Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?*

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Abstract

Are there productivity spillovers from FDI to domestic firms, and, if so, how much should host countries be willing to pay to attract FDI? To examine these questions we use a plant-level panel covering U.K. manufacturing, 1973 through 1992. Across a wide range of specifications, we estimate a significantly positive correlation between a domestic plant's TFP and the foreign-affiliate share of activity in that plant's industry. This is consistent with positive FDI spillovers. We do not generally find significant effects on plant TFP of the foreign-affiliate share of activity in that plant's region. Typical estimates suggest that a 10 percentage-point increase in foreign presence in a U.K. industry raises the TFP of that industry's domestic plants by about 0.5 percent. We also use these estimates to calculate the per-job value of these spillovers. These calculated values appear to be less than per-job incentives governments have granted in recent high-profile cases, in some cases several times less.

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1. Introduction

An important part of globalization in recent years has been the ongoing rise in Foreign Direct Investment (FDI). UNCTAD (2000) reports that from 1979 to 1999, the ratio of world FDI stock to world gross domestic product rose from 5% to 16% and the ratio of world FDI inflows to global gross domestic capital formation rose from 2% to 14%. One consequence is that an increasing share of country's output is accounted for by foreign affiliates of multinational firms. The foreign-affiliate share of world production is now 15% in manufacturing and other tradables (Lipsey, et al, 1998).

An obvious policy issue for governments is whether incentives should be offered to multinational firms to induce local affiliate production. In recent decades dozens of countries have altered laws to at least grant multinationals national treatment, if not to favour these firms via policies such as subsidies and tax breaks (UNCTAD, 2000).[1] Policy promotion of FDI is now common not just in developing countries but in many developed countries as well. The exact values of FDI incentive packages are typically hard to know, but the values of many well-known FDI packages appear very high. In the late 1980s the U.S. state of Kentucky offered Toyota an incentive package worth (in present value) \$125-\$147 million for a plant planning to employ 3000 workers (Black and Hoyt, 1989). In 1994 the state of Alabama offered Mercedes an incentive package of approximately \$230 million for a new plant planning to employ 1500 workers (Head, 1998). In 1991 Motorola was paid £50.75 million to locate a mobile-phone plant in Scotland, employing 3,000 workers. The factory closed in 2001, and Motorola paid back £16.75 million in grants. Siemens was offered £50 million in 1996 to locate a 1000-worker semiconductor plant in Tyneside, in Northeast England. The factory closed 18 months later, at which point Siemens had to repay £18 million in grants.[2]

Is there economic justification for this kind of policy promotion? There would be if the social returns to FDI exceed the private returns. One often-claimed possibility is that inward FDI generates positive externalities for host countries in the form of productivity spillovers to domestic firms. If FDI brings new knowledge to the host economy that is, in part, a public good,

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[1] For example, as Aitken and Harrison (1998) document, before 1989 foreign firms in Venezuela were taxed at a higher rate than domestic firms (50% versus 35%), were forced to repatriate profits at officially fixed exchange rates and could not enjoy confidentiality privileges in joint ventures, provisions which have since been mostly relaxed.

[2] The Appendix describes how the U.K. government subsidizes inward FDI. For information on the Siemens case see <http://news.bbc.co.uk/hi/english/business/the_company_file/newsid_332000/332560.stm> and on the Motorola case see <http://news.bbc.co.uk/hi/english/uk/scotland/newsid_1294000/1294662.stm>.

then FDI may raise the productivity of domestic plants—where the commonly told stories about spillovers hypothesize that they arise along industry lines and/or regional lines.[3]

There are thus two empirical questions that we seek to shed light on in this paper. First, are there productivity spillovers from FDI to domestic firms? Second, if so, how much should host countries be willing to pay to attract FDI? Despite the public interest and policy importance of these two questions, there is very little empirical evidence offering answers.

Existing evidence on whether there are productivity spillovers is of three types. The first are case studies. Cases can offer rich description about episodes and exemplify general issues, but they do not always offer quantitative information and do not easily generalize. Second, there are industry-level studies. Many have documented a positive correlation between FDI inflows and productivity. But the causal meaning of this industry-level correlation is unclear. It may be that inward FDI raises host-country productivity via spillovers. It may also be that inward FDI raises host-country productivity by forcing the exit of low-productivity domestic plants, or simply by raising the market share of foreign firms who are, on average, more productive. Or it may be that multinationals tend to concentrate in high-productivity industries. This latter interpretation is consistent with recent "knowledge-capital" models of multinational firms, in which these firms generate knowledge assets that can be deployed in different countries (e.g., Carr, et al, 2001).

The third set of studies are micro-level analyses. These studies examine whether the productivity of domestic plants (or firms) is correlated with FDI presence in the industry and/or region of the domestic plants. Of the few micro-level studies we are aware of, only one finds any evidence of spillovers. Haddad and Harrison (1993) find increased industry-level FDI is correlated with lower domestic-plant productivity in Moroccan manufacturing plants. Aitken and Harrison (1999) find the same negative result for Venezuelan manufacturing. They suggest these negative spillovers reflect adverse effects of FDI due to competition and further that FDI spillovers might not be positive in developing countries who do not have the capacity to absorb potential positive gains. The one micro study we are aware of for a developing country, Girma and Wakelin (2001), looks at one industry, U.K. electronics, and finds a positive correlation between domestic-firm productivity and regional Japanese FDI.[4]

[3] Black and Hoyt (1989) consider an alternative justification for FDI subsidies, the case of distortions in the provision of public services. See Hanson (2001) for a discussion of various possibilities.
[4] Using data not on firms or plants but rather data on patent citations, Branstetter (2001) looks for spillovers of Japanese FDI into the United States.

To bring some fresh evidence to bear on this issue, we use a plant-level panel for all U.K. manufacturing, 1973-1992. Our main innovation is that we are, to the best of our knowledge, the first paper to study FDI spillovers using plant-level data spanning the entire manufacturing sector of a developed country. The U.K. is of interest for a number of reasons. First, by virtue of being a high-income country that is among the top-five R&D producers in the world (Keller, 2001), there is *ex ante* reason to suppose that it has sufficient absorptive capacity to realize FDI spillovers. Second, in recent decades the U.K. has seen substantial inflows of FDI, such that the foreign-affiliate share of manufacturing employment has risen from 14% in 1973 to 23% in 1992. Third, in recent years the U.K. government has spent hundreds of millions of pounds in incentives to attract inward FDI. With estimates of spillovers, we can undertake some simple calculations to evaluate these actual government outlays.

Figure 1 offers an initial suggestive look at the recent U.K. experience. The bottom three lines show the fraction of manufacturing employment in foreign-owned plants in three U.K. regions: East Midlands (EM), Scotland (S), and Wales (W). Note the rising foreign shares, albeit with three distinct periods: an initial rise until the early 1980s, then some plateauing until about the mid-1980s, and finally a resumed rise in the last years of the sample. By 1992 almost 30% of employment in Welsh manufacturing is in foreign-owned plants. The upper three lines plot average labour productivity across all domestic plants in each of these three regions. For each region the labour-productivity time series generally follows the foreign-presence series, with about a three-year lag. For example, in both Scotland and Wales the sharp fall in foreign presence between 1985 and 1986 was followed by labour-productivity falls from 1988 to 1989. This pattern suggests FDI presence may, with some lag, influence domestic productivity.

Building on Figure 1, our general approach will be to regress plant-level output on plant-level inputs, measures of FDI presence in the plant's industry and region, and other control regressors. We interpret coefficient estimates on our FDI regressors as evidence consistent with spillovers from inward FDI to domestic-plant total-factor productivity (TFP). As we will discuss, this rich data set raises a number of estimation issues regarding endogeneity, measurement, and selection. We will exploit the panel nature of our data in various ways to try to address these issues and thereby gauge the robustness of our FDI results. In addition, we will examine if FDI spillovers vary across dimensions including absorptive capacity of domestic plants and nationality of foreign investors.

Our main finding is evidence consistent with FDI spillovers. Across a wide range of specifications, on our full sample we estimate a significantly positive correlation between a domestic plant's TFP and the foreign-affiliate share of activity in that plant's industry. Typical estimates suggest that a 10 percentage-point increase in foreign presence in a U.K. industry raises the TFP of that industry's domestic plants by about 0.5 percent. We estimate this TFP/foreign-affiliate correlation to be stronger for plants that are smaller, less technologically advanced, and less skill intensive. This suggests that spillovers accrue predominantly to the "lagging" domestic plants, not the "leading" ones. We also find this correlation to be stronger for U.S. and French FDI, suggesting different spillover potentials for different parent countries.

