LOWER PRODUCTIVITY IN SCOTLAND, 1997-2012: IMPLICATIONS POST-2016

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ABSTRACT

This paper finds that total factor productivity in Scotland was 11% below the 'rest of the UK' in 2012. This is found to be mainly due to negative plant 'composition' effects in those (service) sectors where the productivity gap is largest. It is also found that new plant start-ups and foreign-owned plants both contributed negatively to TFP growth during 1997-2012. This casts doubt on whether relying on greater tax incentives post-2016 to increase the rate of new firm formation and encourage foreign investment will result in a 'step-change' in productivity growth.

Key words: micro-based TFP; productivity gap; Scotland

JEL classification: R11, D24

I. INTRODUCTION

Firm-level data from the 2011 Community Innovation Survey (BIS, 2014) shows that, of 12 UK regions, Scotland had the third lowest percentage of establishments innovating (either product or process innovation) for manufacturing, and the second lowest for services. It also had the second lowest percentage of establishments engaged in R&D for manufacturing, but third highest for services. Using micro-data from the UK Government's Business Enterprise R&D survey shows that R&D intensity is much lower in Scotland than in the 'rest of the UK'.[1] For exporting, Scotland had the lowest percentage of establishments involved during 2008-10 in manufacturing, and the lowest in services.[2] Since innovation, R&D spending, and exporting are all known to be vitally important in raising productivity (ATKESON AND BURSTEIN, 2010; AW *et al.*, 2011; BERNARD *et al.*, 2003; BUSTOS, 2011; GREENAWAY AND KNELLER, 2007; MELITZ, 2003; YEAPLE, 2005), as well as themselves being determined by productivity levels (i.e., there are two-way causal relationships about these variables – see Harris and Moffat, 2011a), and current data shows Scotland underperforms on these measures, this suggests, not only that a likely productivity gap exists between Scotland and the 'rest of the UK', but that achieving any 'step change' in performance will be difficult within any reasonable timeframe following the vote for Scottish independence in September 2014.

This is of critical importance given that productivity is viewed as the most important long-run driver of economic growth in both economic theory and empirical research. KRUGMAN (1997) claims that '… productivity isn't everything, but in the long run it is almost everything'; while BAUMOL (1984) similarly states that 'without exaggeration in

[1] R&D intensity is calculated by computing the R&D stock for plants (see HARRIS, LI AND TRAINOR, 2009, for details of the methodology used) and dividing this stock by real output; HARRIS AND MOFFAT (2014, Figure 2).
[2] See Figure 1 in HARRIS AND MOFFAT (2014).

the long run probably nothing is as important for economic welfare as the rate of productivity growth'. Using standard growth-accounting methods, large-scale country and industry studies tend to confirm the importance of TFP and its dominance in explaining differences in output growth across different economies (e.g., Figure 1.2, OECD, 2003; Figure 6.3, BERR, 2008; Figure 10, MOURRE, 2009; Table 2, O'MAHONY and TIMMER, 2009). For example, according to KLENOW AND RODRÍGUEZ-CLARE (1997), total factor productivity (TFP) growth accounts for 90% of the international variation in output growth.

The crucial role that productivity plays has also been recognised by the Scottish Government in making its case to the electorate for an independent Scotland. In presenting the outlook for Scotland's public finances (SCOTTISH GOVERNMENT, 2014), the impact of increases in productivity, employment and population growth are discussed.[3] The first, and arguably the most important scenario is that Scotland experiences an above-trend year-on-year increase in labour productivity of 0.3%, which by 2029-30 would improve Scotland's net fiscal position by £2.4 billion a year (in 2012/13 prices). That is, by 2029-30 actual labour productivity would have undergone a 'step-change' and be some 4.2% higher than the level that would be attained based on current trends.[4] Certain policy options on how to achieve this are mentioned but not discussed in detail (e.g., establishing an industrial strategy to rebalance and diversify the economy; ensuring core national infrastructure is appropriate; and establishing a more efficient tax regime targeted to promote investment, entrepreneurship and innovation); we shall return to policy options below.

[3] Note, these have been core targets since 2008. In their discussion of the interrelation between them, CPPR (2008) have discussed the linkages between productivity and other key variables and thus set out (see their Figure 2) how the former 'drives' the latter.

[4] This figure of 4.2% is obtained by compounding higher productivity growth against the assumed trend of 2.2% p.a. [i.e. $(1 + 0.025)^{11} - (1 + 0.022)^{11}$].

In order to cast light on whether Scotland has a productivity problem, this paper will begin by establishing the extent to which there is a productivity gap between Scotland and the rest of the UK. It will then seek to explain why such a gap exists. Finally, drawing on the previous analysis there is a discussion of what policies could be pursued to raise productivity in Scotland post-2016, operating within an independent country or in a more devolved environment.[5]

Total factor productivity (where TFP captures the productivity of *all* factors of production) is used rather than labour productivity as the measure of productivity in our analysis.[6] The units of analysis are local units (plants) and firms (rather than basing our analysis on aggregate gross value-added – GVA – per head data), since these are the units in any economy that actually generate productivity gains. TFP is estimated for plants operating in those parts of the market-based sector of the economy (i.e., those operating as part of the public sector are excluded) for which our dataset includes information. Having obtained estimates of TFP for market-sector plants operating during 1997-2012, these are used to compare Scotland with other UK regions and the 'rest of the UK'[7] (section 2). In section 3 differences between Scotland and the 'rest of the UK' are disaggregated according to whether they are due to 'place' versus 'composition' effects. In section 4, there will be a discussion of policy options, and which

[5] It would appear that all pro-union parties in Scotland are in favour of greater devolution of (tax) powers if the Scottish people vote 'no' to independence (REUTERS, 2014).

[6] It can be shown (cf. HARRIS AND MOFFAT, 2011a, paragraph S.7) that increases in labour productivity (output-per-worker) are determined by the extent to which other factors are being used to substitute for labour (e.g., through capital deepening or greater intermediate inputs intensity), as well as increases in TFP (which itself is driven by efficiency and technical progress). That is, labour productivity can rise because firms substitute other, cheaper factor inputs for higher wage labour; and ultimately it is TFP that is the long-run determinant of this growth process (not relative prices).

[7] In actual fact, data is available for the 'rest of Great Britain' but the commonly used term of the 'rest of the UK' is employed for simplicity (and because, given the small size of Northern Ireland, the GB and UK figures are likely to be very similar in value).

are most likely to lead to the 'step-change' in productivity that is required to improve Scotland's fiscal position. Finally, there is a summary and conclusion.

Table 1 around here

II. MEASURING TFP

The earlier analysis of HARRIS AND MOFFAT (2011b) that estimates TFP for each market-sector plant operating in Great Britain in 1997-2006 has been updated. They describe in detail the data used and the econometric methodology chosen. Here an overview is provided, and the reader is referred to the earlier article for more information.

TFP is estimated by plant for each year covering 1997-2012 for most market-based sectors for Great Britain.[8] TFP was obtained using a system-GMM approach to estimate separate Cobb-Douglas log-linear production functions for the industry sub-groups set out in Table A.1:[9]

$$y_{it} = \alpha_i + \alpha_E e_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \alpha_X X_{it} + \alpha_T t + \varepsilon_{it} \tag{1}$$

where *y*, *e*, *m* and *k* refer to the natural logarithms of real gross output, employment, intermediate inputs and capital stock in plant *i* in time *t* (*i* = 1,…, *N*; *t*=1,…*T*) respectively; and *X* is a vector of observed (proxy) variables determining TFP (as set out in Table 1), including spatial variables such as proxies for agglomeration and diversification and dummy variables denoting whether a plant was located in a specific assisted area, region and city. In order to calculate TFP, equation (1) is estimated

[8] Manufacturing includes all those plants and firms that belonged to SIC's 15111 to 37200 (using the 1992 Standard Industrial Classification); for services all those in SIC50101 to SIC93010 are included, with the following industries being excluded: financial intermediation (SIC65-67); public services (SIC75-85); and private households and extra-territorial activities (SIC95-99). Agriculture and fishing, utilities and construction are also excluded because of lack of data.

[9] Note, low KI services was sub-divided into 4 sub-groups: sales and repairs (SIC50); wholesale (SIC51); retail (SIC52); and the remainder. Equation (1) was estimated separately for each of these sub-groups.

directly (e.g., HARRIS, 2005a) providing values of the elasticities of output with respect to inputs (α_E, α_M, and α_K), and then (logged) TFP is calculated as the level of (logged) output that is not attributable to factor inputs (employment, intermediate inputs and capital) – i.e., TFP is due to efficiency levels and technical progress:

$$\ln \hat{P}_{it} = y_{it} - \hat{\alpha}_E e_{it} - \hat{\alpha}_M m_{it} - \hat{\alpha}_K k_{it} = \hat{\alpha}_i + \hat{\alpha}_X X_{it} + \hat{\alpha}_T t + \hat{\varepsilon}_{it} \qquad (2)$$

Note, using equation (2) to predict TFP allows for all determinants in the vector *X* to be included; others who use an alternative two-stage procedure to obtain TFP, based on estimating equation (1) with the vector *X* omitted, obtain biased estimates of TFP. Other estimators (such as OLLEY AND PAKES, 1996) are based on assumptions we believe are more restrictive (e.g., there are no fixed-effects in the model[10] – see the discussion in HARRIS, 2009, especially par. A6.16ff).

The data used to estimate equation (1), and as described in Table 1, comprise mostly plant level data from the Annual Respondents Survey (*ARD*), which has been extensively discussed by previous users (see especially, HARRIS, 2005a; but also HARRIS, 2002; and GRIFFITH, 1999). Data on R&D spending is available from the Business Enterprise R&D database (*BERD*) and Office for National Statistics (ONS) enterprise level and reporting unit codes (together with information on the postcode and industry classifications) that are available in both the *ARD* and *BERD* are used to match records. Information on outward foreign direct investment (OFDI) subsidiaries and branches is available from the Annual Foreign Direct Investment survey carried out by the ONS, covering some 8,500-12,000 observations per year (although only about 980-2,500 firms, since many

[10] The inclusion of fixed effects is necessary as empirical evidence using micro-level panel data consistently shows that plants/firms are heterogeneous (productivity distributions are significantly ‘spread’ out with large ‘tails’ of plants/firms with low TFP), but more importantly that the distribution is persistent – plants and firms typically spend long periods in the same part of the distribution (see, for instance, BARTELSMAN AND DHRYMES, 1998; HASKEL, 2000; and MARTIN, 2008). Such persistence suggests that firms have ‘fixed’ characteristics (associated with access to different path dependent (in)tangible resources, managerial and other capabilities) that change little through time, and thus need to be modelled.

firms have multiple subsidiaries/branches in different countries); these data were amalgamated into a single observation per firm per year and merged into the *ARD* using the ONS codes available in both datasets. In all, over 95% of *BERD*/*AFDI* records are matched into the *ARD*. Estimates of plant level capital stock are obtained using the perpetual inventory approach and plant level estimates of real investment; the methods used are set out in HARRIS (2005b).

The estimates for the output elasticities used to predict TFP are provided in Table 2; firstly as the diagnostics show, the estimates obtained are economically sensible, and pass various tests of the validity of the instruments used[11] and, in most cases, tests for autocorrelation. That is, all 11 models are deemed sufficient in terms of tests for over-identification (i.e., the Hansen test of validity of the instrument set used), and generally for autocorrelation (*cf*. the AR(1) and AR(2) test statistics). With regard to the latter, STATA reports tests for the first-differenced residuals, thus there should be evidence of significant negative first order serial correlation in differenced residuals and no evidence of second order serial correlation in the differenced residuals, which is mostly the case here.

