THE SOURCES OF THE SCOTLAND-REST OF THE UK PRODUCTIVITY GAP: IMPLICATIONS FOR POLICY

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ABSTRACT

This paper finds that aggregate total factor productivity in Scotland was 16% below the 'rest of the UK' in 2012. This is mainly due to negative 'non-place' effects in the service sector. It is also found that new plant start-ups and foreign-owned plants contributed negatively to TFP growth during 1997-2012. This casts doubt on whether continuing to focus on increasing the rate of new firm formation and 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

Productivity is widely recognised to be the most important long-run driver of economic growth. KRUGMAN (1997) states that '… productivity isn't everything, but in the long run it is almost everything' and empirical evidence has tended to confirm the importance of total factor productivity (TFP) in explaining differences in output growth across different economies (e.g., Figure 1.2, OECD, 2003; Table 2, O'MAHONY and TIMMER, 2009).

As a result, productivity is crucial in determining whether the public finances of regions are likely to be sustainable if they were to become independent countries without access to inter-regional fiscal transfers (this was an important campaign issue in the independence referendums in both Quebec in 1980 and 1995 – see HOUSE OF COMMONS, 2013 – and Scotland in 2014). The (pro-independence) Scottish Government's analysis of Scotland's public finances (SCOTTISH GOVERNMENT, 2014) suggested that it is likely that Scotland would have had a fiscal deficit in 2016 had it become independent (see ARMSTRONG and MCLAREN, 2014; ARMSTRONG and EBELL, 2014 for detailed analyses of Scotland's public finances). Having noted that Scotland's labour productivity is slightly below that of the UK (and in the third quartile of OECD countries), it showed the fiscal deficit would be eliminated by 2029-30 if Scotland experienced an above-trend year-on-year increase in labour productivity of 0.3%, which would increase productivity by 4.2% relative to the level that would be attained based on current trends[1]. Certain policy options on how to achieve this were 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

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

establishing a more efficient tax regime targeted to promote investment, entrepreneurship and innovation).

While the rejection of independence in the referendum means that Scotland will remain in the United Kingdom for the immediate future, the Scottish Parliament is set to receive further fiscal powers, most notably over income tax, through the Scotland Bill (UK PARLIAMENT, 2015). This will give the Scottish Parliament responsibility for 40% of revenues and 60% of expenditure in Scotland (a discussion of these changes is provided in LECCA et al., 2014) and represents a considerable increase, particularly on the revenue side, on the powers the Scottish Parliament was granted on its opening in 1999. Furthermore, the Scottish Government would like Scotland to receive 'full fiscal autonomy' (SCOTTISH GOVERNMENT, 2015) and there remains considerable public support for full independence (CURTICE, 2015) which could lead to a second referendum in the near future (especially if there was a UK-wide vote in favour of leaving the European Union – see BBC, 2016). Therefore, Scotland's fiscal position, and the role of productivity in improving it, remains of crucial importance.

In this paper, we firstly quantify the scale of the Scotland's-rest of the UK[2] productivity gap. TFP, which captures the productivity of *all* factors of production, is used rather than labour productivity as the measure of productivity.[3] This is estimated for plants operating in those parts of the market-based sector of the economy (i.e. the public sector is excluded) covered by our dataset (section 2). In section 3 differences between

[2] 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).

[3] It can be shown (cf. HARRIS, 2005a) that increases in labour productivity (output-per-worker) are determined by changes in the usage of factors of production (e.g., labour, capital and intermediate inputs), as well as 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).

productivity levels in Scotland and the 'rest of the UK' are disaggregated according to whether they are due to 'place' or 'non-place' effects. In section 4, a discussion of policy options for achieving a 'step-change' in productivity is provided. Finally, there is a summary and conclusion.

Table 1 around here

II. MEASURING TFP

The earlier analysis of HARRIS and MOFFAT (2015a) that estimates TFP for each market-sector plant operating in Great Britain[4] in 1997-2008 has been updated. They describe in detail the data and econometric methodology used. Here an overview is provided, and the reader is referred to the earlier article for more information.

TFP is obtained through system-GMM estimation of separate Cobb-Douglas log-linear production functions for the industry sub-groups set out in Table A.1 (in the online appendix):[5]

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

where *y*, *e*, *m* and *k* refer to the natural logarithms of real gross output, employment, intermediate inputs and capital stock in plant *i* at 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 an

[4] Manufacturing includes plants in SIC15111 to SIC37200 (using the 1992 Standard Industrial Classification); for services those in SIC50101 to SIC93010 are included, with the following exceptions: 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.

[5] Note, low KI services was sub-divided into 4 sub-groups: sales and repairs (SIC50); wholesale (SIC51); retail (SIC52); and the remainder.

assisted area or a specific region and city. In order to calculate TFP, equation (1) is estimated *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:

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

The data used to estimate equation (1), 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 HARRIS, 2005a; HARRIS, 2002; GRIFFITH, 1999).[6] Data on R&D spending and outward foreign direct investment (*OFDI*) are available from the Business Enterprise R&D Database (*BERD*) and the Annual Foreign Direct Investment (*AFDI*) survey respectively. 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[7]. That is, all 11 models are deemed sufficient in terms of tests for over-identification (i.e., the null of valid instruments in the Hansen test is not rejected at the 5% level).

