



# The United Kingdom productivity paradox: Myth or reality



Robert Peter Howard-Jones<sup>a</sup>, Hossein Hassani<sup>a,b,\*</sup>

<sup>a</sup> Executive Business Centre, Bournemouth University, Bournemouth, 89 Holdenhurst Road, BH8 8EB, UK

<sup>b</sup> International Institute for Energy Studies (IIES), No. 14, Sayeh St., Valiasr Ave., Tehran, Islamic Republic of Iran

## ARTICLE INFO

### Article history:

Received 10 April 2014

Received in revised form 10 January 2015

Accepted 13 January 2015

Available online 20 February 2015

### Keywords:

Population

Unemployment

Productivity

Output gap

Financial crisis

Economic restructuring

## ABSTRACT

The stagnation in full time employment and increasing numbers of part time and self-employed workers pose a significant challenge to the UK economy. However, the key to the paradox might actually lie in a long term evaluation of all these factors of production. Whilst economists, politicians and the media puzzle over the UK paradox of rising employment and falling output, this paper attempts to evaluate the relationship between output hours, productivity hours and employment together with the continuing rise of the UK population, an increasing dependency on services and a tendency to increasing unemployment.

© 2015 Published by Elsevier B.V.

## 1. Introduction

The 2008 financial crisis had a devastating effect on the global economy particularly in the UK given its position in world financial markets and the predominant role of the investment banking sector in the disaster. The ensuing recession continues to impact markets and the UK is no exception. As [Oulton and Sebastia-Barriel \(2013\)](#) point out, labour productivity has illustrated a puzzling behaviour following the onset of the 2008 recession. “Despite some modest improvements in 2013, whole-economy output per hour remains around 16% below the level implied by its pre-crisis trend” ([Barnett et al., 2014](#)). Rising levels of employment, allied to a decline in labour productivity, has led to speculation that forces are at work in the UK which are contrary to economic theory.

The two most popular hypotheses explaining the productivity paradox are labour hoarding and damage to capacity. The former is strongly argued in [Martin and Rowthorn \(2012\)](#) which states that output remains well below the potential as labour whilst being cheap, fails to work to potential and that the production of more output in itself might not convert into increased sales as a result of demand failure, under-utilization of labour and high unemployment. The latter, damage to capacity is heavily argued in [Reinhart and Rogoff \(2009\)](#) which states the financial crisis has left long lasting effects on employment, output and asset prices with declining house prices and rising unemployment being a key feature. Favouring the latter, a paper by [Oulton and Sebastia-Barriel \(2013\)](#) argues that the financial crisis will have a long term effect on the British economy, justifying their hypothesis on studies of previous financial crises by [Reinhart and Rogoff](#), also [Barrell et al. \(2010\)](#) together with their own paper Long and Short-Term Effects of the Financial Crisis on Labour Productivity, Capital and Output ([Oulton & Sebastia-Barriel, 2013](#)). Clearly, considerable academic work has been conducted on the subject

\* Corresponding author.

E-mail address: [hhassani@bournemouth.ac.uk](mailto:hhassani@bournemouth.ac.uk) (H. Hassani).

and this paper is not designed to match the depth of analysis and the academic rigour deployed. There is also universal agreement that the financial crisis has created a long term effect on the global economy, particularly in the UK as a result of the prominence of the City of London and the importance of the banking sector. However, this study does pose the question whether the financial crisis has brought to a head an underlying issue in the UK economy relating to the long run decline of output against the hours of work employed. It is inconceivable that, over the long term, UK companies have been operating with more labour than necessary and there is no evidence of a real lack of productive investment (Oulton & Sebastia-Barriel, 2013). It should be noted that output grew quickly post the 1991 recession whilst productivity hours and employment grew at a steadier pace. Since the model demonstrates that increased output came from factors other than hours worked, it is not unreasonable to look for other reasons to explain its rapid rise.

Solving this puzzle continues to be work in progress amongst economists and this paper is designed to investigate the dynamics of the labour market over a 25 year period. A number of published papers seek to examine the productivity paradox over a short term period examining data from immediately before the financial crisis and the post crisis period to date. Here we use output as the dependent variable and the indices of productivity hours, defined as labour input as a measure of hours worked and LFS employment, an ONS survey of households which collects employment information on a headcount basis, as the independent variables. This paper will seek to establish whether a four year investigative cycle is too short a period to draw any positive conclusions. The dependent variable output per hour is derived by dividing measures of output by some measure of labour input, in this case hours. Most of the output measures used in the Labour Productivity statistical outputs are taken directly from the ONS National Accounts system, and are measures of real (inflation-adjusted) GVA, for the whole economy (Office for National Statistics, 2012).

