A COMMENT ON OULTON, ‘THE UK PRODUCTIVITY PUZZLE: DOES ARTHUR LEWIS HOLD THE KEY?’

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Abstract

In Version 1 of his new paper, Oulton merges supply-side and demand-side theoretical models as a means better to understand why, since the financial crisis that broke in 2007, the UK's productivity growth has not only been negligible but also a very poor outlier judged by international experience. Drawing on Arthur Lewis's famous model of development, Oulton concludes, 'rapid rates of immigration in conjunction with low rates of growth of export demand in the aftermath of the Great Recession can explain the UK productivity puzzle'. According to Oulton, the UK's relatively poor productivity performance is attributable to a combination of the export demand constraint and of the continued growth of labour supply, which led to capital shallowing – a reduction in the rate of growth of capital services per hour worked. I conclude, alas, that Arthur Lewis does not hold the key. The dominant, proximate 'explanation' of the UK's relatively poor performance is relatively weak Total Factor Productivity (TFP), not relatively weak capital intensity. Moreover, the UK was not relatively more exposed to export demand shocks but delivered relatively worse output growth outcomes. Oulton nevertheless articulates the profound idea that full-employment capacity has adjusted to weak effective demand arising from adverse global developments. If this deep insight is correct, TFP would be a 'measure of our ignorance' of the mechanisms that drove productive capacity to align with low aggregate demand.

Keywords: productivity, slowdown, immigration, capital, Lewis, TFP.

JEL Codes: E24, O41, O47, J24, F43, F44.

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1. Introduction

The supply-side school and majority opinion hold that the explanation of the post-2007 shortfall in productivity growth in the UK and elsewhere is to be found in a slowing pace of technical progress or its diffusion (Gordon, (2016); 'zombie firms') or in the impact of other supply-side influences such as demography, education and on-the-job training. The demand-side school and minority view, to which Robert Rowthorn and I subscribe (Martin and Rowthorn (2012)), emphasise instead a financial-crisis related systemic effective demand failure combined, in the UK, with cheap labour. We argued, inter alia, that low wages aided the relative expansion of low-productivity, labour-intensive activities while demand deficiency may have undermined investment and endogenous total factor productivity (TFP).

Oulton seeks to deepen the demand-side explanation of the UK experience by grafting onto a standard Solow growth model the Lewis model of development with unlimited supplies of labour: a 'neo-Lewis' model.[1] Oulton observes that the Solow model's transitional dynamics that arise from an increase in labour supply – a temporary increase in investment, productivity and the real wage – do not square with developments in the UK since 2007. Oulton posits a regime change. Before the financial crisis, output growth is Solow-like supply determined. After the crisis, output growth is demand determined. Employment and technology grow exogenously, while investment adjusts to ensure the economy's capacity grows in line with weak demand. The process leads to declining capital intensity (capital services per hour worked). Oulton locates the demand shortfall in the post-crisis decline in export demand, acting through a balance of trade constraint to limit domestic demand.

This short comment focuses on the question posed by Oulton's title: does Arthur Lewis hold the key to the UK productivity puzzle? My short answer is, alas, 'no'. Capital shallowing and world trade shocks are mechanisms that do not adequately explain why the UK's post-crisis productivity performance is so unusually poor judged by international experience. More positively, Oulton's account articulates the profound idea that full-employment supply capacity has adjusted to weak effective demand arising from adverse global developments. This deep insight warrants further research.

2. Capital shallowing as a driver of the UK's underperformance

To add empirical support, Oulton examines the productivity experience of two dozen advanced economies between what he defines to be the pre-crisis (2000-2007) and post-crisis (2008-2015) periods. Oulton finds that the UK experience is not that unusual in terms of the post-crisis rate of economy-wide output growth. In comparison with other economies, Oulton notes instead the UK's abnormally low (zero) post-crisis productivity growth (output per hour worked) and abnormally high (and compared with the pre-crisis period, similar) rate of employment growth fuelled by an abundant supply of immigrant labour from low wage countries. The UK saw the 'largest decline in the growth of capital intensity of any country here'. Oulton also notes the widespread decline in TFP growth.

Although mentioned briefly in a later section of his paper,[2] the reader could be forgiven for not appreciating from Oulton's description and his Table 2 that it is the decline in the growth of TFP rather than of capital intensity that accounts (in the standard growth accounting framework) for much the greater part of the decline in UK productivity growth, relative to both the UK's pre-crisis performance and the international experience. Oulton's Table 2 does not offer complete growth accounts and the general message is perhaps too easily obscured by the detail.