Based on equation (2), and using the elasticities reported in Table 2, TFP can be calculated for each plant for 1997-2012; Figure 1 summarises the mean values across plants for each region in Great Britain, including Scotland and the 'rest of the UK'.[12] Scotland has significantly lower average productivity compared to the 'rest of the UK' in all years except 1997 (when it had significantly higher productivity) and 2007 (when

[11] Output and factor inputs (*y*, *e*, *m* and *k*), are treated as endogenous. Brownfield foreign-ownership, R&D, and OFDI in Table 1 are also treated as endogenous. In all cases endogenous variables are replaced by their lagged values. The validity of the instruments (i.e. the fact that they are correlated with endogenous regressors but are not correlated with the production function error term – and hence productivity) can be assessed using the Hansen test of over-identification.

[12] Note, all our estimates of TFP have been normalized to be consistent with 1997=1 for Scotland.

the difference was only 0.1 and statistically insignificant). Table 3 presents more detailed information on the size of this ‘productivity gap’ for 2008-12 and 2012, separately for different industry groups. Scotland had a productivity advantage of 9 – 10 points for low-tech manufacturing (or 9-10% relative to the normalisation that has been applied – see footnote (a) to Table 3); however, it had a significantly lower level of TFP in all service sector industries, especially in the low knowledge-intensive (KI) sector. Overall, the ‘gap’ was around 11% across all sectors.

Table 2 around here

Figure 1 around here

Table 3 around here

Mean values (as depicted in Table 3) only capture a point-estimate of the differences across plants. Therefore, the distribution of plant TFP (ordered from lowest-to-highest) for different sub-groups (e.g., years and sectors) is presented in Figures 2 and 3. The first diagram shows that in all years except 2009, the TFP distribution for plants operating in the rest of the UK consistently ‘dominates’ (i.e., lies to the right of) the distribution for Scottish plants. The K-S statistic tests whether the largest gap between the two distributions is significantly different from zero, with the gap being measured under the assumption that (i) Scotland dominates and (ii) that the ‘rest of the UK’ dominates. Thus, the gap for all years in favour of the ‘rest of the UK’ dominating is significant and between 0.06-0.08. However in 2009, Scottish plants also dominated the ‘rest of the UK’ at the top end of the TFP distribution; the maximum gap was 0.1, and statistically significant at the 1% level.

Figure 3 shows the TFP distributions for 2012 by sector. For high-tech manufacturing, there is no statistical evidence that either Scotland or the ‘rest of the UK’ dominated, although there is weak evidence that plants in the ‘rest of the UK’ did slightly better at the top end of the productivity distribution (note this is in contrast to the mean values presented in Table 3 which suggest that on average Scotland did better, although the difference was not significant at better than the 10% level).[13] In contrast, Scotland does better in medium high-tech manufacturing in 2012, at the top end of the distribution where the maximum gap is 9% (and statistically significant at better than the 5% level). There is little to distinguish TFP between plants across the two areas in medium low-tech manufacturing; while there is clear evidence that for most of the distribution plants in Scotland have relatively higher TFP in low-tech manufacturing.

Figure 2 around here

Figure 3 around here

Turning to services, there is evidence that in 2012 plants in the 'rest of the UK' had higher TFP in hi-tech KI services (the maximum gap was 5%); at the lower end of the distribution Scotland tended to dominate in the KI services sector (although the difference was not large and only significant at better than the 10% level); Scottish plants were everywhere 'dominated' in the low KI sector; and there is a mixed pattern for other low KI services (Scotland dominates for parts of the distribution, while the 'rest of the UK' dominates in the middle range of the TFP distribution). Overall, there is fairly consistent evidence based on TFP distributions, that Scottish plants did less well in services; in contrast, Scotland did better than the 'rest of the UK' in medium high-tech and low-tech manufacturing. Given the relative size of the manufacturing and services sector, the overall outcome was a lower level of TFP in Scottish plants.

[13] This discrepancy shows that comparing the distribution of TFP, rather than just a point-estimate of the average difference, provides more information that is useful in deciding which 'country', if any, dominates.

III. EXPLAINING DIFFERENCES IN TFP

To explain differences in TFP between Scotland and the 'rest of the UK', 'place' and 'composition' effects are considered. The former is based on considering what would potentially be the outcome if plants with exactly the same characteristics were spatially relocated from the 'rest of the UK' to Scotland – are there (dis)advantages associated with Scotland that can account for some of the 'productivity gap' discussed in the last section? In contrast, 'composition' effects are linked to whether there are too many (or too few) plants in Scotland with characteristics associated with lower (higher) TFP – for example, more old plants which tend to have lower TFP, or fewer plants doing R&D which is associated usually with higher TFP.

'Place' effects

These are captured in equation (1) through the inclusion of variables that measure the impact of location on TFP. There have been a number of studies to date that suggest that 'spillover' effects associated with location have a positive impact on productivity and growth (a detailed discussion and review of the extant literature is provided in HARRIS AND MOFFAT, 2012; see also HARRIS, 2011). Agglomeration externalities are usually distinguished in the literature according to whether they are an intra - or inter-industry phenomena. Intra-industry externalities are termed MAR (MARSHALL, 1890; ARROW, 1962; ROMER, 1986) or localisation externalities, while inter-industry externalities are termed Jacobian (JACOBS, 1970, 1986) or diversification externalities. In addition to the potential 'spillover' benefits of plants being co-located, there are specific 'place' effects associated with a particular area (*inter alia*, covering infrastructure, remoteness, and other systematic factors that are often difficult to measure); dummy variables that takes on a value of 1 for those plants located in an 'assisted area' are therefore used,[14] in a major city, or in a particular geographic region. It might be expected that those located in assisted areas (which are areas deemed to be economically underperforming) to experience overall negative externalities associated with location. City and region effects will depend upon the characteristics of these areas and can be positive or negative. Previous empirical literature based on micro-data studies has tended to show that in general localisation (or MAR) economies are positive while diversification economies are either less important or negative (cf. HENDERSON, 2003; CAPELLO, 2002; BALDWIN et. al, 2010; MARTIN et. al., 2011; VAN DER PANNE, 2004).

The parameter results from our estimation of equation (1) generally confirm this (see Table A2-A4 summarised in Table 4 below) – intra-industry agglomeration is linked to higher TFP and inter-industry agglomeration lead to lower TFP in most sectors. While previous UK analysis of whether plants in assisted areas have lower TFP suggests this is likely (HARRIS AND ROBINSON, 2004, Table 3), 'mixed' results are obtained here (Table 4). Our parameter estimates of a 'Glasgow-effect' show that, cet. par., plants in high-tech manufacturing experienced a significant negative impact on TFP from being located in the city (there are smaller negative effects for repairs and sales, SIC50, and wholesale, SIC51); while being located in Glasgow had positive impacts for plants operating in medium low-tech manufacturing, other low KI services, retailing (SIC52), and especially low KI services. Edinburgh effects were less prevalent, and only relatively large (and positive) for low-tech manufacturing (with smaller impacts in low KI-market services and retailing). Lastly, the column headed $\hat{\beta}$ under 'Scotland' in Table 4 shows that being located in Scotland, vis-à-vis the benchmark region (the South East) had large negative

[14] Assisted areas are those agreed by the European Commission to be eligible for government help (e.g., Grants for Business Investment – formerly Regional Selective Assistance).

impacts on plant-level TFP in high-tech KI services, low KI market services, and to a lesser extent repairs and sales and retailing. There was a beneficial Scottish 'place' effect for plants operating in KI market services and in wholesaling.

While the parameter estimates reported in Table 4 show the absolute impact of 'place' effects on Scottish TFP, we also want to try to explain Scotland's position relative to the 'rest of the UK'. The figures in the columns (generally denoted $\bar{X}_S - \bar{X}_{rUK}$) next to each set of parameter estimates indicate whether on average Scotland had higher or lower agglomeration or diversification, had more plants in assisted areas and the extent to which Scottish plants were located in Glasgow or Edinburgh. The column headed $\hat{\beta}_{rUK}$ represents the weighted 'place' effects for plants located in the 'rest of the UK' relative to the benchmark region (the South East).[15] Multiplying the two set of column figures for each 'place' effect (i.e., parameter estimates $\times$ relative means) shows how each effect contributes to the overall total (the last column in Table 4).[16]

In general the impact of 'place' is less important in explaining Scotland's relative TFP in manufacturing (the exception is medium low-tech manufacturing and less significantly medium high-tech manufacturing – where both indicate location in Scotland is beneficial[17]); but 'place' did have a large impact in services (it was especially beneficial in KI market services and to a lesser extent wholesaling; but significantly negative in high-tech KI services, and a lesser extent low KI market services, including repairs and

[15] To gauge the relative impact of 'Scotland' on TFP, it is necessary to compare against the impact of the other regional/city effects on TFP in those locations – all relative to the benchmark region (the South East). Footnote (d) to Table 4 explains how this is calculated.

[16] Note, the last column under 'Scotland' is subtracted from the first, not multiplied by it. The first set of figures in the last column in Table 4 is based on using all the values available, and not setting statistically insignificant parameter values to zero. This is because all the parameter estimates obtained when estimating equation (1) are used to derive TFP in equation (2) – not just significant values. The second set of figures set statistically insignificant parameter estimates to zero.

[17] If only significant parameter estimates are used, the overall 'place' effect for medium low-tech manufacturing is 0.058; if all parameter values are used, both medium-high and medium-low tech manufacturing have 'place' effects of around 0.07.

sales). In services, these positive and negative 'place-based' externalities were mainly the result of by the overall 'Scotland' effect, except in other low KI services where Scottish plants overall benefited from having less diversification (because diversification itself was found to have a negative impact on TFP).[18]

Table 4 around here

'Composition' effects

These are included in equation (1) through the inclusion of the 'non-place' variables measuring plants characteristics in vector *X*. When estimating models of TFP, internal and external knowledge creation is usually represented by both endogenous technical progress due to undertaking R&D in the firm, and by exogenous gains over time, as well as its obsolescence. The latter is captured by the age of the plant as it is expected that younger firms produce with greater efficiency and better technology than older plants (a vintage capital effect); on the other hand, productivity may increase as the firm ages through learning-by-doing e.g. JOVANOVIC AND NYARKO, 1996). R&D is expected to have an impact on TFP through two channels. Most obviously, performing R&D may generate process innovations that allow existing products to be produced with greater efficiency (through lower costs). It may also generate product innovations which will improve TFP if the new products are produced with greater efficiency or using better technology than existing products (i.e. an outward shift of the firm's production possibility frontier). The second channel is through the development of absorptive capacity (see COHEN AND LEVINTHAL, 1990, and especially ZAHRA AND GEORGE, 2002, for a detailed discussion of the concept). Absorptive capacity permits the

[18] Other important, although less dominant, 'place' effects include the impact of agglomeration in hi-tech KI and retail – in both cases agglomeration has a positive impact, as shown by the parameter estimates, but in Scotland these sectors are relatively less agglomerated so Scotland does not obtain the same positive impact relative to the 'rest of the UK'.

identification, assimilation and exploitation of innovations made by other firms and R&D actors, such as universities and research institutes, and is therefore also expected to lead to improvements in TFP.

A single-plant firm dummy, equal to one if that plant is the only plant owned by the firm, is also included in X_{it} in equation (1), together with a multi-plant dummy equal to one if the plant belongs to an enterprise that operated in more than one region. The benchmark sub-group is therefore multi-plant firms that operate in only a single region. HARRIS (1989) summarised the literature developed in the 1970s and 1980s on why plants belonging to multi-plant enterprises may have higher productivity. The more recent literature has moved away from placing traditional economies of scale at the centre of whether single- or multi-plant firms should benefit most in terms of their productivity levels; instead more emphasis has been placed on the wider advantages of small versus large firms. Thus it is argued by DHAWAN (2001) that the '… higher productivity or efficiency of smaller firms is the result of their leaner organizational structure that allows them to take strategic actions to exploit emerging market opportunities and to create a market niche position for themselves' (p.271). Larger firms can suffer from diseconomies in managerial efficiency due to coordination costs and incentive difficulties (WILLIAMSON, 1967) while smaller firms are more responsive to change and are less risk-adverse (UTTERBACK, 1994; SCHERER, 1991; AUDRETSCH, 1995).