At the same time, this paper seeks to look at trends in employment and unemployment in the entire economy from 1971, and ally that data to trends in output, employment and productivity hours in the manufacturing, production and services sector from 1997 to 2012; the timescale when information became available. The models, including time series analysis, will also explore the relationship between the plateauing of growth in output in all sectors in 2005–2006, allied to a similar pattern in employment and productivity hours which coincided with a significant increase in government expenditure. This poses the question whether the possibility of the crowding out of private investment was the real catalyst for the ensuing drop in output, exacerbated by the financial crisis.

The remainder of this paper is organized as follows. Section 2 presents the methodology and hypothesis underlying the analysis whilst Section 3 provides a brief analysis of the data used in this study. Section 4 reports the results along with a discussion, and the paper ends with some conclusions in Section 5.

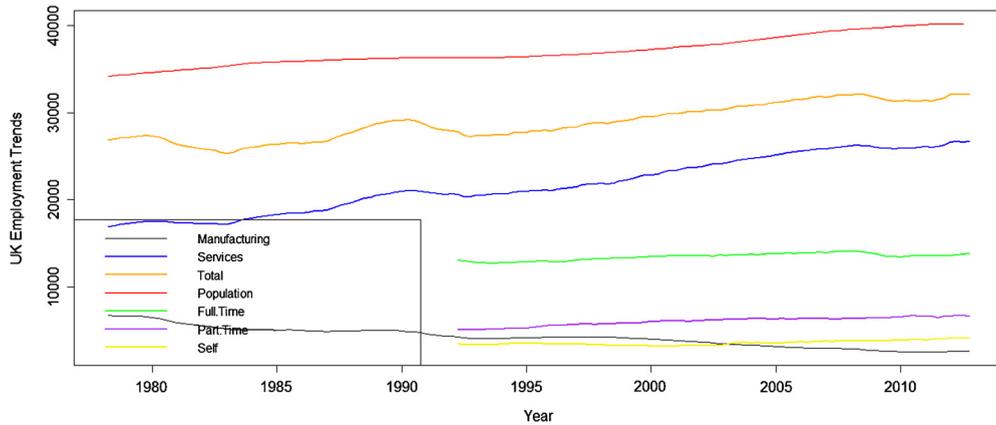
## 2. Methodology

### 2.1. Linear regression model

The methodology adopted for this paper is a linear regression model. Two multiple regression models were created, the first spanning the period 1987 to 2012 with data collected on a quarterly basis and output per labour hour selected as the dependent variable, since this represents the most accurate measure of labour productivity. The model with the index of labour output per hour as the dependent variable and the indices of labour survey employment and labour productivity hours as the independent variables was predicated using multiple linear regression model. The second model has been constructed with the 16–64 years age group population as the dependent variable and with full time, part time, self-employment and unemployment as the independent variables. The time series is from quarter 2, 1992, which is when records began to report all the required data. The data has been indexed with a reference point of 2009 as 100.