Figure 1 around here

Table 2 around here

[6] A more detailed discussion of the data is provided in the online Appendix B.

[7] Output and factor inputs (*y*, *e*, *m* and *k*), brownfield foreign-ownership, R&D, and OFDI are treated as endogenous.

Using the elasticities reported in Table 2, Figure 1 provides aggregate indices of TFP based on the mean values across plants for Scotland and the 'rest of the UK', weighted by their shares in total output.[8] Scotland has lower aggregate productivity than the 'rest of the UK' in 9 out of 16 years but a major gap has opened up since the 2007 financial crisis. Table 3 presents more detailed information on the size of this 'productivity gap' for 1997-2012, 2008-12 and 2012, separately for different industry groups. Scotland had a productivity advantage for manufacturing covering the whole of 1997-2012, although much of this (except in medium low-tech manufacturing) was lost by the end of the period; however, it had a significantly lower level of TFP in all service sector industries (except knowledge-intensive services over the whole period), especially in the low knowledge-intensive (KI) sector. Overall, the 'gap' increased over time from 5% to 8% and then 16% across all sectors.[9]

Table 3 around here

III. EXPLAINING DIFFERENCES IN TFP

To explain differences in TFP between Scotland and the 'rest of the UK', 'place' and 'non-place' effects are considered. The former is based on considering the effect on productivity if plants with exactly the same characteristics were relocated from the 'rest of the UK' to Scotland. In other words, it shows whether there are (dis)advantages associated with location in Scotland that can account for some of the 'productivity gap' discussed in the last section. In contrast, 'non-place' effects show whether there are too

[8] TFP has been normalized to be consistent with 1997=1 for Scotland. The (weighted) mean values of all the variables used in estimating equation (1) for Scotland and the 'rest of the UK' are available in Table A.2 in the online appendix.
[9] Weighted 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 more recent years is presented in in the online Figure A.1 of the online Appendix A.

many (or too few) plants in Scotland with characteristics not directly related to location that are associated with lower (higher) TFP – for example, there may be more old plants (which tend to have lower TFP) or fewer plants doing R&D (which is associated 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 that suggest that 'spillover' effects associated with location have a positive impact on productivity (a detailed review of the literature is provided in HARRIS and MOFFAT, 2012). Agglomeration externalities are usually distinguished 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. Variables that proxy for both types of spillover are therefore included in the model. In addition to the potential 'spillover' benefits of co-location, there are '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 take a value of 1 for plants located in an 'assisted area', a major city, or a particular geographic region are therefore used. Previous empirical studies based on micro-data have tended to show that localisation 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).

The parameter results from estimation of equation (1) generally confirm this (see Tables A.3-A.5 summarised in Table 4 below) – intra-industry agglomeration is linked to higher TFP and inter-industry agglomeration leads to lower TFP in most sectors.

While previous UK analysis have shown plants in assisted areas have lower TFP (HARRIS and ROBINSON, 2004), 'mixed' results are obtained here (Table 4). Our parameter estimates of a 'Glasgow-effect' show that, cet. par., plants in high-tech manufacturing, repairs and sales (SIC50) and wholesale (SIC51) experienced a significant negative impact on TFP from being located in the city but plants in medium low-tech manufacturing, other low KI services, retailing (SIC52), and especially low KI services experienced a negative effect. 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, Table 4 shows that being located in Scotland, vis-à-vis the benchmark region (the South East) had large negative impacts on 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 in KI market services and in wholesaling.

While the parameter estimates reported in Table 4 show the impact of 'place' effects on TFP, we also want to try to explain Scotland's productivity 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, more plants in assisted areas and more plants located in major cities (i.e. Glasgow or Edinburgh). The column headed $\hat{\beta}_{rUK}$ represents the weighted 'place' effect for plants located in the 'rest of the UK' relative to the benchmark region (the South East).[10] Multiplying the column figures for each 'place' effect (i.e.,

[10] Footnote (d) to Table 4 explains how this is calculated.

parameter estimates × relative means) shows how each effect contributes to the overall total (the last column in Table 4).[11]

In general the impact of 'place' is less important in explaining Scotland's relative TFP in manufacturing (the exceptions are medium low-tech and medium high-tech manufacturing – where both indicate location in Scotland is beneficial); 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 to a lesser extent low KI market services, including repairs and sales) where positive and negative 'place-based' externalities were mainly the result of the 'Scotland' effect.

Table 4 around here

'Non-place' effects

These are included in equation (1) through 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 and 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 improve TFP if it leads to process innovations or product innovations (if new products are produced with greater efficiency). The second channel is the development of absorptive capacity (see COHEN

[11] 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 parameter estimates obtained from estimating equation (1)– not just significant values. The second set of figures set statistically insignificant parameter estimates to zero.

and LEVINTHAL, 1990, ZAHRA and GEORGE, 2002, for a detailed discussion of the concept) which permits the identification, assimilation and exploitation of innovations made by other firms and R&D actors, such as universities and research institutes.