A measure of the concentration of output across firms, and therefore of market power, is usually included to take account of competition effects. Under the assumption that the elasticity of demand does not vary too greatly across firms in an industry, this is a valid measure of competition within an industry (see, for example, CABRAL, 2000). Intuitively, one would expect that greater competition will pressure firms into adopting new technologies and operating more efficiently (e.g. NICKELL, 1996; MEYER AND VICKERS, 1997). However, it can also be argued – following SCHUMPETER (1943) and more recent endogenous growth theory models – that the level of competition may be inversely related to productivity if monopoly rents are required for management to invest in R&D which in turn leads to innovation and improvements in TFP (DIXIT AND STIGLITZ, 1977; AGHION et al., 2001; AGHION AND HOWITT, 1992 and 1999; ROMER, 1990; GROSSMAN AND HELPMAN, 1991).[19]

Lastly, multinational firms – especially US-owned MNEs – are expected to possess characteristics (e.g. specialised knowledge about production and better management or marketing capabilities) that give them a cost advantage over plants that only operate in the domestic market (HYMER, 1976). These firms (whether foreign-owned or UK-owned engaged in outward FDI) are therefore expected to be more efficient. Conversely, cultural differences between the owners of the firm and the workforce may act to lower levels of TFP in foreign owned plants, especially in the immediate period after the establishment of new 'greenfield' operations, or the acquisition of an existing enterprise. DUNNING (1988) suggests a lack of understanding of management and labour attitudes as one such disadvantage possessed by foreign owned firms in developed countries. Furthermore, firms may undertake FDI to source technology from the host economy rather than to exploit superior technology from the home country (DRIFFIELD AND LOVE, 2007). Plants owned by foreign owned firms that are motivated by technology sourcing rather than technology exploiting are likely to have lower TFP than plants owned by foreign owned that are technology exploiting (FOSFURI AND MOTTA, 1999; CANTWELL et al., 2004; DRIFFIELD AND LOVE, 2007).

[19] It has also been shown that, under some conditions, increased competition can lower the expected income of managers and therefore their effort (HERMALIN, 1992). This reduced effort may be reflected in reductions in plant efficiency levels.

To make predictions about the relative TFP levels of 'greenfield' and 'brownfield' plants, it is helpful to consider the motives of the foreign firm when undertaking such investment. Greenfield investment involves the opening of a new plant while 'brownfield' investment involves the merger/acquisition of an existing plant. For firms that undertake FDI in order to secure access to and thereby to internalise complimentary local assets, 'brownfield' investment would be the preferred form of investment. This idea is supported by the model of BUCKLEY AND CASSON (1998), which shows that 'brownfield' investment will be preferred when the costs of learning about the domestic market are high and these costs can be avoided through acquisition. This implies that 'brownfield' plants may well have higher TFP than 'greenfield' plants which do not have access to these assets. An extension of this argument is that plants with better assets will be a more attractive target for foreign-owned firms seeking to acquire plants. If so, plants acquired through 'brownfield' investment will be a self-selected group of the population of plants. Assuming that these assets manifest themselves in the form of higher productivity, it is expected that multinationals tend to acquire plants that have high levels of TFP. Empirical evidence in support of this proposition is provided by HARRIS AND ROBINSON (2003) and MCGUCKIN AND NGUYEN (1995). However, there may be problems associated with 'brownfield' investment. For instance, there may be difficulties with integration of the plant into the firm and the establishment of trust between owners and employees (HARRIS, 2009). New 'greenfield' investments may also allow foreign-owned firms to introduce modern technology and modern management practices, and establish their own forward and backward supply-chains with plants that are a closer match with their own needs and requirements. The limited empirical on this question appears to suggest that foreign-owned 'greenfield' plants do indeed have higher TFP than 'brownfield' plants (HARRIS, 2009; HARRIS, 2010).

The parameter estimates for 'composition' effects obtained here (Tables A2 – A4 reproduced in Table 5) are generally in line with the previous micro-based studies reported in the literature. Plants that undertake R&D have higher productivity, although the effect is not as widespread as expected (only two manufacturing sectors have positive, significant parameter estimates, and in services impacts are confined to SIC 50-52). In contrast, older plants tend to have uniformly lower TFP, indicating that technology obsolescence is very important. Single-plant firms had 13% higher TFP in hi-tech manufacturing, 17% higher in low-tech manufacturing and over 40% higher in hi-tech KI services.[20] In most of the other service-based sectors, single plant firms had significantly lower TFP (with the cet. par. effect being large in most sub-sectors). Generally, plants belonging to multi-region enterprises had higher TFP, while lower competition (a larger Herfindahl index) resulted in higher TFP in mostly service industries (the main exception was KI market services where a doubling of the Herfindahl index reduces TFP by 5.4%). Plants belonging to foreign-owned enterprises generally had higher TFP, especially if US-owned and to some extent if they were 'greenfield' operations. Plants belonging to UK-owned multinationals also had higher TFP (principally if they were in the service sector) while plants belonging to foreign-owned MNEs who also had overseas operations associated with their UK subsidiaries did not generally benefit further from outward FDI (the overall impact for these plants is the sum of the parameter estimates associated with 'outward FDI' and 'outward FDI × foreign-owned').

[20] Note the marginal effect is calculated as $100 \times e^{\hat{\beta}} - 1$.

Table 5 around here

As in the last sub-section, while the parameter estimates reported in Table 5 show the absolute impact of 'composition' effects on Scottish TFP, there is a need to explain Scotland's position relative to the 'rest of the UK'. This information is derived from multiplying the $\hat{\beta}$ by the $(\bar{X}_S - \bar{X}_{rUK})$ columns, which are then summed to the totals presented in the last column of Table 5. Overall, 'composition' effects were negative, and large in the case of low KI services, where in particular single plant firms had much lower TFP and Scotland had a larger relative share of such enterprises. Having a relatively greater proportion of older plants also contributed significantly to the overall large, negative compositional effect for this sector. Other sectors with relatively large, negative compositional effects included SIC51 and SIC52, other low KI services, KI services and to a lesser extent high-tech manufacturing. For nearly all of these (except low KI services), again having too many single, older plants helps to explain the overall impacts reported. In high-tech manufacturing, relative competition effects were also important (a higher Herfindahl index leads to lower TFP, and Scotland operated in sub-sectors with relatively higher levels of concentration[21]). For 'other low KI services', the most important contribution to the overall negative 'composition' effect was Scotland having relatively few plants belonging to enterprises that also operated in other regions. The only sector with a relatively large positive 'composition' effect in Scotland was high-tech KI; the largest contributors to this were the impact of lower competition and

[21] Note the contrast with hi-tech KI, where Scotland benefited from having more plants in those industries that had lower levels of competition. In KI market services, the situation is very different; here Scotland benefited from having more plants operating in industries with relatively lower concentration, and the latter (higher competition) led to higher TFP in this sector.

relatively younger plants (positive effects) and having relatively fewer single-plant and UK-owned outward FDI enterprises (negative effects).[22]

Comparing the relative importance of 'place' and 'composition' effects, in most instances these two effects have opposite signs. Thus for the manufacturing sector, the small totals recorded in the final columns of Tables 4 and 5 combine to produce overall little difference between Scotland and the 'rest of the UK' for hi-tech and low-tech manufacturing; however in medium low-tech manufacturing, and – if insignificant parameter estimates are allowed to count – also medium high-tech manufacturing, there are relatively larger positive 'place' effects. This is in line with the results discussed in Figure 3, with the exception of low-tech manufacturing where in Tables 4 and 5 relatively similar 'place' and 'composition' effects for Scotland vis-à-vis the 'rest of the UK' are reported, but a productivity advantage to Scotland in the distribution of TFP (Figure 3) is also observable.[23] For hi-tech KI, the small favourable 'composition' effect is insufficient to counter the much larger and negative 'place' effect; thus again this result matches with Figure 3. In contrast, the negative 'composition' effect for KI market services does not fully mitigate the much larger positive 'place' effect in that sector; thus Scotland does relatively better (cf. Figure 3). In low KI market services, the two large negative effects combine to give a large overall negative aggregate total for Scotland vis-à-vis the 'rest of the UK'. In addition, the negative 'composition' effect also reinforces the negative 'place' effects for SIC50 and SIC52, while they virtually cancel each other out for wholesaling (SIC51). Overall, low KI market services in Scotland (encompassing

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[22] Note, foreign-ownership has little role in explaining productivity differences between Scotland and the 'rest of the UK', as Scotland's share of such plants is mostly in line with the share of such plants in other areas.

[23] Thus, and with respect to equation (2), the difference in Figure 3 for low-tech manufacturing is captured in the following terms: $\hat{\alpha}_i + \hat{\varepsilon}_{it}$, which measure 'fixed effects' and random shocks. This is more likely due to 'fixed effects' that persist over time, capturing undefined but discernable (i.e., measured) positive TFP effects at the lower end of the TFP distribution in favour of Scottish plants.

SIC50-52) have the lowest relative TFP levels (Figure 3); this sector is found to have the largest negative 'place' and composition' effects (Tables 4 and 5).

To explain differences in TFP between Scotland and the 'rest of the UK', both 'place' and 'composition' effects are considered to account for some of the 'productivity gap' discussed in the section 2. That is, our findings in this section help to explain the sources of the productivity gap; positive 'place' effects help explain the situation in medium-tech manufacturing and KI market services, while negative 'place' effects dominate in hi-tech KI, and repairs and sales (SIC50). Negative 'composition' effects dominate and help explain Scotland doing relatively badly in low KI market services, other low KI services, and retailing. There is no single source to explain Scotland's productivity gap; policy therefore needs to be tailored to the needs of different sectors, taking into account any differences in the underlying sources of these 'place' and 'composition' effects.

IV. SOME POLICY OPTIONS

In this section some of the policy options that could increase TFP in Scotland and obtain the 'step-change' in productivity levels needed to boost long-run growth and thus government revenues are considered. Our focus is on efforts to promote more investment (particularly higher inward investment), and entrepreneurship (e.g. business start-ups). These have often been favoured in the past as a means of achieving growth and higher employment, although UK policy instruments to date have tended to be micro-based involving grants and other forms of assistance such as 'advice'. It is only more recently, with the discussion of devolved and independently operated tax systems, that policy has been couched more in terms of macroeconomic tax incentives (such as cuts in corporation tax).

In order to provide some insight on the role of investment from the rest of the UK, the productivity levels of essentially Scottish versus non-Scottish plants are calculated (where the latter include plants owned by firms who mostly operate in the 'rest of the UK'), to consider what might be the impact on productivity if investment from the 'rest of the UK' had to face higher entry barriers that could result if Scotland left the Union.

The analysis in sections 2 and 3 showed that younger plants tend to have uniformly higher TFP, while plants belonging to foreign-owned enterprises generally had higher TFP, especially if US-owned and to some extent if they were 'greenfield' operations. Thus suggests that policy that encourages more entrepreneurial activity and higher inward foreign direct investment should boost TFP. Table 6 presents the results from applying a Haltiwanger-type approach (FOSTER et. al., 1998) to decomposing productivity growth between 1997-2012 into: the (within-plant) contribution of plants operating in both 1997 and 2012 that internally increased their productivity; the between-plant contribution of plants operating in both 1997 and 2012 gaining market shares as their productivity changes; and the contribution of entering and exiting plants. The first set of results headed 'totals' presents aggregate results for Great Britain, as well as Scotland and the 'rest of the UK'. Overall TFP growth p.a. in 1997-2012 was 1.3%, of which Scotland contributed -0.07% p.a. Since the results in column (1) are dependent not only on productivity growth but also the relative size of the economy, the figures in column (2) divide those in column (1) by output shares in 1997. These show that – adjusted for size – Scotland experienced -0.9% p.a. growth in TFP while the 'rest of the UK' experienced 1.5% p.a. growth. The main contribution to overall TFP growth in Great Britain was the 1.1% p.a. increase in TFP due to the entry of new, more productive plants; this was complimented by a 0.2% increase due to the closure of lower productivity plants; while plants that were open throughout the period contributed very little to TFP growth (–0.3% through internal TFP improvement cancelled out by 0.3% higher shares going to more productive plants). However, when Scotland and the 'rest of the UK' are looked at separately, in the case of Scotland 'churning' is still dominant but the contribution of new plant start-ups and the closure of existing plants were both negative. In contrast, new plants in the 'rest of the UK' contributed substantially to productivity growth, while on average lower productivity plants were closed-down. For both areas, the contribution of plants open throughout 1997-2012 was generally very small. These first set of results show that net plant entry has not benefited TFP growth in Scotland, whereas it did in the 'rest of the UK'.

