Econometric Analysis of SET Technicians

A European Comparative Study

Nick Jagger

Report 482

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Institute for Employment Studies

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Executive Summary

This short paper provides the results from a series of econometric analyses of the relative impact of SET Professionals, SET Technicians and R&D expenditures at the sectoral level across the European Economic Area. Data on exports, value added, total employment and R&D expenditures were derived at the level of nine sectors for 22 countries for a 15 year period of 1992–2007 from the OCED's Structural Analysis (STAN) database. Comparable data on Total Factor Productivity was derived from the EU-KLEMS database. In principle these combined sources provide 2,970 cases, however due to missing data the actual number of cases available is smaller. Added to the data from the European Labour Force Survey we generated comparable data on the numbers of SET Professionals and SET Technicians.

A range of output measures were then produced to account for different aspects of sectoral performance, these were:

- Value Added per Capita, a sectoral equivalent to Gross Domestic Product per Capita
- Revealed Comparative Advantage, which examines the sectors relative exporting performance
- Balance of Trade, which compares the imports and exports associated with each sector, and
- Total Factor Productivity, which examines the residual productivity once capital inputs and personal inputs have been accounted for.

The data was then analysed using regression techniques and a range of dummy variables to account for any annual, national or sectoral variation and allow the full impact of SET Professionals and SET Technicians to be examined. These regressions showed that in terms of Total Factor Productivity, SET Professionals had a greater positive impact than SET Technicians. In part this is to be expected as SET Professionals are more educated than SET Technicians. However, the regressions on the other output variables showed a slight negative impact for SET Professionals and a positive impact for SET Technicians. This suggests that in some sectors and countries with low exports and low value added per capita there are too many SET Professionals and not enough SET Technicians. However, the pattern was also sustained when only manufacturing was examined. This suggests that it is not simply a sectoral mix issue, but that technician level skills are essential to the effective production of exports.

Overall, this is sufficient to suggest that the levels of UK public subsidy for SET Professionals should be matched by similar levels of support for SET Technicians and the apprenticeship programmes that supply them.

1 Introduction and Background

This report builds on a previous report for the Gatsby Foundation by IES (Jagger, Sigala, Sumption, 2010), where the definition and descriptive data covering SET Professionals and SET Technicians are covered in more detail. However, this report concentrates on an econometric analysis of the relative contribution of SET Professionals and SET Technicians to a range of sectoral performance measures. This first chapter discusses the indicators used and the data that underlies the indicators as well as providing some descriptive statistics. The second chapter provides the details of the econometric analyses undertaken and the third chapter discusses the interpretation and implications of the analyses.

1.1 Objectives

The objective of this analysis is to determine the relative importance of SET Professionals, SET Technicians and R&D expenditure in driving a range of sectoral economic performance measures. In order to do this a large dataset has been assembled from a range of data sources and structured to allow regression analysis. Data has come from the European Labour Force Survey, the OECDs STAN database and STAN Indicators database, as well at the EU-KLEMS database. Data was sought for a period covering 1992–2008, countries included the EU15 plus the Czech Republic, Hungary, Poland, Slovenia, Slovakia, Iceland and Norway. The sectors were:

- Agriculture, Hunting, Forestry and Fishing or SIC 92 codes 01–05
- Mining, Quarry, Oil and Gas Extraction or SIC 92 codes 10–14
- Manufacturing or SIC 92 codes 15–37
- Construction or SIC 92 code 45
- Wholesale and Retail Trade; Restaurants and Hotels or SIC 92 codes 50–55
- Transport, Storage and Communications or SIC 92 codes 60–64

- Finance Insurance Real Estate and Business Services or SIC 92 codes 65–74
- Community Social and Personal Services or SIC 92 codes 75–99.

In principle this means that we could have nine sectors times 22 countries times 15 years or 2,970 cases. However, in practice for many variables the numbers of cases were significantly less and this is particularly the case when more complex regressions are involved. In order to ensure that small sectors in small countries did not overwhelm the impact of large sectors in large countries the regressions were weighted by the number of employees in the sector.

1.2 SET Professionals

SET Professionals are defined in terms of International Standard Classification of Occupation (ISCO) 1988 codes. ISCO is the UN developed classification of occupations used by Eurostat as part of the common European Labour Force Survey (Elias and Birch, 1994). Table 1.1 shows the codes and associated descriptions included in the SET Professionals category. Generally these occupations require at least a first degree level qualification in a linked subject and often require a higher degree.

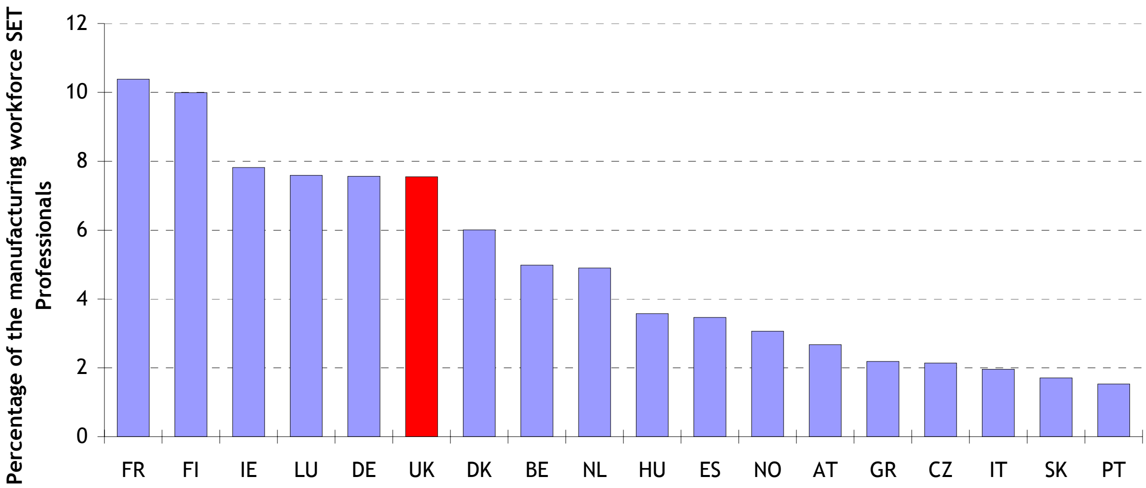
Table 1.1: SET Professionals ISCO definition

ISCO code	ISCO description
211	Physicists, chemists and related professionals
212	Mathematicians, statisticians and related professionals
213	Computing professionals
214	Architects, engineers and related professionals
221	Life science professionals

Source: IES

Figure 1.1 shows the percentage of the manufacturing workforce in a SET Professional occupation by country. This shows that the UK is part of a group of countries (Ireland (IE), Luxembourg (LU) and Germany (DE)) with just under eight per cent of their manufacturing workforce in a SET Professional occupation. France (FR) and Finland (FI) have ten per cent or just over as SET Professionals, while there is a long tail of countries with levels at or below about two per cent.

Figure 1.1: Percentage of the manufacturing workforce SET Professionals in 2008



Source: IES and European Labour Force Survey

1.3 SET Technicians

SET Technicians are also defined in terms of a series of three digit ISCO codes. Generally these occupations require a higher vocational level qualification in a linked subject. Table 1.2 lists the ISCO occupations within our definition of SET Technicians.

