on the set of regressors. Thus quantile regressions allow us to focus attention on specific parts of the productivity distribution, and help us answer questions like 'what are the FDI-induced externalities to firms below the 10^{th} percentile level of TFP?' This is a practically important question, since different responses to FDI may be expected from firms at different points of the productivity distribution.

Furthermore, another advantage of quantile methods is that they provide a more robust and efficient alternative to least squares estimators when the error term is non-normal. This may be important here since establishment level TFP does not appear to be (log)normally distributed. Figure 1 shows, for the years 1980 and 1992, Kernel density estimates of log TFP and the corresponding normal density if the data were normally distributed. There are departures from normality apparent, in particular for the electronics sector. Table 1 shows some more detailed summary statistics and the p-values for two tests of normality. In all cases we can reject the null hypothesis that log TFP be normally distributed.

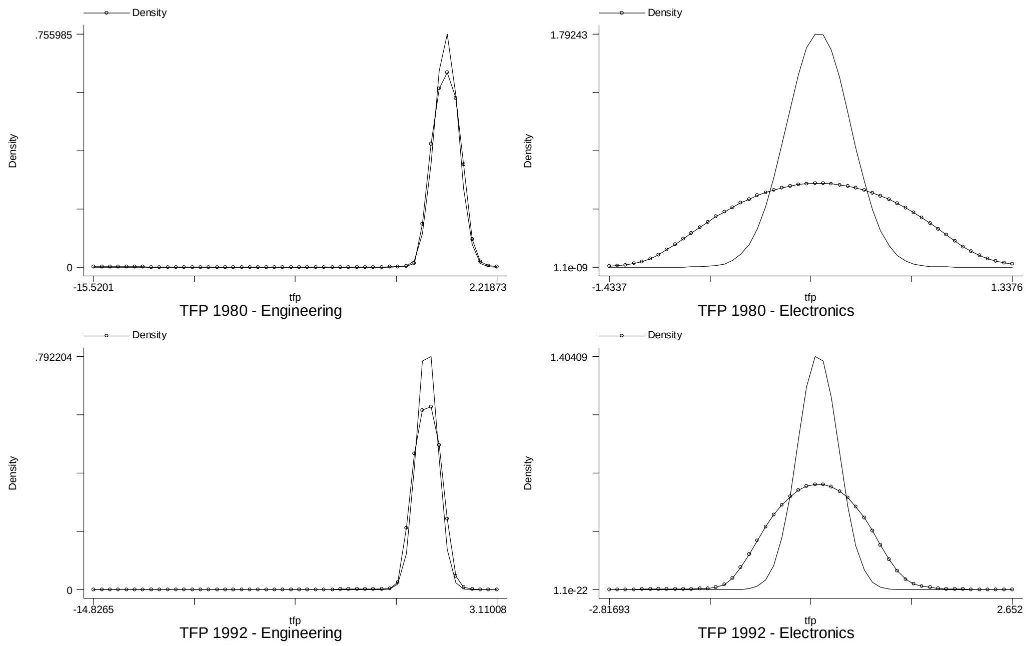
Since the data set contains a finite number of observations, only a finite number of quantiles are distinct. In this study we consider regression estimates at five different quantiles, namely, the 10^{th}, 25^{th}, 50^{th} (median), 75^{th} and 90^{th} percentiles of the TFP distribution. The use of an absorptive capacity proxy in the set of regressors implies that, even within a particular conditional quantile, the response of plant level productivity growth to FDI will vary according to initial level of productivity.

3.3 TFP estimation

For the estimation of equation (1) we need to have reliable estimates of plant level TFP. Using log values, we write the production function as $y_{it} \equiv f(l_{it}^s, l_{it}^u, k_{it}, m_{it}, TFP_{it})$, where y is output and there are four factors of production: skilled labour (l^s), unskilled labour (l^u), materials or cost of goods sold (m) and capital stock (k). For estimation purposes we employ a first-order Taylor approximation and write the production function as:

$$y_{it} = \beta_0 + \beta_s l_{it}^s + \beta_u l^u{}_{it} + \beta_k k_{it} + \beta_m m_{it} + TFP_{it} \quad (6)$$