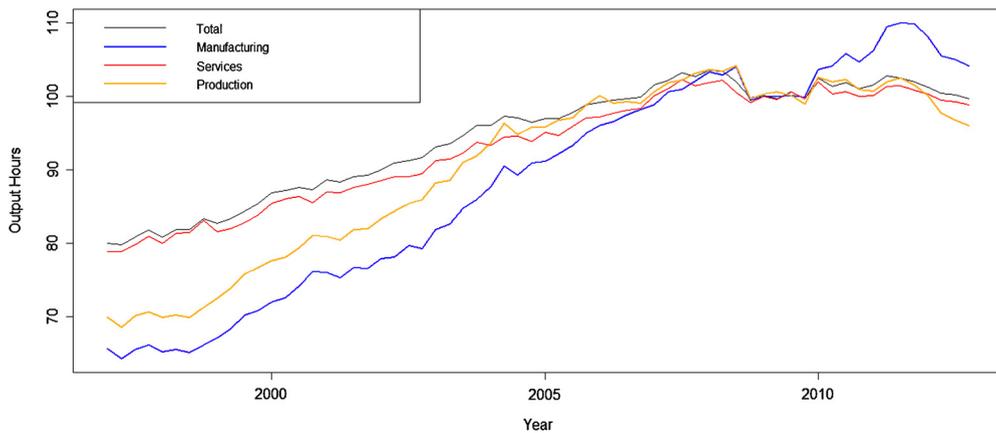
### 2.2. Hypothesis

Reference to the Office of National Statistics Handbook published in 2007 bears testament to the complexity of any study of productivity. However, the current paradox of increasing employment against a background of reducing output is challenging economists in this field. The models appear to demonstrate that, over the last 25 years, increasing labour hours productivity is accompanied by a fall in output, remedied by an increase in headcount. There are several implications to this trend ranging from the influence of increasing numbers of part time and self-employed workers to the movement away from manufacturing to the more labour intensive and less productive service sector and could be allied to possible inadequate investment and the gradual reduction in national capacity. Fig. 1 indicates the rising trend of part time and self-employment and the slowing of full employment, particularly since quarter 1, 2006 and notably before the financial crisis. It also shows the inexorable rise of services as the driving force behind the increase in total employment and the rapid decline of manufacturing jobs. It can also be observed that, after the 1991 recession, the gap between total employment growth and the growth of service sector jobs began to narrow and continue to do so. If the service sector employment potential is slowing over the long term, it is inevitable that part time or self-employment will be the options for work seekers. This trend in the rise of services and decline of manufacturing has accelerated since the structural changes to the UK economy during the conservative government 1979 to 1997 and the Labour government between 1997 and 2010 did nothing to change it. In fact it could be argued that further deregulation and privatisation, together with a significant increase in government expenditure, maintained an increasing trend towards an unbalanced economy. This trend, illustrated



**Fig. 1.** UK employment trends by working age population, status and market sector 1978–2012.

Source: Author from Office of National Statistics Data.



**Fig. 2.** UK output hours by market sector 1997–2012.

Source: Author from Office of National Statistics Data.

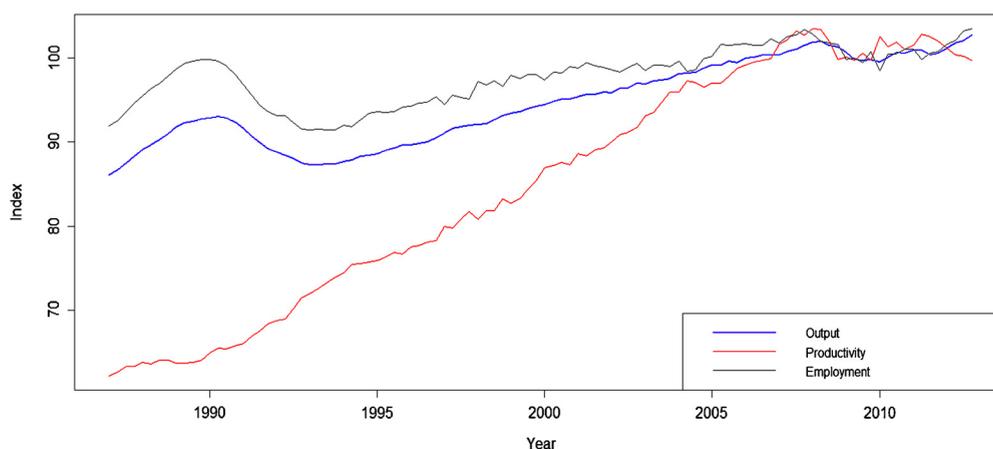
by Table 1 below, supports the hypothesis in the second regression model that a rising population, due to increasing human longevity, the recent rise in birth rates and an increase in immigration, is increasingly reliant on part time service sector jobs or self-employment to maintain personal economic activity.

### 3. The data

The data has been mined from the Office of National Statistics and can be found online at <http://www.ons.gov.uk>. This data includes the Labour Force Survey Employment and Unemployment Indices, together with full time, part time and self-employment figures converted into indices. Time series data has also been collected for output hours for the whole economy, manufacturing, production and services, together with matching data for productivity hours. Government expenditure and the percentage spent in relation to GDP has been collected annually from the same source (Office for National Statistics, 2012). Definitions of manufacturing include all fabricators. Production includes quarrying, extraction and energy supply and the services sector is self-explanatory.

However, as mentioned in Taylor (2013), over half of the new jobs are related to part time postings and the employees are not earning up to expectations. In addition according to the Office for National Statistics (2012), since 2008, there has been a steep increase in the number of workers searching for more hours. The implications of this trend for output are illustrated in Fig. 2, which shows the increase in output of the total economy with the trends of the key market sectors for comparative purposes. It is clear that manufacturing and production output grew rapidly during the period, clearly driven by other factors of production since employment in both sectors was falling. The Services sector grew more slowly and given its size in relation to the total economy, basically follows the total output trend line.

Interestingly, manufacturing has continued to grow beyond the crisis period, although this will do little for employment given the highly automated nature of the industrial base. The most appealing aspect of this figure is the convergence and plateauing of the output trends which began in 2005, well before the financial crisis. There could be several reasons for this which requires further study, but the concentration of economists on the financial crisis and its aftermath as the



**Fig. 3.** Trend of output hours, productivity hours and employment index 1987–2012.

Source: Author – Derived from Office of National Statistics.

cause of the current economic malaise, may be short sighted. Firstly, it is worth exploring whether the policy of successive governments relying primarily on services and consumerism for growth in an island economy with an increasing working age population outstripping the job opportunities available, is sustainable in the long run. It is possible that the UK is now seeing the maximisation of capacity and without radical structural change reversing the current trend, there will be a stagnation of economic growth. It is important at this stage to emphasise what the model is not indicating. It is not suggesting any reduction in output over the intervening years since reference to Fig. 3 indicates quite clearly that output per hour increased and peaked in Q4, 2007 (Oulton & Sebastia-Barriol, 2013). Furthermore these are whole economy figures and do not distinguish between the public and private sector. What it does indicate is that increasing output per hour was more a function of rising employment levels than increasing productivity per hour. In other words, the more people employed the less productive they appear to become.