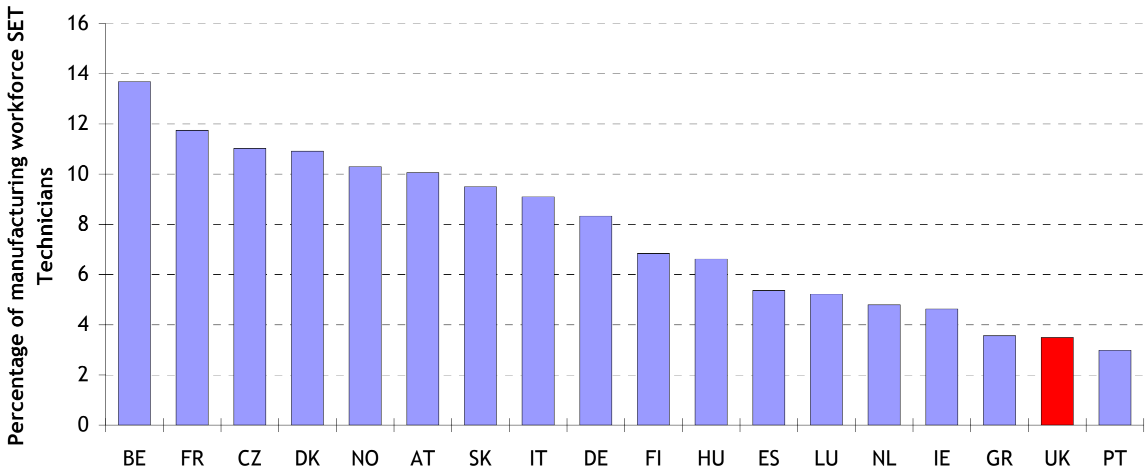
Table 1.2: SET Technicians ISCO definition

ISCO code	ISCO description
311	Physical and engineering science technicians
312	Computer associate professionals
313	Optical and electronic equipment operators
314	Ship and aircraft controllers and technicians
315	Safety and quality inspectors
321	Life science technicians and related associate professional
322	Health associate professionals (except nursing)

Source: IES

Figure 1.2 shows that the UK has one of the lowest levels of SET Technicians amongst its manufacturing workforce, with only Portugal (PT) having a smaller proportion.

Figure 1.2: Percentage of the manufacturing workforce SET Technicians in 2008



Source: IES and European Labour Force Survey

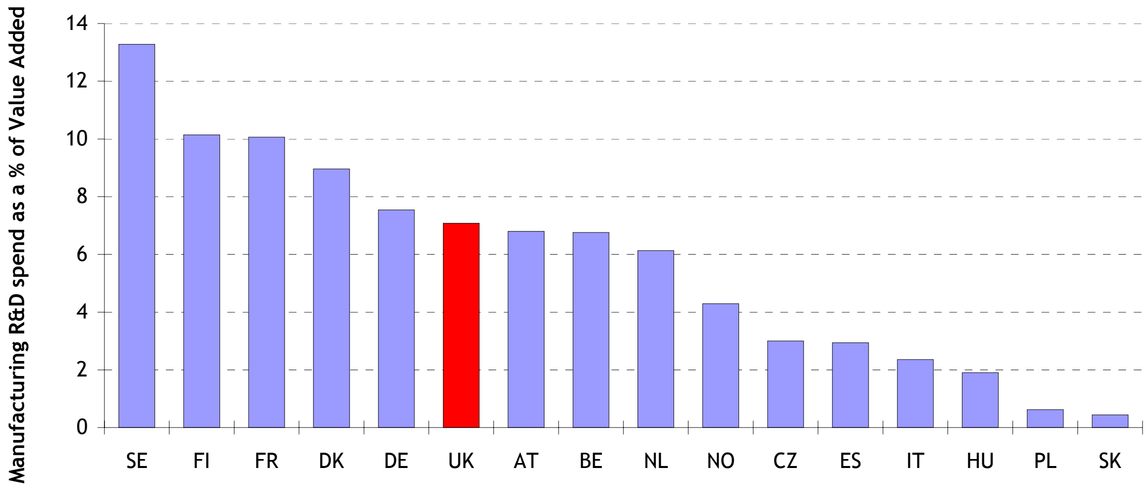
1.4 R&D Expenditure

Research and Development (or R&D) activity is defined as:

> *"Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."* (OECD, 1994)

Using this definition and others in the Frascati Manual, surveys were undertaken in all the countries and we collected data from the OECD STAN Indicators database. Specifically, we obtained sectoral R&D expenditure as a proportion of sectoral added value and R&D expenditures in national currencies. The R&D expenditure in national currencies were converted into PPP US dollars and used to produce a comparable R&D expenditure per SET Professional. The second measure was generated as there was concern that R&D expenditures were heavily linked to the numbers of graduates and SET Professionals within a sector. The use of a PPP expenditure per SET Professional was an attempt to produce a measure of R&D intensity that was independent of the number of SET Professionals. The main driver of this alternative measure is the high correlations between the proportion of the workforce that are SET Professionals and the R&D expenditure as a proportion of value added for each sector. Entering highly correlated variables into the same regression equation can cause multi-colinearity and make the coefficients unreliable.

Figure 1.3: Manufacturing R&D spend as a percentage of sectoral value added



Source: IES and OECD STAN Indicators

1.5 Sectoral performance measures

Given that a range of sectoral performance measures are available and that they each measure slightly different aspects of performance we choose four measures to look at, these are:

- Total Factor Productivity
- Value Added per Capita
- Revealed Comparative Advantage
- Balance of Trade

These measures, their definition and underlying data sources are described in turn in the sections below.

1.5.1 Total Factor Productivity

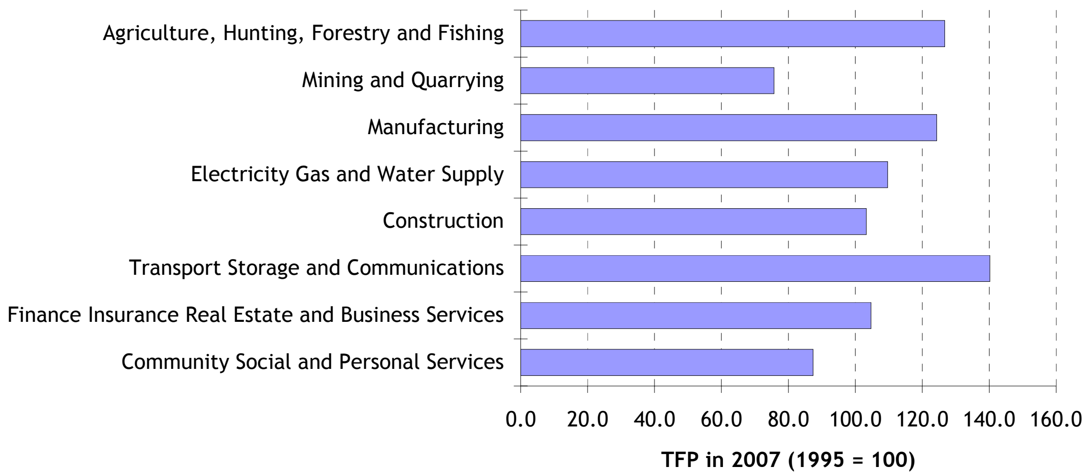
Total Factor Productivity (TFP) as a performance measure has a long history with an increasingly sophisticated understanding of the measure (Hultern, 2000; Islam, 1999). The approach, although requiring detailed information, has been used for a wide range of studies including O'Mahony (2002) and Maudos et al. (1999). Total Factor Productivity is often a preferred productivity measure as it takes into account the amount of capital invested in a sector and the number of workers. The concept is based on Solow's (1956) neo-classical growth model, which expresses growth as a function of capital and human capital and a residual.

