CAN INTANGIBLE INVESTMENT EXPLAIN THE UK PRODUCTIVITY PUZZLE?

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Abstract
This paper investigates whether intangibles might explain the UK productivity puzzle. We note that since the recession: (a) firms have upskilled faster than before; (b) intangible investment in R&D and software has risen whereas tangible investment has fallen; and (c) intangible and telecoms equipment investment slowed in advance of the recession. We have therefore tested to see if: (a) what looks like labour hoarding is actually firms keeping workers who are employed in creating intangible assets; (b) the current slowdown in TFP growth is due to the spillover effects of the past slowdown in R&D and telecoms equipment investment. Our main findings are: (a) measured market sector real value added growth since the start of 2008 is understated by 1.6% due to the omission of intangibles; (b) 0.75pppa of the TFP growth slowdown can be accounted for by the slowdown in intangible and telecoms investment in the early 2000s. Taken together intangible investment can therefore account for around 5 percentage points of the 16% productivity puzzle.

Keywords: Intangible investment, productivity

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1. Introduction

Between 2007 and 2009 real UK market sector value added fell by 7.4%. Market sector hours worked fell by 3.5% and hence market sector productivity fell by 4%.[1] In 2010, hours started to grow again, but output has grown very slowly. Between 2011 and 2012Q3, the latest period for which market sector data are available, hours have grown by 3.4% but market sector value added by 0%. Hence productivity has fallen by 3.4%. Market sector output per hour is now around 16% below its pre-crisis trend. Why?

The standard explanation for the *initial* fall in productivity is labour hoarding. In most previous recessions, firms cut output but kept labour in reserve for the recovery. Productivity, output per worker, falls at first, but then recovers as the firm uses the reserve inputs. Strictly speaking the fall in productivity is mismeasurement since the output per utilised input is the same, but with utilisation typically poorly measured this shows up as a fall, then rise, in productivity.

This explanation seems to carry less and less weight for the post 2008 years, for it seems very unlikely that firms are still carrying underutilised workers four years on. Further, as we document below, during the recession and since, firms have upskilled at a much faster pace (skill-adjusted labour composition rose at 0.5%pa 2005-08, but at 1.1% after 2008[2]). Thus if firms are holding onto workers, it is the high skilled, not the low skilled.

Therefore a number of different explanations of the UK productivity puzzle have been put forward. First, there are the arguments on labour hoarding and labour utilisation noted above. Second, that this recession has come at a time of greater labour market flexibility so that declines in real wages have allowed firms to keep on less productive workers. At the same time the financial crisis may have increased the cost of capital so that at the margin firms are substituting away from capital and towards labour, thus reducing labour productivity. Third, that the financial crisis has impaired the re-allocation of capital and that there is less migration of capital away from low return activity to higher returns (Broadbent, 2012). Fourth, that a greater degree of forbearance and also increased risk aversion on the part of banks has resulted in less entry and exit since the recession, with 'zombie firms' maintained and few high productivity entrants. Fifth, that a decline in business investment has

[1] Productivity as measured by GDP per hour looks very similar. For example, GDP in 2012, for which complete data are now available, rose by 0.0% (data downloaded in January 2013). We prefer to work with market sector output where possible in this paper, given the problems of accurately measuring government output.

[2] Average growth for 2005 to 2008 and 2009 to 2010 for the market sector (Acheson and Franklin, 2012)

reduced the capital-labour ratio and therefore labour productivity. We consider here a potential sixth explanation to do with the role of intangible investment in terms of both measurement and its impact on growth.

In this paper we thus examine the role of intangibles. A broad range of intangible assets are included, under three main intangible asset classes, based on the definitions first developed in Corrado, Hulten and Sichel (2005). Firstly, computerised information (mainly software), secondly, innovative property (covering scientific and non-scientific R&D) and finally firm-specific resources (company spending on reputation, human and organisational capital.

To examine the role of intangibles, our starting point is the observation that whilst investment in *tangibles*, plant/vehicles/buildings has fallen and stayed low, a point perhaps not noticed is that *investment in intangibles, specifically Research and Development (R&D) and software has risen* since the recession (software fell and has since been rising, R&D was flat and then rose). Consider then a firm who has reduced production but maintained investment in intangibles. Its skill level rises, since intangible investment typically requires high qualified workers. Its measured output falls, since the output of e.g. R&D projects might not manifest itself for a few years. Thus labour productivity falls, in a pattern *that looks just like labour hoarding*.

There is a second effect. Although intangible investment has been relatively robust over the recession, it fell before 2008. This was because there was a huge surge in intangible investment in the late 1990s around the introduction of the internet, with new software, machinery etc. In addition, as is well known, R&D investment as a share of GDP has been falling for quite some time in the UK. If such investment has spillovers, and they take some time, then it might be that productivity/total factor productivity (TFP) would have fallen in the late 2000s anyway, due to the slowdown in intangible investment in the early 2000s.

This paper then reviews these hypotheses. It therefore attempts to add an additional hypothesis to that literature on the UK productivity puzzle. There is a wide range of commentary and articles written on the productivity puzzle and offering a number of different explanations[3]. For example, the productivity puzzle has been discussed in various speeches by MPC members including Dale (2011),

[3]Explanations for the recent weakness in productivity are summarised in a box on page 33 of the November 2012 Inflation Report.

Broadbent (2012) and Weale (2012) and by other commentators such as Martin and Rowthorn (2012). See also Hughes and Saleheen (2012) for the UK productivity puzzle in an historical and international perspective. See ONS (2012a, 2012b) for a measurement perspective on the productivity puzzle and ONS (2013) for a microdata perspective. See Disney et al (2013) for a review of most of the explanations put forward to explain the productivity puzzle.