Figure 1: Kernel density estimates of log TFP



Note: dotted line is density, solid line is normal distribution

Table 1: Summary statistics for log TFP

	all observations	Engineering 1980	Engineering 1992	Electronics 1980	Electronics 1992
Mean	0.004	-0.005	0.011	0.005	0.016
std.dev.	0.379	0.525	0.472	0.221	0.280
Skewness	-19.163	-20.056	0.222	0.372	-0.358
Kurtosis	753.977	560.842	-16.350	4.966	16.236
10^{th} quantile	-0.257	-0.265	-0.248	-0.240	-0.236
25^{th} quantile	-0.136	-0.145	-0.120	-0.125	-0.125
Median	-0.010	-0.013	0.006	-0.013	0.001
75^{th} quantile	0.133	0.134	0.159	0.124	0.130
90^{th} quantile	0.303	0.304	0.324	0.271	0.296
observations	40432	2112	1821	857	1022
test1 (p-value)	--	0.000	0.000	0.000	0.000
test2 (p-value)	0.000	0.000	0.000	0.000	0.000

Notes: test1: test for normality (Shapiro and Francia, 1972)
test2: skewness and kurtosis test for normality (D'Agostino et al, 1990)

TFP is assumed to follow the following AR(1) process:

$$TFP_{it} = \rho TFP_{it-1} + \delta D_t + f_i + v_{it} \qquad (7)$$

where D is a common year-specific shock, f is a time-invariant firm specific effect and v a random error term. Note that we do not simply model productivity as a fixed effect, as that would imply that TFP differences are fixed, and there is no role for technology diffusion (convergence).

Recently the fundamental assumption of pooling individual times series data has been questioned. Pesaran and Smith (1995) demonstrate that standard GMM estimators of dynamic panel models lead to invalid inference if the response parameters are characterised by heterogeneity. They argue that one is better off averaging parameters from individual time series regressions. This is not feasible here since the individual firm's time series data is not of adequate length (75 percent of them have no more than 6 observations). However, we take some comfort from a recent comparative study by Baltagi and Griffin (1997) which concludes that efficiency gains from pooling are likely to more than offset the biases due to individual heterogeneity. Baltagi and Griffin (1997) especially point out the desirable properties of the GLS-AR(1) estimator, and we use this estimator to obtain estimates of the factor elasticities, and derive TFP as a residual term. We estimate equation (7) for each of the 49 the four-digit SIC80 industries available in our sample, including subsidiaries of foreign firms to facilitate the computation of the relative technology gaps described in equation (2).[13]

4 Data

We use establishment level panel data for UK manufacturing industries from the Annual Respondents Database (ARD) provided by the Office for National Statistics for the empirical analysis. The database is described in more detail in Appendix I. This

[13] The estimations of equation (7) are not reported here to save space. Note that we have a large number of observations even when estimating the equation for each of the 49 four digit sectors; the minimum number of observations is no less than 170. Figure 1 and Table 1 provide some summary statistics for the estimated TFP values.

paper uses data for two broad industries, electronics and mechanical and instrument engineering, spanning 49 four-digit SIC80 industries.[14]

Since there is evidence of substantial heterogeneity of productivity even within, let alone across sectors, we decided to estimate the equations for different sectors rather than pooling data for the whole manufacturing sector. Furthermore, focusing explicitly on two narrowly defined sectors should mitigate concerns that the location of FDI in a sector might be correlated with factors affecting plants' productivity.

Our choice of sectors is motivated by the following considerations. First, FDI is important in both sectors. As Griffith and Simpson (2004, Table 4) show, employment in foreign-owned establishments accounted for almost 19 percent of total employment in the electronics sector, and around 15 percent in the engineering sector in 1996. Second, there appears to be evidence of contrasting motives for inward FDI in the two sectors. According to Driffield and Love (2002), R&D activity in the UK engineering industry is greater than R&D intensity in the corresponding sectors in the FDI source countries. This suggests that FDI into this sector might be largely motivated by technology sourcing considerations (see Fosfuri and Motta, 1999). Hence, at least in theory, the scope for technology spillovers may be limited compared to potential spillovers from FDI in the electronics sector, where multinational firms in the UK are known to undertake a significant proportion of their innovative activity in the host country.[15]

We excluded from our regression analysis domestic establishments with zero output, negative capital stock and with no regional information. Table 2 gives the panel structure of the resulting sample of establishments used in this study. A sizeable proportion are only observed once. Our estimation cannot use these due to the need to use lagged variables to construct TFP growth.