The election of the Conservative government in 1979 brought significant structural change to the UK economy including the privatisation or closure of state industries, labour market reforms and financial deregulation (Van Reenen, 2013). This undoubtedly produced productivity gains as measured in GDP, however, a distinction needs to be drawn between national output and the hourly labour input. It is entirely conceivable that the other factors of production significantly outweighed any continuing under performance of labour productivity. Fig. 3 shows the significant output improvement between 1987 and Q4, 2007. However, since that time, there is a convergence and a flattening out of all three measures suggesting that the potential for growth to slow, as a result of labour capacity constraints, was beginning to manifest itself some five years before the financial crisis.

Fig. 4 indicates the percentage growth for the periods 1979 to 1997 and 1997 to 2007 and reveals the percentage growth of producing industries slowing from 16% to 11%, whilst the service sector increased from 10% to 19%. From a GDP growth perspective this is not necessarily detrimental, but may justify the assertion that the rise in the services sector brings with it a reduction in output per productive labour hour.

#### 4. Empirical results

Table 1 shows the relative rise in average weekly hours worked against the rise in total employment and the rise and fall in unemployment. Noteworthy is the rise in output during the period 1979 to 2012 is mirrored by a rise in employment of 17.1% but a rise of average weekly hours worked of only 7%. This reinforces the argument that an increase in productivity hours has not contributed to output and that other factors of production are at work.

It is interesting to note that, until the crisis, employment was rising faster than hours worked, but post 2008 there is a convergence in employment and hours worked. This, allied to the inexorable growth of unemployment over a 33 year period, leads to the assertion that labour productivity is either a drag on economic growth or there exists an unsustainable reliance on services. Clearly there are other factors at work in the labour market, namely the rise in part time working, self-employment and the influence of public services. Productivity in these areas is notoriously difficult to measure. The low unit labour cost and high redundancy payments could encourage labour hoarding, although 4 years post crisis this seems unlikely (Oulton & Sebastia-Barriol, 2013). Almost an aside but “the university system certainly expanded under Labour ... the proportion of university educated people rose much faster than in other countries from under a quarter to over a third” (Corey et al., 2011). This prompts a further question as to where all the graduates have gone and whether the UK’s concept of university education is flawed. Should it in fact be replaced by a more Germanic approach encouraging both higher education and apprenticeships?

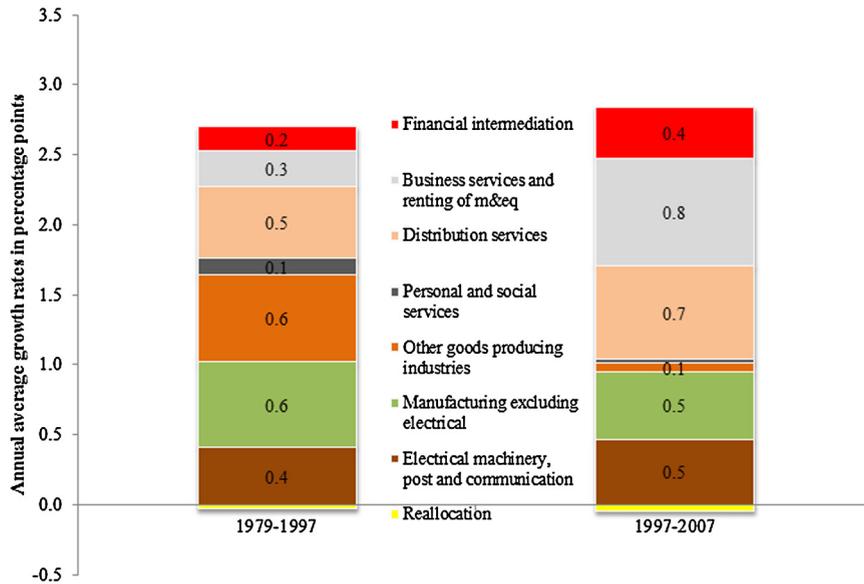


Fig. 4. Annual average percentage growth rates for industry sectors 1979–2007.

Source: LSE Growth Commission 2013.

Table 1

Employment, average weekly hours worked, unemployment 1979–2012.