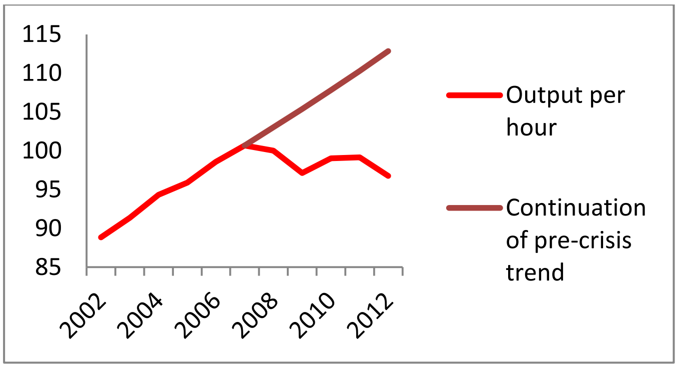
Our main conclusions are as follows. First, measured market sector real value added growth since the start of 2008 is understated by 1.6% due to the omission of intangibles. Second, TFP growth would have slowed down anyway by around 0.75pppa. The actual slowdown has been much larger than this, since TFP has gone from a pre-recession average of 1.39%pa (2002-7) to -2.29%pa (2007-10)[4]. Taken together this accounts for around 5 percentage points of the 16% productivity puzzle.

2. Productivity, TFP growth and investment

IIa. Some facts

Figure 1 shows the UK productivity puzzle for the market sector. As the figure shows, market sector output per hour[5] fell very sharply in 2008, but then recovered somewhat afterward before falling again. Output per hour is around 16 per cent below its pre-crisis trend. Mechanically, there has been weak output growth combined with a much more robust labour market than most people expected. Hours have not fallen by as much as previous falls in output would predict.

Figure 1: UK Labour Productivity Index (2008=100)

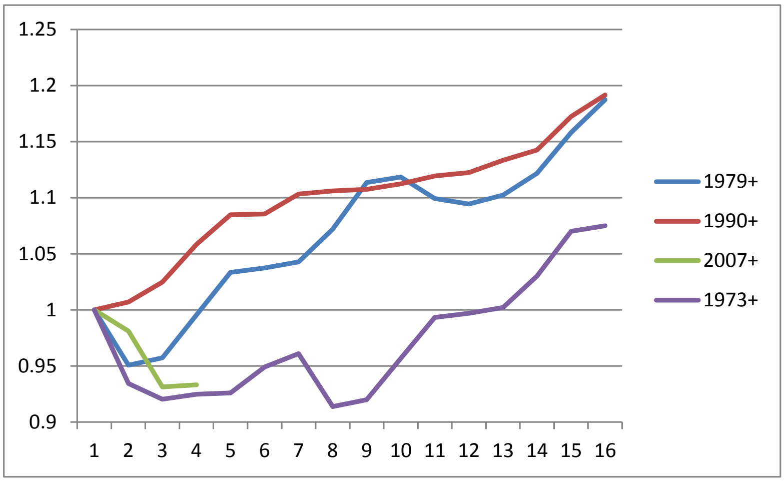


[4] Estimates based on Goodridge, Haskel and Wallis (2012a), where R&D, software, artistic originals and mineral exploration are the only intangibles capitalised. Data extended to 2010 using ONS TFP estimates.
[5] Note the market sector data underlying this chart (and Figure 6) differ slightly from that quoted from ONS. The ONS data include private delivery of education and health and exclude public services in section 'O'. These data are based on GHW (2012) and do not include private health/education and do not exclude public services in 'O'.

Notes: Solid line is an index of output per hour worked. Dark red line is a trend of output per hour worked prior to the recession. Data from Goodridge, Haskel and Wallis (2012a), for the UK market sector, based on a National Accounts definition of GDP where software, artistic originals and mineral exploration are the only capitalised intangibles.

Figure 2 sets out the TFP growth picture (TFP calculated as output per hour less share weighted capital and labour services per hour). It shows the weakness of the recovery in TFP, with the current situation remarkably similar to the UK experience in the 1970s.

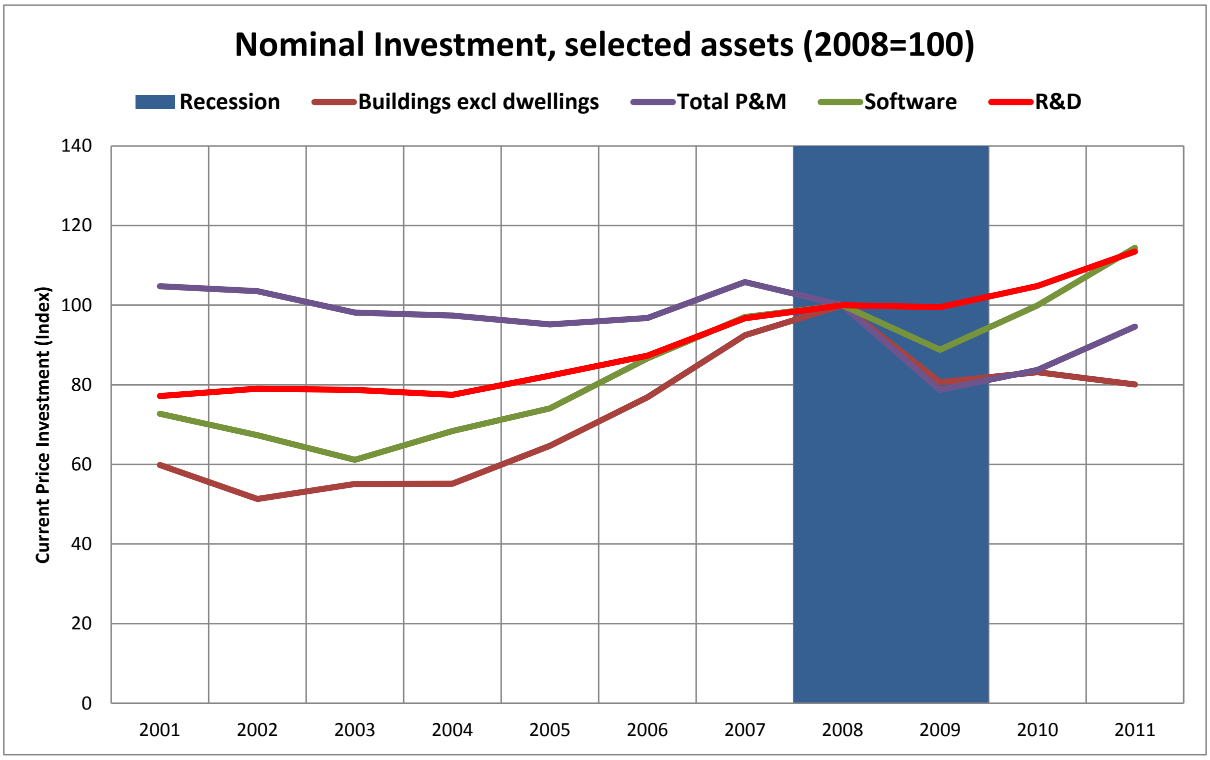
Figure 2: Index of TFP following UK recessions



Notes: TFP estimates taken from the UK EUKLEMS dataset and extended using ONS estimates. X-axis marks the number of years from each recession. TFP has been estimated accounting for changes in labour composition.