[14] These are SIC80 industries 33 and 34 (electronics) and 32 and 37 (mechanical and instrument engineering). We refer to the latter as "engineering" throughout the paper.

[15] For example Cantwell and Iammarino (2000) indicate that in semiconductors the share of foreign-owned firms in total patents was over 60 percent for the UK as a whole, and 75 percent for South East England in particular.

Table 2: Number of domestic plants by number of years observed

	Electronics		Engineering	
Years	# plants	%	# plants	%
1	807	27.19	2078	30.32
2	514	17.32	1203	17.55
3	316	10.65	776	11.32
4	245	8.25	572	8.35
5	197	6.64	468	6.83
6	150	5.05	378	5.52
7	134	4.51	269	3.93
8	98	3.3	221	3.22
9	97	3.27	181	2.64
10	72	2.43	155	2.26
11	72	2.43	127	1.85
12	94	3.17	147	2.15
13	172	5.8	278	4.06
Total	2968	100	6853	100

5 Empirical results

Estimates of plant level TFP were calculated as described in equations (6) and (7). These were then used in the productivity spillovers estimations of equation (1), the results of which are presented in Tables 3 and 4 for the electronics and engineering sector respectively.[16] The tables give results for estimations of the conditional mean as well as for the 10th, 25th, 50th (median), 75th and 90th quantile of the TFP distribution.

Overall, our estimations produce statistically significant coefficients on all FDI variables in both sectors and across quantiles, suggesting that the presence of FDI matters for productivity growth. While the results in terms of the signs of the coefficients seem to be similar across quantiles and between sectors, there is apparent heterogeneity in the magnitude of the coefficients. For example, for the electronics sector we find the lowest coefficients for the median and neighbouring quantiles, while

[16] In Appendix II we also report results for regressions including the simple FDI variable without the ABC interaction terms. From these regressions, we do not find robust evidence for spillovers. This highlights the importance of allowing for different effects of FDI for establishments with different levels of absorptive capacity, as we have done in our paper.

the magnitudes of coefficients are much more similar across quantiles for the engineering sector.

Table 3: Effect of FDI on domestic establishments' TFP – Electronics sector
(dependent variable: Δln TFP)

	(1)	(2)	(3)	(4)	(5)	(6)
	Mean	10th quantile	25th quantile	median	75th quantile	90th quantile
Age	-0.000	0.004	0.002	0.000	-0.002	-0.004
	(0.001)	(0.001)***	(0.000)***	(0.000)	(0.000)***	(0.001)***
Herfindahl index	-0.018	-0.190	-0.153	0.010	0.044	0.219
	(0.075)	(0.095)**	(0.048)***	(0.037)	(0.043)	(0.085)***
ΔFDI	1.511	1.205	0.819	0.487	0.632	1.065
	(0.345)***	(0.457)***	(0.214)***	(0.172)***	(0.224)***	(0.602)*
ΔFDI * ABC	-5.433	-4.183	-2.761	-1.845	-2.201	-3.083
	(1.261)***	(1.878)**	(0.842)***	(0.628)***	(0.784)***	(2.081)
ΔFDI * ABC^2	4.659	3.656	2.262	1.729	1.903	2.031
	(1.096)***	(1.822)**	(0.787)***	(0.546)***	(0.654)***	(1.720)
Constant	-0.003	-0.280	-0.140	-0.030	0.087	0.197
	(0.021)	(0.027)***	(0.014)***	(0.011)***	(0.013)***	(0.025)***
Observations	9555	9555	9555	9555	9555	9555

Notes: Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1% regressions include time and regional dummies

Table 4: Effect of FDI on domestic establishments' TFP – Engineering sector
(dependent variable: Δln TFP)

	(1)	(2)	(3)	(4)	(5)	(6)
	mean	10th quantile	25th quantile	median	75th quantile	90th quantile
age	0.001	0.003	0.001	0.000	-0.001	-0.003
	(0.001)*	(0.001)***	(0.000)***	(0.000)	(0.000)***	(0.001)***
Herfindahl index	0.005	-0.050	-0.029	0.013	0.026	0.072
	(0.076)	(0.067)	(0.034)	(0.025)	(0.034)	(0.059)
ΔFDI	3.808	0.831	0.923	0.938	0.963	1.603
	(0.336)***	(0.381)**	(0.158)***	(0.111)***	(0.177)***	(0.415)***
ΔFDI * ABC	-14.423	-3.120	-3.671	-3.473	-3.616	-5.881
	(1.345)***	(1.614)*	(0.656)***	(0.442)***	(0.681)***	(1.563)***
ΔFDI * ABC^2	12.127	2.464	3.204	2.836	3.138	5.002
	(1.249)***	(1.599)	(0.635)***	(0.410)***	(0.608)***	(1.353)***
Constant	-0.039	-0.256	-0.123	-0.001	0.115	0.259
	(0.026)	(0.024)***	(0.012)***	(0.009)	(0.012)***	(0.022)***
Observations	18474	18474	18474	18474	18474	18474