A single-plant firm dummy and a multi-region enterprise dummy are also included in equation (1). The benchmark sub-group is therefore multi-plant firms that operate in only a single region. It is argued by DHAWAN (2001) that smaller firms have higher productivity because '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 less risk-adverse (UTTERBACK, 1994; SCHERER, 1991; AUDRETSCH, 1995).

A measure of the concentration of output across firms, and therefore market power, is included to take account of competition effects. Under the assumption that the elasticity of demand does not vary 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 (AGHION and HOWITT, 1999; ROMER, 1990; GROSSMAN and HELPMAN, 1991).

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 (DUNNING, 1998). 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).

Motivations for foreign investment also allow predictions about the relative TFP levels of 'greenfield' and 'brownfield' plants. 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 internalise complimentary local assets, 'brownfield' investment would be the preferred form of investment (BUCKLEY and CASSON, 1998). This implies that 'brownfield' plants may have higher TFP than 'greenfield' plants. 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. 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, difficulties with integration of the plant into the firm and the establishment of trust between owners and employees may arise (HARRIS, 2009). The limited empirical work on this question appears to suggest that foreign-owned 'greenfield' plants do indeed have higher TFP than 'brownfield' plants (HARRIS and MOFFAT, 2015a).[12]

The parameter estimates for 'non-place' effects obtained here (Tables A.3 – A.5 reproduced in Table 5) are generally in line with those of previous studies. Plants that undertake R&D have higher productivity, although the (cet. par.) effect is not as widespread as expected (only two manufacturing sectors have positive, significant parameter estimates, and, in services, impacts are confined to SIC50-52).[13] In contrast, older plants have uniformly lower TFP, indicating the importance of technology obsolescence. Single-plant firms had higher TFP in hi-tech manufacturing, low-tech manufacturing and hi-tech KI services[14] but in most other service-based sectors, single plant firms had significantly lower TFP (with the cet. par. effect being large in most sectors). Generally, plants belonging to multi-region enterprises had higher TFP, while lower competition (a larger Herfindahl index) resulted in higher TFP in most service industries (the main exception was KI market services where a doubling of the Herfindahl index reduces TFP by 5.4%). Foreign-owned plants 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 (especially in the service sector) but plants belonging to foreign-owned MNEs that also had overseas operations associated with their UK subsidiaries did not generally benefit further from

[12] Note, in this paper we only consider the direct impact of FDI – through ownership of plants – and not potential spillover effects (except as these contribute to our variables that measure agglomeration and spatial effects).

[13] At the suggestion of a referee, we experimented with replacing plant-level with firm-level R&D (i.e., all plants belonging to an enterprise where a plant was doing R&D were coded 1). This resulted in fewer significant results. Note, we do not necessarily take our results as evidence that R&D does not lead to higher TFP; the results are conditional on the inclusion of a number of other variables that themselves would be expected to be linked with higher R&D (e.g., ownership variables, location, industrial sector).

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

outward FDI (the overall impact for these plants is the sum of the parameter estimates associated with 'outward FDI' and 'outward FDI × foreign-owned').

Table 5 around here

As in the last sub-section, the total non-place effects are derived from multiplying the $\hat{\beta}$ by the $(\bar{X}_S - \bar{X}_{rUK})$ columns, and then summed to the totals presented in the last column of Table 5. 'Non-place' effects were negative in all sectors (if significant and insignificant parameter estimates are used). They were particularly large in the case of low KI services, where single plant firms had much lower TFP and Scotland had a relative large share of such enterprises. Having a relatively greater proportion of older plants also contributed significantly for this sector. Other sectors with relatively large, negative effects included other low KI services, KI services and to a lesser extent SIC50 and SIC52. For these sectors (except low KI services), the prevalence of single, older plants again helps to explain the overall impacts. For 'other low KI services', the most important contribution to the overall negative 'non-place' effect was Scotland having relatively few plants belonging to enterprises that operated in other regions. Unlike in the service sectors, the 'non-place' effect tended to be small in manufacturing.[15]

Comparison of effects

For the manufacturing sector, the relatively small totals recorded in the final columns of Tables 4 and 5 combine to produce little difference between Scotland and the 'rest of the UK' for hi-tech and low-tech manufacturing; however in medium low-tech, and – if insignificant parameter estimates are counted –medium high-tech manufacturing, there are relatively larger positive 'place' effects. For hi-tech KI services and SIC50, the small and negative 'non-place' effect is reinforced by a much larger and negative 'place' effect.

[15] 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.

In low-KI market services, which is the largest sector and has the lowest relative TFP levels, and SIC50, a small negative ‘place’ effect is reinforced by a larger and negative ‘non-place’ effect. In all other service sectors, negative ‘non-place’ effects are offset by positive ‘place’ effects: the former are dominant in KI market services and SIC51 and the latter are dominant in other low KI services. Overall, 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 differences in the underlying sources of these ‘place’ and ‘non-place’ effects.