The difference between productivity and TFP is that the latter accounts for changes in capital deepening and labour composition. To shed light on capital deepening, Figure 3 shows business investment over the same period, with investment broken out into (non-residential) buildings, total plant & machinery (including computers), software and R&D. The data show the well-known collapse in buildings and plant investment after 2007 and the remaining low investment levels. Less well-known, however are the levels of R&D and software investment. Both hardly fell over the period and indeed have risen in contrast to other categories.

Figure 3: Index of UK nominal private sector investment in selected assets (2008=100)



Notes: Data for buildings, plant and machinery (P&M) and software are private sector business investment in current prices. Since this is business investment, buildings exclude dwellings. The data for software only refer to purchased and do not include own-account. Data for Plant & Machinery include ICT hardware. The data for R&D are the BERD data for Total Civil intramural R&D. Source: Buildings, P&M (Blue Book tables); Software (GFCF First Release); R&D (BERD)

Table 1 shows recent labour productivity and TFP growth for the UK before and during the recession from a number of sources.

Table 1: Productivity and Labour Composition before and during the recession

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Δln(V/H) (without intangibles, market sector)	**sL.Δln(L/H) (contribution of labour composition, whole economy)**	**sK.Δln(K/H) (contribution of capital deepening, whole economy)**	**ΔlnTFP (without intangibles, market sector)**			**ΔlnTFP (with intangibles, market sector)**	**Utilisation (hours per worker, market sector (000's))**
	ONS	*ONS*	*ONS*	*GHW(2012)*	*ONS*	Conference Board: Total Economy Database	*GHW(2012)*	ONS
2001-07	2.7%	0.4%	1.0%	1.3%	0.9%	0.8%	1.1%	1.71
2008	-1.6%	0.3%	1.0%	-1.9%	-2.3%	-0.8%	-2.0%	1.70
2009	-2.3%	1.0%	1.6%	-5.0%	-3.6%	-4.4%	-5.1%	1.67
2010	1.5%	0.9%	0.6%	-	0.4%	0.3%	-	1.68
2011	0.1%	-	-	-	-	-0.4%	-	1.68
2012	-2.8%	-	-	-	-	-	-	-

Notes: Data for 2012 in column 1 are extrapolated from three quarters of data. Data in column 1 do not quite match figures in introduction since those are to 2012Q3. Columns 2 and 3 are the contributions of labour composition and capital deepening as reported in ONS TFP estimates. TFP estimates in columns 4 to 6 are estimated accounting for labour composition. Note that ONS estimates of TFP and factor contributions do not sum to labour productivity as the data are from different sources and apply to different aggregations (factor contributions refer to the whole economy and ONS TFP to the market sector). Abbreviations: V=GDP; H=actual person-hours; L=labour services; K=capital services.. Sources: Column 1 (ONS Labour Productivity First Release); Columns 2, 3 and 5 (ONS TFP estimates); Columns 4 and 7 (Goodridge, Haskel and Wallis, 2012a); Column 6 (The Conference Board, Total Economy Database); Column 8 (ONS Labour Productivity data).

Data for growth in labour productivity, measured as growth in value-added per hour worked, are presented in column 1. The story they tell is by now familiar. Labour productivity fell sharply in the recession of 2008 and 2009, but has remained weak in the recovery and the decline in productivity in the second recession of 2012 is even greater than that in either year of the initial recession itself.

IIb. Capital/labour substitution and labour hoarding

Columns 2 and 3 show the contributions to labour productivity growth of growth in capital services per hour and labour services per hour. Both columns shed light on two hypotheses concerning the labour market. One is that the decline in real wages has lowered the relative price of labour to capital thus incentivising substitution away from capital towards labour. At the same time, tightening of credit conditions since the financial crisis might have further increased the relative price of capital.

The data here give some slight support for this view. As column 3 shows, the contribution of capital services per hour up to the recession was 1% pa. In 2009, that contribution rose strongly, that is, labour was reduced more than capital. In 2010 by contrast, the contribution fell quite markedly, suggesting that firms are, relative to before, substituting towards labour. This pattern is reflected in columns 4, 5, and 6 which show TFP growth. As we set out below, TFP growth measures labour productivity growth controlling for capital/labour inputs. TFP growth declined very sharply in the recession, suggesting that labour productivity did not just fall due to capital/labour substitution.

A second view is labour hoarding. Rowthorn and Martin (2012) advance the view that the fall in labour productivity is due to labour hiring behaviour. Consider a firm with "overhead" and "variable" labour. An initial fall in demand causes overhead labour to be hoarded and variable to be fired, though these effects are moderated with a fall in real wages. Productivity falls as overhead labour is under-utilised. A recovery in demand, at low wages, causes variable labour to be hired. Productivity rises as overhead labour utilisation recovers, but might fall as more labour is hired. To get an overall fall in productivity and then no rise in the employment recovery, they posit high and low productivity sectors. In the initial recession the high productivity sector fired variable labour and kept on overhead labour at low utilisation. In the recovery, that sector hired few new workers and raised utilisation: a jobless recovery with rising productivity in that sector. The low productivity sector by contrast fired both types, so that in the recovery they hired both types, lowering overall productivity via a mix effect. They present evidence that the recovery in employment since 2008 has been entirely in the low productivity sector (see their Chart 14 and Table 12, www.cbr.cam.ac.uk/pdf/BM_Report3.pdf). (their high productivity sectors are manufacturing, financial and business services, low productivity are agriculture, construction, distribution, hotels and restaurants).