Table A presents my attempt roughly to conflate the international experience (Europe excluding the UK plus the United States) and, in passing, to correct what appears to be an anomaly in the EU KLEMS productivity growth accounting data for the UK (see Annex A).[3] Subject to standard qualifications about data quality, the following developments pre and post crisis stand out:

(i) UK output growth declined by a little more than the international average from a somewhat higher pre-crisis base.

(ii) Hours worked in the UK grew a little faster than overseas pre-crisis and continued unabated post-crisis while, on average, overseas employment fell.

(iii) The contribution to UK output growth of the growth of capital services both before and after the crisis was a little lower than the international average. The decline in capital services contribution to output growth pre and post crisis was the same in the UK as overseas (0.6 percentage points p.a.)

(iv) The contribution to UK productivity growth of capital intensity – capital services per hour worked – was materially lower than the international average after the crisis having been only a little lower prior to the crisis. The fall across the periods was greater in the UK than overseas (0.6 percentage points p.a. versus 0.2 percentage points p.a.).

(v) The greater decline in the contribution of capital intensity to UK productivity growth arises from the UK's internationally atypical post-crisis growth of employment, not an international atypical decline in the contribution of capital services to output growth.

(vi) UK TFP growth was greater than the international average before the crisis and less than the slower international average after the crisis. UK TFP 'growth' turned negative.

The final column in Table A shows the UK's relative performance, deducting the changes in average overseas rates of growth between the two periods from the comparable changes in the UK. It is this relative performance that is of key concern. As Oulton notes, '… it is important to show how and why the UK differs from other comparable countries. This is because in labour productivity terms (as we have seen) the UK is an outlier, at least amongst developed economies' (Oulton, 2017, p21).

The stand-out feature of Table A is the relative fall in the UK's TFP growth rate; it is the dominant contributor to the decline in the UK's relative productivity growth. Of the 1.1 percentage point fall in relative productivity growth, the fall in relative TFP growth accounts for 0.8 percentage points. The contribution of the decline in relative capital intensity growth is half as large.

These traditional growth accounting results suggest that the answer to the question in the title of Oulton's paper is 'no': some light may be shed, but Arthur Lewis does not hold the key. In the Lewis model, the explanation of the decline in the UK's relative productivity growth rests *entirely* on the role played by capital intensity. No explanation is offered by neo-Lewis for the decline in the UK's relative TFP growth yet it apparently accounts for 70% of the relative fall in UK productivity growth.

Table A: UK versus Europe and USA – output and productivity growth accounting

Whole economy excluding SIC industry sections T & U	United Kingdom			Europe (excluding UK) and USA			UK Relative
	Logarithmic growth, p.a. %		Change	Logarithmic growth, p.a. %		Change	Change
	2000-2007	2007-2015	% points	2000-2007	2007-2015	% points	% points
Output	2.6	0.8	-1.8	2.0	0.6	-1.4	-0.4
of which, contributions of:							
Hours worked	0.4	0.4	0.0	0.2	-0.1	-0.3	0.3
Labour quality	0.3	0.4	0.1	0.2	0.2	0.0	0.1
Capital services	0.9	0.3	-0.6	1.1	0.5	-0.6	0.0
Total factor productivity	1.0	-0.3	-1.3	0.5	0.0	-0.5	-0.8
Hours worked	0.7	0.7	0.0	0.4	-0.2	-0.6	0.6
Productivity, of which:	1.9	0.1	-1.9	1.6	0.8	-0.8	-1.1
Capital intensity contribution	0.6	0.0	-0.6	0.8	0.6	-0.2	-0.4

Source: EU KLEMS, September 2017 release (www.euklems.net) Notes: (1) Standard Industrial Classification industry sections T and U cover the activities of households and of exterritorial organisations for which capital stocks data are not typically available. (2) Estimates of the contribution to UK productivity growth of capital intensity are adjusted to conform with output growth accounting data (see Annex A). (3) Europe excluding UK refers to the UK-excluded EU KLEMS aggregate EU-12 for which growth accounting data are available since 2001: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, Netherlands, Spain, Sweden. (4) Europe (excluding the UK) and USA aggregate formed using basic prices value added (excluding T & U activities) fixed weights for the 2000-2015 period. (5) The UK Relative column shows the change in growth rates between the two periods for the UK minus the Europe (excluding UK) and USA aggregate.

Table B: UK versus Europe and USA – productivity growth accounting with 'new' intangible assets

Market sector	United Kingdom			Europe (excluding UK) and USA			UK Relative
	Logarithmic growth, p.a. %		Change	Logarithmic growth, p.a. %		Change	Change
	2000-2007	2007-2013	% points	2000-2007	2007-2013	% points	% points
Productivity	2.5	-0.2	-2.7	2.0	0.9	-1.1	-1.6
of which, contributions of:							
Capital intensity	0.6	0.4	-0.2	1.0	0.8	-0.2	0.0
TFP and labour quality	1.9	-0.6	-2.5	1.0	0.1	-0.9	-1.6

Source: Corrado et al. (2016) See notes to Table A. Europe (excluding UK) and USA aggregate formed using fixed weights as in Table A but for the 2000-2013 period

How robust is this empirical result? It is beyond the scope of a short comment fully to explore the vagaries of growth accounting, a vast endeavour. However, two matters can be briefly addressed.