$\Delta Y = A(\Delta K, \Delta L, \text{residual})$

Where ΔY is the change in real output (or growth), ΔK is the change in physical capital, ΔL is change in labour input and A is a constant. The residual, or the part of the growth in output that is not explained by changes in capital and labour is Total Factor Productivity. Various improvements to the method include taking account of the impact of different types of physical capital such as computers, accounting for the quality of the workforce using their highest qualification, and looking at energy inputs. We have taken sectoral TFP data from the EU-KLEMS database (O'Mahony and Timmer, 2009).

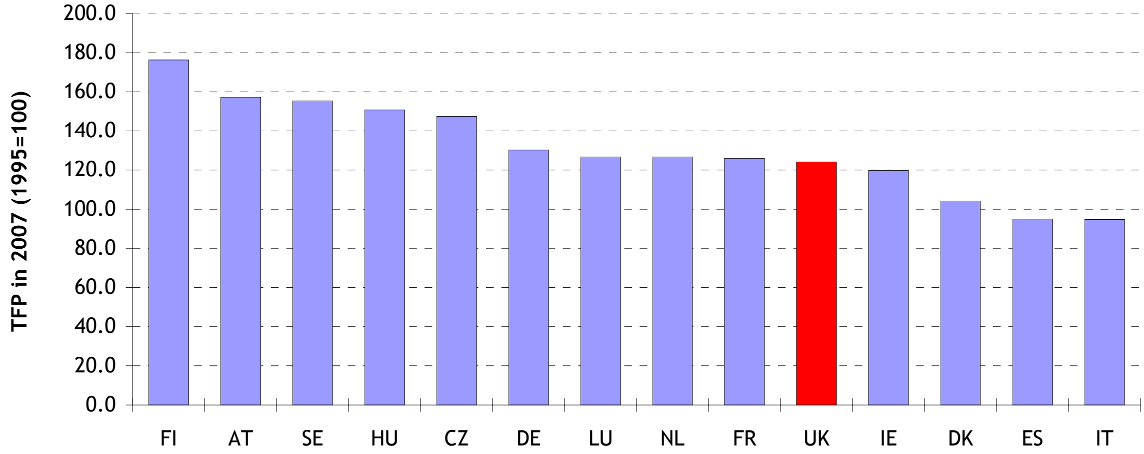
Figure 1.4 shows the relative TFP by UK sector in 2007, the figures are based to 100 in 1995, so a TFP of above 100 shows a growth in TFP from 1995 and a figure below 100 shows a decline in TFP from 1995. This shows a pattern similar to that found with Added Value per Capita, with the Transport, Storage and Communications sector showing the most growth in TFP and Mining and Quarrying showing the greatest decline.

Figure 1.4: TFP in 2007 with 1995 equal to 100 by UK Sector



Source: IES and EU-KLEMS

Figure 1.5: Manufacturing TFP in 2007 with 1995 equal to 100 by country



Source: IES and EU-KLEMS

Figure 1.5 shows the relative TFP of manufacturing sectors by country. This shows the UK at the lower end of the mid-range of values with Denmark (DK), Spain (ES) and Italy (IT) having lower values.

1.5.2 Value Added per Capita

Value Added per Capita is the sectoral measure that is conceptually closest to Gross Domestic Product per Capita, which is commonly used to measure the relative performance of national economies. This measure looks at the financial inputs and outputs of the sector and looks at the value that is added by the sector. This measure has been taken from the OECD's Structural Analysis (STAN) database.[1] As the data provided is in millions of national currencies, at current prices, we used the appropriate sectoral value added deflators to express everything in year 2000 prices in the national currencies. Then using year 2000 Purchasing Power Parity (PPP) data, the data was further converted into year 2000 PPP US dollars. This allows the data to be examined statistically in a consistent manner.

Figure 1.6 shows the relative value added per capital by broad sector in the UK in 2008. This shows that using this measure the Transport, Storage and Communications sector was the most productive in 2008. The other relatively productive sectors in the UK were Agriculture, Hunting, Forestry and Fishing as well as Manufacturing.

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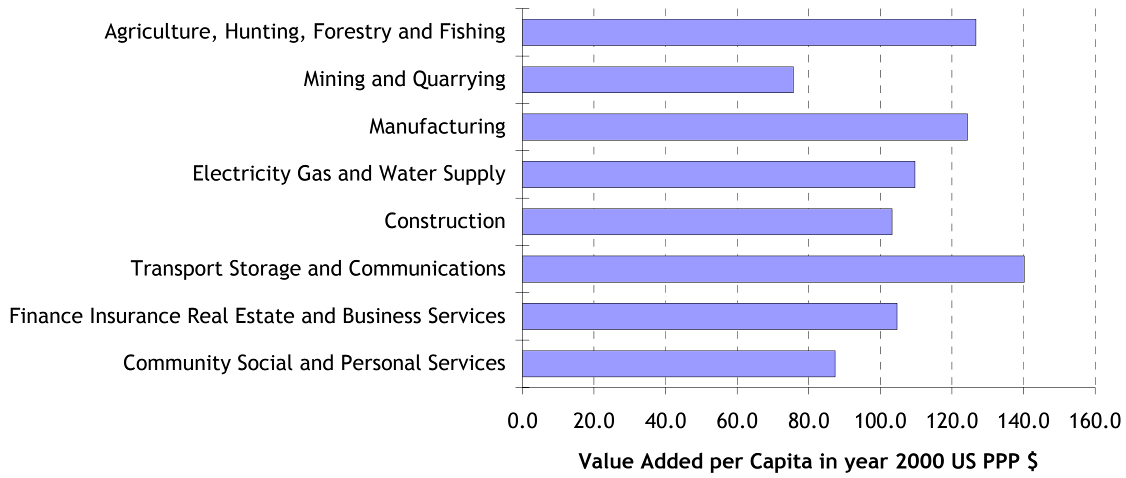
1 www.oecd.org/sti/stan/

