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Firm performance in Wales –

An analysis of productivity using company accounts

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Abstract

Output and productivity growth are indicators of standards of living and prosperity. From the perspective of a devolved region, a better understanding of the determinants of productivity will lead to more informed policy formation. This paper takes a look at Wales and its recent performance using the FAME company accounts data. We model performance at the company level within Wales, specifically exploring the role of regional skills and international activity as a means of achieving better performance. Our analysis suggests that internationalisation matters - be it overseas sales or foreign ownership. Measures of regional characteristics indicate that shares of high skilled workers in a region are positively associated with productivity and appear to dominate agglomeration effects.

1. Introduction

The rate at which output is generated from inputs is of great interest for international comparisons of performance and as local measures of efficiency of resource allocation. Output and productivity growth are indicators of standards of living and prosperity and are important indicators of international competitiveness. In 2004, the Treasury identified 5 drivers of productivity; investment, innovation, enterprise, competition and skills. These drivers go some way in explaining why productivity may be higher in some regions and sectors than in others (HM Treasury, 2004). Other research has highlighted the importance of macroeconomic conditions and demand side factors (c.f. Peneder et al, 2009). Proxies for these drivers can be included in an augmented production function to estimate their impact (if any) on output and consequently, productivity. However, it has been argued that such drivers are not straightforward to measure (Foreman-Peck, 2003).

Moreover, existing regional evidence on these drivers at the NUTS1 level (Wosnitza and Walker 2008a and 2008b) shows Wales to be consistently in the bottom 3 regions (along with Northern Ireland) in relation to expenditure on R&D and in terms of entrepreneurial activity (monitored by VAT registrations and de- registrations). Latest measures of competitiveness for the UK regions (Huggins and Thompson, 2010) show Wales to be at the bottom of the regional rankings, losing relative ground in recent years to the North East. With respect to skills, Wales has one of the highest proportions of workers with no qualifications. European Structural Funding (ESF) is designed to address concerns about skills at a regional level, where GDP is found to be below 75 per cent of the EU average. This has been in place in West Wales and the Valleys since 2002, but appears to have had limited success in raising relative productivity levels. Given that GVA in this part of Wales is still below 75% of the EU average it is likely that it will qualify for the highest level of European funding for a third time from 2014 onwards[1]. In 2008 GVA per head was just 62.6% of the UK average – the lowest figure of the 37 NUTS2 regions in the UK. A deeper understanding of why Wales is consistently falling in the bottom 3 regions is required if we are to identify ways of raising its productivity performance in the longer run.

The aim of this paper is to explore productivity within Wales and to better understand the extent to which drivers of growth operate in Wales. We focus on internationalisation, skills and agglomeration effects. Wales is obviously of interest given its lowly position in the

[1] West Wales and the Valleys received approximately £3bn in Objective 1 European funding between 1999 and 2005 and a further £2bn in Convergence funding between 2007 and 2013.

regional productivity league tables and the need to halt the increase in regional inequality in the UK.

Wales also faces issues with regard to peripherality, rurality as well as low skills. These factors have been highlighted in the literature as constraining productivity growth. Wales is also dominated by its capital city, Cardiff, with possibly agglomeration economies. In 2011, following a referendum, Wales was given further law making powers and so has greater potential to influence factors determining the underlying growth rate of the economy. Here, we consider a number of factors that are thought to affect productivity, specifically, whether or not foreign ownership has a positive impact on productivity, the importance of the experience of the company, skills and finally, whether agglomeration economies exist in the areas considered. We use micro economic data to analyse this, derived from the FAME Company Accounts database, 1995-2008. The data set covers the period of continuous economic growth before the most recent recession in 2008 and so the data is not likely to be affected by major demand and supply shocks. It should therefore provide a good reflection of the underlying productivity position[2].

This paper begins by reviewing the conceptual issues surrounding growth and considering some of the more recent empirical evidence on Wales, both within the wider context of the UK and within Wales variations. Section 3 provides an outline of the main data source for the analysis whilst in section 4 we provide the basic methodology employed and discuss the variables to be included in the modelling. Section 5 contains our findings and in Section 6 we discuss the implications of our findings and directions for future research.

2. Productivity and regional growth

Labour productivity is a conceptually straightforward measure of productivity in which output is divided through by a unit of labour input. It provides an indication of how efficient a plant/firm/region/country is. In a productivity comparison of urban and rural England, Gibson et al (2009) highlight the fact that at lower levels of geography the preferred labour productivity measure should be based on 'per filled job' since reliable hours data are not yet available. Here we use data per employee which is more akin to the per job filled measure.

A theoretically superior measure to labour productivity is total factor productivity (TFP), which nets out the effects of all known inputs. Commonly referred to as the Solow residual,

[2] The analysis can also provide a benchmark against which to analyse productivity levels in more turbulent times after the recent recession which is likely to have increased the rate of structural change in the economy.

this is the proportion of output over and above that generated by inputs such as labour, intermediate inputs (in a gross output specification) and capital stock. TFP is therefore regarded as a pure measure of efficiency. TFP is often described as the measure of our ignorance, since as a residual measure, if one fails to take account of all inputs in the production process, TFP can reflect missing inputs. Another common problem with the estimation of TFP is the complication of estimating meaningful capital stocks. The choice of functional form is also crucial to accurate TFP measurement. Finally, it could be argued that TFP if it is to be accurately measured is more of a firm based concept and is therefore suited to micro data. TFP is not without its problems. Constructing meaningful company capital stocks is not straightforward. There are conceptual issues related to production function estimation because of endogeneity,

Moreover, GDP - or turnover - as indicators of social well-being have been criticised and recent research has turned to the development of alternatives (Thomas and Evans, 2010). GDP covers principally market sectors only, it does not take into account the distribution of income, nor does it directly reflect consumption, rather it is a measure of production. The Stiglitz Commission was tasked with finding ways to better capture societal progress, building into the measure concepts that relate to sustainable development and quality of life indicators. Thomas and Evans (2010) review existing UK government efforts in these areas, arguing that a large amount of indicative data is already available and that what is missing is coherence in interpretation. They present a Happy Planet Index alongside the GDP per head for the UK. Whilst GDP per head has increased steadily, the HPI has remained constant since the 1970s. Eventually it may be possible to extend this sort of analysis to the sub regional level, but for now, we focus on the traditional measures of productivity, whilst acknowledging its relatively narrow focus.