Table 6 around here

The second bloc in Table 6 present separate results for manufacturing and services, for Scotland and the 'rest of the UK'. These show a similar pattern, although with additional information that shows manufacturing had negative TFP growth (especially in Scotland), with the largest contribution being the closure of higher productivity plants; while services performed well in the 'rest of the UK' but badly in Scotland (mainly through the opening of less productive plants). Finally, TFP growth is considered in terms of whether the plant was UK-owned or foreign-owned, separately for Scotland and the 'rest of the UK'. The worst relative performance is associated with the foreign-owned sector in Scotland (-2.6% p.a. TFP growth), and the best with the foreign-owned sector in the 'rest of the UK' (3% p.a. TFP growth). The Scottish performance is dominated by the closure of relatively productive foreign-owned plants post-1997, while in the 'rest of the UK' the foreign-owned sector opened more productive plants that overall provided a significant proportion of total TFP growth in this period. This suggests that Scotland suffered from what has been labelled a 'branch plant' effect whereby the more 'footloose' foreign-owned sector is more likely to close productive capacity in 'peripheral' regions when called upon to restructure their international operations, even when such plants have relatively high TFP.[24] This 'branch plant' syndrome has been documented in the literature (e.g., Harris, 1989, 1991, provides a review and evidence for the period up to the 1980s), and is summarised by PHELPS (2009) as the '… road to nowhere: the transformation of the UK's old industrial regions into branch plant economies'.[25]

The above analysis points to the problem of assuming that promoting business start-ups and more inward investment, per se, will produce the desired outcome of higher TFP. Clearly over 1997-2012 Scotland should have benefited, but the actual foreign-owned plants that were attracted were insufficiently embedded into the economy (and/or had insufficient higher value-added functions that could help to guarantee that they remained open); similarly, many of the new business start-ups (especially in services) were of insufficient quality to contribute to higher TFP. It is also difficult to see why relying on greater tax incentives post-2016 as the main policy instrument should result in different outcomes, unless government-funded bodies like Scottish Development International and Scottish Enterprise are able to encourage and help start-ups and inward investors with the 'right' characteristics that will boost productivity in the longer term.

Table 7 around here

[24] Since in this period foreign multinational companies were significantly engaged in 'offshoring' to parts of the world with much lower (wage) costs, it is likely that lower valued-added – but efficient – facilities in countries like Scotland would have been at risk of closure. Such an example would be the foreign-owned plants that made up the computer and electronics industry known as 'Silicon Glen' (i.e., SIC 30+32, 1992 SIC; see MCCANN, 1997). It employed some 7.7% of all manufacturing workers in 1997, but by 2012 this figure was only 1.7% (amounting to a decline in employment of over 500% during the period).

[25] As detailed in PHELPS (op. cit.), branch plant economies suffer from: 'functional truncation' (the absence or removal of high-value-added segments such as management, R&D, sales and marketing); concerns over product and process innovation rates in branch plants; concerns over employment quality; a lack of local linkages; and (v) concerns over the stability of employment. HARRIS and HASSASZADEH (2002) show using ARD data for UK manufacturing that new plants acquired by the foreign-owned sector were much more likely to be closed down.

Lastly, plants that operated in Scotland are separated into those that were essentially Scottish plants and those which were non-Scottish. If a plant operating in Scotland belonged to an enterprise that produced 75+% of real gross output in Scotland, it was classified as 'dominant Scottish'; if it is belonged to a UK enterprise that produced less than 75% of its total output in Scotland, the plant was designated as belonging to a 'non-dominant Scottish' enterprise. Table 7 shows the percentage of output produced in each UK region that can be attributed to plants belonging to dominant enterprises; in Northern Ireland, some 85% of output was from plants belonging to firms that mostly operated just within Northern Ireland, while in the North East only some 60% of regional output came from plants that belonged to enterprises that operated mostly in other regions of the UK.

If Scotland were to become independent post-2016, the UK Treasury (2014) suggests that the costs of a 'non-dominant Scottish' enterprise operating in Scotland would rise. Some examples of the potential new costs are those associated with operating in different currencies if Scotland were not to use sterling; possible (pecuniary and non-pecuniary) tariffs if Scotland had to renegotiate entry into the European Single Market; a potential higher cost of borrowing if Scotland had a lower credit rating; higher income taxes for Scottish workers if Scotland needed to raise extra tax revenues (either to meet any short-falls, or to achieve a more egalitarian society). If such higher entry barriers arose and subsequently 'non-dominant Scottish' firms reduced their levels of Scottish production, the impact on Scottish productivity is likely to be significantly negative (Figure 4). This is because when the TFP distribution of Scottish plants is separated into 'dominant Scottish' and 'non-dominant Scottish', the former plants have much lower

TFP, and thus if they were to become relatively more important, average Scottish TFP would decline.[26]

Figure 4 around here

V. SUMMARY AND CONCLUSIONS

Fewer plants and firms in Scotland innovate, undertake R&D and export vis-à-vis the 'rest of the UK'; consequently it was not surprising to find that there exists a 'productivity gap', with Scotland in 2012 (the latest year for which plant-level data is available) having overall TFP 11% below the 'rest of the UK' (and 22% below the leading UK region). And yet productivity is recognized as the most important driver of long-run economic growth; indeed a 'step-change' in productivity underpins the Scottish Government's case for a net improvement in the fiscal balance of £2.4 billion a year (2012/13 prices) by 2029-30.

To explain differences in TFP between Scotland and the 'rest of the UK', 'place' and 'composition' effects are considered to account for some of this 'productivity gap'. There was a mix of positive and negative 'place' effects that helped explain the situation in different industries. However, negative 'composition' effects dominated overall and helped to explain Scotland doing relatively badly in those (service) sectors where the productivity gap is largest. But is important to note that there is no single source to explain Scotland's productivity gap and therefore policy needs to be tailored to the needs of different sectors.

ur estimates of TFP were then used to consider whether certain policy instruments are likely to increase TFP in Scotland and help obtain the 'step-change' in productivity

[26] Of course this also likely to be true for other UK regions in the 'rest of the UK'; but they would not be subject to such 'entry barriers'.

levels needed to boost long-run growth and thus government revenues. We focused on the promotion of more investment (particularly higher inward investment), and entrepreneurship (e.g. business start-ups), especially as it was found that newer, younger plants tend to have higher TFP, as do plants belonging to foreign-owned enterprises. While new plants in the 'rest of the UK' contributed substantially to productivity growth during 1997-2012 (while on average lower productivity plants were closed-down) in Scotland the contribution of new plant start-ups and the closure of existing plants both contributed negatively to TFP growth. Furthermore, when split by ownership, it was shown that while in the 'rest of the UK' the foreign-owned sector opened more productive plants that overall provided a significant proportion of total TFP growth, in Scotland performance was dominated by the closure of relatively productive foreign-owned plants post-1997 – that is, Scotland suffered from a 'branch plant' syndrome with the more 'footloose' foreign-owned sector being more likely to close productive capacity in 'peripheral' regions when called upon to restructure their international operations, even when such plants had relatively high TFP. Thus while promoting business start-ups and more inward investment, per se, should have produced the desired outcome of higher TFP, Scotland had too many plants with the 'wrong' characteristics that lead to relatively poor outcomes. This leads us to conclude that it is difficult to see why relying on greater tax incentives post-2016, as the main policy instrument, should result in a closing of the 'productivity gap', let alone a 'step-change' in productivity growth. Scotland would benefit from more start-ups and more inward investment, but only if government-funded bodies like Scottish Development International and Scottish Enterprise are able to encourage and help start-ups and inward investors with the 'right' characteristics that will boost productivity in the longer term.

Finally the consequences of the raising of higher 'entry barriers' to inward investment into Scotland from firms with their major operations located in the 'rest of the UK' were considered. *If* such higher entry barriers resulted, should Scotland leave the Union, and subsequently firms mainly based in the 'rest of the UK' reduced their levels of Scottish production, the impact on Scottish productivity is likely to be significantly negative.

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Table 1: Variables needed to estimate TFP in equation (1)

Variable	***Definitions***	***Source***
Real gross output	Plant level gross output data deflated by 2-digit ONS producer price (output) indices. Data are in £'000 (2000 prices)	ARD
Real intermediate inputs	Plant level intermediate inputs (gross output minus GVA) deflated by 2-digit ONS producer price (input) indices (non-manufacturing only has a single PPI). Data are in £'000 (2000 prices)	ARD
Employment	Number of employees in plant.	ARD
Capital	Plant & machinery capital stock (£m 1995 prices) plus real value of plant and machinery hires (deflated by producer price index) in plant. Source: Harris and Drinkwater (2000, updated).	ARD
Age	Number of years plant has been in operation based on year of entry	ARD/ IDBR
Single-plant	Dummy coded 1 when plant comprises a single-plant enterprise	ARD
>1 region multiplant	Dummy coded 1 if plant belongs to multiplant enterprise operating in more than 1 UK region	ARD
Greenfield US-owned	Dummy coded 1 if plant is US-owned and newly opened during 1997-2011	ARD
Brownfield US-owned	Dummy coded 1 if plant is US-owned and not newly opened during 1997-2011	ARD
Greenfield EU-owned	Dummy coded 1 if plant is EU-owned and newly opened during 1997-2011	ARD
Brownfield EU-owned	Dummy coded 1 if plant is EU-owned and not newly opened during 1997-2011	ARD
Greenfield Other foreign-owned	Dummy coded 1 if plant is foreign-owned by another country and newly opened during 1997-2011	ARD
Brownfield Other foreign-owned	Dummy coded 1 if plant is foreign-owned by another country and not newly opened during 1997-2011	ARD
Herfindahl	Herfindahl index of industry concentration (3-digit level)	ARD
Industry agglomeration	% of industry output (at 5-digit SIC level) located in travel-to-work (TTWA) in which plant is located – MAR-spillovers	ARD
Diversification	% of 5-digit industries (from over 650) located in TTWA in which plant is located – Jacobian spillovers	ARD
R&D*	Dummy coded 1 if plant had positive R&D stock based on undertaking intramural and/or extramural R&D since 1997	BERD
Assisted Area	Dummy coded 1 if plant is located in assisted area	ARD
Region	Dummy coded 1 if plant is located in particular administrative region	ARD
City	Dummy coded 1 plant is located in major GB city (defined by NUTS3 code)	ARD
Industry	Dummy coded 1 depending on 1992 SIC of plant (used at 2-digit level).	ARD
OFDI	Dummy coded 1 if plant belongs to a UK firm involved in outward FDI	ADFI

* R&D stocks are computed using perpetual inventory method with 30% depreciation rate for the largest components of R&D spending (intra-mural current spending and extra-mural R&D). See HARRIS, LI AND TRAINOR (2009) for details of methods used.