We then use our typical estimates of FDI spillovers to calculate the amount by which an additional foreign job in a U.K. industry boosts the output of domestic plants in that industry. This amount is about £2000 per year at 1992 prices. We also calculate our best guess at the per-job incentives governments have granted in several recent high-profile cases. The spillover magnitudes appear to be less than actual per-job incentives, in some cases several times less. This suggests that productivity spillovers alone might not justify some of the recent high-profile policy initiatives.

There are four sections to the rest of the paper. Section 2 briefly discusses productivity spillovers. Section 3 discusses our data, measurement, and estimation issues. Section 4 presents our empirical findings, and Section 5 concludes.

2: Multinationals and Theories of Industrial and Regional Productivity Spillovers

Many standard models of multinational firms assume they possess knowledge assets (e.g., patents, proprietary technology, trademarks, etc.) that can be deployed in plants outside the parent country. This knowledge feature of multinationals is a key feature of recent general-equilibrium models such as Carr, et al (2001) and earlier work such as Dunning's (1981) "OLI" framework, in which a necessary condition for a firm to become multinational is that it possess an "ownership advantage" over some mobile knowledge asset. This knowledge-asset view is supported empirically. For example, multinationals are much more R&D-intensive than are purely domestic firms.

If multinationals transfer knowledge from parents to their foreign affiliates, then it is possible that some of this knowledge "spills over" to domestic firms in the host country. Some spillovers may operate along industry lines. In Rodriguez-Clare (1996), for example, affiliates increase a host country's access to specialised varieties of intermediate inputs, the improved knowledge of which raises the TFP of domestic producers. Less formally, the case-study literature offers many anecdotes of domestic firms learning from affiliates in the same industry via informal contacts (e.g., trade shows; supplier/distributor discussions; exposure to affiliate products and marketing; technical support from affiliates).

Other spillover mechanisms may operate along regional lines. One avenue is via labor turnover. If at least some of the knowledge particular to foreign affiliates is embodied in their labor force, then as affiliate employees leave to work for domestic firms this knowledge may move as well. For example, Song, et al (2001) use U.S. patent records to trace the movement of scientists between domestic and foreign firms (also see Motta, et al, 1999, and Moen, 2000). This knowledge need not be firm-specific (e.g., inventory-control or management techniques). If inter-regional labor mobility within a country is low, then these spillovers are likely to be concentrated within regions where the affiliates operate rather than dispersed country-wide.

Overall, then, there is reason to suppose that inward FDI may boost the productivity of domestic plants either along industry lines or along regional lines. Accordingly, we plan to investigate both empirically.

3. Data, Measurement, and Econometrics

3a. Overview of the ARD Data Set

Details of our data can be found in Griffith (1999), Oulton (1997), Disney, Haskel and Heden (2000), and the Data Appendix. Here we briefly set out the main features of the data, and concentrate on issues involved in calculating productivity and foreign presence.

Our main data set is the ARD (Annual Census of Production Respondents Database) which is the micro-data underlying the *U.K. Census of Production*. Under the 1947 Statistics of Trade Act reply to the *Census* forms is mandatory. All businesses must provide information on at least ownership, employment, industry, and location. Beyond this basic information, the more detailed "full" Census form also requires extensive operational information on inputs and output.

Each year, the smallest business unit for which a full Census form can be completed is a plant, i.e., an "establishment" in the *Census*.[5] Upon its birth, each plant is assigned a unique identification number: this allows plants to be linked over time into a panel. Computerized records go back to 1972; paper records for earlier years have been destroyed. In 1993 and 1994, a complete recoding of identification numbers was undertaken that has generated non-trivial problems in matching plants before and after. Thus, our data span 1972 to 1992, a period which fortunately covered a substantial increase in FDI inflows (see introduction and below).

If a plant is part of a multi-plant firm, then it has a second identification number enabling such plants to be linked. In principle, we can create a firm-level dataset by aggregating the plant data using the firm-identifiers. But spillovers may be obscured for multi-plant firms, because these firms may span multiple regions and/or multiple industries. Thus, we choose to use the plant as the basic unit of observation. This also increases comparability with most other micro studies.

Because of its desire to relieve small business of paperwork, the U.K. government does not require all plants to fill out the full Census form. Each year, all plants with employment over some minimum size (100 in most years) are sampled. Plants with employment below this threshold are sampled with probabilities decreasing in size: in most years, 50% of plants with employment from 50 to 100 are sampled, and 25% of plants with employment from 20 to 50. The very smallest plants each year are excluded from the full forms. Thus, each year's sample consists of a mix of larger plants sampled with certainty and smaller plants sampled with varying probabilities. Although in a given year we do not see some of the smaller plants, each year our sample accounts for over 90% of total U.K. manufacturing employment. Below, we will address selection issues that might relate to this sampling structure.

Finally, before our analysis we cleaned the data via extensive checks for nonsense observations, outliers, coding mistakes and the like. This task is important in itself, but takes on additional significance for any analysis on time-differenced data, as differencing tends to magnify the role of data error. For example, plant identification numbers are supposed to die with the plant, so we deleted any observations where plant identifiers returned after dropping out

[5] There is some limited information collected for the sub-plant level, but not on output or most inputs, which prevents any reliable productivity measurement at this level.

of the entire data set.[6] We dropped publicly owned plants (mainly in utilities), and plants that seemed to change ownership, industry, or region in unusual fashion. Finally, when running the regressions we deleted plants in the top and bottom percentiles of changes in all the plant-specific output and input variables.

3b. Specification, Measurement, and Estimation Issues

To investigate whether inward FDI generates productivity spillovers for domestic plants, we estimate variations of the following basic equation specification.

$$\ln Y^{d}_{it} = \alpha \ln INPUT^{d}_{it} + \sum_{k=0}^{T} \gamma_1^{\ k} FOR_{R,t-k} + \sum_{k=0}^{T} \gamma_2^{\ k} FOR_{I,t-k} + \delta Z^{d}_{it} + \varepsilon_{it} \qquad (1)$$

In equation (1), i, t, k, R and I denote plant, time, lag length, region, and industry; α, γ, and δ are parameters to be estimated; and the superscript d denotes that plants are domestically owned. Output of domestic plants is denoted Y^d, their inputs denoted $INPUT^d$, foreign presence in the region and industry FOR_R and FOR_I, Z^d are other control regressors, and ε is an unobserved influence on domestic plant productivity. Thus (1) is a production function for domestic plants, augmented by measures of foreign presence and other controls. As in all micro-level empirical work with production functions, we face important concerns involving measurement, endogeneity, and the consequences of unobservables. We discuss each of these issues in turn.[7]

Measurement

For *INPUT* we use capital, K; production and non-production labour, L^U and L^S (for unskilled and skilled); materials, M; and hours, h. L^U, L^S and M are available directly from the *Census* full-form surveys. L^U and L^S count employment of both part-time and full-time workers, and M measures the value of both energy and non-energy materials purchases. Hours are available only at the two-digit industry level. The ARD does not ask plants to report capital stocks, so we used plant investment data to calculate capital stocks. We chose industry-level starting capital-stock values and depreciation rates for buildings, plant and machinery, and vehicles taken from O'Mahony and Oulton (1990). We deflated each component of investment by industry-year investment deflators provided by the Office of National Statistics. We experimented with

[6] A plant might truly do this if it happens not to be sampled for full Census information for some period because of its small size, but we can check on this using the plant records for those who do not fill out the full Census form.
[7] See Bartelsman and Doms (2000) for a detailed discussion of data issues specific to micro-level data sets.

different capital-stock computations (the two main variables affecting the capital-stock path are starting values and depreciation rates), but these did not overly affect the results.