Certainly, from a regional perspective, GDP still has considerable relevance. A key objective of the Welsh Assembly Government was to increase Welsh GDP per head to 90 per cent of the UK average by 2010 – a ten percentage point improvement on its position in 2002 (Welsh Assembly, 2002). This target was later dropped but recent evidence suggests that if anything, the gap is widening (see figure1). There are a number of reasons put forward for Wales' relative poor performance; low employment rates and low average wages (reflecting low average productivity), thought to be due in large part to a larger than average proportion of the workforce with no or low skills, the absence of a large conurbation and a large proportion of retired people (Welsh Assembly Government, 2010). In its most recent economic policy document 'Economic Renewal: A new direction' (WAG, 2010) the Welsh Government sets out its plans to tackle the economic problems in Wales by investing in

infrastructure, skills and attempting to make improvements in the area of business support. This strategy focuses support on six strategically important sectors; ICT, Energy and environment, Advanced materials and manufacturing, Creative industries, Life sciences and Financial and professional services – where it believes improved targeted interventions in growing markets could give Wales a competitive advantage. These are sectors that are believed to generate significant spillovers, not least through knowledge. There is however a danger with a "picking winners" strategy especially if the same high value added sectors are targeted by other countries.

Identifying causes of regional differences in productivity growth and finding ways to facilitate the catch-up of lower productivity regions is an important objective of most regional policy makers. Harris (2010) reviews the various models of regional growth, from the early neoclassical models without any spatial dimension, to the technological innovation systems (TIS) in which the regional system is assumed to affect each firm's ability to exploit external knowledge. Between these two extremes lie the most relevant models – those put forward in the New Economic Geography literature, which relate agglomeration economies and the existence of spillovers to productivity, and the development of refinements to the neoclassical growth models in which matrices are used as weights in convergence models (Chatterji and Dewhurst, 1995; Henley, 2005).

Harris (2010) identifies two main concerns. Firstly, we need to define the unit of analysis. Recognising that regional growth needs some sort of spatial dimension, we need to identify the area over which we want to measure productivity growth. This should be large enough to ensure that intra regional activities are maximised and inter regional activities are minimised. The second factor, which is particularly important from a policy perspective, relates to understanding the relative importance of external spillovers compared with internal determinants of productivity and growth. Future research would be best served, Harris argues, by fostering a better understanding of firm heterogeneity and the way in which firms are able to break down barriers to growth with the continued use of micro data to deal with many of the issues.

Recent studies attempted to explain why Wales is consistently failing to catch up with other regions of the UK in areas of competitiveness, entrepreneurship and education have focused on a number of issues, including industrial structure, skills, slow uptake of ICT technology, remoteness etc. Harris (2004) identifies a number of causes for lower labour productivity in Welsh manufacturing, over the period 1990-1998. He notes that Wales has high levels of outsourcing, relative to other regions within the UK and that this is growing over time. His

findings suggest that Wales does not have a productivity problem per se but that firms with lower productivity tend to be single plants, in assisted areas or in receipt of regional assistance.

Boddy (2006) uses a decomposition approach to measure the Welsh productivity gap (relative to London) using data for 2003. The overall gap relative to London is estimated to be around 42 per cent. Boddy (2006) separates a variety of factors that drive the gap, including different capital stock structures (accounting for around 9 per cent of the 42 per cent), different industrial structure (also around 9 per cent of the difference). Other factors that relate to the labour force, such as the skills structure in the local area, population density, ratio of full time to part time workers, reduce the gap further by 8 per cent – in total a 20 percentage point reduction in the gap. Travel to work time and other measures of peripherality account for a further 8 per cent. Thus, whilst there is still a productivity gap between London and Wales, many plausible factors can be used to account for this.

At the sub-regional level Boddy (2006) analyses the productivity gap between regions relative to Cardiff. He finds that Conwy and Denbighshire, closely followed by Swansea have the most substantial gap with Cardiff. In the case of Swansea, he attributes this to differences in capital stock, the ratio of full time to part time workers, industrial structure and the local qualification levels and the population density. Boddy does note however that he finds these factors to account for less of the difference than he expected (p14, para 56.). Boddy concludes that efforts should be devoted to the regeneration of Swansea in a similar fashion to that of Cardiff. Whilst he acknowledges this may not be the most equitable approach from an "All Wales" perspective, it is likely to increase productivity through the additional benefits of urban agglomeration and scale 'through strengthening networks, access to markets and information, specialist suppliers and opportunities for collaboration' (p18, para 82).

In an update of this work, Boddy et al (2010) look at the importance of 'remoteness' or 'peripherality' in creating downward pressure on productivity and the impact on the competitiveness of Welsh businesses. They report that productivity of the average firm fell by 0.7 per cent for every 10 per cent more in travel time when measured by an index which calculates the average travel time from the district in which a plant was located, to London and the next four largest conurbations in Great Britain. They find that localised differences matter, which points to the usefulness of a more disaggregated approach to analyses and also hints at agglomeration factors influencing productivity.