IV. POLICY OPTIONS

In this section some of the policy options that could allow Scotland to achieve 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 inward investment), and entrepreneurship (e.g. business start-ups). These have often been favoured in the past in Scotland, 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 tax systems, that policy discussion has been couched more in terms of macroeconomic tax incentives (such as cuts in corporation tax).

The analysis in sections 2 and 3 showed that younger plants tend to have higher TFP (and in Scotland having relatively too many single, older plants helps to explain its lower aggregate 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. This suggests that policy that encourages more entrepreneurial activity and higher inward foreign direct investment should boost TFP. Table 6 presents the results from a decomposition of aggregate productivity growth (FOSTER et al., 1998) in 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 reallocations of output share between plants operating in both 1997 and 2012; 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 2.1%, of which Scotland contributed -0.03% 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 -0.5% p.a. growth in TFP while the 'rest of the UK' experienced 2.3% p.a. growth. In Scotland, the contribution of new plant start-ups was strongly negative. In contrast, new plants in the 'rest of the UK' contributed substantially to productivity growth, although the overall impact of 'churning' was lowered to some extent by the closure of on average higher productivity plants. For both areas, the contribution of plants open throughout 1997-2012 was very small.[16]

Table 6 around here

Next, TFP growth is disaggregated in terms of whether the plant was UK- 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 (-1.9% p.a. TFP growth), and the best with the foreign-owned sector in the 'rest of the UK' (6.4% p.a. TFP growth). The

[16] Negative 'within-plant' effects are common using plant level data with TFP estimates (see HARRIS and MOFFAT, 2013, 2015b). Estimates by HARRIS and ROBINSON (2005) found a positive within component using labour productivity estimates, but a negative within component for TFP. Regarding TFP, this suggests that firms achieve positive 'within-firm' gains by acquiring/selling plants, rather than 'turning around' their existing plants. Some initial evidence in support of this is available in HARRIS and MOFFAT (2013, Tables 2 and 3).

Scottish performance is dominated by the closure of relatively productive foreign-owned plants post-1997 (which is not counter-balanced by the opening of sufficient capacity in new, more productive plants), while in the 'rest of the UK' the foreign-owned sector opened more productive plants (foreign-owned firms in the rest of the UK were also closing plants with relatively high levels of TFP). This suggests that Scotland suffered heavily from what has been labelled a 'branch plant' effect whereby the 'footloose' foreign-owned sector is more likely to close productive capacity in 'peripheral' regions when called upon to restructure their operations, even when such plants have relatively high TFP.[17] This 'branch plant' syndrome has been summarised by PHELPS (2009) as the '… road to nowhere: the transformation of the UK's old industrial regions into branch plant economies'.[18]

The first and second panels of Table A.6 decompose productivity growth by manufacturing and services[19] and by single and multi-plant status, respectively, as well as into Scottish and 'rest of UK' components. This shows that in Scotland, the opening of less productive plants was dominated by UK-owned enterprises operating in the service sector, while the closure of more productive plants was dominated by foreign-owned enterprises operating in manufacturing.

The above analysis points to the problem of assuming that promoting business start-ups particularly through more inward investment will produce the desired outcome of

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[17] Since in this period foreign multinational companies were significantly engaged in 'offshoring' to parts of the world with 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 in 'Silicon Glen' (see MCCANN, 1997). It employed some 7.7% of all manufacturing workers in 1997, but only 1.7% by 2012.

[18] 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.

[19] Table A.7 disaggregates further, using the sub-sectors employed to estimate TFP.

higher TFP.[20] While foreign-owned plants have, on average, higher productivity, those that set up in Scotland seem to have been insufficiently embedded into the economy (and/or had insufficiently high value-added functions to guarantee that they remained open); similarly, many of the new plants were of insufficient quality to contribute to higher TFP. However, it should be noted that the productivity growth decompositions undertaken above only show the direct contribution of new and foreign-owned plants. There will also be indirect effects if these plants, by increasing competition, increase the productivity of existing plants or lead to productivity-enhancing reallocations of output share (BRIXY, 2014).

Lastly, in order to provide some insight into the role of investment from the rest of the UK, the productivity levels of 'dominant Scottish' versus 'non-dominant Scottish plants' are calculated, to consider the potential impact on productivity if investment from the 'rest of the UK' faced higher entry barriers. 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 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.[21][22] If Scotland were to return to being an independent country (despite the rejection of independence in the referendum in 2014), the UK TREASURY (2014) suggests that the costs of a 'non-dominant Scottish' enterprise operating in

[20] Promoting new start-ups of 'independent' single-plant firms is supported by the results presented here; Table 6 shows that Scottish single-plant TFP growth was 'driven' by the entry of new plants. The results in Section 3 also showed that Scotland had too many single, older plants, which suggests that encouraging new independent start-ups should be pursued. However, it should be noted that single-plant firms in Scotland only accounted for less than 12% of market-sector output covered in this study, so encouraging entrepreneurship is very much a long-term option when increasing TFP.