Date	Employment	Avg. weekly hours	Unemployment
1979 Q4	25 195	879.6	1414
1997 Q1	26 381	873.7	2066
%	4.7	−0.7	46.1
2007 Q1	29 510	941.3	1605
%	11.9	7.7	−22.3
2012 Q4	29 751	947.8	2481
%	0.81	0.69	54.6

Table 2

The ANOVA results—first model.

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% confidence interval for B	
	B	Std. error				Beta	Lower bound
(Constant)	84.867	0.341		249.141	0.000	84.191	85.543
Productivity hours	−3.785	0.284	−0.911	−13.332	0.000	−4.349	−3.222
LFS employment	4.963	0.192	1.762	25.788	0.000	4.581	5.344

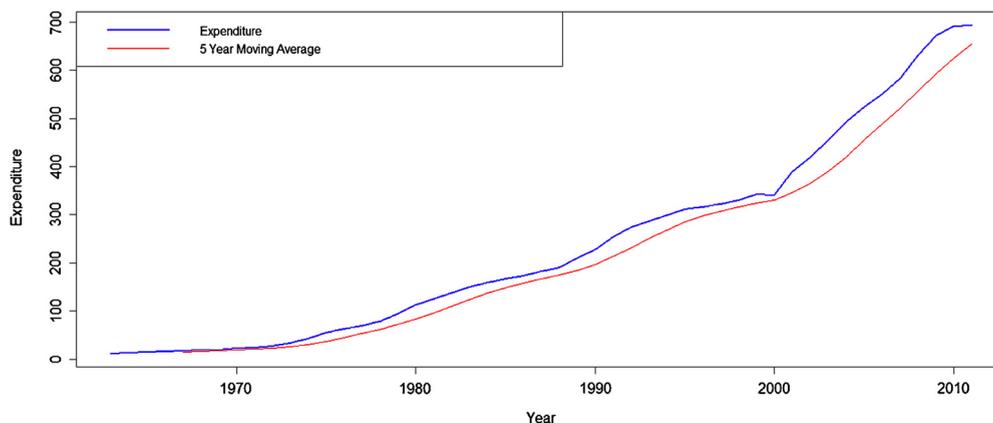
#### 4.1. First model

Initially, we model the impact of productivity and employment and output. Here, we first test the data for the assumption of normality using the Shapiro–Wilk test and find that the variables concerned are in fact normally distributed. Where the variables are not normally distributed, we used log transformations to ensure the normality assumption is fulfilled. Pearson's correlation results were statistically significant and indicate strong positive linear relationships in all cases. Next, we developed a regression model for which the results are shown in Table 2. The statistically significant adjusted  $R$ -square for the model is 0.938, therefore approximately 93.8% of output hours is explained by the independent variables and the regression equation is valid with the  $R^2$  value close to 1. The ANOVA test determined that, at the 1% significance level, the model could be used for predictive purposes since the  $F$  score is above the critical value which, measured at the 1% significance level, is tabled at 99.49. The model now can be expressed as follows  $Y = -3.785x + 4.963z + 84.859$ . The independent variables have been centralised through subtraction of their mean, where  $x$  and  $z$  are the centralised variables for productivity hours and LFS employment.

**Table 3**

The ANOVA results—first model—second model.

Model		Unstandardized coefficients		Standardized coefficients	t	Sig.	95.0% confidence interval for B	
		B	Std. error	Beta			Lower bound	Upper bound
1	(Constant)	95.448	0.073		1313.062	0.000	95.303	95.593
	Full time employment (x)	0.228	0.051	0.198	4.473	0.000	0.127	0.330
	Part time employment (z)	0.211	0.023	0.463	9.342	0.000	0.166	0.256
	Self employment (j)	0.253	0.015	0.465	16.829	0.000	0.223	0.282

**Fig. 5.** Government expenditure 1963 to 2012.

Source: Author from Office of National Statistics Data.

#### 4.2. Second model

Table 3 reports the results of the regression model. The  $t$ -tests with  $p$ -values showing less than 0.05 indicate that the data is different from zero for all the variables. The model summary indicates that ' $R$ ' = 0.982 which is a strong positive correlation. The ' $R$  square' value of 0.964 indicates that 96.3% of the variance of population change will be calculated by changes in the independent variables. However, the purpose of the model is to determine the relationship between the dependent and independent variables, given the requirement of the labour market at any given point.

The model now can be expressed as follows:  $Y = 0.228x + 0.211z + 0.253j + 95.448$ . The independent variables have been centralised through subtraction of their mean, where  $x$ ,  $z$  and  $j$  are the centralised variables for full time employment, part time employment and self-employment.