Table 2: Estimated long-run parameters for factor inputs from estimating equation (1), by sector, Great Britain 1997-2012

	Manufacturing				Services						
	High-tech	Med High-tech	Med Low-tech	Low-tech	High-tech-KI	KI-market	Low KI	Other Low KI	SIC50	SIC51	SIC52
ln Intermediate Inputs	0.436***	0.288**	0.380***	0.533***	0.495***	0.565***	0.421***	0.652***	0.769***	0.304**	0.319***
	(3.66)	(2.57)	(3.71)	(2.65)	(5.90)	(5.21)	(8.09)	(25.47)	(24.34)	(2.17)	(3.92)
ln Employment	0.203*	0.554***	0.430***	0.360**	0.442***	0.527***	0.515***	0.863***	0.310***	1.019***	0.620***
	(1.83)	(3.23)	(4.54)	(2.41)	(5.84)	(4.93)	(4.94)	(4.94)	(9.02)	(4.64)	(8.45)
ln Capital	0.229***	0.224*	0.167**	0.247**	0.091**	0.135**	0.229***	0.107**	0.021***	0.095**	0.071***
	(2.72)	(1.85)	(2.21)	(2.20)	(2.28)	(2.14)	(2.18)	(2.37)	(4.71)	(1.96)	(3.84)
AR(1) z-statistic	-5.15***	-4.60***	-4.33***	-4.38***	-8.97***	-2.73***	-26.06***	-10.78***	-5.44***	-3.67***	-14.46***
AR(2) z-statistic	1.74*	1.33	-0.76	1.67*	0.44	1.33	1.73*	1.77*	-1.36	-1.59	-1.11
Hansen test	33.37	30.79	15.95	4.10	5.52	12.92	3.62	31.81	5.72*	9.00	0.40
Observations	10,191	31,836	39,022	62,225	69,580	41,595	616,672	185,581	76,170	110,128	700,143
Number of local units	3,538	10,208	13,330	18,596	22,618	14,875	167,821	43,416	18,677	23,314	152,647

Note, *t*-values are given in parenthesis. */**/*** denote significance at 10%/5%/1% levels. Full results are available in Tables U.2 – U.4.

Table 3: Weighted mean differences in weighted TFP[a]: Scotland vs. Rest of UK, 2008-12

	2008-12	2012
Hi-tech manufacturing	0.039	0.068
Medium-high tech manufacturing	0.033	-0.038
Medium low-tech manufacturing	0.020	0.014
Low-tech manufacturing	0.090***	0.097***
High-tech KI services	-0.015**	0.015
KI-services	-0.007***	-0.002
Low KI market services[b]	-0.166***	-0.166***
Other low KI	-0.033**	-0.034***
Total	-0.113***	-0.110***

*** 1%/** 5% significance levels (based on *t*-test) Source: Equation (2) and Table 2

[a] Estimates of TFP have been normalized to be consistent with 1997=1 for Scotland.

[b] Includes SIC 50-52

Table 4: Impact of 'place' effects on Scottish TFP, 2008-2012

Sectors[a]	*ln* Agglomeration		*ln* Diversification		Assisted Area		Glasgow		Edinburgh		Scotland		Total[e]
	$\hat{\beta}$[b]	$\bar{X}_S - \bar{X}_{rUK}$[c]	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S$	$\hat{\beta}$	$\bar{X}_S$	$\hat{\beta}$	$\hat{\beta}_{rUK}$[d]	
Manufacturing													
High-tech	0.105***	0.095	-0.231*	-0.072	-0.003	0.376	-0.156**	0.091	-0.183	0.083	0.001	-0.005	0.002/0.017
Med High-tech	0.065***	-0.098	-0.097	-0.066	-0.044*	0.207	-0.011	0.065	0.056	0.030	0.049	-0.036	0.076/0.020
Med Low-tech	0.062***	-0.227	-0.105**	-0.147	0.004	0.161	0.065*	0.074	0.133	0.024	0.009	-0.052	0.071/0.058
Low-tech	0.005	-0.453	0.001	-0.157	-0.027	0.181	0.007	0.077	0.106*	0.064	0.017	-0.002	0.019/0.009
Services													
Hi-tech-KI	0.052***	-1.326	-0.376***	-0.123	-0.015	0.289	0.066	0.144	0.046	0.187	-0.135***	-0.040	-0.104/-0.118
KI-market services	-0.029***	-0.909	-0.018	-0.252	-0.011	0.357	0.000	0.160	0.006	0.209	0.077**	0.012	0.093/0.091
Low KI-market services	0.025***	-0.535	-0.243***	-0.181	0.023***	0.263	0.139***	0.117	0.062*	0.099	-0.166***	-0.073	-0.035/-0.035
Other Low KI Services	0.035	-0.435	-0.251***	-0.133	0.031*	0.252	0.075*	0.116	-0.010	0.092	-0.025	0.007	0.002/0.043
SIC50	0.003	-0.344	-0.019	-0.158	-0.005	0.255	-0.032*	0.073	-0.001	0.068	-0.042***	-0.010	-0.034/-0.035
SIC51	-0.055***	-0.626	0.101***	-0.137	-0.039***	0.238	-0.064**	0.092	-0.010	0.066	0.054***	0.007	0.051/0.052
SIC52	0.048***	-0.260	-0.266***	-0.096	0.006*	0.182	0.020**	0.077	0.020*	0.063	-0.042***	-0.021	-0.004/-0.004

Notes: [a] Sectors are defined in Table A.1

[b] Parameter values are taken from Tables A2 – A4 (where ***/**/* denotes significant at 1%/5%/10% levels)

[c] Mean value for variable for 1008-2012: Scotland minus 'rest of UK' (underlying values available in unpublished appendix Table U.1)

[d] The estimate of the coefficient for the rest of the UK is a weighted average of the coefficients for regions and cities in rUK. More formally, it is $\sum_{a=1}^{18} \hat{\beta}_a \times \bar{X}_a / \sum_{a=1}^{18} X_a$

where $\hat{\beta}_a$ is the parameter estimate in Table A2, A3 or A4 for area a (city or region) and $\bar{X}_a$ is the proportion of plants in each sector located in area a. Note that there are nine regions and nine cities in rUK

[e] Sum across row of $\hat{\beta} \times (\bar{X}_S - \bar{X}_{rUK}) + \hat{\beta} \times \bar{X}_S + (\hat{\beta} - \hat{\beta}_{rUK})$. Note first figure is based on calculations using all the values in the table; the second only uses significant $\hat{\beta}$ setting non-significant values to 0.

Table 5: Impact of 'composition' effects on Scottish TFP, 2008-2012

Sectors[a]	R&D		*ln* Age		Single-plant		Multi-region		Outward FDI		Outward FDI x Foreign		*ln* Herfindahl	
	$\hat{\beta}$[b]	$\bar{X}_S - \bar{X}_{rUK}$[c]	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$
Manufacturing														
High-tech	0.084^{*}	0.052	-0.198^{**}	0.121	0.096^{**}	0.003	0.126^{***}	0.005	0.175^{***}	0.014	-0.298^{***}	0.004	0.171^{***}	-0.100
Med High-tech	0.023	-0.003	-0.271^{**}	-0.009	0.001	-0.029	0.072	0.031	0.074	0.022	-0.191	-0.004	0.022	-0.107
Med Low-tech	-0.001	-0.022	-0.174^{**}	0.009	0.015	0.008	0.145^{**}	-0.053	0.046	0.011	-0.122	-0.012	-0.003	-0.286
Low-tech	0.136^{***}	-0.014	-0.306^{**}	-0.039	0.159^{***}	-0.100	0.103^{***}	-0.013	-0.041	0.031	-0.025	-0.006	0.021	0.161
Services														
Hi-tech-KI	0.027	0.031	-0.180^{***}	-0.085	0.338^{***}	-0.082	0.089^{**}	-0.014	0.447^{***}	-0.022	-0.406^{***}	-0.004	0.147^{***}	0.355
KI-market	0.055	-0.006	-0.173^{***}	0.122	-0.188^{**}	0.141	-0.070	-0.092	0.379^{***}	-0.032	0.127	-0.001	-0.049^{***}	-0.624
Low KI-market	-0.039	0.004	-0.206^{**}	0.259	-0.817^{***}	0.170	0.052^{***}	-0.077	-0.106^{***}	-0.010	0.015	0.011	0.054^{**}	-0.435
Other Low KI	0.049	0.001	-0.179^{***}	0.022	0.030	0.062	0.601^{***}	-0.069	0.374^{***}	0.005	-0.469^{***}	0.000	0.029	-0.069
SIC50	0.103^{***}	0.002	-0.028^{***}	0.214	-0.102^{***}	0.086	0.026^{**}	-0.054	0.022^{***}	0.028	0.024^{**}	-0.009	0.013	-0.320
SIC51	0.782^{**}	-0.002	-0.175^{***}	0.083	-0.471^{***}	0.054	0.121^{***}	-0.029	0.153^{***}	-0.024	-0.291^{***}	-0.003	0.075^{***}	-0.094
SIC52	0.128^{***}	0.000	-0.086^{***}	0.151	-0.382^{***}	0.050	0.072^{***}	-0.046	0.121^{***}	-0.031	-0.144^{***}	-0.001	0.019^{***}	-0.075

Sectors[a]	Greenfield US		Brownfield US		Greenfield EU		Brownfield EU		Greenfield other FO		Brownfield other FO		Total[d]
	$\hat{\beta}$[b]	$\bar{X}_S - \bar{X}_{rUK}$[c]	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	
Manufacturing													
High-tech	0.348^{***}	0.011	0.380	0.028	0.251^{**}	0.014	0.222	0.003	0.262^{*}	-0.006	-0.060	0.012	-0.018/-0.029
Med High-tech	0.149	-0.003	0.183	-0.002	0.226^{**}	-0.003	0.122	-0.003	0.278^{**}	0.002	0.196	-0.009	0.002/0.002
Med Low-tech	0.222^{***}	-0.001	0.101	-0.002	0.119	-0.012	-0.127	-0.025	0.138^{*}	-0.002	0.180	-0.007	-0.007/-0.010
Low-tech	0.013	-0.005	0.017	-0.021	-0.024	-0.009	-0.029	0.015	0.003	-0.001	-0.083	0.002	-0.006/-0.007
Services													
Hi-tech-KI	0.398^{***}	-0.005	0.329^{***}	0.003	0.123^{*}	-0.010	0.238^{***}	-0.002	0.145^{***}	-0.002	-0.057	-0.007	0.029/0.027
KI-market	0.121	-0.002	0.402^{*}	-0.004	0.003	-0.006	-0.635	-0.009	-0.031	-0.004	1.549	-0.004	-0.026/-0.031
Low KI-market	0.037	0.000	-0.110^{***}	0.004	0.141^{**}	-0.005	0.115^{***}	0.005	0.106	-0.004	-0.288^{***}	-0.009	-0.217/-0.216
Other Low KI	0.439^{***}	-0.001	-0.230^{***}	-0.005	-0.493^{***}	-0.004	0.066	-0.007	-0.968^{***}	-0.001	-1.007^{***}	-0.003	-0.038/-0.038
SIC50	0.039^{***}	0.001	0.037^{***}	-0.015	0.071^{***}	-0.009	0.007	-0.023	0.019^{*}	-0.003	0.035^{***}	-0.012	-0.022/-0.017
SIC51	-0.090	-0.010	-0.060^{**}	-0.006	0.152^{***}	-0.002	0.190^{***}	-0.011	0.026	-0.001	0.076	-0.004	-0.056/-0.056
SIC52	0.021	-0.002	0.131^{***}	-0.004	0.430^{***}	0.000	0.290^{***}	-0.004	0.146^{***}	-0.002	0.098^{***}	-0.001	-0.042/-0.042

Notes: see Table 4.