[21] We have no data on the location of the HQ of a plant. But even if we did, our approach here might still be preferable if enterprises with Scottish HQ's and most of their operations in the rest of UK decided to move their HQ to the rest of the UK – for reasons given below.

[22] Table A.8 in Appendix A shows the percentage of output produced in each UK region that can be attributed to plants belonging to 'dominant' enterprises. Scotland ranks fourth on this measure.

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; and, related to full fiscal autonomy, 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 'non-dominant Scottish' firms reduced their production in Scotland, the impact on productivity is likely to be significantly negative (Figure 2). This is because Scottish plants have much lower TFP than 'non-dominant Scottish'.[23]

Figure 2 around here

V. SUMMARY AND CONCLUSIONS

Productivity is generally recognised as the most important driver of long-run economic growth and increasing it will be crucial for improving Scotland's fiscal position. The latter has assumed greater importance recently because the Scottish Parliament will will shortly receive substantial further powers. To explain the large differences in TFP between Scotland and the 'rest of the UK', 'place' and 'non-place' effects were estimated. This showed both positive and negative 'place' effects in different industries but that 'non-place' effects were negative in all sectors and particularly in low KI services – the largest sector - where the productivity gap is greatest. But there is no single source to explain Scotland's productivity gap and therefore policy needs to be tailored to the needs of different sectors.

[23] Of course this is 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'.

The 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 levels needed to boost growth and thus government revenues. In Scotland the direct contribution of plant start-ups to TFP growth was negative. Furthermore, Scotland suffered more than the rest of the UK from the closure of relatively high productivity foreign-owned plants, suggesting it is experiencing a 'branch plant' syndrome. Although these issues need further case study investigation of the type of inward-FDI being attracted to Scotland, they imply that for Scotland to benefit from more start-ups, especially through inward investment, government-funded bodies like Scottish Development International and Scottish Enterprise should seek ways of preventing the closure of high productivity plants.[24]

Finally, it was shown that, *if* higher entry barriers were to result following full fiscal autonomy (or if Scotland should leave the Union), and subsequently firms mainly operating in the 'rest of the UK' reduced their levels of Scottish production, the impact on Scottish productivity is likely to be significantly negative.

Although the analysis undertaken above relates solely to Scotland, it could also be conducted for other regions with strong secessionist movements. For example, Quebec, which narrowly rejected independence in a referendum in 1995, has lower labour productivity than the Canadian national average (OECD, 2016) and receives substantial 'fiscal equalisation payments' from the Canadian government (Department of Finance Canada, 2016). It would therefore be interesting to undertake a detailed investigation of its productivity performance vis-à-vis the rest of Canada. Many other regions with

[24] UK Trade & Investment (responsible for inward investment in the UK) has since 2007 sought to encourage 'high value' inward FDI (see UKTI, 2015) that is not just about producing (short-term) employment, but rather long-term growth in the UK economy. Thus 'high value' FDI tends to be much more knowledge intensive (e.g., undertake relatively more R&D in the UK).

strong independence movements have relatively high productivity: Catalonia, the Basque Country, Navarre, Venice and Flanders all have higher labour productivity than the national average (OECD, 2016) and make net contributions to the public finances of the countries to which they belong (ARMSTRONG and EBELL, 2015). Nevertheless, it would be interesting to assess the extent to which this advantage is dependent upon membership of a larger state.

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Table 1: Variables used to estimate 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 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	ARD
Single-plant	Dummy coded 1 when plant comprises a single-plant enterprise	ARD
Multi-region Enterprise	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 1997-2012	ARD
Brownfield US-owned	Dummy coded 1 if plant is US-owned and not newly opened during 1997-2012	ARD
Greenfield EU-owned	Dummy coded 1 if plant is EU-owned and newly opened during 1997-2012	ARD
Brownfield EU-owned	Dummy coded 1 if plant is EU-owned and not newly opened during 1997-2012	ARD
Greenfield Other foreign-owned	Dummy coded 1 if plant is foreign-owned by another country and newly opened during 1997-2012	ARD
Brownfield Other foreign-owned	Dummy coded 1 if plant is foreign-owned by another country and not newly opened during 1997-2012	ARD
Herfindahl	Herfindahl index of UK industry concentration (3-digit level)	ARD
Industry agglomeration	% of industry output (at 5-digit SIC level) located in travel-to-work (TTWA) of plant– MAR-spillovers	ARD
Diversification	% of 5-digit industries (from over 650) located in TTWA of plant– 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 area agreed by European Commission to be eligible for government help (as defined in 1997)	ARD
Region	Dummy coded 1 if plant is located in particular region	ARD
City	Dummy coded 1 plant is located in major 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
Local units	3,538	10,208	13,330	18,596	22,618	14,875	167,821	43,416	18,677	23,314	152,647

t-values are given in parenthesis. */**/*** denote significance at 10%/5%/1% levels. Full results are available in Tables A.3 – A.5 available in the online appendix.