Finally we can make the following conclusions. As the population grows, the proportion of labour utilized in full time employment is growing at a slower pace than in part time or self-employment. In relation to UK employment and GDP, this has some profound consequences. For 25 years until the financial crisis of 2008, the UK enjoyed a debt fuelled boom, which masked the potentially negative trends occurring in the labour market. The financial crisis and its aftermath have, in relation to the labour market, raised the issue of declining output but raised employment (Office for National Statistics, 2012). Alternatively, reference to Fig. 5 may suggest a more traditional economic theory of the crowding out of private sector investment by a significant increase in government expenditure in 1999/2000, which doubled in a 10 year period. It is beyond the scope of this paper to explore in depth the potential for crowding out in the UK economy during this period, particularly since the bailing out of the banking sector and the establishment of quantitative easing will significantly distort the picture. However it is a consideration which bears further examination.

Furthermore, it is important to reflect on the growth of unemployment, which has risen steadily over the past 41 years. Looking at Fig. 6 it is easy to suggest that unemployment rises under a Conservative government and falls under Labour. However, the moving average clearly demonstrates that, despite its cyclical nature, it is a rising trend regardless of who is in power and is almost certainly a reflection of a trend to reducing economic capacity with the long term unemployed taking up the slack of an unbalanced economy.

In drawing together the potential for drawing conclusions from the paper, the regression models seem to indicate that the economy is finding it increasingly difficult to maintain full or full time employment with a rising population dependent on a service sector possibly close to capacity. The rise of part time and self-employed workers almost certainly reduces productivity, but employment continues to rise as a result of the labour intensive nature of the service sector. This trend pre dates the financial crisis and the answers to the current issues may lie further back down the time line than merely concentrating on the financial crisis to provide the answers.

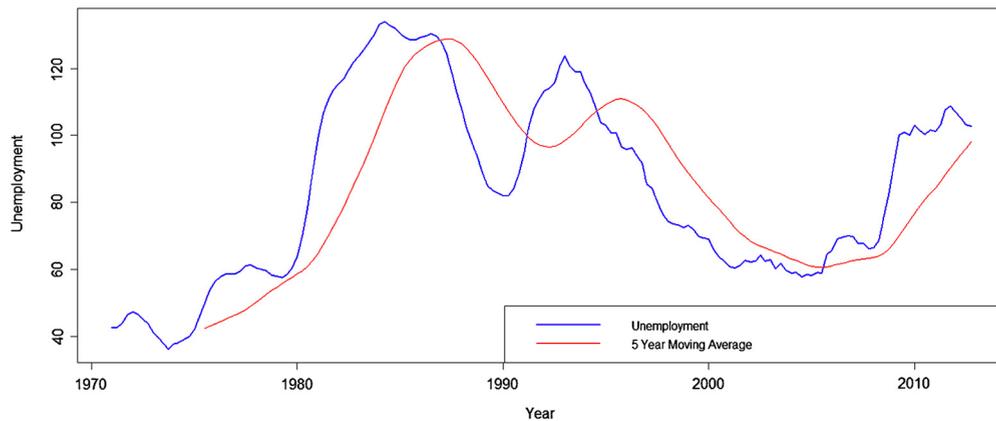


Fig. 6. Unemployment 1971 to 2012.

*“The Coalition government’s assumption is too often that if men and women look for work they will find work, and that the overall unemployment numbers will come down as a result. The figures presented here show that at best this assumption is only likely to have any relevance in the most prosperous parts of southern England where our figures still point to unemployment rates of just 3 or 4 per cent. In the rest of Britain, the notion that the unemployment problem can be solved simply by encouraging the unemployed to look for work seems distinctly far-fetched.”*

[Beatty, Fothergill, & Gore, 2012]

## 5. Conclusion

Whilst the financial crisis was a catastrophic event in the global economy and in particular the UK with its pre-eminent banking sector, there are historical key events that may hold the key to current trends in productivity and the labour market. The infrastructure changes in the 1980’s, poor regulation of the financial sector from 1986 to the present day, the 30 year experiment in private finance initiatives and the privatisation of national infrastructure now in the hands of foreign investors, may well be more important catalysts than the financial crisis itself. The need for a skilled and efficient workforce is clearly a pre requisite for a successful economy however, the long term trend towards higher unemployment mitigates against a drive towards this goal. The development of a highly qualified population demands an infrastructure to meet its more sophisticated demands and attention must be given to not only reducing unemployment, but increasing the need for a full time labour force.

The productivity paradox remains unresolved despite the best endeavours of leading economists. Undoubtedly the financial crisis has dealt a major blow to the global economy and particularly to the UK, which has failed to recover at the same pace as other G8 nations. It is interesting to note that the statistics support the monetarists in relation to GDP growth, although the evidence would suggest that a more Keynesian approach, as demonstrated between 1997 and 2008, had a more advantageous effect on the growth/employment ratio between 1997 and 2008 despite the fact that increased government expenditure led to a possible crowding out of private sector investment. The long held belief that an overly dependent emphasis on the City of London which has led, in the post crisis era, to the UK’s dilemma, has little credence other than the increase in government borrowings to finance the “bail out”.