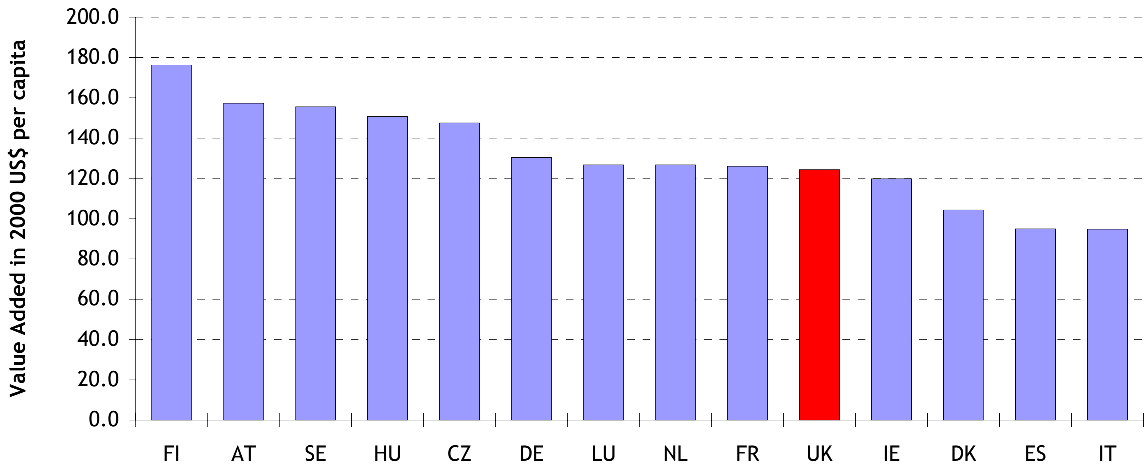
Figure 1.7 shows the relative performance of the UK's manufacturing sector in 2008 compared with other countries manufacturing sectors. This shows that using this productivity measure a range of countries have quite similar manufacturing value added per capita. These mid-range countries include Germany (DE), Luxembourg (LU), Netherlands (NL), France (FR) and Ireland (IE). There was also another group of countries with higher levels of manufacturing productivity. These countries were Finland (FI), Austria (AT), Sweden (SE), Hungry (HU) and the Czech Republic (CZ). Three countries had manufacturing sectors with a lower level of productivity than the UK, these were Denmark (DK), Spain (ES) and Italy (IT).

Figure 1.6: UK Value Added per Capita by sector, in 2008



Source: IES and OECD STAN data

Figure 1.7: Manufacturing Value Added per Capita in year 2000 US PPP Dollars



Source: IES and OECD STAN data

1.5.3 Revealed Comparative Advantage

Another measure used in international comparisons is the Revealed Comparative Advantage (RCA) measure. This looks at the sector's exports as a proportion of all exports, compared with all the available countries' exports for that sector as a proportion of total exports across all the countries. This measure was developed by Balassa (1965) as a method of using trade data to reveal the relative attractiveness of products from one country. The formula is:

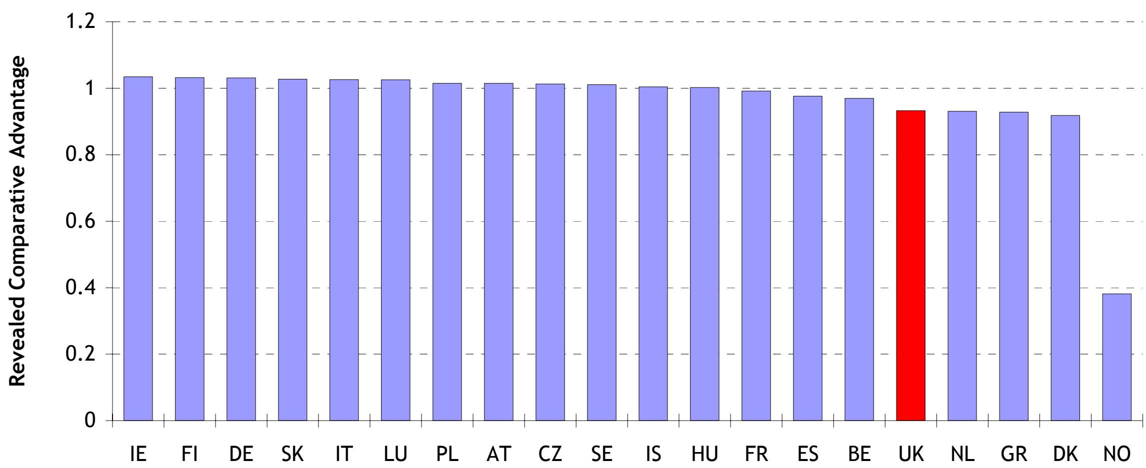
$RCA = (E_{ij} / E_{it}) / (E_{nj} / E_{nt})$

Where:

- E_{ij} measures the exports of a specific country and specific sector
- E_{it} measures the exports of the country across all sectors
- E_{nj} measures the exports for all countries for the specific sector, and
- E_{nt} measures all the exports for all countries and all sectors.

We used the OECD STAN database's trade data as the basis for this, but converted everything into US PPP dollars in order to provide meaningful aggregates. Using this indicator a value above one shows relatively more exports than other countries. Figure 1.8 shows the RCA for the manufacturing sectors for a range of European countries. The UK is at the lower end of the scale. However, it is notable that the oil and gas exporting countries of the UK, the Netherlands (NL), Denmark (DK) and most notably Norway (NO) have low scores on this measure.

Figure 1.8: Manufacturing Revealed Comparative Advantage in 2008

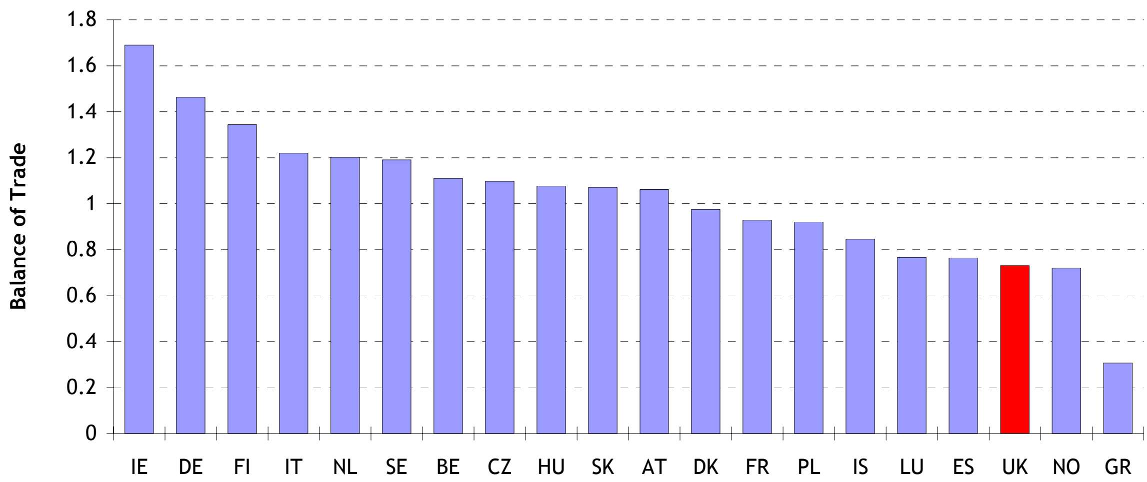


Source: IES and OECD STAN data

1.5.4 Balance of Trade

Another trade data based measure, which is less influenced by oil and gas exports, is the simple Balance of Trade measure – this looks at the ratio of exports to imports for a particular sector. Here the trade data is taken from the OECD's STAN database, data is provided in millions of national currencies. However, as we are looking at the ratio within a year there is no need to convert into real prices or to convert to a common currency. Again it is implied that if there are more exports than imports the products of the sector in the particular country are more attractive. Figure 1.9 uses this measure to look at the relative position of various countries manufacturing sectors. This shows the UK's manufacturing sector performing relatively badly with only Norway (NO) and Greece (GR) in particular performing worse.