Table 6: Results of Haltiwanger productivity growth decomposition for Scotland and the Rest of the UK, 1997-2012 (figures are percentages)

	Actual TFP growth[a] (1)	Weighted TFP growth[b] (2)	Within plant[c] (3)	Between plant[d] (4)	Entry[e] (5)	Exitors[f] (6)	Output share (1997) (7)	Output share (2012) (8)
Totals								
Scotland	-0.07	-0.90	-0.13	0.15	-0.59	-0.33	7.4	6.0
RUK	1.34	1.45	-0.36	0.29	1.26	0.26	92.6	94.0
All	1.28	1.28	-0.34	0.28	1.12	0.22	100	100
Manufacturing and services								
Scotland Manufacturing	-0.02	-0.77	-0.16	0.20	0.65	-1.47	2.2	1.3
RUK Manufacturing	-0.04	-0.17	-0.40	0.42	0.74	-0.93	23.4	16.7
Scotland Services	-0.05	-0.95	-0.12	0.14	-1.11	0.14	5.2	4.7
RUK Services	1.39	2.00	-0.34	0.25	1.43	0.67	69.3	77.3
All	1.28	1.28	-0.34	0.28	1.12	0.22	100	100
UK- and foreign-owned								
Scotland UK-owned	-0.02	-0.30	-0.16	0.12	-0.65	0.39	5.5	3.8
RUK UK-owned	0.65	0.94	-0.40	0.10	0.70	0.54	69.6	52.2
Scotland Foreign-owned	-0.05	-2.58	-0.07	0.27	-0.42	-2.36	1.9	2.2
RUK Foreign-owned	0.69	3.02	-0.22	0.85	2.95	-0.57	23.0	41.8
All	1.28	1.28	-0.34	0.28	1.12	0.22	100	100

Source: estimates of TFP obtained from applying equation (2)

[a] $\Delta lnP_t = lnP_t - lnP_{t-k}$ where $lnP_t = \sum_i \theta_{it} lnP_{it}$ and θ_{it} is the share of real output for plant *i* in period *t* for the economy

[b] Column (1) ÷ [column (7) ÷ 100]. Note column (2) = column(3) + column(4) + column(5) + column (6)

[c] $\sum_i \theta_{it-k} \Delta lnP_{it}$ (productivity gains × output share in 1997)

[d] $\sum_i (lnP_{it-k} - lnP_{t-k})\Delta\theta_{it} + \sum_i \Delta\theta_{it-k} \Delta lnP_{it}$ (between plant resource reallocations × relative productivity in 1997 + productivity gains × resource reallocations)

[e] $\sum_i (lnP_{it} - lnP_{t-k})\theta_{it}$ (relative productivity of plants in 2012 that opened post-1997 × output share of plants in 2012 that opened post-1997)

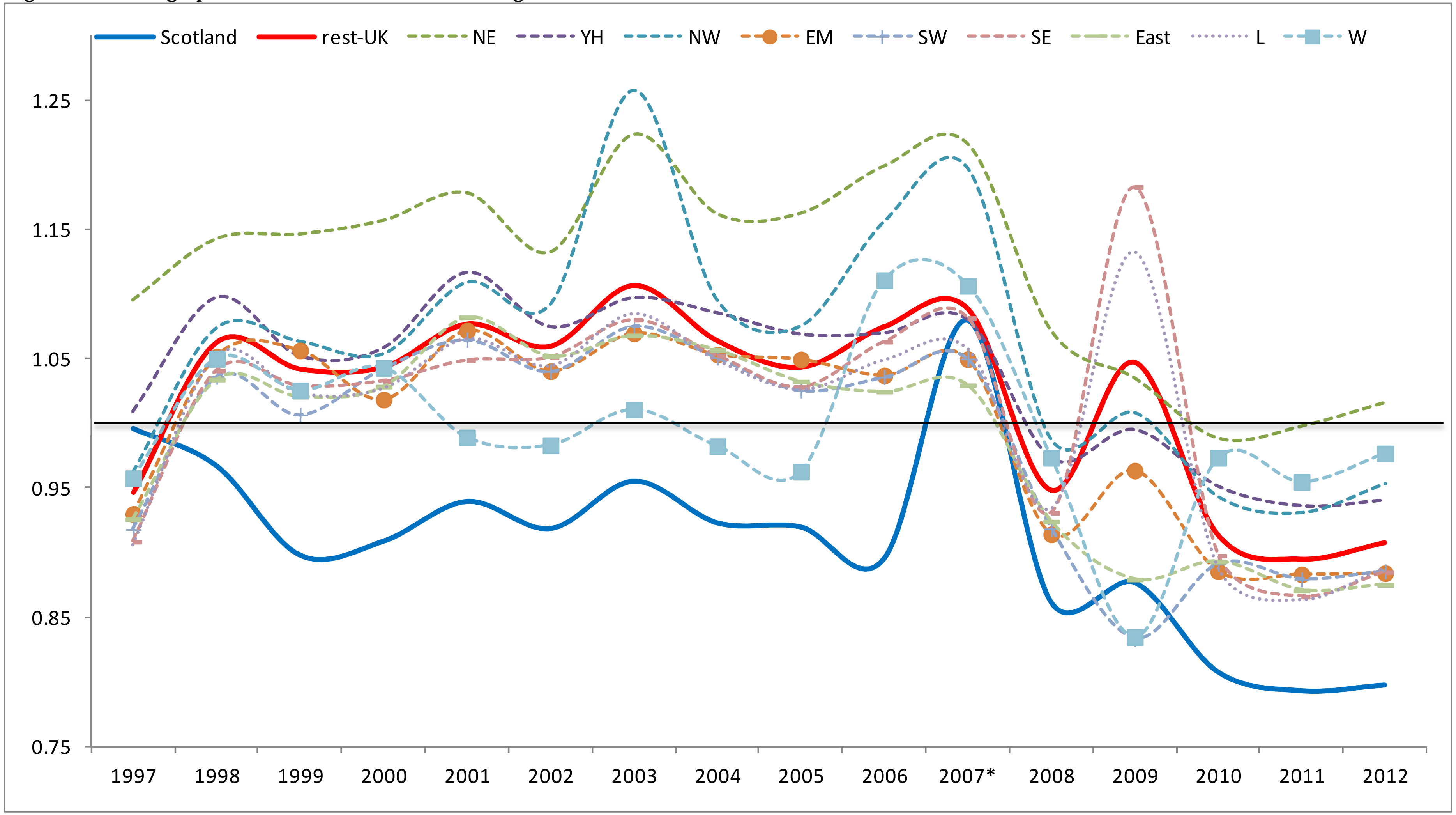
[f] $\sum_i (lnP_{it-k} - lnP_{t-k})\theta_{it-k}$ (relative productivity of plants in 1997 that closed before 2012 × output share of plants in 1997 that closed before 2012)

Table 7: Percentage of real gross output produced in region by enterprises that supply 75+% of output in that region (average 1997-2012)

Region	%
Northern Ireland	84.7
London	78.0
South East	57.8
Scotland	53.0
East Midlands	49.2
Eastern	47.9
South West	47.7
Yorkshire-Humberside	47.6
West Midlands	47.6
Wales	45.7
North West	44.6
North East	40.3