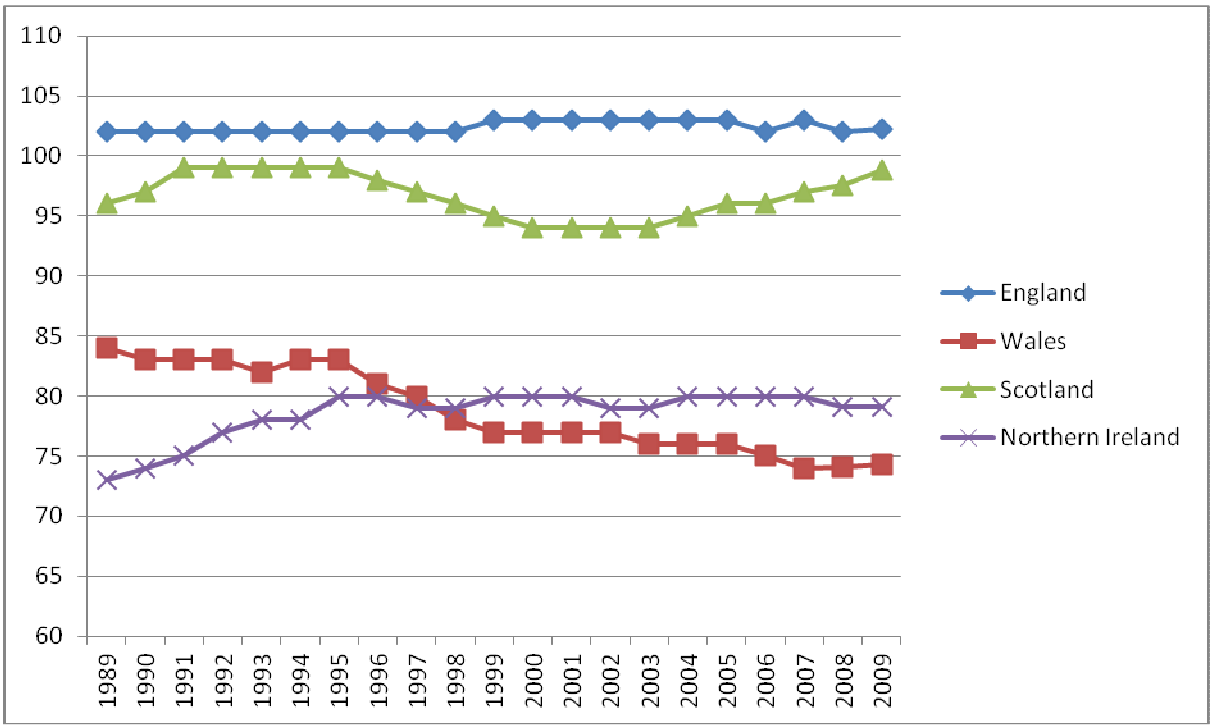
Hudson (2008) uses ONS enterprise-level data (available under secure arrangements) to model performance, and incorporating a number of additional variables to provide a more holistic approach. He focuses firstly on Britain as a whole and then separates Wales, including dummy variables to take account of regional variation at the local authority level and a dummy to try to capture an impact of objective one on these performance measures. He finds that Objective one funding is generally insignificant, thus indicating it has no direct association with productivity. He separately models a number of industries and analyses performance by ownership type. He concludes that firms in Wales perform generally worse than in the UK, and the East of Wales performs better than the West.

The Leitch Review (2006) of skills final report notes that "there is a direct correlation between skills and productivity and employment" and that whilst "skills were once *a* key lever for prosperity and fairness. Skills are now increasingly *the* key lever" (p3, author's emphasis). Leitch found that the skills of the UK workforce as a whole were not world class and lag behind many OECD countries. Follow up work by UKCES (2009) found that the position of Wales was even weaker and was particularly weak with regard to 'low' skills and 'higher' skills. Hudson (2008) also focuses on the skills pool at the regional level. Given the nature of the data source used, there is no information on the skills within the firm, only data on wagebill and numbers employed exist. However, the skills pool in the region does have a significant effect on performance at both the top and the bottom end of the skills distribution. Hudson remarks that in some regions of Wales, basic reading and writing skills could be improved to raise productivity.

Economic performance in Wales

Figure 1 gives an overview of Wales and its relative position in the UK in terms of labour productivity. Overall, Wales accounts for around 4 per cent of UK GVA and a similar share of population. Note from figure 1 that there is little variation in relative position over the period 1989-2009, and we see that, relative to other regions in the UK, Wales performs poorly. In particular, it is clear that compared to the UK, labour productivity in Wales has declined since 1995. This contrasts with Northern Ireland, which recovers with respect to the UK average in about 1995 and maintains a steady relative position. Scotland experiences more mixed fortunes, but is consistently closer to the UK average.

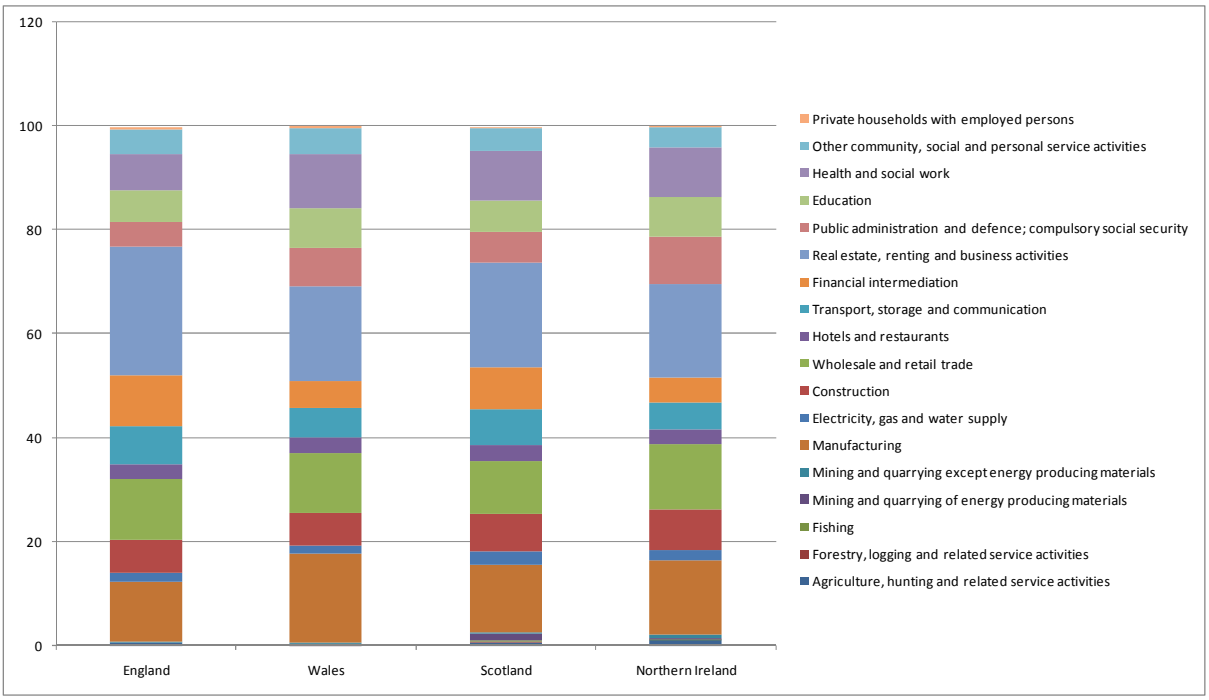
Figure 1: Labour productivity (GVA per head) in UK Regions, 1989-2009