The model and an analysis of the time series data suggest there is a real problem with productivity hours in relation to output. Whilst this may not be a problem at a time of low inflation and interest rates, when this changes the effect on consumption and therefore GDP growth could be catastrophic. It would therefore be timely to evaluate what economic rebalancing is required to increase labour productivity to make it a net contributor to economic growth. Empirical evidence suggests that banking crises have a significant effect on labour productivity in both the long and short term” (Reinhart & Rogoff, 2009). Furthermore, a banking crisis may also decrease the level of investment per employee in the long-run. Therefore the emphasis by some economists to divine the productivity paradox in a timescale between 2008 and 2012 is too short a period. As Van Reenen (2013) states, the UK’s failure to invest in prosperity will remain a prolonged challenge over the next 50 years.

## Appendix A

In the following we evaluate the basic assumption of the linear regression model for each model employed in Sections 4.1 and 4.2.

**Table A.1**

Spearman's rank correlation output.

Spearman's rho		Population	Full time employment	Part time employment	Self employed
Population	Correlation coefficient	1.000	0.799**	0.987**	0.710**
	Sig. (2-tailed)		0.000	0.000	0.000
	N	79	79	79	79
Full time employment	Correlation coefficient	0.799**	1.000	0.784**	0.457**
	Sig. (2-tailed)	0.000		0.000	0.000
	N	79	79	79	79
Part time employment	Correlation coefficient	0.987**	0.784**	1.000	0.695**
	Sig. (2-tailed)	0.000	0.000		0.000
	N	79	79	79	79
Self employed	Correlation coefficient	0.710**	0.457**	0.695**	1.000
	Sig. (2-tailed)	0.000	0.000	0.000	
	N	79	79	79	79

\*\* indicates significance level at 0.01.

**Table A.2**

Collinearity diagnostics.

		Eigenvalue	Condition		
			Index	Tolerance	VIF
1	1	2.282	1.000		
	2	1.000	1.511	0.243	4.122
	3	0.604	1.944	0.194	5.146
	4	0.114	4.475	0.624	1.601

### A.1. The first model: Section 4.1

We then continue to evaluate this model further to see if it meets the Gauss–Markov conditions. The scatter plots indicated that both independent variables are linearly related to output per hour with no discernible outliers. The  $P$ – $P$  plot showed the residuals running close to the diagonal line with approximately 50% above and 50% below. The implication of this is that the difference between the observed and predicted values should average out to zero, which implies that the first Gauss–Markov condition  $E[\varepsilon_i] = 0$  is satisfied. It is therefore reasonable to assume that, as a consequence of the first being satisfied, conditions 3 and 4 are also satisfied since the mean of the errors equalling 0 means that by definition these are met. The second condition has been confirmed, as illustrated by Table A.1, showing an acceptable degree of constancy across the population. This allows us to conclude that the first condition of the Gauss–Markov theorem is satisfied with the sum of the errors equalling 0 and this is confirmed with a score of zero for the standardized mean score. An evaluation of the standardized residuals indicates no outliers, with in excess of 97% of the observations being less than 2 standard deviations away from the mean and all less than 2.5. Leveraged values are all well under 0.2 and can therefore be considered safe. The Cooks distance values are below 1, which confirms that there are no influential cases affecting the regression analysis. The normality of the residual distribution was observed in the  $P$ – $P$  plot and the histogram which shows the distribution of the data. These indicate a normal distribution. We also analyzed a scatter plot of the standardized residual value against the unstandardized predicted value, which indicated a linear relationship between the dependent and independent variables. Together with the other tests conducted to date this indicates a continuing rejection of the null hypothesis at this stage. Finally the autocorrelation and collinearity issue will be re-examined to determine whether the model is robust enough to justify the proposed hypothesis. We find that collinearity exists between the independent variables. However, since the tolerance is in excess of 0.1 and the VIF score below 10, these scores, particularly in the light of the fact that the model is using time series data, are acceptable and justify acceptance of the model.

Next, we model the relationship between the population and the labour market. An evaluation of the initial scatterplot determined that it was homoscedastic and that it was therefore reasonable to run the regression model. The issues relating to autocorrelation prompted running both Pearson (not reported here) and Spearman correlation tests, which are shown below and which indicate significant correlation between the variables. The Shapiro–Wilk test indicates that the data is not normally distributed. Table A.1 indicates a strong correlation between the variables indicating that the coefficient is significantly different from 0; therefore the null hypothesis can be rejected and replaced by the alternative.