Notes: Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1% regressions include time and regional dummies

Marginal effects of changes in FDI

It is, of course, difficult to assess the size of the actual effect of FDI on productivity for establishments in the different quantiles of the TFP growth distribution, not least due to the inclusion of the interaction terms. Establishments that fall within the different quantiles of the TFP growth distribution may also be expected to have different levels of absorptive capacity.

To calculate the effect of FDI at the different quantiles for a given level of absorptive capacity we proceed as follows. First, we calculate the q^{th} quantile ($q = 10$, 25, 50, 75, 90) of the TFP growth distribution and construct a 90 percent confidence interval around that value. Second, we calculate the median absorptive capacity level for establishments within the 90 percent confidence interval of the q^{th} quantile. The results are shown in Table 5. It is noteworthy that the median absorptive capacity level is higher for the electronics sector for all quantiles, although electronics only has higher TFP growth in the lower quantiles of the distribution up to the median. This suggests that, in this sector, there is less of a productivity differential between foreign and domestic establishments.

Table 5: Mean ABC for firms within the 90 percent confidence interval of q^{th} quantile of ΔTFP

	ΔTFP	90% confidence interval for ΔTFP		median ABC
Electronics				
Mean	-0.002	-0.007	0.003	0.453
10^{th} quantile	-0.194	-0.202	-0.188	0.522
25^{th} quantile	-0.086	-0.089	-0.083	0.496
median	-0.001	-0.004	0.001	0.452
75^{th} quantile	0.083	0.080	0.087	0.430
90^{th} quantile	0.190	0.183	0.197	0.393
Engineering				
Mean	-0.009	-0.014	-0.003	0.403
10^{th} quantile	-0.221	-0.226	-0.217	0.442
25^{th} quantile	-0.1001	-0.103	-0.098	0.406
median	-0.003	-0.005	-0.001	0.415
75^{th} quantile	0.091	0.088	0.093	0.391
90^{th} quantile	0.210	0.204	0.215	0.361

We use the median values for absorptive capacity shown in Table 5 to calculate the marginal effect of an increase in the growth of FDI. The marginal effects, which are presented in Table 6, are evaluated at the median absorptive capacity level for the various quantiles. For example, the figures in the table show that, for an establishment in the electronics sector in the 10th percentile of the TFP distribution, a 1 percentage point increase in the growth of FDI in the region will lead to a 0.018 percentage point increase in the growth of TFP. This effect is much larger for establishments in the 90th percentile of the TFP growth distribution, where a 1 unit increase in the growth of FDI is estimated to lead to a 0.167 percentage point increase in the growth of TFP.

Table 6: Marginal effect of increase in FDI, evaluated at median ABC

	Electronics	Engineering
mean	0.006	-0.035
10th quantile	0.018	-0.067
25th quantile	0.006	-0.039
median	0.006	-0.015
75th quantile	0.037	0.029
90th quantile	0.167	0.132

Note: table gives the effect of a one unit increase in FDI on TFP growth, evaluated for the median level of absorptive capacity

The table shows significant differences in the size of the marginal effects across quantiles and sectors. The largest marginal effects are apparent for the 90th quantile both for the electronics and engineering sector. Interestingly, establishments in the 10th quantile in the electronics sector benefit more (in terms of the absolute size of the marginal effect) than those in the 25th or median quantile. This suggests that domestic establishments in either the higher or lower end of the TFP distribution are set to benefit more from FDI spillovers than firms in the middle range of the distribution.

Another important point to note is that the marginal effects for establishments in the lower quantiles of the TFP distribution in the engineering sector are actually negative. In other words, these establishments experience reductions in their productivity growth following increases in FDI in their four digit sector. We are not the first paper to find negative productivity spillovers and the commonly used explanation is that these domestic firms increase average costs due to product market competition with foreign multinationals, hence reducing productivity (Aitken and Harrison, 1999). Our result suggests that this happens only for a sub-group of firms in the two digit engineering industry, namely those establishments in the lower quantiles of the TFP distribution. This result is, thus, broadly in line with our expectation that spillovers in the engineering sector may be limited due to "technology sourcing" FDI, as suggested by Driffield and Love (2002).