Source: StatsWales

It is a possibility that the relatively poor performance of GVA per head is due to different industrial structure across the regions. Figure 2 provides a detailed breakdown of the share of total output by sector across the regions. Firstly, we see that Wales has a relatively larger proportion of its output accounted for by production sectors (agriculture, manufacturing and mining). This is the traditional picture of Wales as being dominated by heavy industry. The second thing to note is the very large public sector (education, health and public administration), accounting for around 30 per cent of total output. Finally, the size of the knowledge intensive service sectors in Wales, such as financial intermediation and business services is relatively small compared with other UK regions, with the exception of Northern Ireland. In fact, these regions have similar structures, but as we noted in Figure 1, there is a real divergence of fortunes with respect to relative GVA per head.

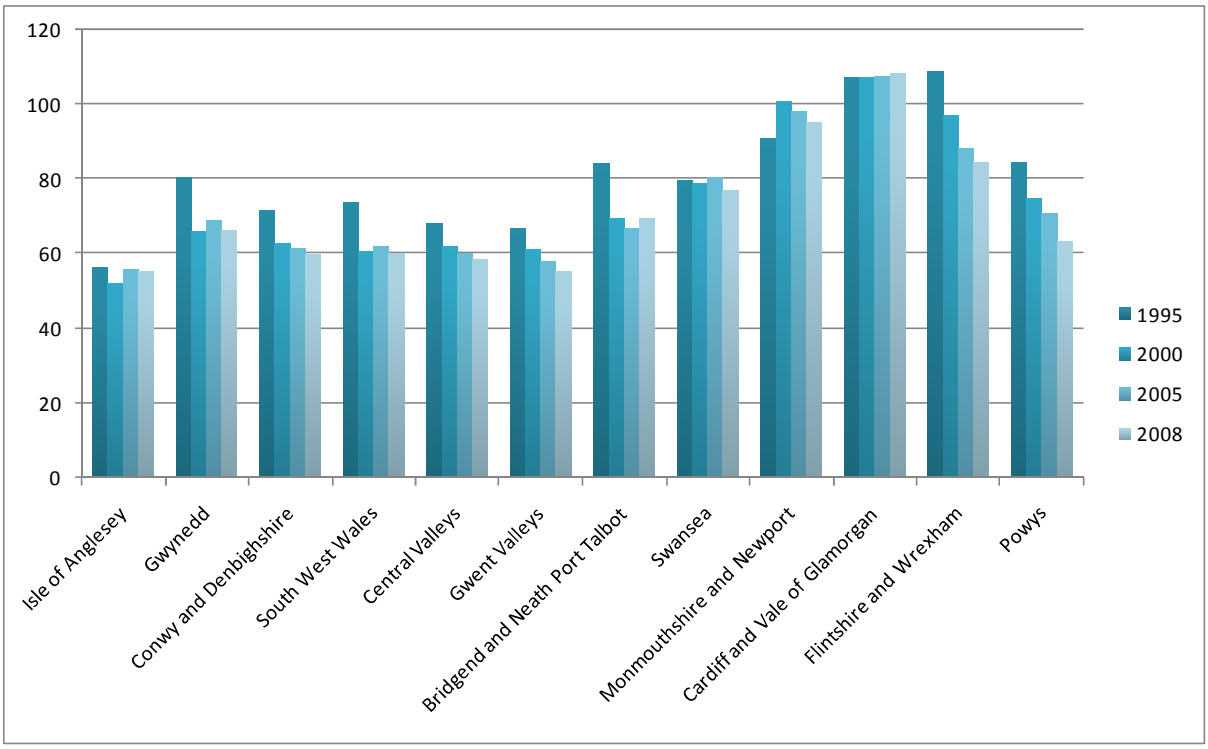
Figure 2: Sectoral breakdown of output by UK Region, 2008



Source: StatsWales

Figure 3 shows Wales' relative labour productivity at a more detailed regional breakdown. Whilst it can be seen that Cardiff and the Vale of Glamorgan experience above national average labour productivity (>100), all other regions are below average, with the majority of the western regions having a relative productivity of around 60 per cent of the UK average and this changes little over time. There is a clear divergence in fortunes between East and West Wales. Proximity to Offa's Dyke and to major lines of communication to neighbouring English centres of population are characteristics of the more successful areas. The north-east of Wales with its good communication links with the North-West of England and those areas bordering the M4 corridor in the south with good road and rail links to the South-East and Midlands have been the most successful. As noted earlier, Boddy et al (2010) suggest productivity differences in Wales reflect sharp differences in accessibility between areas within Wales

Figure 3: Relative Labour Productivity (GVA per head) within Wales (NUTS3) (UK=100)



Source: ONS regional accounts

3. Data description

The core data used here derives from the Company accounts database, Financial Analysis Made Easy (FAME). These are constructed by compiling information from Company's House and other publically available data sources. The advantages of using these data are that they are readily available for the most recent periods, indeed updates are fairly continuous. In addition, there are a number of variables that are available from FAME that are not collected in government data sources. Specifically, FAME is the best source of UK data on exporting behaviour of firms, since the balance sheet reports overseas turnover separately from total turnover. In addition, FAME data are more timely than government sources, which typically lag by 4 years.