Figure 1.9: Manufacturing Balance of Trade in 2008



Source: IES and OECD STAN data

1.6 Interactions between variables

For a variety of reasons the various performance measures are likely to be linked to each other as they are essentially measuring the same underlying good or bad performance. This is shown in the correlation matrix in Table 1.3. The first value shows the correlation coefficient, the one below this shows the significance of the coefficient and then the number of cases in the correlation.

This shows that Balance of Trade is highly correlated with Value Added per Capita and Revealed Comparative Advantage, but not so strongly with Total Factor Productivity.

Table 1.3: Interactions between the outcome variables

	Balance of Trade	Value Added per Capita	Revealed Compar-ative Advantage	Total Factor Product-ivity
Balance of Trade	1			
	- -			
	1,246			
Value Added per Capita	0.4578	1		
	0.0000	- -		
	1,186	2,911		
Revealed Comparative Advantage	0.8982	0.4716	1	
	0.0000	0.0000	- -	
	1246	1230	1290	
Total Factor Productivity	0.0784	0.0678	0.0333	1
	0.0244	0.0046	0.3316	- -
	824	1,745	850	1,760

Source: IES

Table 1.4 shows the correlations between the potential explanatory variables. This shows that the proportion of SET Professionals is highly correlated with the proportion of SET Technicians. Equally, the two R&D measures are also highly correlated with each other, but not particularly correlated with SET Professionals.

Table 1.4: Interactions between the explanatory variables

	SET Professional s	SET Technicians	R&D spend per SET Professional	R&D as a % of Value added
SET Professionals	1			
	- -			
	3024			
SET Technicians	0.157	1		
	0.0000	- -		
	3024	3024		
R&D spend per SET Professional	-0.0210	0.0101	1	
	0.4826	0.7342	- -	
	1122	1122	1122	
R&D as a % of Value added	-0.0061	0.055	0.8177	1
	0.7992	0.0223	0.0000	- -
	1726	1726	1122	1726

Source: IES

2 Econometric Analysis

This chapter contains the results of the econometric analysis. However, before moving on to the results the concept and implementation of dummy variables are introduced and the impact of weighting is examined.

2.1 Dummy Variables

Regression is a powerful method of looking at the interaction between a wide range of variables and a dependent variable. However, as is often the case it is more powerful with more data. The problem is that by definition we only have one item of data in each sector in each country and each year, and it is also likely that there will be sector, country and annual effects on the analysis. The most common method to deal with this is to use indicator or dummy variables for sector, country and year (Suits, 1957). This allows the common impacts of these variables to be taken into account in the regressions and this in turn allows us to examine data from a range of years, countries and sectors in order to examine the underlying relationships of interest.

The dummy variables were set up to allow comparison from the UK in terms of countries, manufacturing in terms of sectors, and 2000 in terms of years. The coefficients and significance of the standard errors are listed in Annex A for critical regressions.

In order to determine whether the results are due to sectoral differences (Jagger et al., 2005) further regressions were undertaken using only data for the manufacturing sector. These manufacturing only regressions, although necessarily based on fewer cases, eliminate any sectoral effect not picked up by the dummy variables.

2.2 Weighting

The regressions were run weighted and unweighted, the results being broadly similar in both cases. The total number of people employed by the sector in the country in the specific year, expressed in thousands, was used as the weight. As the weighted approach meant that small sectors in small countries had less influence on the results and large sectors in large countries had a greater impact, it was felt that the weighted approach was preferable. The results presented in this report are from the weighted regressions. However, in order to get an idea of the amount of underlying data in the regressions the unweighted as well as weighted base is also reported.

2.3 Regressions

A series of regressions were undertaken and the results are shown in a series of tables covering:

- Total Factor Productivity
- Value Added per Capita
- Revealed Comparative Advantage, and
- Balance of Trade.

These are covered in turn below, following a short introduction to the interpretation of regression outputs.

2.3.1 Interpreting the regression output

This section is included in order to make the regression output more understandable to non-technical readers. Each table presents the results of six different regressions, each represented by different numbered columns. Down the side are the explanatory variables that have been included in the regressions. All of the regressions also include a series of indicator/dummy variables, which are detailed in these tables.

The first number in the table cells is the regression coefficient, which measures the size of the impact of the explanatory variable on the outcome variable. If the coefficient is negative the impact is negative and similarly a positive coefficient represents a positive impact. The relative size of the coefficient is also a measure of the size of the impact. The second figure, in brackets, is the significance of the interaction and here the smaller the significance figure, the greater the significance.

Also included in the table is the R Squared value, which represents the proportion of the overall variance explained by the variables included in the equation. A maximum possible value for R Squared is one and anything above 0.3 is considered acceptable. Finally, the tables also include the unweighted number of cases and the weighted number of cases, as well as the Variance Inflation Factor (VIF). The VIF tests for multi-collinearity, which is a common problem with the number of dummy variables being used. The general rule of thumb is that the VIF value should be below 10.

2.3.2 Total Factor Productivity

Table 2.1 provides the output regressions using Total Factor Productivity (TFP) as the outcome measure. This is a different type of measure than the ones which follow, as it is a measure of productivity and quality of the workforce as an input alongside other factors such as capital and labour force numbers. SET Professionals generally show a larger contribution than SET Technicians. As TFP is essentially a measure of the quality of the workforce and their organisation this is perhaps to be expected. SET Professionals are likely, all other things being equal, to be more productive than SET Technicians.

The results of six regressions using TFP are presented in Table 2.1. Regression one just uses SET Professionals and the country, sector and year dummies as explanatory variables. For simplicity the dummy coefficients are not shown in this table. However, for selected regressions, the full details of the regressions including the dummy coefficients are presented in Annex A. The output for regression one shows that as expected there is a large and significant impact on TFP due to SET Professionals. Although, the R Square of 0.44 suggests that less than half the variance in the TFP is explained by SET Professionals alone.

Regression two shows a slightly smaller positive and significant impact of SET Technicians alone on TFP. However, again the R Square of about 0.41 suggests that almost 60 per cent of the variance is unexplained when using SET Technicians alone. Regression three shows that when both SET Professionals and SET Technicians are included in the regression, SET Professionals are more important than the SET Technicians.

Regression four is different than the others presented in this table in that the data is limited to the manufacturing sector only. This shows that in this context SET Technicians have a negative impact on TFP, while SET Professionals have a positive impact. Despite the reduced number of cases that this regression is based on it has the highest R Square.

Regression five which covers all the available sectors shows that when R&D Spend is included in the regression there is a small negative impact associated with SET Technicians, but a smaller positive impact for SET Professionals and R&D spend intensity. Regression six shows that when R&D spending intensity by R&D spend per SET Professional is used, both SET Professionals and SET Technicians become associated with significantly positive impacts.