Marginal effects of changes in ABC

While the effect of changes in FDI for a *given level* of absorptive capacity is informative in its own right we are also interested in the impact of changes of absorptive capacity on establishments' ability to benefit from spillovers. This is an important issue, as policy is likely to be more easily targeted at improving absorptive capacity rather than at fine tuning the level or growth of inward investment.

In order to tackle this issue we, firstly, turn back to the regression results in Tables 3 and 4 to determine the shape of the relationship between absorptive capacity and TFP growth. From the coefficients on the interaction terms we see that, for both sectors and all quantiles, there is a convex (u-shape) relationship for the interaction of absorptive capacity with FDI. Hence, for a given level of FDI growth, increases in absorptive capacity will first reduce but eventually increase productivity growth.

In order to rationalise this result we should take into account that the relationship may reflect the counteracting effects of positive spillovers and negative competition effects, as discussed by Aitken and Harrison (1999). Domestic firms with low absorptive capacity levels are not able to benefit from positive spillovers but are also unlikely to be in direct competition with multinationals due to their relative backwardness. As firms improve their absorptive capacity by becoming more productive they start competing with multinationals (thus beginning to be exposed to the negative competition effect and potentially experiencing reductions in productivity) but are not yet able to benefit from spillovers. Only as they improve their absorptive capacity beyond the critical value are they able to benefit from positive spillovers, which then outweigh the negative competition effect as they become more able to compete with the multinationals.

To be more precise about the shapes of the functions we can calculate the critical values (turning points) at which the effect of *ABC* on productivity spillovers switches from negative to positive. These calculations for the two sectors and the various quantiles are given in Table 7. The first point to note is that the critical values are all around 0.5 – 0.6 for all quantiles in both sectors. For example, we find for the electronics sector that establishments having productivity levels around the 25th quantile start to benefit from increasing growth of FDI once they achieve an absorptive capacity level of over 0.61. Below this threshold they will experience a negative productivity growth effect. From Table 5 we know that the median absorptive capacity level of establishments in the 25th quantile is 0.49, which is well below the critical value. As a matter of fact, our summary statistics (which are not reported in this paper) show that over 70 percent of establishments in the 25th quantile of the TFP distribution have absorptive capacity levels below the critical value.

Comparisons of Table 7 and Table 5 show that, indeed, for all cases the median value of the productivity gap is below the critical value. This implies that more than 50 percent of establishments with productivity levels in these quantiles are negatively affected by a growth in the change of FDI.

Table 7: Calculation of critical values for ABC

	Electronics	Engineering
mean	0.583	0.595
10th quantile	0.572	0.633
25th quantile	0.610	0.573
median	0.534	0.612
75th quantile	0.578	0.576
90th quantile	0.759	0.588

Using the regression results in Tables 3 and 4 we can calculate the marginal effects of changes in absorptive capacity for a constant level of growth of FDI. Such a calculation enables us to say something about the effect on productivity growth of improving absorptive capacity levels in the host country. The results of these calculations are charted in Figures 2a and 2b. Figure 2a shows the marginal effect of changes in absorptive capacity on productivity growth for a given level of FDI growth for the electronics sector.[17] These marginal effects are equal to zero at the critical values shown in Table 7. We find that establishments in the 10^{th} quantile appear to benefit most from increasing absorptive capacity beyond the turning point. These results are different for the engineering sector (Figure 2.b), where establishments in the 90^{th} percentile of the TFP distribution appear to benefit most from increasing absorptive capacity. Overall, however, it is clear that all establishments can increase their potential for positive spillover effects on productivity growth by increasing their absorptive capacity beyond the turning point.