FAME has been used to explore a number of issues such as wage and productivity inequalities (Faggio et al, 2007) and the effect of exporting on performance (Harris and Lui, 2005). As in Faggio et al (2007) we drop a number of sectors from the analysis because of heavy state control thought to distort productivity measures. These sectors include agriculture, mining, utilities, health and education.

The attrition rate of companies within FAME is high, indicating that there are a large number of entries in the database for which very little information is available. For our purposes, we will keep a company provided it has employment of at least 1 employee (772 companies) and we also keep only those for which there is at least one year in which turnover is greater than 1,000GBP (563 companies in sectors 01-37). For all sectors, for the period 1995-2009, we have 12,830 year/company observations. 1,866 observations are based on consolidated accounts, the rest are unconsolidated. We choose therefore to analyse the unconsolidated accounts of firms available in Wales.[3]

Labour productivity can be captured in two ways, value added per worker or sales per worker. There is little to be done about the denominator since we have only numbers employed as our labour input, however, in terms of the numerator there are a number of possibilities. Firstly, sales is advantageous because it is a readily available item on the balance sheet, however a theoretically preferred measure would be one that tries to capture value added. This is not so readily available, but following Faggio et al (2007) it can be constructed by summing gross profits before tax and staff expenses.

We augment the company level data with additional regional variables which explore the nature of regional effects. We discuss these in greater detail below but they broadly consider skills, agglomeration distinct from additional regional effects, which are captured by a standard regional dummy variable.

4. Model description

So far we have considered trends in regional labour productivity defined as GVA per head. In analysing the FAME company accounts data we opt to estimate the more holistic measure of company performance by estimating the full production function, incorporating additional controls that we feel may affect productivity and that offer us a better understanding of the sources of productivity differences across regions.

Productivity can be measured in two ways. The growth accounting approach and the production function approach. There are advantages and limitations to both methods, since some of the underlying assumptions differ – most notably, the functional form is defined at the outset when estimating the production function, and here we adopt a Cobb Douglas specification. If the functional form chosen is not appropriate, then this may alter the findings significantly. Harris et al (2006) argue that in order to analyse the causes of TFP, a

[3] Consolidated accounts may include subsidiaries, thus to include consolidated and unconsolidated accounts runs the risk of double counting for some of the more complicated companies.

production function approach is best suited. This does not impose the constraints of constant returns to scale or perfect competition.

Therefore, we estimate the following augmented Cobb Douglas production function (and variations therein) in which output is a log linear function of employment, capital, our control variables, regional, time and industry effects:

$$lnY_{it} = \alpha_1 + \beta_1 lnEmp_{it} + \beta_2 lnW_{it} + \beta_2 lnK_{it} + \beta_3 FO_i + \beta_4 lnAGE_{it} + \beta_5 Export_{it} + \beta_6 HiSkill_j + \beta_7 lowSkill_j + \beta_8 Density_j + R_i + T_{it} + I_i + \varepsilon_{it}$$

Where Y is turnover for each company (i) in time (t) In the case of labour, our measure is employees (Emp=Employees). We have no detailed information on the nature of these employees, not even whether they are full time or part time. The only indicator of quality is the wage bill. Dividing this by the number of employees it gives an indication of the quality of the workforce (W in the equation above), but we have no indication of the skills or qualifications held. To proxy for capital services, we use tangible assets (K=tangible assets). In this specification, we have turnover proxying for value added. In reality, as a sales-based measure, it is more similar to gross output. Our measure of Y could be replaced with an estimate of value added per firm since any productivity change may be the results in changes in input (intermediates specifically) mix.

Our additional controls include a dummy variable for foreign ownership (FO=foreign ownership dummy=1 if foreign owned). There is an extensive literature on foreign owned firms being more productive than their domestic counterparts, see Munday et al (2008) for a comprehensive survey. In addition there has been substantial government investment designed to attract foreign firms to locate in Objective 1 regions in Wales. Thus, we would expect the foreign ownership dummy to be positive and significant..[4] Therefore, the foreign ownership marker refers only to 2008/9 or when the last return was made. Thus, a company reported here may have only recently been taken over, or may have been foreign owned since birth. As another measure of internationalisation, we include a dummy variable that picks up whether the Company operates in overseas markets too (overseas turnover>0). This information is not collected in alternative sources to FAME and is a clear advantage to using company accounts data.

[4] Note that data on nationality in FAME is a current variable, updated at the point of last submitted accounts. It therefore does not vary over time. Details on mergers and acquisitions are available in a separate database held by the data providers, Bureau van Djik at additional cost.

Evidence suggests that young firms are generally more likely to exit than more mature firms, and thus we would expect to see a positive and significant correlation with our experience term. We include therefore a term that captures the experience of the company, proxied by the year of incorporation (AGE=year-date of incorporation). Whilst this is not likely to completely correspond to start up, it is a meaningful proxy for age.

Empirical studies testing endogenous growth theory show knowledge spillovers to be an important factor driving economic growth. Moretti (2004) notes that as early as 1890 Alfred Marshall outlined how interactions between workers may create learning opportunities which can increase productivity and Lucas (1988) notes that human capital externalities comprising of learning spillovers could account for income differences between rich and poor countries. Moretti (2004) estimates a plant-level production function for manufacturing plants and finds a 1 per cent increase in college graduates living in a city leads to a 0.5-0.6 percentage point increase in a plants output.

As well as a firm specific measure of labour quality (the average wage per worker), we incorporate terms to capture the quality of labour in the local authority (area j) in which the firm is based. The proportion of high skilled and the proportion of workers with no qualifications in each Welsh local authority are derived from the Annual Population Survey (APS) between 2004 and 2007. The APS combines the Quarterly Labour Force Survey, Local Area Labour Force Survey and the Annual Population Survey Boost. We calculate the percentage of persons aged 16 to 64 with no qualifications and the percentage of persons educated to degree level and above. Qualification rates are calculated at the local authority level. The APS data used here cover Wales only and are weighted using population weights.