The FOR_R and FOR_I terms in equation (1) are foreign presence by region and by industry. Nationality of plant ownership is defined according to whether an overseas investor has an "effective voice in the management of the enterprise," where "an effective voice is taken as equivalent to a holding of 20% of more in the foreign enterprise." In our data, then, foreign-affiliate plants are those plants owned at least 20% by an overseas business interest. Note that the ARD does not measure the degree of foreign ownership. Also note that domestic plants mix both U.K.-headquartered multinational firms and purely domestic U.K. plants, as the ARD does not provide any ownership distinction among domestically owned plants. Despite these caveats, one important advantage of the ARD over similar data sets for most other countries is it reports nationality of ownership in every year.[8]

Given this information on nationality of ownership, we measure FOR_R as the share of total employment in region R accounted for by foreign-owned plants. FOR_I is constructed analogously, as the share of total employment in industry I accounted for by foreign-owned plants. These shares capture the idea that what matters for spillovers is how prevalent foreigners are in the domestic region or industry, scaling for the overall size of that industry or region. Other micro-level spillover studies have also used share measures.[9] We use employment as the activity measure because many common spillover stories (Section 2) involve interpersonal interactions. That said, for robustness we check results using alternative activity measures. Also, as indicated in equation (1) we allow these foreign-presence measures to enter both contemporaneously and with lags. This is because theory suggests that spillovers may take time to arise after foreigners arrive (e.g., labor turnover to domestic plants), but does not offer any sharp guidance as to exactly how long. Our specifications will try many lag structures.

[8] In contrast, the widely used analogous U.S. data base, the Longitudinal Research Database, does not track nationality of ownership. The only year in which nationality information was merged in (from the U.S. Bureau of Economic Analysis) was 1987 (see examination of this one year in Doms and Jensen, 1998). For the countries providing information and data to the current OECD micro-data project (Finland, Holland, France, U.S., U.K., Germany and Italy), nationality of ownership data is missing for Germany, Holland, Italy, and the U.S.; the French data are incomplete; and only the U.K. and Finland have such data.

[9] Different papers have used slightly different specifications of foreign presence, though. For example, Aitken and Harrison (1999) use FOR_I and also the interaction of foreign ownership in the same industry and region. One advantage of separating our foreign-presence measures by industry and region is that if spillovers along these different dimensions take different times, then our separated terms can be entered with different lag lengths. We tried various specifications with interacted measures, but these were consistently insignificant.

Theory also offers no sharp prediction as to how narrowly or broadly regions and industries should be measured. We distinguish 11 different U.K. regions. These are commonly used regions originally identified in the U.K. censuses of population, and they fall across conventional political and other boundaries. For FOR_I we distinguish 22 different manufacturing industries; these are roughly comparable to two-digit Standard Industrial Classification industries for U.S. manufacturing. There was a major revision to the U.K. industry classifications in 1980. These reclassifications make it difficult to separate industries in greater detail with confidence, so to minimize potential measurement error our baseline is to use the 22 two-digit industries. This practical issue aside, there may be reason to think industry-mediated spillovers are not "too narrow". For example, inventory-management techniques in apparel production might apply to a wide range of goods—men's, women's, and children's.

Table 1 reports some basic ownership information in our ARD panel. As column 1 shows, we have usable data on around 10,000 plants per year. Columns 2 and 3 show the bulk of those are British, but column 4 shows that the fraction of manufacturing employment accounted for by foreign affiliates grew from 14% in 1973 to 23% in 1992. Tables 2a and 2b show the regional and industrial variation, respectively, in foreign-employment shares for 1977 and 1992. Foreign presence by region was highest in the South East in the 1970s, but by 1992 Wales was the highest. Foreign presence by industry was highest in chemicals and computers and office products. But the ranking of foreign presence in regions and industries is not fixed: the rank correlations for regions is 0.69 and for industries is 0.72.

We now turn to measuring the control Z regressors in equation (1). There is a growing literature suggesting that competition affects productive/X-inefficiency in firms (for a review of the theory see Vickers, 1995, and for evidence see Nickell, 1996). This is particularly important in present context. It seems reasonable that the entry of foreign firms might raise the degree of competition and hence the effort level that domestic firms must exert to remain viable. This pro-competitive effect might be regarded as a spillover effect, but the welfare consequences of this are different from the knowledge spillovers that theory tends to focus on. Knowledge spillovers are Pareto-improving positive externalities, whereas increased effort represents a welfare transfer away from the harder-working employees to shareholders and/or customers. Hours is our only possible effort measure thus far, so the coefficient on FOR_I might reflect both knowledge spillovers and the effects of competition. Indeed, Aitken and Harrison (1999) ascribe their finding of negative spillovers to competition: foreign entrants take domestic firms' market shares, and thereby force domestic incumbents up their average-cost curves. All this suggests the need to control for product-market competition.[10]

Following Nickell (1996), we use four potential measures of product-market competition: industry concentration ($CONC_{It}$), import penetration ($IMPORT_{It}$), market share ($MSHARE_{it}$) and rents ($RENTS_{it}$). *IMPORT* is defined at the industry-level as imports as a share of domestic production. *MSHARE* is measured as plant output as a proportion of four-digit-industry output.[11] This is unlikely to be a reliable cross-section measure of market power, since it is affected by technological differences between industries (e.g., capital intensity) which also likely affect productivity. Accordingly, we use changes in market share, $\Delta MSHARE$, to measure changes in competitive pressure. *RENTS* aims to capture *ex ante* rents potentially available to workers and managers to take as increased leisure. It is defined as sales less material, capital and labour costs, expressed as a proportion of net output (where we measure labor cost using industry-region average wages instead of actual plant wages).

Estimation Issues

One important estimation issue is endogeneity. This is a particular concern for our key regressors of interest, FOR_R and FOR_I. Foreign firms may be attracted to regions and/or industries with high-productivity domestic plants—e.g., perhaps learning spillovers flow in both directions. To address this possibility, we use lagged measures of FOR_R and FOR_I. Above, we argued that lags may be appropriate because spillovers take time to materialize. Lagged foreign presence is also predetermined relative to current plant productivities. We also suspect that the competition regressors may be endogenous: e.g.,. higher plant efficiency might raise rents and market share. We therefore lag *RENTS* and $\Delta MSHARE$ by two years.[12]

A second estimation issue is omission of unobserved variables. There are likely to be a host of plant-, time- and regional-specific influences that are unobservable to the econometrician but are known to the plant. These unobservables might underlie any observed correlation between productivity and foreign presence. For example, unmeasured features of regions or industries—

[10] Note that including inputs in equation (1) may also help control for the output consequences of plants moving along their average-cost curves. Also, it seems unlikely that manufacturing plants compete along regional lines. This suggests that FOR_R is unlikely to reflect increased effort.

[11] We also calculated market shares for three- and two-digit industries. The coefficient standard error rose as we did this, suggesting that the measure becomes increasingly inaccurate as we use a broader base, which is plausible.

e.g., sound infrastructure or high-quality management—might both raise domestic productivity and attract foreign firms.

We attempt to address this omitted-variables problem via time differencing and fixed effects. First, we estimate (1) on time-differenced data. In addition to removing any fixed plant-specific unobservable variation, differencing also removes fixed regional and industrial effects such as infrastructure and technological opportunity. One well-known cost of differencing is that it can aggravate measurement error in the regressors, and thereby introduce biases. In a multivariate setting, the direction of the bias cannot be signed (Greene, 1993). Longer time differences tend to attenuate this problem (Griliches and Hausman, 1986), so we report results for one-year, three-year, and five-year differences.

Second, in our differenced specifications we also include full sets of time, industry, and region fixed effects. These additional fixed effects control for unobservables that may be driving changes in key variables (e.g., we control not just for "Wales is an attractive region" but also for "the attraction of Wales is rising over time"). Thus, our findings rely not on differences in plant productivity and differences in foreign presence but on the deviation of differences in plant productivity and foreign presence from their year-, region and industry means.

If our differencing and fixed effects are sufficient, then in equation (1) the error term ε is left uncontaminated by omitted variables. This will not be the case, however, if there are important unobservables that vary both across plants and over time. For example, managerial talent may not be fixed over time within plants. Without measures of these plant-and-time-varying factors, estimates from (1) may still be biased. Olley and Pakes (1996) show that these remaining unobservable shocks can be proxied from investment behavior, on the assumption that these shocks influence current investment but, since investment takes time, not current output. Olley and Pakes (1996) implement their method on telecommunication plants, as does Pavcnik (2000) on Chilean manufacturing plants.

As Griliches and Mairesse (1995) discuss, however, this structural approach depends on a number of assumptions: e.g., plants cannot undertake zero investment, other factors besides capital fully adjust to shocks each period, and markets are perfectly competitive. The sensitivity of this approach to violations of assumptions is an ongoing research question. For example,

[12] The other obvious option would be to instrument for foreign presence, using some variable correlated with foreign presence but uncorrelated with unobservable determinants of plant productivity. In our data we know of no good candidates.