Table 2.1: Total Factor Productivity regressions

	(1)	(2)	(3)	(4) Manu-facturing only	(5)	(6)
SET Professionals	116.3367 (0.000)		103.2521 (0.000)	493.4634 (0.000)	77.5871 (0.000)	92.1854 (0.000)
SET Technicians		74.7023 (0.000)	27.3324 (0.000)	-273.1837 (0.000)	-0.1076 (0.754)	78.6895 (0.000)
R&D as % of Value Added					1.6181 (0.000)	
R&D Spend per SET Professional						-91.7226 (0.000)
Country dummies	X	X	X	X	X	X
Year dummies	X	X	X	X	X	X
Sector dummies	X	X	X		X	X
R Squared	0.4400	0.4133	0.4421	0.8292	0.4658	0.6037
Mean VIF	1.92	1.54	1.97	4.04	2.40	2.66
N - unweighted	1,760	1,760	1,760	220	1,037	707
N - weighted	1,620,337	1,620,337	1,620,337	362,321	1,280,603	633,039

Source: IES

Overall these regressions show that in terms of TFP the numbers of SET Professionals and SET Technicians are important given the size of the coefficients. Generally, SET Professionals are more important than SET Technicians and in some cases SET Technicians have a negative impact. However, apart from the manufacturing only regression, the R Squares are relatively small suggesting that other factors are also at play.

2.3.3 Value added per capita

Table 2.2 essentially shows that in terms of Value Added per Capita (VCA) all the variables are significant in each of the regressions. However, as the coefficients for SET Professionals are consistently negative, in this case it means that the regressions suggest that sectors with smaller proportions of SET Professionals are more productive in terms of VCA. However, these effects are small. The most plausible regression result, based on the highest R Squared value, is from regression number ten, which used SET Professionals and SET Technicians only in the manufacturing sector. The next highest R Squared used SET Professionals, SET Technicians and R&D Spend as a proportion of value added. Using these variables the coefficients are generally low. However, this regression suggests that VAC, once the sectoral, year and country effects are taken into account, was positively impacted by the proportion of SET Technicians in the workforce, very slightly negatively by the proportion of SET Professionals and very, very slightly positively by the R&D spend as a proportion of value added. There is a similar pattern in regression four when R&D spend per SET professional is used instead of R&D spend as a proportion of value added. The R Squares for the various regressions are relatively high which indicates that the factors included in the regressions have a high explanatory power.

Overall, this suggests that in terms of VAC that the number of SET Professionals has a slightly negative impact while SET Technicians have a slightly larger positive impact.

Table 2.2: Value Added per Capita regressions

	(7)	(8)	(9)	(10) Manu-facturing only	(11)	(12)
SET Professionals	-0.0062 (0.000)		-0.0077 (0.000)	-0.0014 (0.020)	-0.0039 (0.000)	-0.0125 (0.000)
SET Technicians		0.1965 (0.000)	0.2110 (0.000)	0.3903 (0.000)	0.1435 (0.000)	0.2627 (0.000)
R&D as % of Value Added					0.0030 (0.000)	
R&D Spend per SET Professional						0.0381 (0.000)
Country dummies	X	X	X	X	X	X
Year dummies	X	X	X	X	X	X
Sector dummies	X	X	X		X	X
R Squared	0.6526	0.6542	0.6551	0.9487	0.8424	0.7989
Mean VIF	1.70	1.32	1.71	1.44	2.06	1.92
N - unweighted	2,911	2,911	2,911	329	1,634	1,112
N - weighted	2,401,341	2,401,341	2,401,341	434,762	1,668,012	1,083,285

Source: IES

2.3.4 Revealed Comparative Advantage

Generally, the Revealed Comparative Advantage (RCA) regressions in Table 2.3 had lower explanatory power as evidenced by the relatively low R Squared values. In part this is due to the relatively limited availability of sectoral import and export data as evidenced by the lower unweighted and weighted bases. Importantly, there is a systematic bias to the missing import and export data, which meant that most of the service sectors are not included in the analysis.[2] However, the manufacturing only regression (number 16) has a high R Squared, but a slight positive impact for SET Professionals and a slight negative impact for SET Technicians.

Table 2.3: Revealed Comparative Advantage Regressions

	(13)	(14)	(15)	(16) Manu-facturing only	(17)	(18)
SET Professionals	-0.4339 (0.003)		-0.5652 (0.000)	0.0062 (0.000)	-0.0116 (0.000)	-1.0079 (0.002)
SET Technicians		2.6061 (0.000)	3.3589 (0.000)	-0.0422 (0.000)	0.3695 (0.004)	24.0058 (0.000)
R&D as % of Value Added					0.0216 (0.000)	
R&D Spend per SET Professional						28.5570 (0.000)
Country dummies	X	X	X	X	X	X
Year dummies	X	X	X	X	X	X
Sector dummies	X	X	X		X	X
R Squared	0.1669	0.1670	0.1678	0.9269	0.1766	0.1382
Mean VIF	1.65	1.37	1.67	1.44	2.02	4.05
N – unweighted	1,290	1,290	1,290	324	524	250
N - weighted	578,591	578,591	578,591	434,629	403,175	139,215

Source: IES

Having said this, the regressions generally indicate a small negative contribution by SET Professionals and a small positive contribution from SET Technicians. However, the relatively small R Squares indicate other variables not included in the regression explain the majority of the variation in RCA.

2 In regression eight the following sectors were dropped: Construction; Wholesale and Retail Trade; Restaurants and Hotels; Transport Storage and Communications; Finance Insurance Real Estate and Business Services, and; Community and Personal Services.

2.3.5 Balance of Trade

Table 2.3 shows the main results of the regressions examining Balance of Trade (BoT), a more detailed result of regression 24 which includes the coefficients associated with all the dummy variables in included in Annex A. The balance of trade measure suffers from the same problem as the revealed comparative advantage measure, in that there is limited data covering imports and exports and the available data tends to exclude service sectors. The main impact of this was to reduce the sample size upon which the regressions were based, which in turn tends to reduce the power of explanation (or R squared) of the regressions.

However, even taking these provisos into account the common pattern across the explanatory variables is that SET Professionals makes a small negative contribution while SET Technicians make a small positive contribution. Sectoral R&D expenditure as a proportion of sectoral value added makes a small, but still significant contribution to the balance of trade. Similarly R&D expenditure per SET Professional has a positive contribution, but in this case a larger as well as significant contribution.

Table 2.4: Balance of Trade regressions

	(19)	(20)	(21)	(22) Manu-facturing only	(23)	(24)
SET Professionals	-0.2180 (0.000)		-0.3058 (0.000)	-0.0362 (0.000)	-0.0119 (0.094)	-0.4134 (0.001)
SET Technicians		1.8265 (0.000)	2.2424 (0.000)	1.9824 (0.000)	2.2902 (0.000)	13.3996 (0.000)
R&D as % of Value Added					0.0659 (0.000)	
R&D Spend per SET Professional						17.5506 (0.000)
Country dummies	X	X	X	X	X	X
Year dummies	X	X	X	X	X	X
Sector dummies	X	X	X		X	X
R Squared	0.2295	0.2303	0.2320	0.9324	0.2603	0.2537
Mean VIF	1.63	1.37	1.66	1.44	2.04	4.04
N - unweighted	1,246	1,246	1,246		495	249
N - weighted	576,863	576,863	576,863	434,629	401,584	139,206

Source: IES

3 Discussion and Conclusions

Traditionally SET Professionals are seen as economically more important than SET Technicians and the public funding patterns reflect this. The regressions linking Total Factor Productivity to SET Professionals and SET Technicians support this view. However, SET Technicians are almost as important as SET Professionals in terms of TFP and therefore provide an important additional input.