The first is the sensitivity of the result to the definition of the pre-crisis and post-crisis periods. Aggregating estimates for individual industries that comprise the UK's market sector, Silvana Tenreyro, an external member of the Bank of England's Monetary Policy Committee, finds that '… in aggregate, capital deepening is at least as important as TFP, accounting for over half of the overall productivity slowdown.' (Tenreyro, 2018, p19). She, like Oulton, defines the pre-crisis period as the 2000-2007 interval but excludes the recession years from the post-crisis period. Without that exclusion, comparing 2000-2007 with 2007-2015, Tenreyro reports that TFP accounts for 78% of the UK market sector productivity slowdown, twice as large as the contribution of capital shallowing. Tenreyro concludes, '… as an investment recovery has failed to arrive, it [labour for capital substitution] has become increasingly important.'

Since unmeasured under-utilisation of capital and labour would have amplified the decline in measured TFP, notably during the 2007-2009 recession, it is relevant to re-assess the sensitivity of Table A's results using Tenreyro's period definitions. It is found in Annex B that TFP remains the main contributor to the productivity slowdown at the UK national and market sector level using the EU KLEMS data deployed by Oulton and at the market sector level using official (but 'experimental') Office for National Statistics (ONS) data.

It appears that Tenreyro's contrary results owe more to growth accounting measurement than to timing. Tenreyro's capital services data are constructed by the Bank of England using the methodology of Oulton and Wallis (2016). Aggregation to the market sector from industry level estimates uses relative price and employment weights. Differences from the EU KLEMS and official ONS data may arise for a number of reasons, including implicit differences in individual industry level and market level capital depreciation rates (Goodridge, Haskel and Wallis (2016)), and the interaction between the weighting scheme and industry-level measurement errors that are normally offsetting at the aggregate level (Oulton (2016)). These matters are left for future enquiry.

The apparent explanatory dominance of TFP could also be challenged by questioning the veracity of standard growth accounting. In the original Lewis model, labour is instantaneously endogenous, a function of the level of technology and capital. The implied production function is of the *AK* kind found in the early Keynesian and early endogenous growth models. The contribution of capital intensity to productivity enters with a unit weight, well above the income share of capital (about 35% in the case of the UK) used in standard growth accounting (Annex C). A unit weight on capital would greatly elevate the measured contribution of the decline in capital intensity to the fall in the UK's productivity growth, and depress the measured contribution of TFP.

This response, however, would founder on the burden of empirical evidence, including that of Oulton (Oulton and Maloney (1984)) who finds, like others, that ordinary capital is not 'special'. Its weight in the production function is better represented by something close to capital's income share.

Further challenge to the declining capital intensity explanation of the UK's atypically poor post-crisis productivity performance comes from the not-uncontroversial 'new' intangibles growth accounting school associated with Corrado, Hulten and Sichel (2005), henceforth referred to as CHS.

The CHS framework reclassifies and capitalises as intangible investment various categories of business spending that are recorded as intermediate consumption in the national accounts. The reclassification is not without its critics, including Martin and Rowthorn. As Eggertsson, Robbins and Getz (2018) argue, firms' expenditure on branding and marketing included with the CHS definition of economic competencies serves to divert activity from one firm to another. Such expenditure having that outcome should not be counted in an economy aggregate production function.

Noting the controversy, it is nevertheless pertinent to observe that, under the CHS methodology, 'new' intangible investment has been more resilient than tangible investment spending during the crisis period, if not before. As a result, the contribution of capital intensity to productivity growth has been greater under CHS accounting than recorded by conventional accounting.

Table B repeats the comparisons of Table A using updated CHS-consistent 'new' intangibles growth accounting for the market sectors of advanced economies between the periods 2000-2007 and 2007-2013. The source is Corrado et al. (2016), Table 8, the results of which have been simply weighted to form the regional aggregate of Europe (excluding the UK) and the USA.

The key point is that the relative decline, UK versus the international norm, in the capital intensity contribution to productivity growth seen across the two periods in Table A disappears altogether in Table B. Instead, the sole – not simply dominant - contributor to the decline in the UK's relative market sector productivity growth (1.6 percentage points) comes from the relative fall in the UK's TFP growth rate and the probably trivial impact of changes in labour quality.