### A.2. The second model: Section 4.2

Once again, we test the model further. A collinearity problem was experienced and therefore the data was centred to overcome the issues. Table A.2 indicates that this solved the problem with no eigenvalues approaching zero and the

**Table A.3**  
Residual analysis.

	Minimum	Maximum	Mean	Std. deviation	N
Predicted value	90.0023	101.5237	95.4481	3.29103	79
Std. predicted value	-1.655	1.846	0.000	1.000	79
Standard error of predicted value	0.085	0.223	0.141	0.034	79
Adjusted predicted value	89.9108	101.5923	95.4415	3.29359	79
Residual	-1.31465	1.40745	0.00000	0.63355	79
Std. residual	-2.035	2.178	0.000	0.981	79
Stud. residual	-2.053	2.221	0.005	1.003	79
Deleted residual	-1.33805	1.46257	0.00664	0.66328	79
Stud. deleted residual	-2.099	2.282	0.005	1.014	79
Mahal. distance	0.377	8.307	2.962	1.881	79
Cook's distance	0.000	0.080	0.012	0.016	79
Centred leverage value	0.005	0.107	0.038	0.024	79

condition indices measuring significantly less than 15. Furthermore, the table also shows VIF scores of less than 10 indicating that centring the data resolved the issue.

An analysis of the studentized residual and unstandardized predicted values indicates that the model is homoscedastic and therefore there is a linear relationship between the variables. Furthermore it indicates that the second Gauss–Markov condition has been met, with the error term constant throughout the population. The normality of the residuals in the model was confirmed via the histogram and *P–P* plot. The latter confirms that the first Gauss–Markov condition is satisfied with the residuals being close to zero. Table A.3 further confirms that the first Gauss–Markov condition has not been violated, with the standardized residuals indicating zero. Additionally reference to the Cook's distance ( $< 0.2$ ) and leverage scores ( $< 1$ ) indicate no violation of either parameter. Indicate that each independent variable has a linear relationship with the dependent and it should be noted that the full time employment variable has a shallower trajectory than either variable of the part time or the self-employed. This may prove an important distinction when the model is discussed in the hypothesis section of the document. The Durbin–Watson statistic at 0.251 suggests that the error terms are positively autocorrelated. However, given the time series nature of the data and the purpose of the model, which is in fact to examine the relationship between the trends in the individual variables, in this instance, presence of autocorrelation can be regarded as positive. Additionally, in all other respects the model appears robust and therefore the null hypothesis is rejected at this stage.

The *F* test value indicates the reliability of the model by testing to see if the percentage changes in the independent variables predict the percentage change in the dependent. The 'Sig' value of 0.000 is lower than the alpha value of 0.05. Essentially the *F* test is evaluating whether there is any violation  $H_0 : \beta_1 = \beta_2 = 0$  at a significance level of  $\alpha = 0.05$ . The *F* score is above the critical value which, measured at the 1% significance level, is tabled at 99.49. Since the model meets both criteria, the null hypothesis can be rejected and the conclusion drawn that the model is useful in predicting population growth. However, the model is not designed for that purpose but to demonstrate the behaviour of the labour market in the context of a rising population and changes to industrial infrastructure.

## References

- Barnett, A., Chiu, A., Franklin, J., & Sebastia-Barriel, M. (2014). *The productivity puzzle: a firm-level investigation into employment behaviour and resource allocation over the crisis*. Bank of England Working Paper No. 495. Available at [www.bankofengland.co.uk/research/Documents/workingpapers/2014/wp495.pdf](http://www.bankofengland.co.uk/research/Documents/workingpapers/2014/wp495.pdf).
- Barrell, R., Davis, P., Karim, D., & Liadze, I. (2010). *The effects of banking crises on productive potential output in OECD countries*. National Institute of Economic and Social Research Discussion Paper 358, September.
- Beatty, C., Fothergill, S., & Gore, T. (2012). *The real level of unemployment 2012*. Report (1). Centre for Regional Economic and Social Research (pp. 1–38).
- Corey, G., Schneider-Corey, M., & Callanan, P. (2011). *Issues and ethics in the helping profession* (8th ed.). Belmont, CA: Brooks & Cole, Cengage Learning.
- Martin, B., & Rowthorn, R. (2012). *Is the British economy supply constrained?*. Centre for Business Research, University of Cambridge.
- Office for National Statistics (2012). *Quality and methodology information*. Information paper. Booklet (complete) (pp. 1–12).
- Oulton, N., & Sebastia-Barriel, M. (2013). *Long and short term effects of the financial crisis on labour productivity, capital and output*. CEP Discussion Paper (1185). Centre for Economic Performance (pp. 1–59).
- Reinhart, C., & Rogoff, K. (2009). *The aftermath of financial crises*. Working Paper (14656). National Bureau of Economic Research (pp. 1–14).
- Van Reenen, J. (2013). *Mrs Thatcher's economic legacy*. Available: <http://www.voxeu.org>. Last accessed 12th April 2013.
- Taylor, J. (2013). *Britain's wasted resources: time for plan B*. Essay. Lancaster University (pp. 1–11).