However, the results from the other regressions show that in terms of global output measures such as Revealed Comparative Advantage, Balance of Trade and Added Value per Employee; SET Technicians are significantly more important than SET Professionals. This may seem counter-intuitive and as such needs to be examined carefully. The suggestion that the proportion of a workforce that were SET Professionals has a negative impact on a range of sectors could potentially be explained by the impact of service sectors. However, this is not the case as the effect still holds when the service sectors are excluded due to lack of import and export data. A more plausible explanation is that in countries and sectors with low levels of exports and per capital value added there is a more plentiful supply of professionals than technicians. While other countries with a more plentiful supply of technicians have a better export record and higher levels of per capital output. The TFP results also suggest that countries with higher levels of technicians may also have better access to capital and other helpful inputs.

In order to test the idea that the results were more a result of the sectors included in the regressions, a further set of regressions were run on data only from the manufacturing sectors. This showed that the patterns seen across the sectors generally held good for the manufacturing only analysis.

Overall, this suggests a re-examination of the levels of support for the training of SET Technicians, which is generally achieved through apprenticeship programmes.

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Annex A

Regression 6 full results

Baseline for the indicator/dummy variables is year 2000, Manufacturing and the UK. This shows that the: Mining and Quarrying; Construction; Finance Insurance Real Estate and Business Services, and; Community Social and Personal Services; sectors had lower TFP than Manufacturing. There was insufficient data from Greece, Portugal, and Poland for these countries to be included. Luxembourg and Hungary has higher TFP than the UK while the other countries had lower TFP.

Table A.1: Regression 6 full results - TFP with SET Professionals SET Technicians and R&D Spend per SET professional

Total Factor Productivity	Coefficient	Standard Error	t	Probability of t
SET Professionals	92.1854	1.0593	87.02	0.000
SET Technicians	78.6895	0.8296	94.85	0.000
R&D Spend per SET Professional	-91.7226	1.5924	-57.60	0.000
y_1993	-25.8279	0.1204	-214.54	0.000
y_1994	-4.5680	0.1079	-42.32	0.000
y_1995	-3.2652	0.0937	-34.86	0.000
y_1996	-3.3673	0.0826	-40.75	0.000
y_1997	-1.6241	0.0709	-22.91	0.000
y_1998	-0.8406	0.0602	-13.97	0.000
y_1999	-1.5242	0.0547	-27.88	0.000
y_2001	-0.6345	0.0523	-12.13	0.000
y_2002	-1.6433	0.0509	-32.31	0.000
y_2003	-1.4492	0.0505	-28.70	0.000
y_2004	-1.5278	0.0591	-25.83	0.000
y_2005	-1.7408	0.0562	-30.99	0.000
y_2006	-0.0470	0.0615	-0.76	0.445
y_2007	-0.3340	0.0611	-5.46	0.000

Total Factor Productivity	Coefficient	Standard Error	t	Probability of t
Agriculture, Hunting, Forestry and Fishing	33.0868	0.2342	141.27	0.000
Mining and Quarrying	-15.6605	0.6215	-25.20	0.000
Electricity Gas and Water Supply	-0.9333	0.2733	-3.41	0.001
Construction	-16.9614	0.1002	-169.24	0.000
Wholesale and Retail Trade; Restaurants and Hotels	(dropped)			
Transport Storage and Communications	7.3900	0.1014	72.86	0.000
Finance Insurance Real Estate and Business Services	-21.8505	0.0909	-240.30	0.000
Community Social and Personal Services	-10.0815	0.0953	-105.81	0.000
Belgium	-10.5529	0.2222	-47.49	0.000
Czech Republic	-15.2635	0.2582	-59.13	0.000
Denmark	-13.5849	0.2322	-58.51	0.000
Germany	-1.9492	0.0690	-28.24	0.000
Ireland	-1.0119	0.4973	-2.03	0.042
Greece	(dropped)			
Spain	-13.3275	0.0605	-220.46	0.000
France	-0.9344	0.0506	-18.47	0.000
Italy	-8.2389	0.0875	-94.18	0.000
Luxembourg	1.5421	0.6317	2.44	0.015
Hungary	15.1969	0.2795	54.38	0.000
Netherlands	-8.6425	0.1424	-60.70	0.000
Austria	-1.9169	0.4539	-4.22	0.000
Poland	(dropped)			
Portugal	(dropped)			
Finland	-0.7203	0.4805	-1.50	0.134
Sweden	-5.9521	0.3013	-19.76	0.000
Constant	110.1531	0.1299	847.95	0.000

Source: IES

Regression 12 full results

Baseline for the indicator/dummy variables is year 2000, Manufacturing and the UK. This shows that: Agriculture, Hunting, Forestry and Fishing; Construction; Wholesale and Retail Trade; Restaurants and Hotels, and Community Social and Personal Services had lower levels of VAC than otherwise expected.

Table A2: Regression 12 full results – VAC with SET Professionals SET Technicians and R&D Spend per SET professional

Value Added per Capita	Coefficient	Standard Error	t	Probability of t
SET Professionals	-0.0125	0.0013	-9.70	0.000
SET Technicians	0.2627	0.0273	9.61	0.000
R&D Spend per SET Professional	0.0381	0.0078	4.87	0.000
y_1993	-0.0194	0.0002	-89.48	0.000
y_1994	-0.0014	0.0003	-4.65	0.000
y_1995	-0.0003	0.0003	-0.94	0.349
y_1996	-0.0006	0.0003	-1.76	0.078
y_1997	-0.0013	0.0003	-3.92	0.000
y_1998	-0.0011	0.0003	-3.38	0.001
y_1999	-0.0019	0.0003	-6.54	0.000
y_2001	-0.0011	0.0002	-4.58	0.000
y_2002	-0.0002	0.0002	-1.10	0.270
y_2003	0.0026	0.0002	13.41	0.000
y_2004	0.0005	0.0002	2.05	0.040
y_2005	0.0023	0.0002	10.88	0.000
y_2006	0.0018	0.0002	8.44	0.000
y_2007	0.0079	0.0002	39.19	0.000
Agriculture, Hunting, Forestry and Fishing	-0.0204	0.0013	-15.54	0.000
Mining and Quarrying	0.2027	0.0449	4.52	0.000
Electricity Gas and Water Supply	0.1172	0.0026	45.19	0.000
Construction	-0.0168	0.0011	-15.35	0.000
Wholesale and Retail Trade; Restaurants and Hotels	-0.0059	0.0013	-4.48	0.000
Transport Storage and Communications	0.0157	0.0006	24.85	0.000
Finance Insurance Real Estate and Business Services	0.0435	0.0004	106.95	0.000
Community Social and Personal Services	-0.0284	0.0004	-64.67	0.000
Belgium	0.6171	0.0033	184.42	0.000
Czech Republic	0.2614	0.0018	141.56	0.000
Denmark	0.4960	0.0049	101.80	0.000
Germany	0.0041	0.0009	4.69	0.000
Ireland	0.7662	0.0119	64.59	0.000
Greece	0.5214	0.0053	97.92	0.000
Spain	0.0146	0.0002	73.62	0.000
France	0.0092	0.0009	10.70	0.000

Value Added per Capita	Coefficient	Standard Error	t	Probability of t
Italy	0.0138	0.0011	12.70	0.000
Luxembourg	1.1709	0.0219	53.42	0.000
Hungary	0.2620	0.0022	120.64	0.000
Netherlands	0.4786	0.0018	272.41	0.000
Austria	0.5794	0.0039	148.49	0.000
Poland	0.0026	0.0001	20.83	0.000
Portugal	0.3553	0.0041	86.53	0.000
Finland	0.5114	0.0052	98.41	0.000
Sweden	0.5184	0.0041	125.14	0.000
Iceland	0.5379	0.0406	13.26	0.000
Norway	0.7695	0.0407	18.89	0.000
Slovakia	0.3279	0.0043	76.70	0.000
Constant	0.0280	0.0014	20.33	0.000

Source: IES

Regression 18 full results

Baseline for the indicator/dummy variables is year 2000, Manufacturing and the UK. This shows that there was insufficient data for the: Construction; Wholesale and Retail Trade; Restaurants and Hotels; Transport Storage and Communications; Finance Insurance Real Estate and Business Services, and; Community Social and Personal Services sectors as well as France.