One way to look at the Martin/Rowthorn hypothesis is via labour composition indices. These are indices of labour hours adjusted for various dimensions of labour composition (e.g. skill, age, gender). In practice they are driven by skill levels so that if the index of labour composition rises (labour services per hour worked), then firms are increasingly hiring more skilled workers per hour worked. ONS data for the contribution of quality-adjusted labour services per hour worked is presented in Column 2 of Table 1. If low-skilled labour had been hoarded, we would expect the contribution of labour composition to either grow less fast or even decline. But growth in the contribution of labour composition in 2009 and 2010 has been extremely strong, suggesting the opposite has occurred. That is that firms have hoarded high-skilled labour at the expense of low-skilled. This is borne out in the analysis contained in Acheson (2011) and Acheson and Franklin (2012). Note that this is also consistent with the data for R&D investment in Figure 1, and other categories of intangible investment, all consistent with the idea that it is the higher skilled "knowledge workers" that have been kept on by firms.

However, the Rowthorn/Martin view is across different sectors. In the recession, they argue, the high productivity sectors have hoarded relatively more skilled labour and let go relatively more unskilled. Thus they should have a relatively large rise in labour composition. In the recovery, the high productivity sector employs more fully their hoarded skilled workers and takes on relatively few unskilled. The low productivity sectors, take on relatively more low skilled labour. So again, the high productivity sector should have a relatively high rise in composition. The data from Acheson and Franklin (2012) do not support this version of the Rowthorn/Martin view. In the initial recession growth in labour composition was 1.6%pa and 2.5%pa in the high and low productivity sectors and in the recovery 1.9% and 2.0%. Thus, in the recession, the low productivity sectors retained relatively more skilled than the high productivity and in the recovery have hired relatively more skilled than the high productivity sectors[6]. The data used to make this comparison are presented in Table 2.

Table 2: Changes in labour composition during and after the 2008-09 recession

	Rowthorn & Martin: Low (L) / High (H) productivity sectors	**2008Q1 - 09Q2: Change in labour composition (Δln(L/H)**	**2009Q3 - 10Q4: Change in labour composition (Δln(L/H)**
Whole economy		1.7	1.5
Market sector		1.1	0.6
Agriculture & Mining	L	2.7	2.4
Manufacturing		1.1	1.0
Construction		2.4	-1.3
Distribution	L	2.3	1.9
Transport		-0.1	1.1
Information & Communication		4.0	4.4
Financial Services		0.8	4.3
Professional & Administrative Services	L	1.4	2.8
Public Services	L	1.3	1.1
Arts & Recreation	L	4.6	1.6
Average High		**1.6**	**1.9**
Average Low		**2.5**	**2.0**

[6] This takes Table 2 and 3 in Acheson and Franklin (2012) and allocates as low productivity sectors (following Rowthorn/Martin) Agriculture, Wholesale/Retail, Administration, Public services and Arts (ABDE, GI, LMN, OPQ and RSTU), the rest being high productivity and calculates the averages of "labour quality index per hour" for high and low, for 2008-9 and 2009-10.

Notes: The table sets out the data from Acheson and Franklin (2012) showing changes in labour composition between the dates indicated, with the second column marking the low productivity sectors (the others being high) as best we can match to the Martin/Rowthorn classification. The final row shows average changes for the high productivity and low productivity sectors.

IIb. Direct evidence on utilisation.

Direct evidence is very hard to come by on utilisation since it is so hard to observe. Basu et al (2006) suggest a theory to measure it essentially by actual hours per worker per year (H/N)[7]. To do this, they suggest estimating the regression

(1) $\Delta \ln TFP^{MEAS} = \hat{\alpha} + \hat{\beta}\Delta \ln(H/N)$

providing an estimate of $\hat{\beta}$ which allows us to form a measure of TFP adjusted for the impact of utilisation as

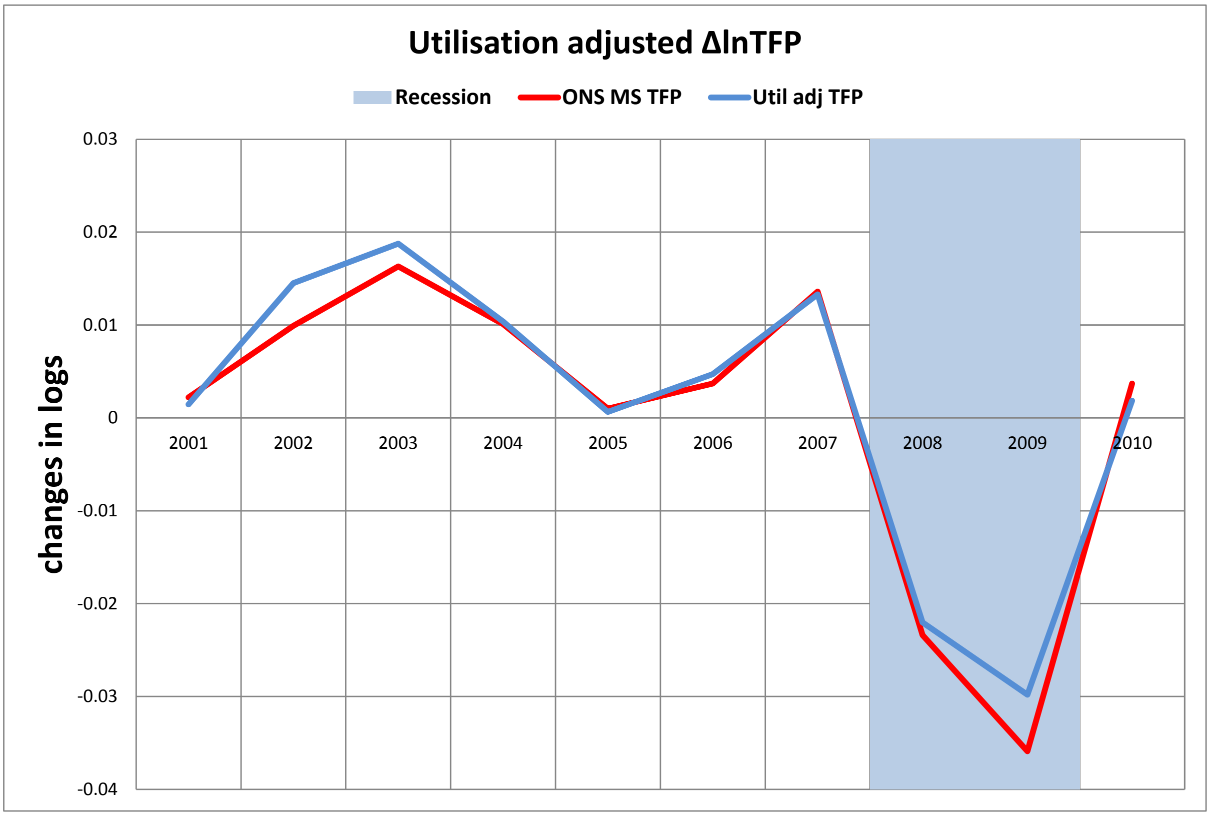
(2) $\Delta \ln TFP^{ADJ} = \Delta \ln TFP^{MEAS} - \hat{\beta}.\Delta \ln(H/N)$