In addition to qualifications, a number of recent studies have outlined the role that the density of economic activity can have on increasing productivity within areas. Ciccone and Hall (1996), for example, use stock data from the US and find that “a doubling of employment density increases average labour productivity by around 6 per cent”. For the UK, Artis et al (2009) find that “agglomeration economies are significant in determining productivity” but are reduced when intangible assets are included in their model. To capture agglomeration effects we include population densities for the 22 local authorities which exist in Wales.

Our models also include year dummies (t) (which proxies for technical progress) and industry dummy variables (I) at the 2 digit SIC. This is based on the company's primary stated business, although Companies may operate in a number of sectors. Table 1 provides an overview of the dimensions of the data in our sample. Note that we have around 8,000 firm-year observations in our dataset. The average age of the firms in our data are around 18 years, but the variation is substantial, from virtual start ups to over 100 years old. Population density is skewed by Cardiff and Swansea, compared to other regions (see Appendix). Around 20 per cent of the firm year observations in our sample participate in exporting. On average, the companies in our data have around 7 year observations, suggesting that we have sufficient variation in the data for a panel analysis. However, as we noted above, there were some variables that do not vary over time.

Table 1: Summary statistics of variables included in the model

	Number of observations	Mean	Std. Dev.	Min	Max
Real turnover	7923	11000.89	21422.10	4.7	195055
Real tangible assets	5495	3334.97	9464.13	0.0	122101
Employment	7923	99.81	223.05	1.0	3955
Foreign owned	7923	0.23	0.42	0.0	1
Firm age	7913	18.60	18.28	0.0	110
Population density	7809	455.20	434.41	25.4	2397
Exporter	7923	0.20	0.40	0.0	1
Share of high skilled in unitary authority	7809	0.19	0.11	0.0	1
Share of low skilled in unitary authority	7809	0.14	0.07	0.0	0

Source: FAME, own calculations; all sectors (01-99)

5. Results

We estimate 3 variations based on the model specified in equation (1), the results of which are shown in table 2. We estimate these firstly using pooled ordinary least squares (OLS) and then using the random effects estimator, which utilises the panel dimension of the data to test the robustness of our findings. Our first model acts as a baseline incorporating time, region and sector dummies, along with capital (tangible assets) and employment and the firm specific labour quality term (proxied by average wage in the company). Note that these are broadly in line with expectation; the coefficients on employment and wage are perhaps a little larger than anticipated and capital coefficient somewhat smaller, given the Cobb Douglas functional form. This is likely to be a feature of an imperfect measure for capital and also the left hand side variable (log turnover), which roughly approximates GVA.

Model 2 incorporates the firm level controls that we believe affect productivity. These include the age of the firm, and an ownership marker for each firm. This is ownership at the point of the last observation in the data. An additional measure of internationalisation is whether or not the firm exports any part of its output. This is captured by using the overseas turnover measure. If this is greater than zero, our export dummy is coded 1. It can be seen from our results in table 2 that turnover is positively and significantly associated with all three variables. Thus we see that company experience has a positive association with turnover, in line with expectations. The effect of exporting is relatively strong and significant, but the foreign ownership effect is dominant. This specification sees a decline in the magnitude of the employment and capital coefficients as the equation is better specified.

In our final model (3), we also include measures of regional skill levels and population density. Both are designed to capture the additional effect at the regional level either as a result of amenities or a skilled labour force, which assist firms in their production processes. Skills information at the local authority level captures how a firm's performance may be influenced by the local pool of skilled labour. We include both the share of highly skilled population in the area as well as the share of those with no qualifications. Our a priori expectation is that the share of high skills in a region will be positively associated with turnover (and hence productivity) and the share of low skills in a region will be negatively associated with turnover. From table 2 we see that the high skills share is positively and significantly associated with turnover in Welsh firms, whereas low skills are insignificant[5][6]. A one per cent increase in the proportion of high level skills in an area is shown to increase output by 0.1 per cent.

Population density is found to be negatively related to productivity which is inconsistent with earlier literature but was found to be positively related to productivity when regional dummies were excluded. It may be that Wales is different to many other countries; Cardiff dominates in terms of population density (see Figure A in appendix) or that we are asking too much of the data by including regional dummies and population density as well as skill levels for the 22 unitary authorities that exist in Wales. However, by including both, the results do appear to have strong policy implications since our findings imply that policies should be directed at

[5] Oguz and Knight (2011) find that NUTS1 regions with higher proportions of level 4 skills have higher levels of productivity. No such relationship however is found with level 3 skills and excluding London, "the relationship between productivity and low skills is fairly weak" (p.139)

[6] We experimented with a number of different ways to capture regional shares of high and low skills, including specifying skills shares by sectors and netting out the public sector workers – to address the criticism that the public sector might 'crowd out' skills in the private sector. None of these results were significantly interesting to include here.

improving the skills base within Wales as a whole rather than increasing the size of conurbations.

As well as pooled OLS, we estimate random effects, which, rather than treating each firm year observation as an additional observation, uses the variation between firms and within firms over time more efficiently. Our findings from the random effects models are consistent with the pooled OLS findings, although we note that the coefficient on log age becomes larger, emphasising the importance of experience. Engaging in overseas sales becomes less statistically significant but still significant at accepted levels (5%) of significance. The foreign ownership coefficient becomes even larger than in the pooled OLS. Agglomeration becomes smaller and significant only at the 10 per cent level of significance. The high skills share remains positive but the level of significance is reduced. The share of low skills and population density remain insignificant.

The results taken as a whole indicate that there is a positive association between turnover (and hence productivity) and the age of a company and the foreign activity of a company. The evidence with respect to regional measures is less clear cut in relation to skills and agglomeration and this is more sensitive to specifications and estimators used. This is in part because of significant correlation amongst these variables.[7] Whilst the random effects models show less significance amongst the regional variables included, this reflects the limitations of the data (given that the regional variables cannot vary by time or by region) - the size of the coefficients are not dramatically different, giving us some confidence in our findings overall. More sophisticated estimation techniques could be employed, such as the Generalised Method of Moments (Arellano 2003) or the Pooled Mean Group estimator (Pesaran, Shin and Smith, 1999). These often require very large datasets to work sensibly and are therefore not suited to the type of small area analysis undertaken here.