Levinsohn and Petrin (2000) propose using intermediate inputs rather than investment to address the underlying omitted-variables problem. For our purposes, we prefer not to assume perfect competition in light of the emphasis in the micro-spillovers literature on the competitive effects of foreign entrants.[13]

A third estimation issue is selection bias. Plants can choose to exit each period, but our data contains only the surviving plants. This might impart a bias to our estimates for foreign presence. Suppose that foreign presence truly does boost domestic-plant productivity, and thereby domestic-plant survival chances. In regions and/or industries with low foreign presence, we will observe only those plants whose unobservable offsetting benefits—e.g., good management—allow them to survive. But in regions and/or industries with high foreign presence, we are much more likely to observe all plants. This suggests that selection bias may understate the true relationship between inward FDI and productivity.

In Olley and Pakes (1996), in addition to addressing unobservables they also address selectivity, by modelling the probability of exit as a fourth order polynomial expansion in investment and capital. Our use of differencing and the like does not control for selection; in fact, longer time differences may exacerbate it. To gauge the robustness of our results to this, we estimate some specifications using a Heckman selection term, where the selection term is determined using a probit of exit on a polynomial in capital and investment.[14]

Summary

In light of these various measurement and estimation issues, we estimate variations of this basic differenced equation.

$$\begin{aligned}\Delta \ln Y^d{}_{it} = {} & \alpha_1 \Delta \ln K^d{}_{it} + \alpha_2 \Delta \ln M^d{}_{it} + \alpha_3 \Delta \ln S^d{}_{it} + \alpha_4 \Delta \ln U^d{}_{it} + \alpha_1 \Delta \ln h^d{}_{it} + \\ & \sum_{k=0}^{T} \gamma_1{}^k \Delta FOR_{R,t-k} + \sum_{k=0}^{T} \gamma_2{}^k \Delta FOR_{I,t-k} + \\ & \delta_1 \Delta MSHARE^d{}_{it-2} + \delta_2 \Delta RENTS^d{}_{it-2} + \delta_3 RENTS^d{}_{it-2} + \lambda_t + \lambda_I + \lambda_R + v_{it}\end{aligned} \qquad (2)$$

[13] Girma and Wakelin (2001) analyze productivity spillovers using both a specification similar to ours and the Olley-Pakes specification, and find that both approaches yield qualitatively identical results about spillovers.

[14] We also have a potential selection bias since plants who have a downward employment shock are more likely to drop out of the ARD sample even though they have not truly died. If we were looking at employment this would mean that we would only see small plants with favourable characteristics, but since we are looking at productivity it is not clear how the selection bias would operate.

Equation (2) includes our variables for inputs, foreign presence, competition, and time, regional and industry dummies (λ_t, λ_R, and λ_I). We tried all the competition variables discussed above, but those in (2) were the most significant. We now turn to our estimation results.

4. Estimation Results

Baseline Results

Table 3 reports our baseline OLS estimates of equation (2) using short and long differences in combination with various lag structures. Each column reports a different difference length and lag structure, with robust standard errors reported below coefficient estimates. Column 1 shows the simplest specification, namely, current FOR_R and FOR_I with one year differences. Both coefficient estimates are positive, consistent with positive productivity spillovers from foreign plants to domestic plants at both the regional and industry level, but the regional coefficient is insignificantly different from zero. The coefficient on FOR_I suggests that a rise of 10 percentage points in FOR_I for some industry, *ceteris paribus*, would raise output in each domestic plant in that industry by about 0.5%. Because we control for inputs in estimating (2), this output increase is a TFP increase.

Since this magnitude is common to a number of the specifications we report below, it is worth trying to put it in some context. One possibility is to calculate the share of actual TFP growth in our sample accounted for by rising foreign presence. For example, the observed rise in FOR_I over the sample period 1973-1992 is about 10 percentage points. By our estimates of the previous paragraph, this implies that industry and regional spillovers raised UK manufacturing industry TFP by about 0.5%. Since actual TFP in U.K. manufacturing rose by about 10% over the estimation period, our regression suggests that industrial spillovers explain about 5% of the observed 1973-1992 rise in U.K. manufacturing TFP.[15]

Returning to Table 3, column 2 shows both foreign-presence measures dated *t-2* and *t-3*, which are predetermined relative to the differenced dependent variables.[16] The second lag of FOR_I is positive and the most significant. While both lags of FOR_R are positive, neither is very significant. To see the magnitude of the overall effects across all lags, two lower rows also report the sum of the individual coefficients for the industry (ΣFOR_I) and region (ΣFOR_R). The

[15] To undertake this calculation, we needed to calculate total manufacturing TFP in a manner consistent with the regression from which we use the coefficients for FOR. We do this by subtracting from the change in log real output the weighted changes in the logs of K, M, S, U and H with the weights being the coefficients taken from estimates of (2).

[16] We also experimented with lags dated four years and beyond, but they were not significant.

P-value for the joint significance of the summed coefficients is reported in the next two rows, entitled P(ind) and P(reg). We see that the net industry effect is about the same magnitude as in column 1, and remains significant. The net regional effect is larger than in column 1, but remains insignificant.

Column 3 reports a specification using all lagged terms. Looking at the P-values, the regional effects are again jointly insignificant whereas the industrial effects are jointly significant. The net regional effect is now larger than in columns 1 and 2. The net industrial effect is smaller, apparently because of a negative but insignificant (t-3) effect.

Columns 4 to 6 set out the three-year differences, and columns 7-9 the five-year differences. Comparing columns 4 and 7 with column 1, the results are similar: a significantly positive coefficient on FOR_I, with about the same magnitude as column 1, and an insignificant coefficient on FOR_R. Columns 5 and 8, using the (*t-2*) and (*t-3*) lags, also give similar results, with a coefficient of around 0.05 for FOR_I. Finally, columns 6 and 9 both give jointly insignificant effects for FOR_R and significant effects for FOR_I. It is also worth noting that the longer differences raise slightly the coefficients on FOR_I. This is consistent with the theory discussed earlier about measurement error and length of differences.

Taken together, the results in Table 3 suggest that industry-mediated productivity spillovers are positive and significant, with a semi-elasticity of 0.05 as our central estimate. Applied to actual data on foreign presence and TFP, this semi-elasticity suggests that spillovers explain about 5% of the actual rise in U.K. manufacturing TFP over our sample period. Our estimates of spillover effects along regional lines are less consistent. These estimates are generally positive, but are also mostly insignificantly different from zero.

These are our basic results. The next tables show a set of extensions and robustness checks.

Absorptive Capacity

It has been argued that the ability of domestic plants to realize FDI spillovers might depend on their absorptive capacity. Absorptive capacity may have something to do with the overall level of economic development in the host country. For example, in discussing their inability to find any FDI spillovers among Venezuelan plants, Aitken and Harrison (1999, p. 617) conjecture that "the economy [might] not [be] sufficiently developed or diversified, to receive large benefits from foreign presence." If there is indeed some minimum level of development countries need to realize spillovers, conditional on a country reaching that level there may also be variation in absorptive capacity among domestic plants due to differences in plant size, skill intensity, or technological "sophistication." Perhaps only the "best practice" plants can take advantage of FDI spillovers. Conversely, perhaps best-practice plants have already implemented ideas and methods that foreign entrants bring, by definition, such that spillovers accrue predominantly to "mediocre practice" plants.

There is no obvious single measure of a plant's absorptive capacity. We proxy for it by splitting our sample into three groups based on their location in the distribution of three different performance measures: total employment, TFP, and skill intensity (i.e., non-production share of total employment). Consider the example of employment. Within each industry-year, we separated all plants into three groups based on their total plant employment: those below the 25th percentile, those between the 25th and 75th percentile, and those above the 75th percentile. Note that this separation is done by industry-year, not just by year: this accounts for cross-industry variation in total employment due to factors like underlying technology differences. We pool across all industry-years to obtain our three sub-samples, and then estimate equation (2) separately on each sub-sample. This process was repeated for our TFP and skill-intensity performance measures. The three different criteria seemed to generate broadly similar sub-samples, consistent with the micro evidence from several countries that "best practice" plants appear as such along several dimensions.[17]

Table 4 reports our estimation results for these various sub-samples, using the same specification as in column 1 of Table 3. There are two features of note. First, the results are consistent with Table 5 in that FOR_I is generally positive and significant and FOR_R insignificant. Second, there is a suggestion that spillovers are somewhat larger at lower points in the distribution. For all three performance measures, the coefficient on FOR_I is insignificant and small for the best-practice plants above the 75th percentile. For the lower two groups in the distribution, for all three performance measures the coefficient on FOR_I is larger and is near or above standard significance levels. These differences we consider to be suggestive, as pairwise F-tests show the coefficients on FOR_I to be significantly different (at the 10% level) in only two of the nine possible comparisons: within the skill-intensity distribution, between plants above the 75th percentile and those between the 25th and 75th percentiles and between plants above the

[17] Since employment in any year may be measured with error, we averaged employment over two years in making the rankings. Results were very similar when not averaging.