Table 3: Percentage differences in Aggregate Total Factor Productivity[a]: Scotland vs. Rest of UK, 1997-12

	1997-2012	2008-12	2012
Manufacturing			
Hi-tech	11.3	-3.6	-2.0
Medium-high tech	11.9	11.9	-1.4
Medium low-tech	11.8	24.1	18.3
Low-tech	0.9	1.9	0.8
Services			
High-tech KI	-5.5	-9.7	-7.0
KI	0.0	-7.5	-15.1
Low KI market	-13.4	-19.1	-21.8
Other low KI	-0.7	-7.5	-12.8
Total	-4.8	-8.4	-16.4

[a] For each sub-group $TFP_t = \sum_i \frac{TFP_{it} \times y_{it}}{\sum_i y_{it}}$, where y_{it} is (weighted) real gross output in plant *i* at time *t*.

[b] Includes SIC50-52

Source: Estimates of TFP from equation (2).

Table 4: Impact of 'place' effects on Scottish TFP, 1997-2012

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*	-0.083	-0.003	0.354	-0.156**	0.073	-0.183	0.071	0.001	-0.004	0.009/0.017
Med High-tech	0.065***	-0.309	-0.097	-0.098	-0.044*	0.235	-0.011	0.083	0.056	0.032	0.049	-0.037	0.065/0.021
Med Low-tech	0.062***	-0.456	-0.105**	-0.163	0.004	0.210	0.065*	0.086	0.133	0.034	0.009	-0.052	0.061/0.059
Low-tech	0.005	-0.521	0.001	-0.204	-0.027	0.197	0.007	0.088	0.106*	0.063	0.017	-0.004	0.021/0.011
Services													
Hi-tech-KI	0.052***	-1.188	-0.376***	-0.149	-0.015	0.282	0.066	0.125	0.046	0.174	-0.135***	-0.033	-0.096/-0.125
KI-market	-0.029***	-0.899	-0.018	-0.242	-0.011	0.332	0.000	0.188	0.006	0.222	0.077**	0.011	0.093/0.091
Low KI-market	0.025***	-0.591	-0.243***	-0.195	0.023***	0.264	0.139***	0.117	0.062*	0.111	-0.166***	-0.070	-0.034/-0.037
Other Low KI	0.035	-0.547	-0.251***	-0.181	0.031*	0.299	0.075*	0.135	-0.010	0.110	-0.025	0.004	0.016/0.046
SIC50	0.003	-0.469	-0.019	-0.190	-0.005	0.260	-0.032*	0.082	-0.001	0.071	-0.042***	-0.010	-0.034/-0.035
SIC51	-0.055***	-0.663	0.101***	-0.133	-0.039***	0.229	-0.064**	0.104	-0.010	0.071	0.054***	0.008	0.053/0.051
SIC52	0.048***	-0.343	-0.266***	-0.118	0.006*	0.198	0.020**	0.085	0.020*	0.070	-0.042***	-0.021	-0.002/-0.005

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

[b] Parameter values are taken from Tables A.3 – A.5 (where ***/**/* denotes significant at 1%/5%/10% levels)

[c] Mean value for variable for 1997-2012: Scotland minus 'rest of UK'

[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 A.3, A.4 or A.5 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 major 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 $\hat{\beta}$.

Table 5: Impact of 'non-place' effects on Scottish TFP, 1997-2012

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*	-0.012	-0.198**	0.063	0.096**	0.035	0.126***	-0.020	0.175***	-0.007	-0.298***	0.013	0.171***	-0.013
Med High-tech	0.023	-0.026	-0.271**	0.032	0.001	0.015	0.072	0.007	0.074	0.008	-0.191	0.000	0.022	-0.130
Med Low-tech	-0.001	-0.021	-0.174**	0.050	0.015	0.040	0.145**	-0.037	0.046	0.000	-0.122	-0.004	-0.003	-0.252
Low-tech	0.136***	-0.007	-0.306**	0.052	0.159***	-0.024	0.103***	-0.062	-0.041	-0.003	-0.025	-0.002	0.021	0.114
Services														
Hi-tech-KI	0.027	0.006	-0.180***	-0.033	0.338***	-0.067	0.089**	0.017	0.447***	-0.022	-0.406***	-0.004	0.147***	0.157
KI-market	0.055	-0.005	-0.173***	0.194	-0.188**	0.068	-0.070	-0.103	0.379***	-0.029	0.127	-0.006	-0.049***	-0.338
Low KI-market	-0.039	0.002	-0.206**	0.224	-0.817***	0.148	0.052***	-0.117	-0.106***	-0.009	0.015	0.009	0.054**	-0.336
Other Low KI	0.049	0.000	-0.179***	0.102	0.030	0.112	0.601***	-0.065	0.374***	-0.003	-0.469***	-0.004	0.029	-0.197
SIC50	0.103***	0.000	-0.028***	0.222	-0.102***	0.108	0.026**	-0.081	0.022***	0.012	0.024**	-0.013	0.013	-0.362
SIC51	0.782**	-0.003	-0.175***	0.023	-0.471***	0.002	0.121***	-0.025	0.153***	-0.007	-0.291***	-0.002	0.075***	-0.015
SIC52	0.128***	0.000	-0.086***	0.084	-0.382***	0.042	0.072***	-0.043	0.121***	-0.022	-0.144***	-0.002	0.019***	-0.080