[7] The correlation coefficients between most of the variables are significant and positive although not above 0.6 in general. These are available on request.

Table 2: Model estimates of Cobb-Douglas production functions, various specifications, 1998-2007

	(1) Basic model	(2) age and international model	(3) agglomeration & skills & regions	(RE1) Basic model	(RE2) age and international model	(RE3) agglomeration & skills & regions
lnemployment	0.820***	0.815***	0.817***	0.878***	0.794***	0.794***
	[0.012]	[0.012]	[0.012]	[0.015]	[0.015]	[0.016]
Lntangible assets	0.084***	0.078***	0.078***	0.042***	0.050***	0.055***
	[0.008]	[0.008]	[0.008]	[0.009]	[0.008]	[0.009]
Lnwage	0.804***	0.761***	0.768***	0.609***	0.551***	0.544***
	[0.020]	[0.020]	[0.021]	[0.021]	[0.021]	[0.021]
Lnage		0.040***	0.030**		0.166***	0.164***
		[0.013]	[0.013]		[0.019]	[0.020]
Export		0.096***	0.120***		0.058**	0.058**
		[0.031]	[0.032]		[0.026]	[0.027]
Fo		0.222***	0.217***		0.342***	0.347***
		[0.030]	[0.031]		[0.082]	[0.085]
Ln highquals			0.094***			0.116*
			[0.025]			[0.067]
Ln low quals			0.017			0.129
			[0.030]			[0.079]
Ln population density			-0.153*			-0.165
			[0.093]			[0.237]
Observations	4,937	4,882		4,937	4,882	4,648
R-squared	0.816	0.822				
F-Stat	332.0	326.7				
Rmse	0.800	0.779		0.379	0.356	0.361
Number of crn				800	791	754
chi2				7173	6770	6390
sigma_e				0.379	0.355	0.359
sigma_u				0.819	0.814	0.816
rho				0.824	0.840	0.837

Notes: All specifications include year, 2-digit industry and regional (22) dummies; Standard errors in parentheses; * indicates significance at the 10 per cent level, ** 5% and ***1%.

6. Conclusions

An improvement in the productivity performance of the Welsh economy is crucial if Wales is to improve its relative GDP position and climb from the foot of the UK earnings league table. Other studies on Wales have focussed on comparison with the rest of the UK and have concentrated on manufacturing. By using FAME we offer more timely results (to 2008) and variables that are not available from other micro sources such as overseas activity. This paper focuses on a number of areas that are likely to affect productivity. Firstly, we consider the extent of internationalisation, by the inclusion of foreign ownership indicators and the engagement in exporting behaviour. We find a strong and positive influence of foreign ownership in Wales, in line with a priori expectations. It is a matter of concern therefore that

Wales is attracting a declining share of UK inward investment, falling from over 12 per cent in 2002/04 to 6 per cent in 2008/2010 in terms of employment (See Blackaby et al, 2011).

Secondly, we consider the experience of the company specifically to test whether age or youth affects a firm's productivity. We find that the age of the company is positively associated with higher turnover.

Finally we explore the role of geography by factoring in regional dummies and including skills and density variables to test for agglomeration economies. Having controlled for the quality of the firm workforce we find similar to Moretti (2004) that the productivity of firms is positively associated with the amount of higher level skills in an area. In a model including regional dummies we find that a regional skills effect dominates the employment density effect in explaining firm productivity. Given the importance of skills in raising productivity both directly at a firm level and through local spillover effects it is important that education policy in Wales provides the skills needed by the economy. In addition it is important that European Structural Funding given to Wales to improve GDP through skill enhancement achieves its maximum potential. So far it has not been successful at closing the GDP gap that exists between East and West Wales.

References

Arellano, M. (2003) *Panel Data Econometrics*, Oxford University Press, Oxford

Artis, M., Miguelez, E. and Moreno, R. (2009) 'Assessing Agglomeration Economies in a Spatial Framework with Endogenous Regressors', SERC Discussion Paper 23.

Blackaby, D., Drinkwater, S., Murphy, P. and Robinson, C. (2011) Inward Investment in Wales. Written evidence submitted to the Welsh Affairs Select Committee, available at: http://www.publications.parliament.uk/pa/cm201011/cmselect/cmwelaf/writev/inwardin/iiw15.htm

Boddy, M. (2010) 'Productivity in Wales: the impacts of peripherality on spatial patterns of productivity' Report to the Economic Research Advisory Panel, Welsh Assembly Government, available at: http://wales.gov.uk/docs//dfm/research/100524productivityen.pdf

Boddy, M. (2006) 'Understanding Productivity Variations between Wales and the Rest of the UK', Report to the Economic Research Advisory Panel, Welsh Assembly Government.

Chatterji, M. and Dewhurst, J. (1996) Convergence clubs and relative economic performancein Great Britain: 1977-1991, *Regional Studies* 30: 31-40.

Ciccone, A. and Hall, R. (1996) 'Productivity and the Density of Economic Activity', American Economic Review, 86 (1), 54-70.

Faggio, G., Salvanes, K. G. and van Reenen, J. (2007) 'The Evolution of Inequality in Productivity and Wages: Panel Data Evidence', CEP Discussion Paper 821.

Foreman-Peck, J. (2003) 'Welsh Living Standards: An International Perspective', mimeograph

Gibson, P., Oguz, S. and Knight, J. (2009) 'Regional Economic Indicators: A focus on rural and urban productivity in the English regions', *Economic and Labour Market Review*, **3**(9) 52-69.

Harris, R. (2004) 'Analysis of Labour Productivity Differences in Service Sectors', Report to National Assembly for Wales.