75th percentile and those below the 25th percentile. Overall, we think Table 4 offers suggestive evidence consistent with the hypothesis that FDI spillovers accrue predominantly to plants further away from the best-practice frontier.[18]

Alternative Measures of Foreign Presence

In Section 3 we argued that employment might be a good measure of foreign-affiliate presence, as many models and stories of spillovers involve interpersonal contacts. That said, we want to verify the robustness of our results to alternative measures. One obvious candidate is capital stocks, as capital is the other primary factor. Another possibility is employment of a particular skill group, rather than total employment. It might be that more-skilled non-production workers embody most of the spillovers thanks, e.g., to their greater knowledge of technology innovations. Or it might be that production workers are those most familiar with specific production techniques (e.g., leaner assembly-line operations) that boost productivity.

Table 5 reports estimation results measuring FOR_R and FOR_I three different ways: replacing employment with either non-production employment, production employment, or capital stock. We again use the same specification as in column 1 of Table 3. As before, industry effects are significant but region effects are not. The very similar results across the three columns suggests that our various measures of foreign presence are highly correlated. This is in fact the case: e.g., the skilled-labor and unskilled-labor activity measures have sample correlations in levels and various differences that range from 0.81 to 0.97. Because of these very high correlations, multicollinearity problems arise from attempts to enter both employment measures in the same regression to see if one employment group matters more.

Nationality of Foreign Ownership

Since the ARD reports the country of ownership of foreign plants, we can examine variation in spillovers with nationality. We are particularly interested in inward FDI from the world's other high-R&D countries: the United States, France, Germany, and Japan.

Table 6 reports estimation results where FOR_R and FOR_I are constructed for each country separately. As with earlier tables, regional effects remain generally insignificant. For industry effects, our estimates are consistent with significantly positive spillovers from U.S. and French FDI, insignificant spillovers from German FDI, and significantly negative spillovers from

[18] We obtain a qualitatively similar picture to that in Table 4 when estimate equation (2) on our full sample using employment-weighted least squares rather than OLS. Our WLS coefficient estimates on FOR_I have lower t-statistics, consistent with more weight being assigned to larger plants—i.e., those with less potential for realizing spillovers.

Japanese FDI. The U.S. finding is consistent with both aggregate and micro-level evidence that the United States is at or near the world technology frontier.[19] And the overall ranking of the four countries is strikingly consistent with Doms and Jensen (1998, Table 7.6): looking at foreign affiliates operating in the United States, they find that relative to U.K. plants French plants have higher TFP, German firms have about the same TFP, and Japanese firms have lower TFP.

Other Robustness Checks

To further verify the robustness of our main results, we performed a number of additional robustness checks. Table 7 reports three representative checks, all using the same lag structure as in column 1 of Table 3. The first column of Table 7 reports results for the sub-sample that excludes all plants located in Wales. As reported in Table 2a, Wales was one of the regions with the largest increase in foreign presence during our sample period, and we wanted to check that our main results were robust to excluding apparently important regions and/or industries. As demonstrated by the Wales exclusion, the results do seem robust in this way.

The second column of Table 7 reports results for a more-general specification of equation (2) in which we allow the various α coefficients on inputs to vary across all two-digit industries (by interacting input terms with industry dummies). One might worry that the assumption of equal α coefficients is not warranted, in a way that biases our estimates for spillovers. This does not appear to be the case, however, as the coefficient estimates on FOR_R and FOR_I are very similar to the basic results in Table 5.

The final column of Table 7 reports results from re-estimating the model in equation (2) correcting for selection using a Heckman correction. The selection equation is a fourth-degree polynomial in real investment and real capital stocks; consistent with the Olley and Pakes (1996) assumption that investment does not affect current output, these variables are assumed to affect the entry/exit decision but not productivity. As Table 7 shows, our estimates on the foreign-presence variables are qualitatively unchanged by performing this selection correction.

Public-Finance Implications: How Much Should Governments Pay To Attract Inward FDI?

In the introduction, for several high-profile cases in the United Kingdom and United States we reported estimated costs of government FDI subsidies. Tables 3 through 7 report our

[19] An example of country-level comparisons is O'Mahony (2001). At the micro-level, Doms and Jensen (1998) document that in the United States, parents of U.S. multinationals are more productive than affiliates of foreign-owned multinationals.

estimates of the spillover benefits to a host country from FDI. In this sub-section we attempt some calculations to compare these costs and benefits on a present-value, per-worker basis. We have in mind that subsidy costs are incurred at the start of a foreign plant's life (and perhaps thereafter as well), after which that plant delivers a flow of productivity-spillover benefits as long as it continues to operate. In performing the calculations, we reiterate the caveat that our estimation results are best interpreted as suggestive evidence consistent with productivity spillovers: we perform these calculations assuming that spillovers actually do exist.

The subsidy costs per worker can be easily calculated given reports of subsidy values and jobs covered. However, it is important to note the uncertainty surrounding both these quantities, as the reports are culled mainly from press reports without systematic verification of either values or jobs involved. For the four cases mentioned in the introduction, the costs per worker (all expressed in 2000 U.K. pounds) are Siemens (UK) £35,417; Motorola (UK) £14,356; Toyota (Kentucky, USA) £39,827; and Mercedes (Alabama, USA) £117,178.[20]

The subsidy benefits per worker arise from the TFP boost enjoyed by the affected domestic plants thanks to the inward FDI. Because our estimates of productivity spillovers are for each year, they accumulate over the duration of foreign presence. This means we need to calculate the per year output boost for domestic plants per extra foreign job, and then discount these output boosts over the length of that job.

Start with the example of a foreign plant coming into a particular industry *I*. If this new plant raises our foreign-presence measure FOR_I by $\Delta\phi_I$, then the percentage rise in output in each domestic plant in that industry is equal to $(\gamma_1)(\Delta\phi_I)$, where (γ_1) is the spillover coefficient in equation (1). If the initial output across all domestic plants in that industry is given by Y_{IO}^d, then the level rise in domestic output in that industry, ΔY_I^d, is given by $\Delta Y_I^d = (Y_{IO}^d)(\gamma_1)(\Delta\phi_I)$.

ΔY_I^d gives the rise in output per rise in the foreign-employment *share*, $\Delta\phi_I$. To transform this into the rise per foreign *worker*, we need to calculate the relation between the rise in foreign employment share, $\Delta\phi_I$, and the rise in foreign employment, ΔN_I^f. This relation is given by

$$\Delta\phi_I = \frac{\Delta N_I{}^f}{(N_{I0}^f + N_{I0}^d)} \frac{1}{\left(1 + N_{I0}^f / N_{I0}^d + \Delta N^f / N_{I0}^d\right)} \qquad \textbf{(3)}$$

where N_{IO}^{d} and N_{IO}^{f} are the number of domestic and foreign jobs in the industry in the base period. The intuition behind this is as follows. Recall that $\phi_I = (N_{IO}^{f})/(N_{IO}^{d}+N_{IO}^{f})$. Thus, an increase in N_{IO}^{f} raises both the numerator and denominator of ϕ_I. This accounts for the two terms on the right-hand side of (3). The first term shows the direct effect on ϕ_I from $\Delta N_I^{\,f}$ via the numerator of ϕ_I. The second terms shows the effect on ϕ_I from $\Delta N_I^{\,f}$ via the denominator of ϕ_I. The second term shows that the higher is foreign employment, the more is N_{IO}^{f}/N_{IO}^{d} and so the less a given rise in $N_I^{\,f}$ raises ϕ_I.

Combining (3) with the expression for ΔY_I^{d}, we can write the extra domestic output per foreign job, $\Delta Y_I^{\,d}/\Delta N_I^{\,f}$, as follows:

$$\frac{\Delta Y_I^{\,d}}{\Delta N_I^{\,f}} = \gamma_1 Y_{I0}^{\;d}\,\frac{1}{(N_{I0}^{f}+N_{I0}^{d})}\,\frac{1}{(1+N_{I0}^{f}/N_{I0}^{d}+\Delta N_I^{\,f}/N_{I0}^{d})} \qquad \textbf{(4)}$$

The extra domestic output per extra foreign job consists of four terms. The first, γ_1, is the estimated coefficient from equation (1) that gives the percentage change in domestic-plant output in response to a rise in foreign-employment share. The second term in (4), Y_{IO}^{d}, converts this percentage change into a level change. The third and fourth terms convert the rise in foreign employment share to rise in foreign employment in actual levels.