In contrast to results in the US, as in Basu et al (2006), it turns out that in the UK data $\hat{\beta}$ is relatively small at 0.39 (compared to $\hat{\beta}>1$ in the US data). The adjustment to TFP is shown in the following chart.[8]

[7] Consider a firm employing N workers for H hours per worker, working with unobserved effort E per hour. Labour input is then N×G(E,H), where G transforms the bundle of E and H into per worker effort-hours. A firm wishing to raise E or H will face some costs of doing so. Assume they are a function of EH and that firms are optimising on all margins. Then the first order condition holds: dG/dH(H/G)=dG/dE(E/G). Log linearising, one can write the unobservable E/N in terms of the observable H/N as lnE/N=βln(H/N) as is done above.

[8] Note that utilisation is partly controlled for in the factor shares following the Berndt-Fuss-Hulten theorem. A new building for example raises ΔlnK. But if is it unoccupied, then its rent income is zero, hence $s_K^Q=0$ and so it has no impact on ΔlnQ. Thus insofar as utilisation is reflected in prices, the income share controls for underutilisation. Berndt-Fuss-Hulten point out that when the operating surplus is calculated residually asset compensation reflects the actual marginal product of capital, in this case zero, thus partly accounting for utilisation in the estimation of TFP.

Figure 4: Measured TFP .vs. TFP adjusted for utilisation



Notes: Red line is UK market sector TFP (ONS). Estimates for hours per worker are from ONS data for market sector hours and workers as used in the Labour Productivity First Release. Blue line is UK market sector TFP adjusted for utilisation. Recession marked with blue columns.

Looking at the years prior to the recession utilisation adjusted TFP was higher than measured TFP in the early 2000s. The adjustment in the years immediately before the recession was very small. The major interest is in 2008 to 2009. As the graph shows, adjusting for utilisation removes some of its impact from TFP, suggesting TFP did not fall as fast as in the measured data. The adjustments are not that large however. The reason is that in 2009 TFP (ONS) was -3.6%. In that year $\Delta \ln(H/N)$ (ONS) was -1.6%. Our UK estimate for $\hat{\beta}$ is 0.39. The contribution of utilisation in 2009 is therefore (0.39*-0.016=)-0.6%, thus adding 0.6% to TFP. Note that if the UK estimate of $\hat{\beta}$ were more similar to that found in the US, say $\hat{\beta}$=1.008[9] the contribution of utilisation would be (1.008*-0.016=)1.59% and would explain around 44% of the fall in TFP.[10]

3. The relation between productivity, TFP growth and investment

To explain these data let us set out a slightly more formal model. Consider the following framework. Let output Q be a function of the services of labour, L, tangible capital, K, and intangible capital, R, with a shift term A. Then we can write GDP in terms of a production function and in terms of nominal expenditure as

$$
\begin{aligned}
&Q_t = A_t F(L_t, K_t, R_t) \\
(3) \qquad &V = C + I \\
&Q = C + I + N
\end{aligned}
$$

Where I and N are the real values of tangible and intangible investment. V is the sum of consumption and tangible investment and will appear below. This means we can write the relation between measured output growth, ΔlnV and true output growth, ΔlnQ, which is

$$(4) \qquad \Delta \ln Q_t = \Delta \ln V_t + s_t^{Q,N}(\Delta \ln N_t - \Delta \ln V_t)$$

We are now in a position to review the possible biases due to omitted intangibles. First, if in the recovery DlnN>DlnV, for which we have seen some evidence in Figure 3, measured DlnV understates true, DlnQ.

The term $s_t^{Q,N}\left(\Delta \ln N_t - \Delta \ln V_t\right)$ is an estimate of the bias to measured output if intangibles are not treated as capital goods. We consider the full range of intangible assets proposed in Corrado, Hulten and Sichel (2005)[11]. Since our intangibles dataset only extends to 2009, some assumptions to extend the series have been made. First we assume that the intangible investment share (excluding software, mineral exploration and artistic originals), $s_t^{Q,N}$, is the same in 2010, 2011 and 2012 as it was in 2009