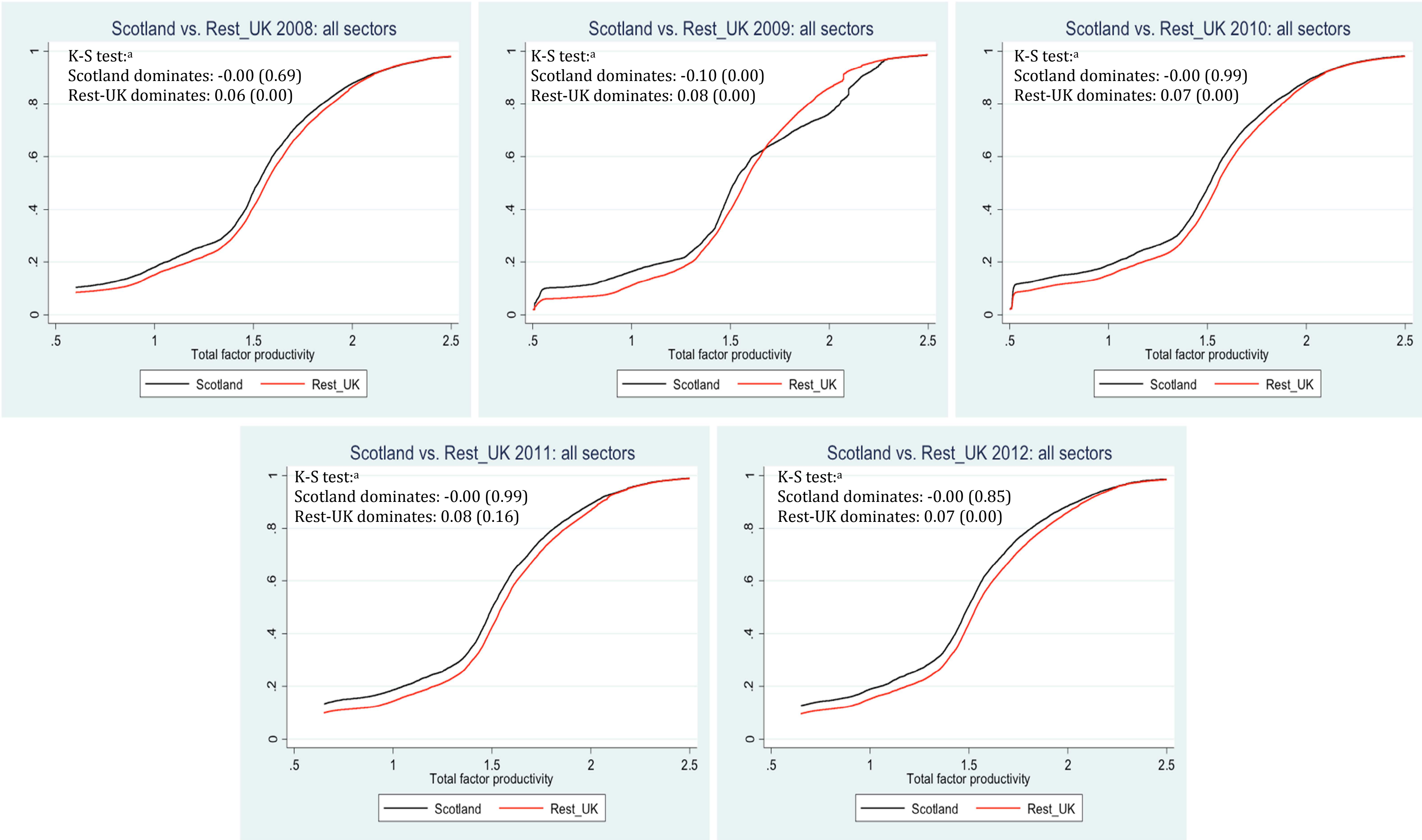
Source: weighted ARD

Figure 1: Average plant level TFP 1997-2012, regions of the Great Britain



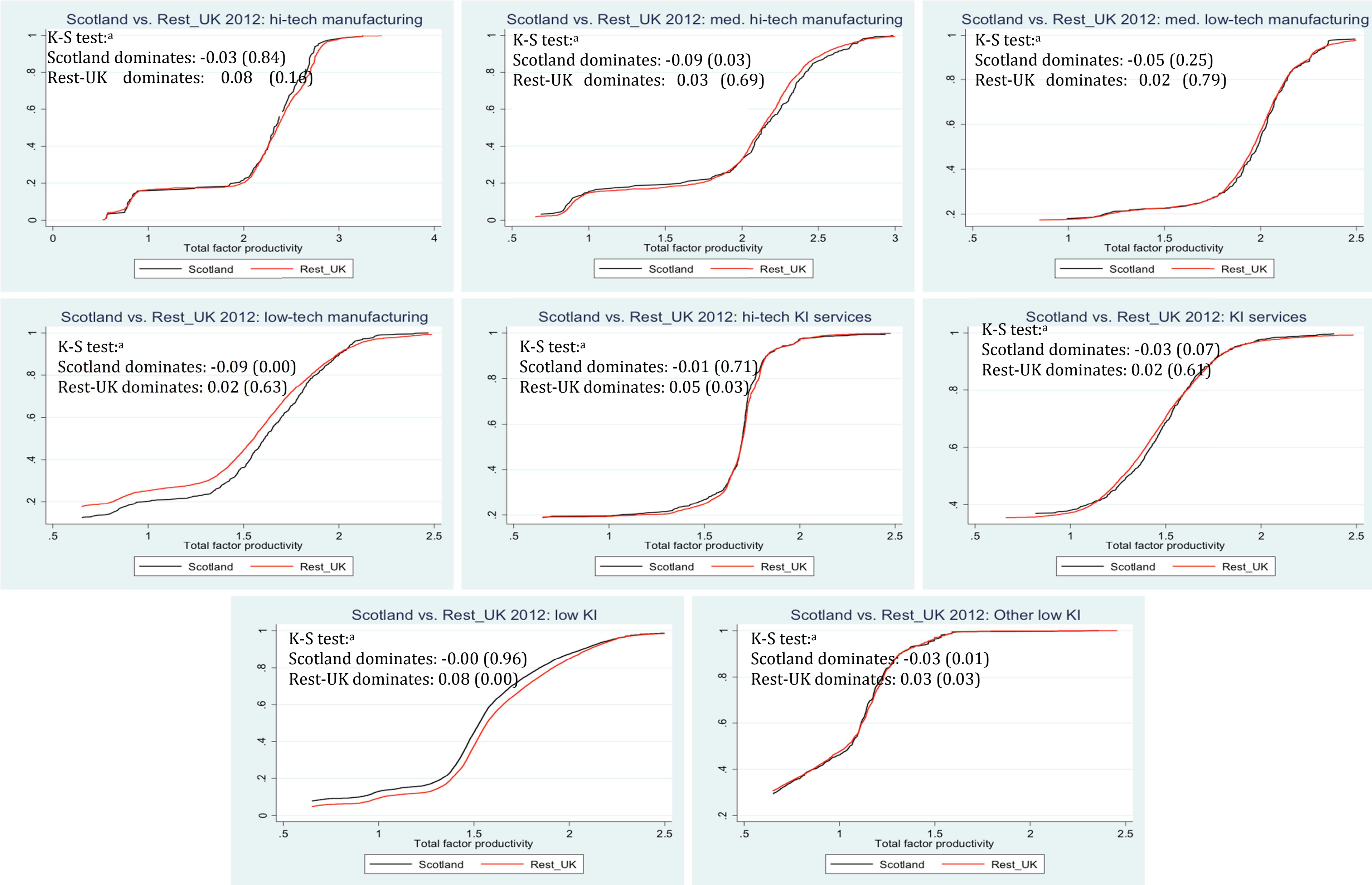
* *t*-test of difference between values for Scotland and the 'rest of the UK' are significant at 1% level except for 2007. Source: equation (2) and Table 2.

Figure 2: Distribution of TFP for plants – various years: Scotland versus ‘rest of UK’: based on equation (2)



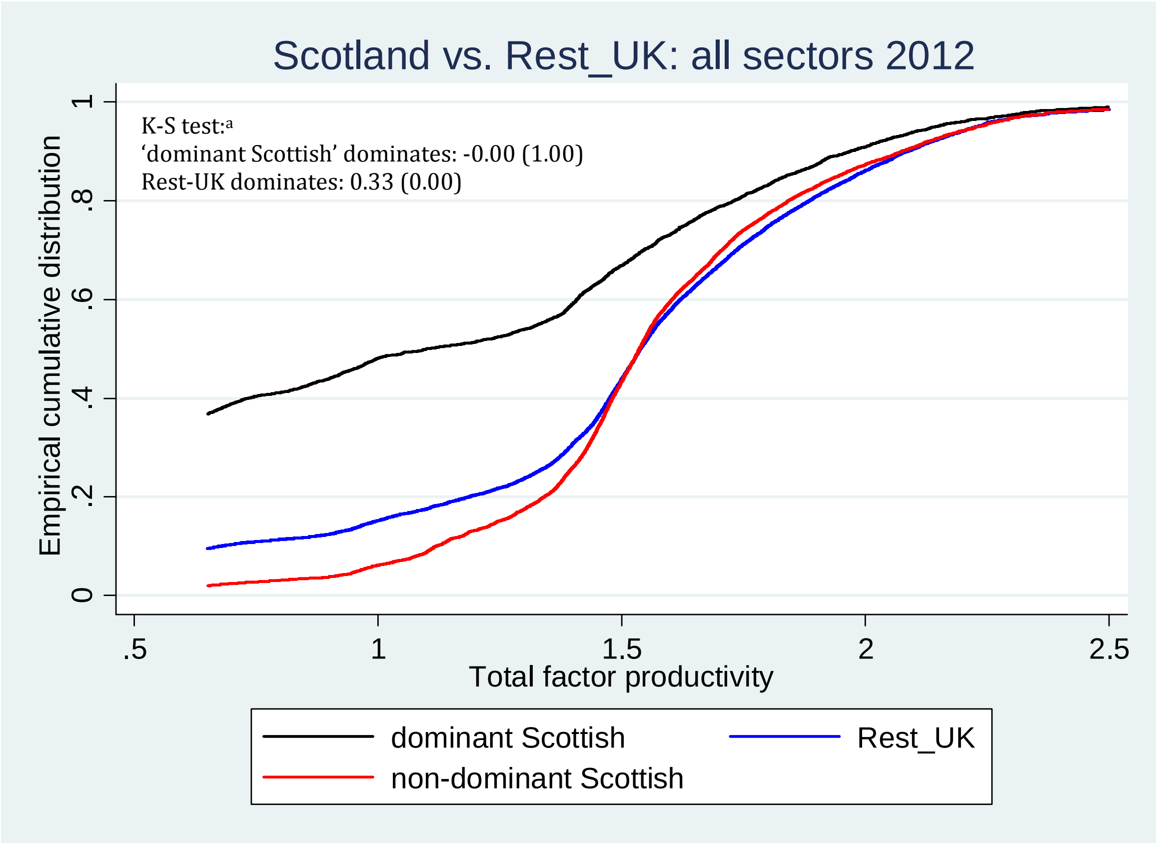
[a] Kolmogorov-Smirnov test for equality of distribution functions; figures represent the maximum gap in favour of Scotland or ‘rest of UK’ with significance level in parenthesis.

Figure 3: Distribution of TFP for plants in 2012 – various sectors: Scotland versus 'rest of UK': based on equation (2)



[a] Kolmogorov-Smirnov test for equality of distribution functions; figures represent the maximum gap in favour of Scotland or 'rest of UK' with significance level in parenthesis.

Figure 4: Distribution of TFP for plants in 2012: Scotland (dominant and non-dominant) versus 'rest of UK'



[a] Kolmogorov-Smirnov test for equality of distribution functions; figures represent the maximum gap in favour of 'dominant Scottish' or 'rest of UK' with significance level in parenthesis.

Appendix

Table A.1: Definitions of industrial sub-sectors (1992 Standard Industrial Classification)

High-tech manufacturing	Pharmaceuticals (SIC244); Office machinery & computers (SIC30); Radio, TV & communications equipment (SIC32); Medical & precision instruments (SIC33); Aircraft & spacecraft (SIC353)
Medium high-tech manufacturing	Chemicals (SIC24 exc. Pharmaceuticals, SIC244); Machinery & equipment (SIC29); Electrical machinery (SIC31); Motor vehicles (SIC34); Other transport equipment (SIC 35 exc. Ships & boats, SIC351, and Aircraft & spacecraft, SIC353)
Medium low-tech manufacturing	Coke & petroleum (SIC23); Rubber & plastics (SIC25); Other non-metallic (SIC26); Basic metals (SIC 27); Fabricated metals (SIC28); Ships & boats (SIC351)
Low-tech manufacturing	Food & beverages (SIC15); Tobacco (SIC16); Textiles (SIC17); Clothing (SIC18); Leather goods (SIC 19); Wood products (SIC 20); Paper products (SIC21); Publishing, printing (SIC22); Furniture and other manufacturing (SIC36); recycling (SIC37)
High-tech knowledge-intensive (KI) services	Telecoms (SIC642); Computer & related (SIC72 exc. Maintenance & repair, SIC725); R&D (SIC73); Photographic activities (SIC7481); Motion pictures (SIC 921); Radio & TV activities (SIC922); Artistic & literary creation (SIC9231)
KI services	Water transport (SIC61); Air transport (SIC62); Legal, accountancy & consultancy (SIC741 exc. Management activities of holding companies, SIC7415); Architecture & engineering (SIC742); Technical testing (SIC 743); Advertising (SIC744)
Low KI services	Wholesale and retail; repairs (SIC50-52); Hotels & restaurants (SIC55); Land transport (SIC60); Support for transport (SIC63); real estate (SIC70); Renting machinery (SIC 71); Maintenance & repair of office machines (SIC725); Management activities of holding companies (SIC7415); Labour recruitment (SIC745); Investigation services (SIC746); Industrial cleaning (SIC747); Packaging (SIC7482); Secretarial services (SIC7483); Other business services (SIC7484); Sewage & refuse (SIC90)
Other low KI services	Postal services (SIC641); Membership organisations (SIC91); Other entertainment services (SIC923 exc. Artistic & literary creation, SIC9231); News agencies (SIC924); Sporting activities (SIC926); Other recreational activities (SIC927); Other services (SIC93).

Table U.1: Long-run weighted two-step system-GMM production function, 1997-2012: manufacturing

Variables	High-tech	z-value	Med High-tech	z-value	Med Low-tech	z-value	Low-tech	z-value
ln Intermediate Inputs	0.436	3.66	0.288	2.57	0.380	3.71	0.533	2.65
ln Employment	0.203	1.83	0.554	3.23	0.430	4.54	0.360	2.41
ln Capital	0.229	2.72	0.224	1.85	0.167	2.21	0.247	2.20
Time	0.031	4.57	0.026	5.21	0.020	4.11	0.018	3.66
R&D	0.084	1.67	0.023	0.31	-0.001	-0.02	0.136	3.02
ln Age	-0.198	-2.15	-0.271	-2.04	-0.174	-2.19	-0.306	-2.32
Single-Plant Enterprise	0.096	2.20	0.001	0.02	0.015	0.53	0.159	6.96
Multi-Region Enterprise	0.126	2.93	0.072	1.61	0.145	1.96	0.103	2.85
Greenfield US-Owned	0.348	3.18	0.149	1.44	0.222	2.75	0.013	0.22
Brownfield US-Owned	0.380	1.28	0.183	1.41	0.101	0.52	0.017	0.47
Greenfield EU-Owned	0.251	2.05	0.226	2.17	0.119	1.62	-0.024	-0.38
Brownfield EU-Owned	0.222	1.36	0.122	0.74	-0.127	-1.24	-0.029	-0.36
Greenfield Other Foreign-Owned	0.262	1.81	0.278	2.12	0.138	1.65	0.003	0.02
Brownfield Other Foreign-Owned	-0.060	-0.22	0.196	1.26	0.180	1.19	-0.083	-1.14
Outward FDI	0.175	2.67	0.074	0.51	0.046	0.29	-0.041	-1.37
Outward FDI × FO	-0.298	-2.77	-0.191	-1.21	-0.122	-0.72	-0.025	-0.35
ln Agglomeration	0.105	3.96	0.065	2.80	0.062	2.38	0.005	0.15
ln Diversification	-0.231	-1.87	-0.097	-1.59	-0.105	-2.13	0.001	0.01
ln Herfindahl Index	0.171	5.31	0.022	0.94	-0.003	-0.14	0.021	1.06
Assisted Area	-0.003	-0.09	-0.044	-1.71	0.004	0.28	-0.027	-1.21
Manchester	-0.177	-1.66	-0.035	-0.35	-0.018	-0.24	0.005	0.07
Birmingham	-0.159	-1.63	-0.078	-1.08	-0.060	-1.38	0.044	0.75
Glasgow	-0.156	-1.96	-0.011	-0.12	0.065	1.65	0.007	0.16
Tyneside	-0.132	-0.73	0.178	1.51	-0.001	-0.02	-0.071	-0.61
Edinburgh	-0.183	-1.34	0.056	0.33	0.133	1.47	0.106	1.69
Bristol	0.107	0.60	0.143	1.35	-0.045	-1.17	0.013	0.29
Cardiff	0.202	1.90	-0.196	-0.92	0.008	0.10	-0.087	-1.13
Liverpool	-0.099	-0.48	-0.077	-0.72	-0.160	-1.14	0.038	0.75