Harris, R., O'Mahony, M. and Robinson, C. (2006) 'Research on Scottish Productivity', Report to the Scottish Executive Office of the Chief Economic Advisor and Enterprise Transport and Lifelong Learning Department – Analytical Services Division.

Harris, R. and Lui, Q. C. (2004) *fame details exporting report for UKTI*

Harris, R. (2010) 'Models of Regional Growth: Past Present and Future', *Journal of Economic Perspectives* (forthcoming)

Henley, A. (2005) "On regional growth convergence in Great Britain", *Regional Studies*, **39** (9), 1245-1260.

HM Treasury (2004) 'Productivity in the UK 5: Benchmarking UK Productivity Performance. A Consultation on Productivity indicators', available at http://www.hm-treasury.gov.uk/consult_productivity_indicators_index.htm

Hudson, J. (2008) 'Extending the Research on Understanding the Productivity Variations between Wales and the UK', Report to the Welsh Assembly Government.

Huggins, R. and Thompson, P. (2010) *UK Competitiveness Index, 2010*, Report published by the Centre for International Competitiveness, Cardiff School of Management, University of Wales Institute, Cardiff.

Leitch, S. (2006) Review of Skills, "Prosperity for all in the Global Economy – World Class Skills", Final Report, December 2006, available at: http://www.delni.gov.uk/leitch_finalreport051206[1]-2.pdf

Lucus, R. E. (1988) "On the Mechanics of Economic Development", *Journal of Monetary Economics*, **22**(1), 3-42.

Marshall, A. (1890) *Principals of Economics*, New York, Macmillan.

Moretti, E. (2004) 'Workers' Education, Spillovers and Productivity: Evidence from Plant-level Production Functions', *American Economic Review*, **94**, 656-690.

Munday, M., Roberts, A. and Roche, N. (2008) *A review of the economic evidence on the determinants and effects of foreign direct investment*, Welsh Economy Research Unit

Oguz, S. and Knight, J. (2011) "Regional Economic Indicators with a focus on the relationship between skills and productivity", *Economic and Labour Market Review*, February 2011

Peneder, M. ed. (2009) *Sectoral Drivers of Growth and Competitiveness in the European Union*, European Commission Enterprise and Industry, Luxembourg.

Pesaran, H., Shin, Y. and Smith, R. (1999). 'Pooled Mean Group Estimation of Dynamic Heterogeneous Panels', *Journal of the American Statistical Association*, vol. 94, 621-634

Thomas, J. and Evans, J. (2010) 'There's more to life than GDP but how can we measure it?' *Economic and Labour Market Review*, **4** (9), 29-36.

UK Commission for Employment and Skills (2009) Ambition 2020: World Class Skill and Jobs for the UK, The 2009 Report", available at: http://www.ukces.org.uk/publications/ambition2020

Welsh Assembly (2002) *A Winning Wales The National Economic Development Strategy of the Welsh Assembly Government*.

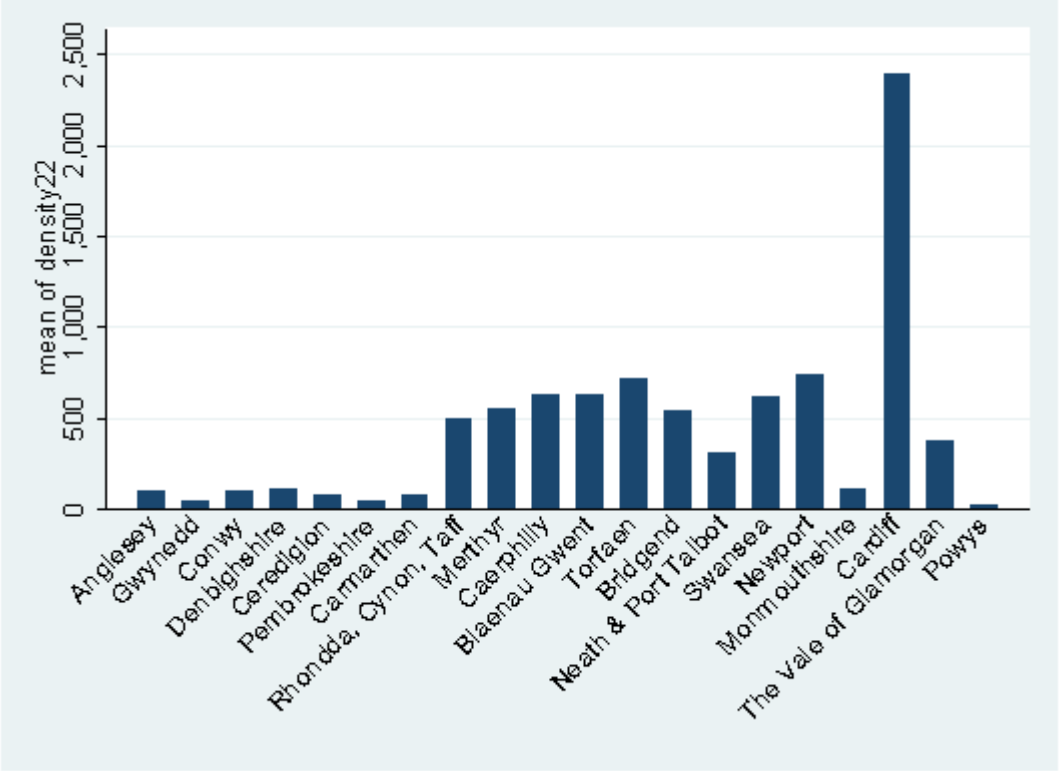
Welsh Assembly Government (2010) *Economic Renewal: A New Direction*, July 2010

Wosnitza, B. and Walker, M. (2008a) 'Regional Economic Indicators May 2008 with a focus on differences in sub-regional economic performances' *Economic and Labour Market Review*, **2**(5) 40-61.

Wosnitza, B. and Walker, M. (2008b) 'Regional Economic Indicators August 2008 with a focus on household income', *Economic and Labour Market Review*, **2**(8) 49-60.

Appendix

Figure A: Population Density by Local Authority, 2005



Source: based on population density data available from StatsWales