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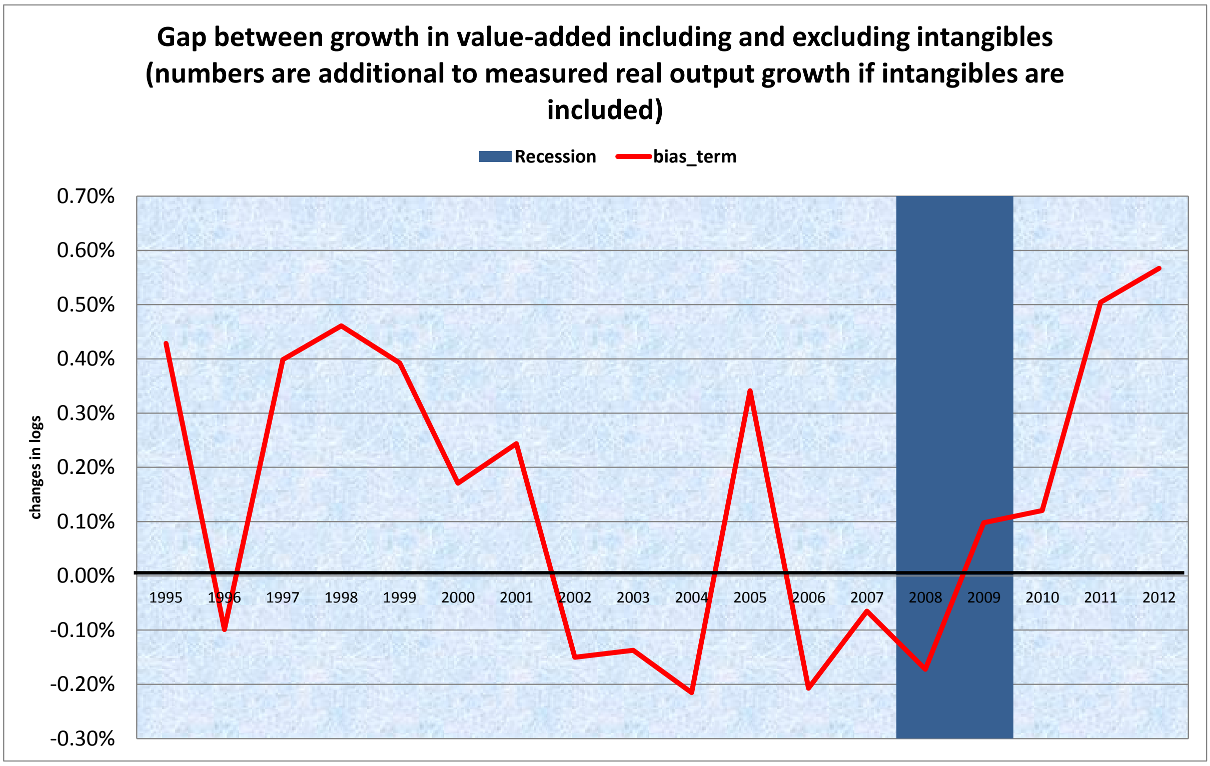
[9] Basu et al (2006) report estimates of $\hat{\beta}$ for durables manufacturing (1.34), nondurables manufacturing (2.13) and nonmanufacturing (0.64). Applying some approximate weights for each within the UK market sector of 0.1, 0.2 and 0.7 respectively, yields a comparable estimate of $\hat{\beta}$=1.008.

[10] To see how much this matters in the US, the Fernald quarterly TFP growth series, www.frbsf.org/csip/tfp.php, and Fernald (2010) show that measured TFP growth was -1.66 and -1.39 in 2008 and 2009, but when utilisation adjusted was 0.47 and 2.51.

[11] Therefore including: software; scientific R&D; non-scientific R&D; design; artistic originals; mineral exploration; financial product innovation; training; advertising; market research; organisational capital.

(at 0.09). Second we assume that real intangible investment is growing at the same rate as real R&D investment in 2010 and 2011, and that the rate for real R&D investment is the same in 2012 as in 2011. Estimates of real measured growth and changes in the output deflator have also been extended with the latest ONS data. The following chart presents an estimate of this bias term.

Figure 5: Bias in measurement of real final output if intangibles are not capitalised



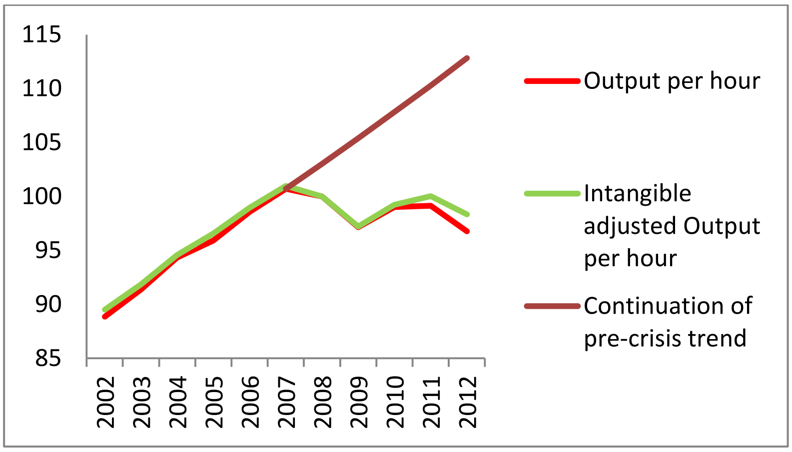
Notes: Chart presents the correction to real output growth if intangible investment is not included in final output. So, for example, in 2011, real output growth should be 0.50% higher than it is measured. For 2012 that figure is 0.57%. Recession highlighted.

The chart shows that in the late 1990s, when there was an intangible investment boom, the term is positive, that is value-added including intangibles was growing faster than measured value-added. In general for much of the 2000s the term is negative, with growth in intangible output weaker than measured final output, suggesting growth was being overstated during that time. However in 2009 the term is positive and suggests an understatement to output growth of 0.1%. The terms for 2010 and 2011 suggest an understatement of 0.12% and 0.5% respectively. In 2011 and 2012 market sector

GVA growth was 1.17% and -0.26% pa respectively. [12] Thus the bias of 0.57% for 2012 means output growth would instead would be 0.31% pa rather than negative.

The impact of this in terms of labour productivity can be seen in Figure 6. There the red line is an index of market sector labour productivity (GDP per hour) as conventionally measured, and the green line an index of labour productivity with the underlying output measure adjusted to treat intangible spending as capital investment. As can be seen, by 2012, not accounting for intangibles results in the index of labour productivity being underestimated by around 1.6 index points.[13] The reason is that market sector growth since the start of 2008 is -4.4%, but adjusted market sector growth is approximately -2.8%.

Figure 6: UK Labour Productivity Index adjusted for intangibles (2008=100)



Notes: Red line is measured labour productivity and dark red line is trend labour productivity based on the pre-crisis data as in Figure 1, with software, mineral exploration and artistic originals the only intangibles that are capitalised. Green line uses an output measure adjusted for the capitalisation of all other intangibles in the Corrado, Hulten and Sichel (2005) framework. Data are based on Goodridge, Haskel and Wallis (2012a). Data for intangible investment in 2010 to 2012 have been projected forward using data for R&D investment as reported in BERD.

4. Spillovers

Intangible investment affects the productivity growth of the firm undertaking the investment. But it has an additional effect if there are spillovers. There is a large body of work suggesting that R&D has spillover effects to other firms see e.g. Griliches (1973) for a survey, concentrating mostly on US work, and Goodridge, Haskel and Wallis (2012b) for recent work for the UK.