An expression similar to (4) would hold for productivity spillovers along regional lines, and we could therefore calculate the extra domestic output in region per foreign job created in a region. Our estimates of regional productivity spillovers were mostly small and insignificant, however, so we do not attempt any regional calculations.[21]

Using data for the last year of our sample, 1992, we apply equation (4) to calculate the extra domestic output per foreign job. This quantity $\Delta Y_I^{d}/\Delta N_I^{f}$ varies by industry: we estimated γ_1 to be the same across industries, but each industry has different values of the other three components of the right-hand side of (4). Averaging our calculations across all industries, we

[20] We converted U.S. dollars to U.K. pounds using market exchange rates, and then converted all values into 2000 prices using the U.K. GDP deflator.
[21] If spillovers truly operated along both industry and region lines, then a new foreign plant would necessarily stimulate spillovers along both lines. Our industry calculations ignore regional effects, consistent with the evidence in Tables 3 through 7.

obtain an average value of $\Delta Y_I{}^d/\Delta N_I{}^f$ of £2,097 in 1992 prices. This figure says that, *ceteris paribus*, each new foreign worker stimulates an extra £2,097 in output across all domestic plants in that worker's industry. This amount is about £2,440 at 2000 prices.[22]

We can now compare our calculations of subsidy costs and benefits. To do this, we need to remember that the subsidy benefits accrue per year, and accordingly measure costs and benefits over the same time spans. For the two U.S. cases, note that we are assuming that our estimates of U.K. productivity spillovers apply in the same way to the United States. We have no way to evaluate this assumption, but maintain it simply for the sake of discussion.

The U.K. Siemens plant stayed open 18 months. At a discount rate of 5%, £2,440 for 18 months is £3,430: this is the value of spillover benefits per worker at this plant. The subsidy cost £35,417 per worker, an order of magnitude more than our best guess as to its spillover benefits. The U.K. Motorola plant survived 10 years. At a discount rate of 5%, this translates into a present-value spillover benefits of £18,841 per worker. The subsidy cost £14,356 per worker, so in this case the government cost of the subsidy was about equal to its estimated productivity benefits.

The two U.S. cases are harder to judge, both because of the spillover caveat mentioned above and because the plants remain open today. The Toyota plant opened in 1988, and so thus far has generated a present-value spillover benefit of £22,920 per worker. The subsidy cost per worker is £39,827 in this case. This amount would be the present value of spillover benefits if the plant operates for 35 years, suggesting the Toyota plant must remain open 22 more years to "break even." The Mercedes plan opened in 1994, with an implied spillover benefit of £14,119 for its seven years of operation. This is an order of magnitude smaller than our calculated subsidy cost per worker of £117,178, which suggests that for this case the subsidy cost will exceed its productivity-spillover benefits.

A number of comments regarding these calculations are worth making. The first and most important is to reiterate that these calculations are only suggestive, as they rely on many assumptions and caveats. In particular, we have not considered benefits to foreign presence

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Alternatively, once could assume that industries and their owners are distributed evenly throughout regions, so that any new foreign plant would have a negligible impact on FOR_R.

[22] As a benchmark, in 1992 gross output per domestic worker averaged about £73,000, with domestic wages averaging about £15,000.

beyond the single issue of productivity spillovers. Foreign plants may bring benefits we have not considered (e.g., reduced crime thanks to lower unemployment).

A second comment is to stress the *ceteris paribus* nature of these calculations. For a foreign plant to continue generating spillovers over time, it needs to maintain its boost to the foreign-affiliate share of its industry employment. It is not length of plant life that is at issue, strictly speaking, but rather the length of increase in foreign-affiliate employment share. These calculations assume no other growth or decline in employment among all other plants. In reality, this may not be the case. For example, if over time spillovers stimulate hiring at domestic plants, then a foreign plant's boost to the foreign-affiliate employment share declines over time.

A final consideration is the incidence of subsidy costs and benefits. In the four cases we considered, host-country governments directly pay the subsidy costs. But these governments do not directly realize the subsidy benefits. Productivity spillovers accrue to domestic firms, not domestic governments. In principle, subsidies could be paid by coalitions of domestic firms that organize to pool contributions used as incentives to foreign firms. In practice, the standard collective-action problem of free riding may make such coalition-forming difficult.

Governments may be willing to pay subsidy costs based on the tax revenues they gain from the domestic-output boost. But if governments care only about their tax-revenue gain, then the cost they should be willing to incur equals just their share of the output bonus. In 1992 the maximum corporate tax rates were 33% in the United Kingdom and 34% in the United States. This means that spillover benefits accruing to governments are only about 1/3 the total benefits calculated above, which makes the cost-benefit calculations even more unfavorable.[23] Alternatively, governments might care about more than their tax-revenue gain, e.g., they may somehow internalize the spillover benefits enjoyed by domestic firms.

5. Conclusions

A large number of countries pay subsidies to attract FDI. One justification is that the social returns to FDI exceed the private returns, because of productivity spillovers from FDI to domestic firms. In this paper we therefore examined two issues. First, are there productivity spillovers from FDI to domestic firms? Second, if there are such spillovers, what level of subsidies would be justified? Using a plant-level panel for U.K. manufacturing covering 1973-

[23] If part of the subsidy package governments offer is tax breaks, then the relevant effective tax rates are even lower.

1992, we estimated production functions for domestic firms augmented with terms measuring foreign presence in the industry and region. Our major findings are as follows.

(a) We estimate a significantly positive correlation between a domestic plant's TFP and the foreign share of employment in that plant's industry. Typical estimates suggest that a 10 percentage-point increase in foreign presence in a U.K. industry raises the TFP of that industry's domestic plants by about 0.5 percent. This correlation is consistent with productivity spillovers from inward FDI to domestic plants. We do not find significant effects for foreign share of employment by region. Our estimates are robust across specifications and measures of foreign presence.

(b) These estimates suggest that the per-job value of spillovers appear to be less than per-job incentives governments have granted in recent high-profile cases, in some cases orders of magnitude less.

We have also found some evidence that spillovers take time to permeate to domestic plants, that they are more important for plants at the lower end of the skill distribution, and that they are the largest from U.S.- and French-owned plants.

While we believe these results to be of interest, there are additional questions we plan to investigate in future work. For example, we can explore the different entry strategies of foreign producers. The stylized picture of FDI is the construction of a new "greenfield" site in a host country. But foreign involvement in a host country can change for several other reasons. First, foreigners may enter not via new plants but rather by merging with or taking over existing plants. Second, surviving foreign plants may expand, contract, be acquired by a British firm, or even die completely. The ARD can allow us to distinguish all these changes, and thereby to examine if they have different links with domestic productivity. Most government subsidies for FDI are for greenfield activity, but perhaps spillover benefits vary across different FDI changes.

Data Appendix

Data definitions and sources

$\Delta \ln Y_t$ The log change in total manufacturing real gross output (£s in 1980) (direct from ARD), deflated by 4 digit annual output price deflators supplied by the ONS.

$\Delta \ln K_t$ The log change in total manufacturing real net capital stock (£s in 1980). Capital stock is estimated from establishment level investment in plant and machinery, vehicles and buildings, using perpetual inventory methods with the starting values and depreciation rates taken from O'Mahony and Oulton (1990) using the selected sample only. Depreciation rates: buildings 2.91%, plant and machinery 11.097%, and vehicles 28.1%. Buildings and plant and machinery are deflated by two digit industry deflators, vehicles by annual deflators. Deflators were supplied, by Rachel Griffiths at IFS. In addition, establishments may disappear and appear from the ARD data due to sampling. This clearly creates problems for the perpetual inventory method. If we drop all establishments that disappear and reappear for at least one year we lose almost 50% of our selected sample. To fill in the missing year's investment data, we multiplied that year's industry investment by the establishment's average share of industry investment over the establishment's lifetime. After some experimentation we used this method to interpolate for establishments with at most three year's missing data. This means we only lose 10% of the sample. Although investment is of course volatile, establishments' investment shares by industry are in fact extremely stable and so we feel the induced inaccuracies are likely to be small relative to very large gain in sample size.

$\Delta \ln L_t$ The log change in total manufacturing employment (direct from ARD).

$\Delta \ln S_t$ The log change in total manufacturing non-manual employment (direct from ARD).