Nottingham	0.206	1.34	0.047	0.40	-0.005	-0.06	-0.076	-0.98
Leicester	-0.136	-1.18	-0.182	-1.60	-0.248	-1.68	0.101	0.93
Coventry	-0.026	-0.23	-0.042	-0.39	-0.001	-0.01	-0.031	-0.40
North-East	0.060	0.42	-0.103	-1.47	-0.050	-1.97	0.058	0.58
Yorkshire-Humberside	-0.008	-0.14	-0.007	-0.17	-0.052	-1.91	-0.004	-0.07
North-West	0.058	1.14	-0.035	-0.93	-0.020	-0.81	-0.046	-1.50
West Midlands	0.077	0.84	-0.043	-0.83	-0.109	-3.97	-0.010	-0.33
East Midlands	0.003	0.06	-0.060	-1.17	-0.027	-1.33	-0.076	-2.21
South-West	-0.013	-0.30	-0.047	-1.03	-0.022	-1.02	-0.016	-0.64
East	-0.027	-0.72	0.007	0.16	-0.018	-0.78	-0.019	-0.93
London	-0.068	-0.88	-0.044	-0.75	-0.124	-2.14	0.108	2.39
Scotland	0.001	0.02	0.049	1.06	0.009	0.39	0.017	0.67
Wales	-0.057	-1.03	-0.059	-1.22	-0.045	-1.93	-0.030	-1.14
Dummy 2008-12	-0.126	-2.54	-0.073	-1.81	-0.141	-2.48	0.002	0.03
Intercept	4.720	5.12	4.485	4.75	3.846	5.14	3.514	2.59
AR(1) z-statistic	-5.15		-4.60		-4.33		-4.38	
AR(1) z-statistic p-value	0.00		0.00		0.00		0.00	
AR(2) z-statistic	1.74		1.33		-0.76		1.69	
AR(2) z-statistic p-value	0.08		0.18		0.45		0.09	
Hansen test	33.37		30.79		15.95		4.10	
Hansen test p-value	0.64		0.16		0.25		0.25	
Observations	10,191		31,836		39,022		62,225	
Number of plants	3,538		10,208		13,330		18,596	

Table U.2: Long-run weighted two-step system-GMM production function, 1997-2012: services

Variables	Hi-tech-KI	z-value	KI-market services	z-value	low KI-market services	z-value	Other Low KI Services	z-value
ln Intermediate Inputs	0.495	5.90	0.565	5.21	0.421	8.09	0.652	25.47
ln Employment	0.442	5.84	0.527	4.93	0.515	4.94	0.863	4.94
ln Capital	0.091	2.28	0.135	2.14	0.229	2.49	0.107	2.37
Time	0.016	2.99	0.004	0.65	0.046	5.55	-0.012	-1.37
R&D	0.027	0.50	0.055	0.71	-0.039	-0.27	0.049	0.19
ln Age	-0.180	-3.59	-0.173	-2.78	-0.206	-1.97	-0.179	-3.43
Single-Plant Enterprise	0.338	7.17	-0.188	-2.29	-0.817	-4.31	0.030	0.38
Multi-Region Enterprise	0.089	2.30	-0.070	-1.45	0.052	2.93	0.601	8.64
Greenfield US-Owned	0.398	11.19	0.121	1.13	0.037	1.13	0.439	3.60
Brownfield US-Owned	0.329	8.07	0.402	1.71	-0.110	-2.61	-0.230	-6.95
Greenfield EU-Owned	0.123	1.63	0.003	0.03	0.141	2.10	-0.493	-2.67
Brownfield EU-Owned	0.238	4.46	-0.635	-1.57	0.115	3.01	0.066	0.75
Greenfield Other Foreign-Owned	0.145	3.13	-0.031	-0.20	0.106	0.75	-0.968	-3.23
Brownfield Other Foreign-Owned	-0.057	-1.01	1.549	1.55	-0.288	-4.81	-1.007	-3.34
Outward FDI	0.447	6.70	0.379	2.60	-0.106	-3.14	0.374	6.29
Outward FDI $\times$ FO	-0.406	-5.89	0.127	0.69	0.015	0.27	-0.469	-4.22
ln Agglomeration	0.052	5.80	-0.029	-2.58	0.025	2.78	0.035	1.34
ln Diversification	-0.376	-6.06	-0.018	-0.45	-0.243	-4.23	-0.251	-4.75
ln Herfindahl Index	0.147	5.03	-0.049	-3.21	0.054	1.93	0.029	1.56
Assisted Area	-0.015	-0.84	-0.011	-0.66	0.023	2.97	0.031	1.79
Manchester	-0.128	-2.06	0.056	1.64	0.034	1.41	0.006	0.15
Birmingham	0.119	1.31	0.090	2.38	0.005	0.23	-0.045	-1.06
Glasgow	0.066	1.19	0.000	-0.01	0.139	3.79	0.075	1.65
Tyneside	0.018	0.13	-0.021	-0.41	0.045	1.60	-0.199	-2.29
Edinburgh	0.046	0.99	0.006	0.19	0.062	1.75	-0.010	-0.18
Bristol	0.052	0.83	0.055	1.60	0.030	1.03	0.098	0.80
Cardiff	-0.034	-0.36	0.081	2.24	0.087	2.50	-0.083	-1.22
Liverpool	-0.011	-0.09	0.049	1.07	-0.107	-2.85	-0.007	-0.06
Nottingham	-0.059	-0.81	0.058	1.51	0.015	0.38	-0.066	-0.68

Leicester	-0.212	-2.14	0.067	1.41	0.039	0.80	0.086	1.11
Coventry	0.038	0.66	-0.002	-0.03	0.105	2.81	-0.101	-1.11
North-East	0.020	0.61	0.047	1.22	-0.110	-5.86	-0.041	-0.67
Yorkshire-Humberside	-0.030	-0.79	-0.039	-1.77	-0.134	-7.96	-0.047	-1.27
North-West	0.050	1.72	-0.031	-1.40	-0.036	-2.16	0.017	0.51
West Midlands	-0.062	-1.53	-0.048	-2.02	-0.042	-2.38	0.034	0.99
East Midlands	-0.022	-0.51	0.007	0.26	-0.081	-2.73	0.032	0.90
South-West	-0.025	-0.73	-0.020	-0.74	-0.016	-1.03	0.035	0.98
East	-0.032	-0.81	0.046	2.11	0.041	3.18	-0.057	-1.69
London	-0.084	-2.74	0.044	1.82	-0.175	-6.81	0.057	0.75
Scotland	-0.135	-3.43	0.077	2.47	-0.166	-5.36	-0.025	-0.68
Wales	-0.117	-2.88	0.002	0.07	-0.114	-3.77	-0.068	-1.54
Dummy 2008-12	0.016	0.39	-0.172	-2.51	-0.355	-5.95	-0.083	-2.31
Intercept	3.058	6.29	2.429	4.31	3.551	4.88	0.874	2.39
AR(1) z-statistic	-8.97		-2.74		-26.06		-10.78	
AR(1) z-statistic p-value	0.00		0.01		0.00		0.00	
AR(2) z-statistic	0.44		1.33		1.73		1.77	
AR(2) z-statistic p-value	0.66		0.18		0.08		0.08	
Hansen test	5.52		12.92		3.62		1.19	
Hansen test p-value	0.14		0.23		0.16		0.55	
Observations	69,580		41,595		616,672		185,581	
Number of plants	22,618		14,875		167,821		43,416	

Table U.3: Long-run weighted two-step system-GMM production function, 1997-2012: other services

Variables	SIC50	z-value	SIC51	z-value	SIC52	z-value
ln Intermediate Inputs	0.769	24.34	0.304	2.17	0.319	3.92
ln Employment	0.310	9.02	1.019	4.64	0.620	8.45
ln Capital	0.021	4.71	0.095	1.95	0.071	3.84
Time	-0.003	-4.48	0.011	1.69	-0.020	-9.71
R&D	0.103	3.40	0.782	2.32	0.128	2.61
ln Age	-0.028	-5.93	-0.175	-2.57	-0.086	-4.21
Single-Plant Enterprise	-0.102	-4.37	-0.471	-3.03	-0.382	-3.68
Multi-Region Enterprise	0.026	2.07	0.121	2.66	0.072	6.10
Greenfield US-Owned	0.039	4.18	-0.090	-1.30	0.021	1.16
Brownfield US-Owned	0.037	3.56	-0.060	-2.42	0.131	8.43
Greenfield EU-Owned	0.071	5.56	0.152	3.38	0.430	7.83
Brownfield EU-Owned	0.007	0.80	0.190	2.96	0.290	7.33
Greenfield Other Foreign-Owned	0.019	1.93	0.026	0.40	0.146	6.75
Brownfield Other Foreign-Owned	0.035	4.68	0.076	1.59	0.098	4.56
Outward FDI	0.022	4.76	0.153	3.06	0.121	7.40
Outward FDI $\times$ FO	0.024	1.99	-0.291	-3.46	-0.144	-9.20
ln Agglomeration	0.003	0.73	-0.055	-3.07	0.048	6.59
ln Diversification	-0.019	-1.31	0.101	3.03	-0.266	-6.03
ln Herfindahl Index	0.013	1.62	0.075	5.28	0.019	2.66
Assisted Area	-0.005	-1.56	-0.039	-3.24	0.006	1.90
Manchester	-0.013	-0.82	0.048	1.40	-0.002	-0.30
Birmingham	-0.009	-0.83	0.061	2.43	-0.008	-0.80
Glasgow	-0.032	-1.81	-0.064	-2.44	0.020	2.21
Tyneside	-0.011	-0.90	-0.033	-1.43	0.014	1.16
Edinburgh	-0.001	-0.08	-0.010	-0.36	0.020	1.95
Bristol	-0.040	-2.86	-0.006	-0.33	0.020	1.80
Cardiff	-0.022	-1.63	-0.007	-0.30	0.041	3.14
Liverpool	-0.023	-1.44	0.066	2.15	0.001	0.08
Nottingham	0.008	0.68	0.045	1.57	0.028	2.29
Leicester	0.002	0.13	0.105	2.37	-0.003	-0.19
Coventry	-0.009	-0.56	0.015	0.49	0.019	1.32

North-East	-0.001	-0.12	0.036	2.10	-0.038	-4.00
Yorkshire-Humberside	-0.024	-4.46	-0.011	-1.12	-0.009	-1.61
North-West	-0.008	-1.77	-0.020	-1.89	-0.017	-2.55
West Midlands	-0.001	-0.25	-0.032	-2.37	-0.023	-4.53
East Midlands	-0.023	-4.48	-0.066	-2.84	-0.003	-0.47
South-West	-0.010	-2.23	-0.027	-2.11	-0.030	-4.47
East	-0.010	-2.53	-0.008	-0.74	-0.001	-0.03
London	0.001	0.11	0.132	3.32	-0.046	-4.50
Scotland	-0.042	-6.65	0.054	3.40	-0.042	-4.08
Wales	-0.005	-0.73	0.034	2.22	-0.053	-5.30
Dummy 2008-12	0.016	2.73	-0.168	-3.70	0.009	0.54
Intercept	1.281	6.71	3.348	5.09	3.455	8.24
AR(1) z-statistic	-5.44		-3.67		-14.46	
AR(1) z-statistic p-value	0.00		0.00		0.00	
AR(2) z-statistic	-1.36		-1.59		-1.11	
AR(2) z-statistic p-value	0.17		0.11		0.27	
Hansen test	5.73		9.00		0.40	
Hansen test p-value	0.06		0.11		0.82	
Observations	76,170		110,128		700,143	
Number of plants	18,677		23,314		152,647	