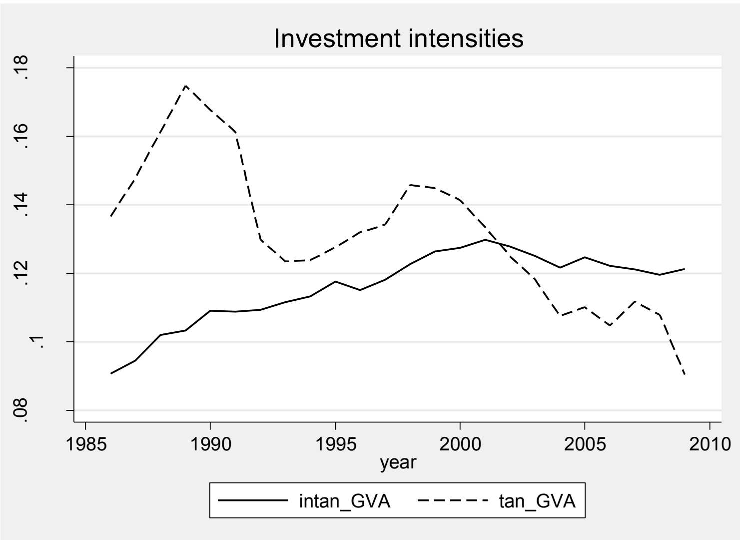
[12] This estimate for 2012 is extrapolated from three quarters of data

[13] Taking the self-employed out of the headline measure of productivity also accounts for about 1 per cent of the productivity puzzle.

A number of US authors (e.g. Fernald (2012)) have noted a slowdown in US TFP growth before the 2008 recession, which they ascribe in turn to a slowdown in intangible investment in the early 2000s following the heavy burst of intangible investment in the late 1990s internet/computer boom. In the UK, there has also been a sustained slowdown in UK R&D/GDP spend noted by a number of authors and policy-makers. We thus examine the data for the UK: was there an intangible investment slowdown and might that have slowed down underlying TFP growth before the recession?

Figure 7 sets out intangible and tangible investment as a proportion of GDP. Intangible investment rose since the 1980s, but slowed down in the early 2000s. Tangible investment has generally been in decline throughout the 2000s. So if there are spillovers from intangible investment to TFP and if they take, say two years to show up, then TFP growth in the late 2000s would slow. Of course, it might well slow down before the shock of 2008 and the shock might have an additional effect, but even so, there remains the possibility that at least some of the slowdown might be due to a feed through from the earlier slowdown in intangible investment.

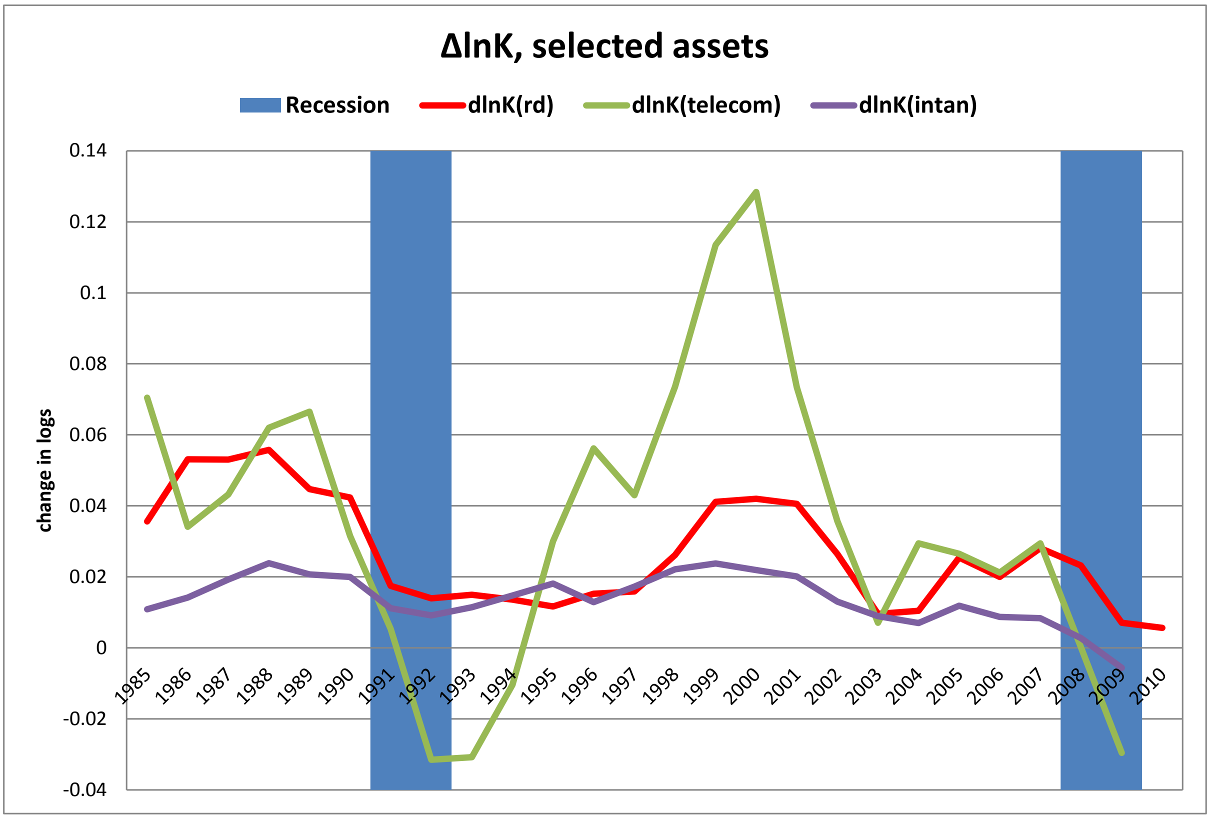
Figure 7: Nominal tangible and intangible investment as a proportion of nominal GDP



Note s: Tangible and intangible investment as a share of GDP. In each GDP has been adjusted for the capitalisation of intangibles. Data from Goodridge, Haskel and Wallis (2012a).