6 Conclusions

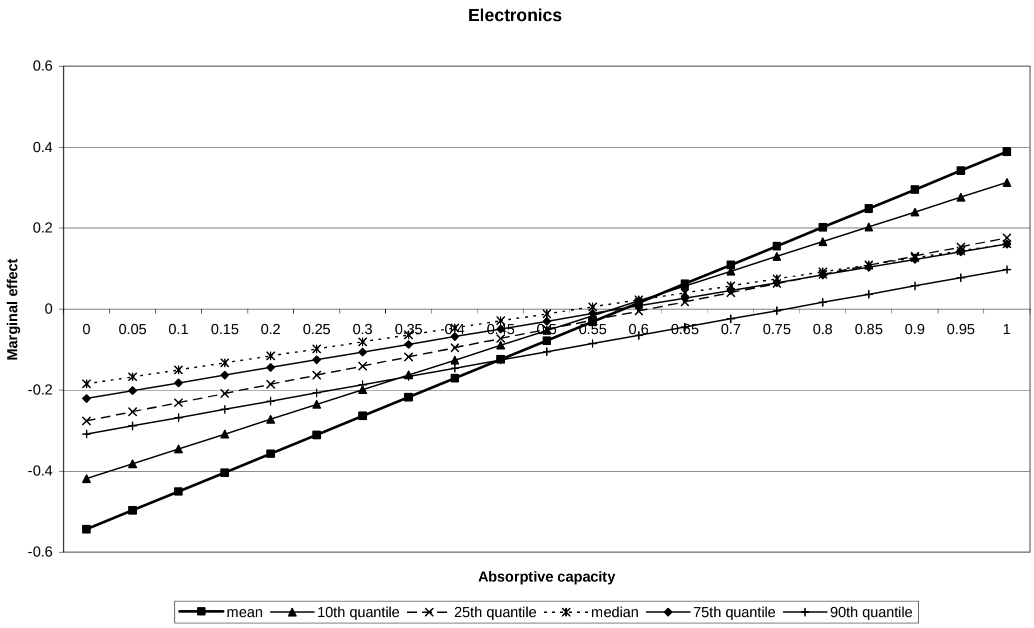
This paper focuses on the role of absorptive capacity in determining whether or not domestic establishments benefit from productivity spillovers from FDI. We analyse this issue using establishment level data for the electronics and engineering sectors in the UK. Absorptive capacity is measured as the difference in TFP between an establishment and the maximum TFP in the industry. We allow for different effects of FDI on establishments located at different quantiles of the productivity distribution by using conditional quantile regression.

Overall, while there is some heterogeneity in results across sectors and quantiles, our findings clearly suggest that absorptive capacity matters for productivity spillover benefits. We find that there is a u-shaped relationship between productivity growth and FDI interacted with absorptive capacity. This indicates that improvements in absorptive capacity at the level of the establishment may enhance its ability to benefit from spillovers from FDI.

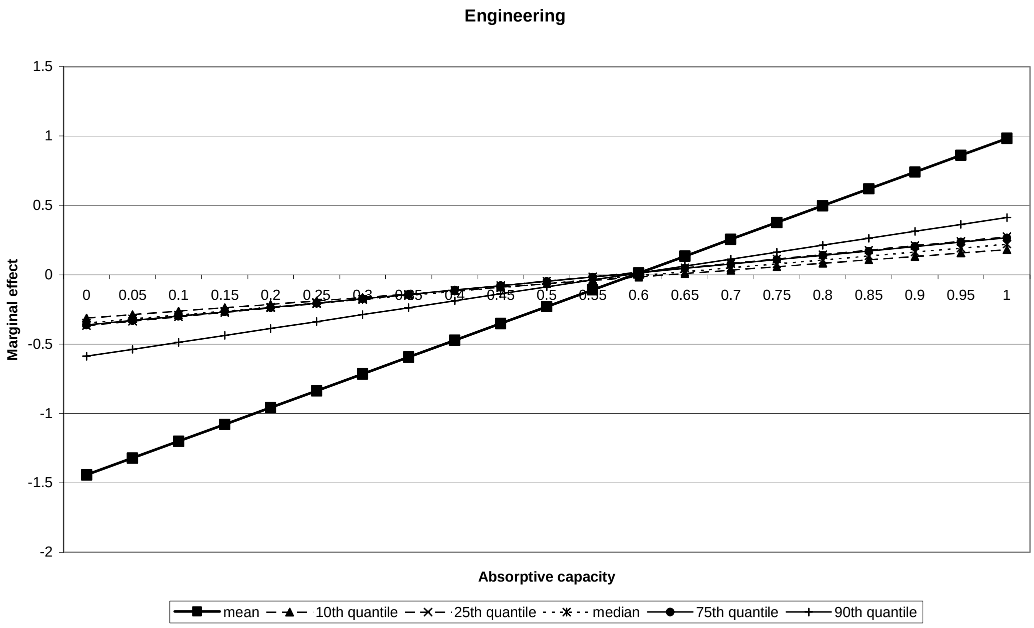
[17] In all graphs we assume this FDI growth to be 0.1, a figure that is well within the range of actual values for FDI growth in the data