Sectors[a]	Greenfield US		Brownfield US		Greenfield EU		Brownfield EU		Greenfield other FO		Brownfield other FO		Total[d]
	$\hat{\beta}$[b]	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	$\hat{\beta}$	$\bar{X}_S - \bar{X}_{rUK}$	
Manufacturing													
High-tech	0.348***	0.009	0.380	0.028	0.251**	0.006	0.222	0.000	0.262*	0.001	-0.060	0.012	-0.005/-0.015
Med High-tech	0.149	0.007	0.183	0.005	0.226**	0.000	0.122	-0.005	0.278**	0.003	0.196	-0.001	-0.009/0.008
Med Low-tech	0.222***	0.000	0.101	-0.001	0.119	-0.006	-0.127	-0.012	0.138*	0.000	0.180	0.005	-0.011/-0.014
Low-tech	0.013	-0.004	0.017	-0.015	-0.024	-0.005	-0.029	0.007	0.003	0.001	-0.083	0.006	-0.025/-0.027
Services													
Hi-tech-KI	0.398***	-0.005	0.329***	-0.007	0.123*	-0.003	0.238***	-0.003	0.145***	-0.003	-0.057	-0.005	-0.006/-0.006
KI-market	0.121	-0.001	0.402*	-0.004	0.003	-0.006	-0.635	-0.004	-0.031	-0.002	1.549	-0.003	-0.038/-0.042
Low KI-market	0.037	0.000	-0.110***	0.004	0.141**	-0.003	0.115***	0.004	0.106	-0.001	-0.288***	-0.002	-0.190/-0.190
Other Low KI	0.439***	-0.006	-0.230***	-0.006	-0.493***	-0.002	0.066	-0.006	-0.968***	-0.001	-1.007***	-0.002	-0.057/-0.054
SIC50	0.039***	-0.004	0.037***	-0.006	0.071***	-0.011	0.007	-0.015	0.019*	-0.003	0.035***	-0.007	-0.026/-0.021
SIC51	-0.090	-0.002	-0.060**	-0.003	0.152***	-0.002	0.190***	-0.009	0.026	-0.001	0.076	-0.003	-0.014/-0.014
SIC52	0.021	-0.001	0.131***	-0.002	0.430***	-0.001	0.290***	-0.004	0.146***	0.001	0.098***	0.002	-0.032/-0.032

Notes: see Table 4.

Table 6: Results of 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	-0.03	-0.45	-0.30	0.62	-1.25	0.48	7.5	6.0
RUK	2.14	2.32	-0.80	0.97	2.77	-0.62	92.5	94.0
All	2.11	2.11	-0.76	0.94	2.47	0.54	100	100
UK- and foreign-owned								
Scotland UK-owned	0.00	0.04	-0.37	0.40	-1.73	1.74	5.6	3.8
RUK UK-owned	0.71	1.01	-0.94	0.48	1.56	-0.10	69.9	52.9
Scotland Foreign-owned	-0.04	-1.86	-0.10	1.27	0.16	-3.19	1.9	2.2
RUK Foreign-owned	1.44	6.36	-0.38	2.46	6.52	-2.24	22.6	41.1
All	2.11	2.11	-0.76	0.94	2.47	0.54	100	100

Source: Estimates of TFP from 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*