Figure 8 shows the changes in capital stocks as a result of this investment, along with changes in R&D capital and telecoms equipment. The latter bears some comment. One way of thinking about the internet is that it is a (very large) piece of communications capital equipment, building on older telecoms capital and being augmented by broadband and mobile technologies. If one thinks of such equipment as building networks it is very natural to ask if there is any evidence of spillovers from telecoms equipment. As Corrado (2010) points out, there are many channels through which communications capital deepening may have contributed to improved growth in TFP e.g. improved opportunity and ability for collaboration; more effective communication and increased quality of information communicated both within and between organisations; improved access to freely available knowledge via the internet; and improved organisational and business processes, including within supply chains, derived from each of the previous effects described. Such spillovers could be even more substantial in more knowledge-oriented economies. In fact, recent studies (Adams, Black, Clemmons and Stephan 2005; Ding, Levin, Stephan and Winkler 2010) have shown a positive impact from the internet on academic collaboration and productivity.

Figure 8: Growth in capital services, selected assets



Notes: Data are changes in the log of the capital stock for selected assets. dlnK(telecom) refers to telecoms equipment defined as I-O groups 71 (Insulated wire and cable), 74 (Television and radio transmitters and apparatus for line telephony and line telegraphy) and 75 (Television and radio receivers, sound or video recording or reproducing apparatus and associated goods). Recessions marked by blue columns. Data are from Goodridge, Haskel and Wallis (2012a).

The figure shows growth in capital services for each of these intangible groups. Growth in R&D capital was very high in the 1980s before slowing, speeding up again around 2000 and then slowing. Growth in telecoms capital was low, even negative, in the early 1990s before growing very fast in the late 1990s and then slowing. In general growth in capital for these assets slows down in the early 2000s relative to the late 1990s. If there is a lagged effect on TFP, this would slowdown TFP in the late 2000s.

How big might these effects be? Table 3 sets this out. In this table, TFP growth is measured including R&D as an intangible (excluding all other intangibles) to study the possible effects from R&D spillovers. We confine ourselves to R&D since R&D spillovers seem quite well established in the literature. The table reads as follows. Column 3 sets out TFP growth, estimated including R&D, for four year-spans, starting in the trough of 1991, being a trough to peak, peak to trough and another cycle. As the table shows, TFP sped up between late 90s and mid 00s, (1998/02 and 2002-07), (0.12%pa), but then slowed down severely in the latest period (-3.68%).

Interestingly, as columns 4 and 5 show, lagged growth in the capital stock for R&D and telecoms equipment show a suggestive pattern. Both sped up in the late 90s relative to the early 90s and late 90s and then slowed down again. Both of these speedups were followed by a speedup in TFP growth. And both slowdowns were followed, this time in the current cycle, by a slowdown in TFP growth. The final two columns show the contribution to the DlnTFP speedup and slowdown, being a coefficient times the lagged growth in the capital stock. The coefficients are drawn from Goodridge, Haskel and Wallis (2012b) and Goodridge, Haskel and Wallis (2013) and are the elasticities of DlnTFP to changes in the stock. As the final columns show, the 2002-07 slowdown is over predicted, but the current slowdown is under predicted. In fact, the effect from the changes in the stock of R&D and telecoms equipment account for 20% ((0.47+0.26)/3.68) of the current slowdown. So a slowdown in current DlnTFP of around 0.75%pa is predicted but these data are insufficient to predict the whole very large slowdown. Of course, much of that slowdown is dominated by the massive fall of around 5% of measured TFP in 2008.

Table 3: Spillovers and the slowdown in ΔlnTFP

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year	**Peak/Troug**	**DlnTFP**	**DlnK(rd)**	**DlnK(com equip)**	**dlnTFP slowdown**	**0.25*lagged dlnK(rd) slowdown**	**0.04*lagged dlnK(com equip) slowdown**
1991-98	T-P	1.83%	1.60%	1.86%			
1998-02	P-T	1.26%	3.75%	8.77%			
2002-07	T-P	1.39%	1.87%	2.28%	0.12%	0.54%	0.28%
2007-10	P-T	-2.29%	1.20%	-1.94%	-3.68%	-0.47%	-0.26%

Notes: Columns 1 and 2 indicate years and peak to trough or trough to peak. Columns 3, 4, and 5 are ΔlnTFP, ΔlnK(R&D) and ΔlnK(telecoms equipment). Column 6 is ΔlnTFP slowdown, that is the respective row less the row above it. Columns 7 and 8 are the indicated coefficient times the slowdown in ΔlnK in the previous periods. So for example, -0.47 in column 7, final row equals 0.25*(DlnK(R&D)(2002-07) - DlnK(R&D)(1998-02)). Data are from Goodridge, Haskel and Wallis (2012a).

5. Conclusion

We have investigated whether intangibles might explain the UK productivity slowdown. We have noted that since the recession

a. firms have held onto their more skilled workers and decreased their unskilled workers at an increasing rate
b. intangible investment in R&D and software has risen whereas tangible investment has fallen.
c. intangible investment and telecoms equipment slowed in advance of the recession

We have therefore tested to see if

a. What looks like labour hoarding is actually firms retaining workers who are employed in creating intangible assets (e.g. R&D teams); whose current output is therefore zero and whose contribution to total investment is unmeasured since intangibles are treated as expenses not investment
b. How much the slowdown in current TFP growth is due to the spillover effects of the slowdown in R&D and telecoms equipment investment in the past.

Our main findings are

a. First, measured market sector real value added growth since the start of 2008 is understated by 1.6% due to the omission of intangibles.

b. 0.75pppa of the TFP growth slowdown can be accounted for by the slowdown in intangible and telecoms investment in the early 2000s.
c. Taken together intangible investment can therefore account for around 5 percentage points of the 16% productivity puzzle.

Does that mean the UK still has an output gap? If potential output growth is determined by TFP growth, as it is in many models, our spillover results suggest that potential output growth has fallen. But potential output growth is not a given, since intangible investment may be amenable to policy levers. One of those levers might be Keynesian demand expansion. Others might be more on the supply side, e.g. expanding the R&D tax credit to other intangible assets. Whichever it is, we believe that unmeasured intangibles are part of the explanation of the productivity puzzle, but not all of it.

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