Table A.3: Regression 18 full results - RCA with SET Professionals SET Technicians and R&D Spend per SET professional

Revealed Comparative Advantage	Coefficient	Standard Error	t	Probability of t
SET Professionals	-1.0079	0.3216	-3.13	0.002
SET Technicians	24.0058	4.8497	4.95	0.000
R&D Spend per SET Professional	28.5570	2.0142	14.18	0.000
y_1993	(dropped)			
y_1994	(dropped)			
y_1995	(dropped)			
y_1996	-0.0697	0.0542	-1.29	0.199
y_1997	0.1855	0.0559	3.32	0.001
y_1998	0.1837	0.0586	3.14	0.002
y_1999	0.0216	0.0433	0.50	0.618
y_2001	0.1159	0.0609	1.90	0.057
y_2002	0.2140	0.0550	3.89	0.000
y_2003	0.1321	0.0527	2.51	0.012

Revealed Comparative Advantage	Coefficient	Standard Error	t	Probability of t
y_2004	0.1884	0.0587	3.21	0.001
y_2005	0.1194	0.0545	2.19	0.028
y_2006	0.1790	0.0541	3.31	0.001
y_2007	0.1340	0.0522	2.57	0.010
Agriculture, Hunting, Forestry and Fishing	2.1534	0.2335	9.22	0.000
Mining and Quarrying	5.8273	0.8337	6.99	0.000
Electricity Gas and Water Supply	0.9189	0.1399	6.57	0.000
Construction	(dropped)			
Wholesale and Retail Trade; Restaurants and Hotels	(dropped)			
Transport Storage and Communications	(dropped)			
Finance Insurance Real Estate and Business Services	(dropped)			
Community Social and Personal Services	(dropped)			
Belgium	-3.5040	0.4873	-7.19	0.000
Czech Republic	-1.5324	0.3141	-4.88	0.000
Denmark	-2.5159	0.3353	-7.50	0.000
Germany	-1.9796	0.2469	-8.02	0.000
Ireland	-0.1662	0.0306	-5.43	0.000
Greece	0.3003	0.1102	2.72	0.006
Spain	-0.0083	0.0318	-0.26	0.794
France	(dropped)			
Italy	-2.4946	0.2501	-9.97	0.000
Luxembourg	-3.6738	0.4718	-7.79	0.000
Hungary	-0.3832	0.0574	-6.68	0.000
Netherlands	-1.5601	0.1407	-11.09	0.000
Austria	-5.4295	0.5591	-9.71	0.000
Poland	-0.6942	0.0639	-10.87	0.000
Portugal	0.4043	0.0876	4.62	0.000
Finland	-2.0153	0.2475	-8.14	0.000
Sweden	-4.9932	0.5543	-9.01	0.000
Iceland	(dropped)			
Norway	7.7790	2.8252	2.75	0.006
Slovakia	-0.8491	0.1885	-4.50	0.000
Constant	-0.7207	0.2662	-2.71	0.007

Source: IES

Regression 24 full results

Baseline for the indicator/dummy variables is year 2000, Manufacturing and the UK. This shows that Construction; Wholesale and Retail Trade; Restaurants and Hotels; Transport Storage and Communications; Finance Insurance Real Estate and Business Services, and Community Social and Personal Services sectors were dropped due to insufficient data.

Table A4: Regression 15 full results- BoT with SET Professionals SET Technicians and R&D Spend per SET professional

Balance of Trade	Coefficient	Standard Error	t	Probability of t
SET Professionals	-0.4134	0.1258	-3.29	0.001
SET Technicians	13.3996	2.3263	5.76	0.000
R&D Spend per SET Professional	17.5506	0.9731	18.04	0.000
y_1993	(dropped)			
y_1994	(dropped)			
y_1995	(dropped)			
y_1996	-0.5468	0.0261	-20.98	0.000
y_1997	0.0912	0.0283	3.22	0.001
y_1998	0.0413	0.0303	1.37	0.172
y_1999	-0.0403	0.0228	-1.76	0.078
y_2001	-0.0465	0.0192	-2.42	0.016
y_2002	-0.0462	0.0164	-2.81	0.005
y_2003	-0.0390	0.0177	-2.21	0.027
y_2004	0.0157	0.0210	0.75	0.454
y_2005	-0.0473	0.0185	-2.56	0.010
y_2006	-0.0258	0.0179	-1.44	0.150
y_2007	0.0042	0.0165	0.25	0.800
Agriculture, Hunting, Forestry and Fishing	0.8776	0.1127	7.78	0.000
Mining and Quarrying	0.8860	0.3200	2.77	0.006
Electricity Gas and Water Supply	-0.0952	0.0645	-1.48	0.140
Construction	(dropped)			
Wholesale and Retail Trade; Restaurants and Hotels	(dropped)			
Transport Storage and Communications	(dropped)			
Finance Insurance Real Estate and Business Services	(dropped)			

Balance of Trade	Coefficient	Standard Error	t	Probability of t
Community Social and Personal Services	(dropped)			
Belgium	-1.4951	0.2346	-6.37	0.000
Czech Republic	-0.5136	0.1468	-3.50	0.000
Denmark	-1.0723	0.1608	-6.67	0.000
Germany	-0.3170	0.1179	-2.69	0.007
Ireland	0.9425	0.0133	71.04	0.000
Greece	-0.0107	0.0528	-0.20	0.839
Spain	0.2088	0.0110	18.91	0.000
France	(dropped)			
Italy	-0.8843	0.1189	-7.44	0.000
Luxembourg	-2.0536	0.2568	-8.00	0.000
Hungary	0.4808	0.0276	17.40	0.000
Netherlands	-0.3459	0.0664	-5.21	0.000
Austria	-2.7907	0.2691	-10.37	0.000
Poland	0.0260	0.0288	0.90	0.368
Portugal	0.3693	0.0414	8.92	0.000
Finland	-0.3637	0.1186	-3.07	0.002
Sweden	-2.3123	0.2677	-8.64	0.000
Iceland	(dropped)			
Norway	3.0359	1.0683	2.84	0.004
Slovakia	0.0204	0.0889	0.23	0.818
Constant	-0.3174	0.1256	-2.53	0.012

Source: IES