Figure 2: Calculation of marginal effects of change in absorptive capacity

Panel A: Electronics



Panel B: Engineering



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Appendix I: Description of the data

The ARD consists of individual establishments' records that underlies the Annual Census of Production. As Barnes and Martin (2002) provide a very useful introduction to the data set, we only include a brief discussion of some of the features of the data that are relevant to the present work. For each year the ARD consists of two files. What is known as the 'selected file', contains detailed information on a sample of establishments that are sent inquiry forms. The second file comprises the 'non-selected' (non-sampled) establishments and only basic information such as employment, location, industry grouping and foreign ownership status is recorded. Some 14,000-19,000 establishments are selected each year, based on a stratified sampling scheme. The scheme tends to vary from year to year, but for the period under consideration establishments with more than 100 employees were always sampled.

In the ARD, an establishment is defined as the smallest unit that is deemed capable of providing information on the Census questionnaire. Thus a 'parent' establishment reports for more than one plant (or 'local unit' in the parlance of ARD). For selected multi-plant establishments, we only have aggregate values for the constituent plants. Indicative information on the 'children' is available in the 'non-selected' file.

Like the majority of researchers using the ARD (e.g., Haskel et al., 2002) we use data on multi-plant establishments as they are. In our sample period (1980-92), about 95 percent of the establishments in these industries are single-plant firms. In the actual sample we used for the econometric estimation this figure is around 80 percent. Hence, most of the data used is actually plant level data and we, therefore tend to use the terms plant and establishment interchangeably.

There are, however, two important ways in which we have made use of the local unit information in the non-selected file. The first is in the construction of measures of regional FDI. Foreign presence in a region and sector is defined as the proportion of employment accounted for by foreign multinationals. Simply relying on establishment data could be misleading, as they could report for plants across different regions or sectors. However, by extracting the employment, ownership and industrial affiliation data of the ‘children’ in the ‘non-selected’ file, it was possible to calculate correctly the regional FDI variables. The second way information in the non-selected file was used is in the identification of single location (region) and multiple location establishments.

Appendix II: Regression results without absorptive capacity
(dependent variable: Δln TFP)

Panel A: Electronics sector

	(1) mean	(2) 10th quantile	(3) 25th quantile	(4) median	(5) 75th quantile	(6) 90th quantile
Age	-0.000	0.003	0.002	0.000	-0.002	-0.004
	(0.001)	(0.001)***	(0.000)***	(0.000)	(0.000)***	(0.001)***
Herfindahl index	-0.050	-0.174	-0.183	-0.021	0.033	0.165
	(0.073)	(0.099)*	(0.050)***	(0.036)	(0.047)	(0.091)*
ΔFDI	0.049	0.016	0.038	0.013	0.030	0.048
	(0.045)	(0.066)	(0.031)	(0.022)	(0.031)	(0.065)
Constant	0.002	-0.216	-0.091	-0.010	0.100	0.245
	(0.021)	(0.028)***	(0.014)***	(0.011)	(0.014)***	(0.027)***
Observations	10173	10173	10173	10173	10173	10173

Panel B: Engineering sector

	mean	10th quantile	25th quantile	median	75th quantile	90th quantile
Age	0.001	0.002	0.001	0.000	-0.001	-0.003
	(0.001)	(0.001)***	(0.000)***	(0.000)	(0.000)***	(0.001)***
Herfindahl index	0.037	-0.005	-0.016	0.019	0.029	0.054
	(0.070)	(0.064)	(0.031)	(0.024)	(0.034)	(0.057)
ΔFDI	0.144	-0.023	-0.011	0.024	0.039	0.149
	(0.062)**	(0.062)	(0.030)	(0.021)	(0.031)	(0.061)**
Constant	-0.023	-0.290	-0.132	-0.002	0.115	0.258
	(0.024)	(0.022)***	(0.012)***	(0.009)	(0.012)***	(0.021)***
Observations	20438	20438	20438	20438	20438	20438

Notes: Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1% regressions include time and regional dummies