$\Delta \ln U_t$ The log change in total manufacturing manual employment (direct from ARD).

$\Delta \ln M_t$ The log change in total manufacturing real intermediate inputs (£s in 1980) (direct from ARD), deflated by four digit input price deflators supplied by the ONS.

$\Delta MSHARE_{it-2}$. The lagged change in market share, *(t-2)-(t-3)* . The market share is establishment nominal gross output as a share of four digit industry nominal gross output.

$RENTS_{it-2}$. Rents lagged twice. It is defined as rents over net output, where rents are net output less material, capital and labour costs, expressed as a proportion of net output. Labour costs are the region- and four digit industry specific average manual and non-manual wage.

$\Delta RENTS_{it-2}$. The lagged change in rents, *(t-2)-(t-3)*.

ΔFOR_{It} The change in employment in a foreign-owned plant as a share of total employment in the industry. Industry is defined at the two-digit level, there are 22 two-digit industries.

ΔFOR_{Rt} The change in employment in a foreign-owned plant as a share of total employment in the region. There are 11 standard regions in the UK.

Appendix: Payments to Foreign Firms Locating in the U.K.[24]

There are many different types of UK Government support for firms (http://www.dti.gov.uk/support/). EU legislation restricts such support to investment that can be shown to be of social benefit in deprived areas or other special cases. There are thus two main sources of support which are available in designated areas[25].

1. EU money from the European Structural funds.[26] This is mostly money paid out to large infrastructure projects.
2. Money from the UK government. In turn this divides into support for small projects (investment under £500,000) and larger projects (investment over £500,000.[27]

The most important funding for foreign investment is for larger projects (support for smaller projects is not large) and comes from Regional Selective Assistance. Grants are discretionary and must either create new employment or safeguard existing employment in the Assisted Areas and must involve over £500,000 worth of capital investment. Applicants have to set out their expected employment creation, their accompanying investment and how long they expect the project to last. Applicants must apply for RSA before investment goes ahead, and RSA is offered to companies making an investment in the UK for the first time, and also to companies already there which plan expansions or modernizations. A government official then judges whether the investment will create jobs and for how long. Quite how this judgement is made is hard to assess, but as an indication the application form states that all of the following criteria must be met for the grant application to be considered.

The project:
Takes place in an Assisted Area. Is aimed at more than a local market Based on forecast growth in the market sector to ensure that displacement is not an issue Will involve a minimum capital expenditure of £500,000 on fixed assets Will directly created or safeguarded job in the business The business as a whole will be financially viable and profitable within 3 years If the project is undertaken by a member of a group, the group will be financially stable RSA is essential for the project to proceed

[24] For more information see www.Invest-in-the-UK.com. Information about grants in general is contained in www.dti.gov.uk/support and www.invest.uk.com.

[25] The EU has designated a series of areas as low income, called Assisted Areas. Such areas are designated as Tier 1, 2 and 3 depending on their deprivation level (the Sheffield and Liverpool areas are for example Tier 1 areas, i.e., the most deprived).

[26] See http://www.dti.gov.uk/europe/structural.html for more information.

[27] For more information on small projects see http://www.dti.gov.uk/enterprisegrant/index.htm) and on larger projects see www.dti.gov.uk/support/rsa.htm).

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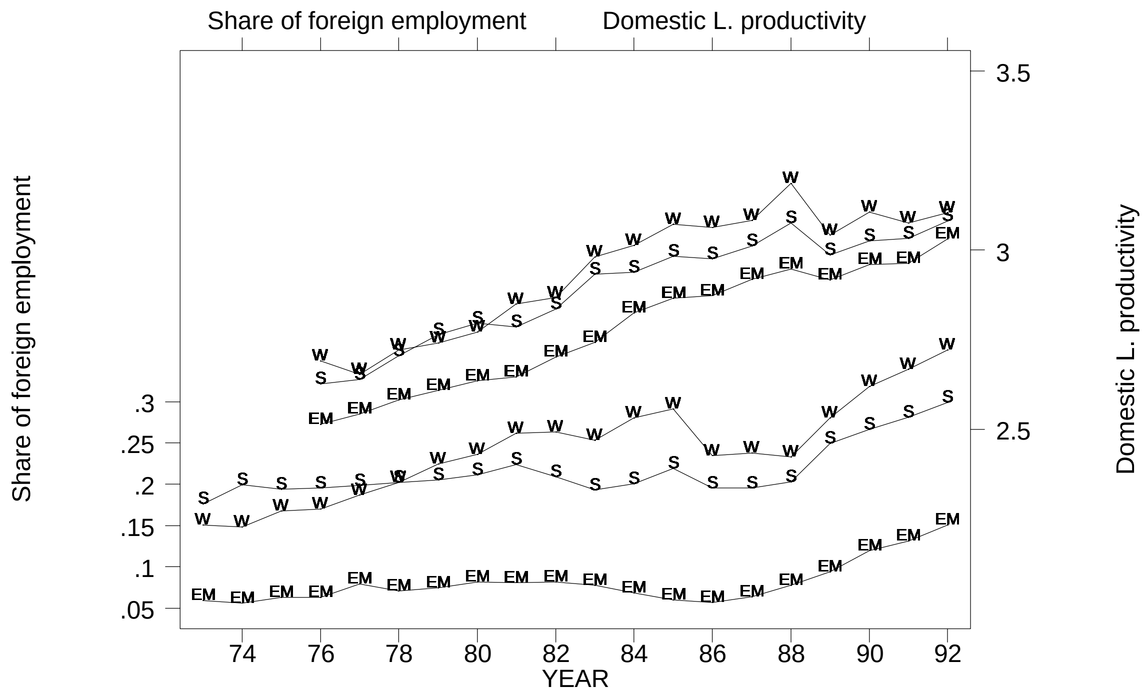
Figure 1
Domestic Labour Productivity
And Shares of Foreign Employment
in Wales, Scotland and East Midlands



Domestic Labour Productivity

Table 1: Basic Facts of the ARD Panel

YEAR	# Plants	# British Plants	# Foreign Plants	% Employment in Foreign Plants
1973	15,687	14,847	840	0.14
1974	15,989	15,085	904	0.13
1975	14,283	13,459	824	0.13
1976	14,480	13,529	951	0.14
1977	13,940	12,846	1,094	0.16
1978	12,140	11,071	1,069	0.15
1979	11,107	10,106	1,001	0.15
1980	9,492	8,466	1,026	0.17
1981	8,829	7,775	1,054	0.17
1982	8,910	7,854	1,056	0.18
1983	8,605	7,533	1,072	0.18
1984	10,011	8,948	1,063	0.17
1985	8,068	7,117	951	0.18
1986	8,497	7,586	911	0.16
1987	8,474	7,553	921	0.16
1988	8,690	7,757	933	0.18
1989	11,395	10,280	1,115	0.20
1990	9,099	8,023	1,076	0.21
1991	8,784	7,657	1,127	0.22
1992	8,385	7,269	1,116	0.23

Table 2a: Share of Foreign Employment, by Region

Region	1977	1992
South East	0.23	0.28
East Anglia	0.26	0.25
South West	0.15	0.19
West Midlands	0.07	0.19
East Midlands	0.08	0.14
Yorkshire /Humberside	0.12	0.19
North West	0.13	0.20
North	0.10	0.24
Wales	0.18	0.35
Scotland	0.15	0.31
N. Ireland	0.25	0.27

Table 2b: Share of Foreign Employment, by Industry[1]

	Two-digit industry	1977	1992
21	Extraction and preparation of metalliferous ores	1.00	1.00
22	Metal manufacturing	0.05	0.17
23	Extraction of minerals not elsewhere specified	1.00	1.00
24	Manufacture of non-metallic mineral products	0.12	0.14
25	Chemical industry	0.29	0.44
26	Production of man-made fibres	0.16	1.00
31	Manufacture of metal goods not elsewhere specified	0.10	0.23
32	Mechanical engineering	0.17	0.29
33	Manuf. of office machinery and data processing equipment	0.31	0.47
34	Electrical and electronic engineering	0.24	0.28
35	Manufacture of motor vehicles and parts thereof	0.17	0.33
36	Manufacture of other transport equipment	0.02	0.20
37	Instrumental engineering	0.33	0.25
41	Food and drink manufacturing industries[2]	0.13	0.09
42	Food, drink and tobacco manufacturing industries[3]	0.11	0.28
43	Textile industry	0.04	0.09
44	Manufacture of leather and leather goods	0.05	0.01
45	Footwear and clothing industries	0.05	0.05
46	Timber and wooden furniture industries	0.03	0.05
47	Manuf. of paper and paper products; printing and publishing	0.17	0.24
48	Processing of rubber and plastics	0.25	0.21
49	Other manufacturing industries	0.14	0.15

1 - Standard Industrial Classification, Central Statistical Office.
2 - Oils, margarines, milk products; freezing, processing and preserving of meat, fish, fruit and vegetables; grain milling, bread and flour confectionery.
3 - Sugar and sugar confectionery, cocoa, coffee, tea, animal feeds and pet foods, and all others.