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

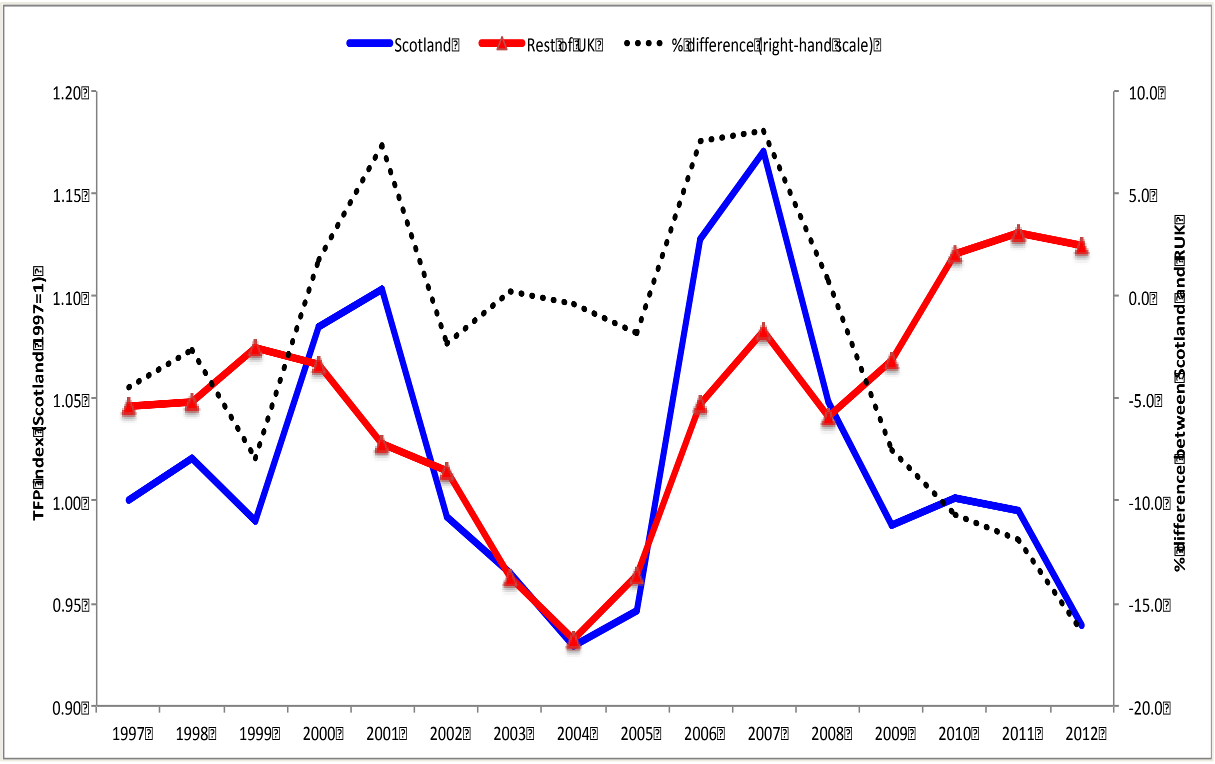
[c] $\sum_i \theta_{it-k} \Delta lnP_{it}$ (productivity gains × output share in 1997)

[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)

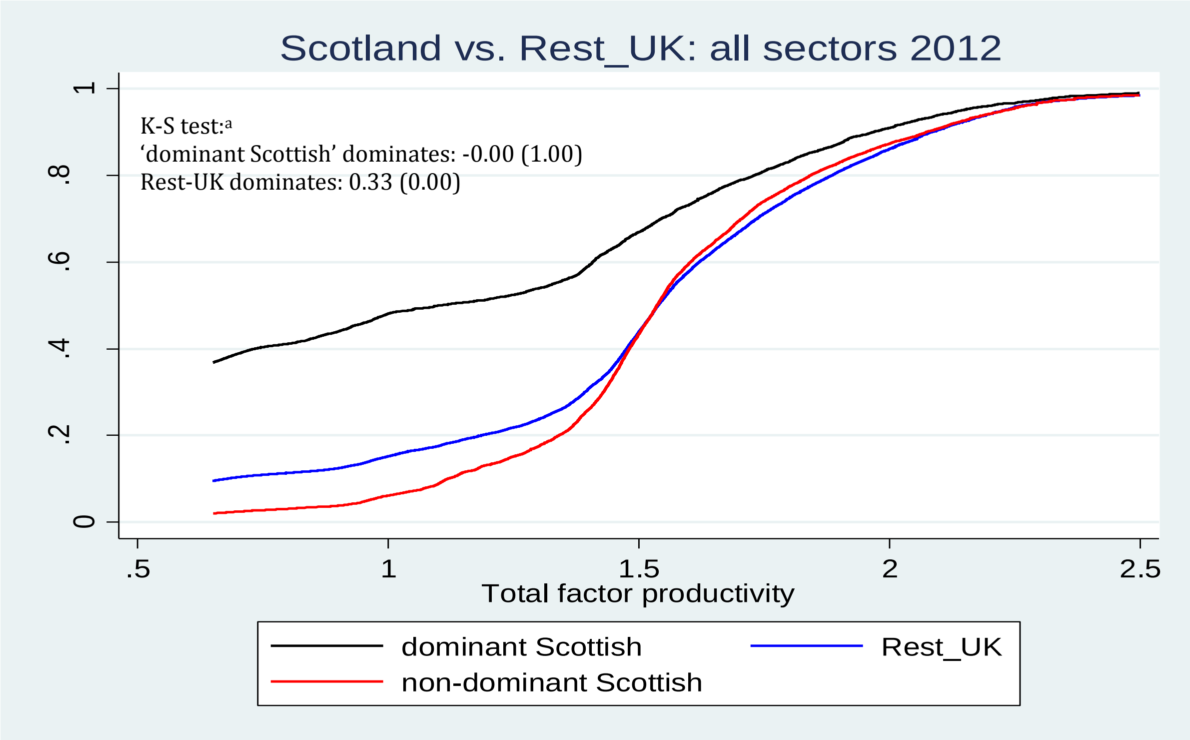
Figure 1: Aggregate Total Factor Productivity (1997=1 for Scotland): all marketable output sectors[a] 1997-2012



[a] $TFP_t = \sum_i \frac{TFP_{it} \times y_{it}}{\sum_i y_{it}}$, where y_{it} is (weighted) real gross output in plant *i* and time *t*.

Source: Estimates of TFP from equation (2).

Figure 2: 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.