Table 3: The Effect of Foreign-Affiliate Presence on Productivity Baseline Specifications of Equation (2)

	1-Year Differences			3-Year Differences			5-Year Differences		
$\Delta FOR_{I,t}$	0.049		0.052	0.053		0.086	0.063		0.022
	(3.70)**		(3.08)**	(3.16)**		(3.58)**	(2.88)**		(0.85)
$\Delta FOR_{I,t-1}$			-0.060			0.003			0.068
			(3.42)**			(0.10)			(2.44)*
$\Delta FOR_{I,t-2}$		0.057	0.043		0.026	-0.005		0.052	0.013
		(3.39)**	(2.31)*		(1.14)	(0.17)		(1.95)	(0.45)
$\Delta FOR_{I,t-3}$		-0.006	-0.028		0.030	0.079		0.011	0.010
		(0.39)	(1.68)		(1.33)	(3.01)**		(0.40)	(0.37)
$\Delta FOR_{R,t}$	0.004		0.015	-0.011		0.044	-0.018		-0.035
	(0.23)		(0.71)	(0.45)		(1.25)	(0.56)		(0.91)
$\Delta FOR_{R,t-1}$			0.006			0.002			-0.020
			(0.25)			(0.05)			(0.46)
$\Delta FOR_{R,t-2}$		0.026	0.030		-0.076	-0.089		0.001	0.019
		(1.25)	(1.30)		(2.34)*	(2.35)*		(0.03)	(0.43)
$\Delta FOR_{R,t-3}$		0.029	0.029		0.075	0.103		0.036	0.034
		(1.28)	(1.24)		(2.28)*	(2.71)**		(0.82)	(0.77)
$\Sigma\, FOR_I$	0.049	0.051	0.007		0.056	0.163		0.063	0.113
$\Sigma\, FOR_R$	0.004	0.055	0.08		-0.001	0.06		0.037	-0.002
P (ind)		0.0009	0.0000		0.0491	0.0003		0.0467	0.0067
P (reg)		0.3026	0.5544		0.0228	0.0452		0.6635	0.6848
Observations	74615	54481	54481	57057	40485	40485	35260	26287	26287
R-squared	0.56	0.58	0.58	0.70	0.71	0.71	0.76	0.76	0.76

Note: Robust t-statistics in parentheses. * significant at 5% level; ** significant at 1% level. The rows $\Sigma\, FOR_I$ and $\Sigma\, FOR_R$ report the sum of the relevant coefficient estimates in that column; P(ind) and P(reg) report the p-value for testing the joint significance of the relevant estimates. The dependent variable is the difference of the log real output. Other regressors are the differenced logs of capital, materials, skilled employment, unskilled employment and hours, year dummies, 20 two-digit industry dummies, 10 region dummies and competition control variables. For brevity, these coefficient estimates are not reported.

Table 4: The Effect of Foreign-Affiliate Presence on Productivity Specifications of Equation (2) By Absorptive Capacity

	Employment within each two digit industry/year			TFP within each two digit industry/year			Skill intensity within each two digit industry/year		
Centile Range	Below 25th	Between 25^{th} & 75^{th}	Above 75^{th}	Below 25th	Between 25^{th} & 75^{th}	Above 75^{th}	Below 25th	Between 25^{th} & 75^{th}	Above 75^{th}
$\Delta FOR_{I,t}$	0.074	0.053	0.027	0.059	0.033	0.022	0.062	0.070	-0.009
	(1.75)	(3.08)**	(1.17)	(1.95)	(1.75)	(0.88)	(2.31)*	(4.03)**	(0.29)
$\Delta FOR_{R,t}$	0.054	-0.014	0.000	0.004	0.033	-0.047	-0.008	0.000	0.033
	(1.08)	(0.60)	(0.01)	(0.12)	(1.38)	(1.31)	(0.24)	(0.00)	(0.89)
Observations	10143	40965	23507	16284	34350	23981	18059	39214	17342
R-squared	0.51	0.58	0.57	0.60	0.60	0.51	0.56	0.58	0.54

Note: Robust t-statistics in parentheses. * significant at 5% level; ** significant at 1% level. The percentiles use the average employment, TFP and skill share in years (t-1) and (t-2) in the corresponding two digit industry. Skill intensity is the share of skilled employment over total employment. The dependent variable is the difference of the log real output. Other regressors are the differenced logs of capital, materials, skilled employment, unskilled employment and hours as described in appendix, year dummies, 20 two-digit industry dummies, 10 region dummies and competition control variables. For brevity, these coefficient estimates are not reported.

Table 5: The Effect of Foreign-Affiliate Presence on Productivity Specifications of Equation (2) By Alternative Measures of Foreign Presence

Measure of For. Presence	Skilled Employment	Unskilled Employment	Capital Stock
$\Delta FOR_{I,t}$	0.048	0.047	0.041
	(3.80)**	(3.67)**	(3.74)**
$\Delta FOR_{R,t}$	-0.010	0.010	0.002
	(0.65)	(0.63)	(0.15)
Observations	74615	74615	74615
R^2	0.56	0.56	0.56

Note: Robust t-statistics in parentheses. * significant at 5% level; ** significant at 1% level. Foreign presence in column 1 (2) is the share of foreign (un)skilled employment on total (un)skilled employment, and in column 3 it is the share of foreign capital on total capital (coefficients reported of first differences of these variables). The dependent variable is the difference of the log real output. Other regressors are the differenced logs of capital, materials, skilled employment, unskilled employment and hours as described in appendix, year dummies, 20 two-digit industry dummies, 10 region dummies and competition control variables. For brevity, these coefficient estimates are not reported.

Table 6: The Effect of Foreign-Affiliate Presence on Productivity Specifications of Equation (2) By Different Source Countries

United States	
$\Delta FOR_{I,t}$	0.063
	(3.95)**
$\Delta FOR_{R,t}$	-0.005
	(0.20)
France	
$\Delta FOR_{I,t}$	0.106
	(2.43)*
$\Delta FOR_{R,t}$	-0.055
	(0.86)
Germany	
$\Delta FOR_{I,t}$	0.048
	(0.42)
$\Delta FOR_{R,t}$	-0.159
	(1.05)
Japan	
$\Delta FOR_{I,t}$	-0.275
	(2.59)**
$\Delta FOR_{R,t}$	-0.070
	(0.57)
Observations	74615
R-squared	0.56

Note: Robust t-statistics in parentheses. * significant at 5% level; ** significant at 1% level. The dependent variable is the difference of the log real output. Other regressors are the differenced logs of capital, materials, skilled employment, unskilled employment and hours as described in appendix, year dummies, 20 two-digit industry dummies, 10 region dummies and competition control variables.

Table 7: The Effect of Foreign-Affiliate Presence on Productivity Specifications of Equation (2) For Various Robustness Checks

Robustness Check	Exclude Wales from Sample	Vary by Sector Coeffs. on All Inputs	Perform Heckman Selection Correction
$\Delta FOR_{I,t}$	0.050	0.048	0.049
	(3.68)**	(3.65)**	(3.72)**
$\Delta FOR_{R,t}$	0.004	0.004	0.004
	(0.21)	(0.24)	(0.25)
Total Observations	71985	74615	164092
Uncensored Obs.	-	-	74615
R^2	0.56	0.57	-

Note: Robust t-statistics in parentheses. * significant at 5% level; ** significant at 1% level. Column 1 excludes Wales from the sample. Column 2 allows the coefficient estimates for all inputs to vary across two-digit industries. Column 3 presents results corrected for sample selection; the Heckman selection equation regressors are a fourth-degree polynomial for log real investment and a fourth degree polynomial for log real capital. The dependent variable is the difference of the log real output. Other regressors are the differenced logs of capital, materials, skilled employment, unskilled employment and hours as described in appendix, year dummies, 20 two-digit industry dummies, 10 region dummies and competition control variables. For brevity, these coefficient estimates are not reported.