3 The fall in TFP growth

Irrespective of the accounting details, it is clear that the UK's post-crisis relative decline in measured TFP growth is a major part of the puzzle. Oulton documents the fall in TFP growth rates around the world but by claiming it to be '*a factor common to virtually all the countries studied here*'[4] he overlooks the dominant role it plays in the UK's post crisis relative decline.

A comprehensive exploration of the TFP phenomenon lies well outside the scope of a short comment: as noted in the Introduction, supply-siders offer a multiplicity of explanations. Oulton's ideas nevertheless give rise to a number of possibilities which can be briefly considered:

- decline in embodied technical progress
- response to changes in relative factor prices and competitive conditions, and
- measurement error and misinterpretation

Decline in embodied technical progress

The possibility that weak investment has had bad TFP outcomes has been entertained by many observers, including Martin and Rowthorn (2012). Low investment may adversely affect the advance in TFP because of reduced embodied technical progress and fewer beneficial spillovers.

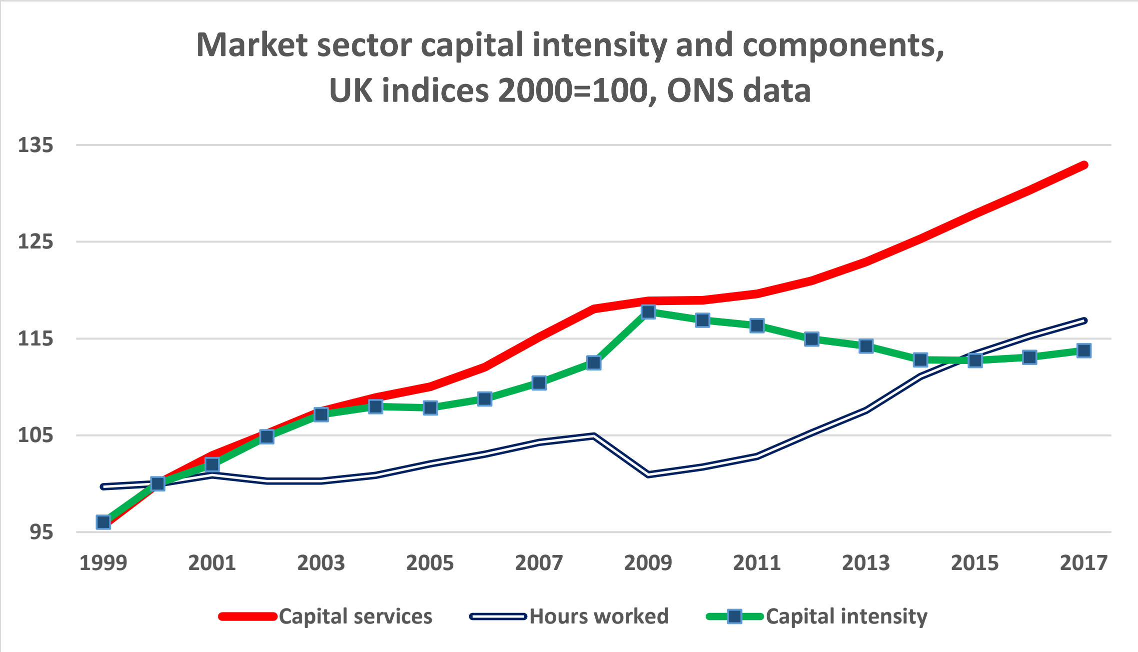
This explanation faces a challenge. The most up-to-date official evidence, displayed in Table C and Chart A, reveals continued growth in UK market sector capital services, which revived after the recession to an average 2 per cent annual rate of growth, hardly distinguishable from that seen in the 2000-2007 period. These estimates take no account of CHS 'new' intangibles. It appears that developments in capital since 2007 are unlikely to be a major cause of weak TFP. In an accounting sense, capital shallowing came about as a result of the acceleration in market sector hours worked.

Table C: UK market sector capital intensity and components

UK market sector ONS data	Logarithmic growth, % p.a. 2000-2007	2007-2012	2012-2017	Change from 2000-2007 to 2012-2017, % points
Capital services	2.0	1.0	1.9	-0.1
Hours worked	0.6	0.2	2.1	1.5
Capital intensity	1.4	0.8	-0.2	-1.6

Sources: Office for National Statistics (a) Volume index of capital services (experimental), February 2018 release, (b) Labour productivity, January 2018 release. Note: 2017 data partly estimated by the extrapolation of latest available year-on-year growth for capital services (second half) and hours worked (last quarter).

Chart A: UK market sector capital intensity and components



Sources: See Table C.

Response to factor prices and changing competitive conditions

A second possibility is that low wages may have discouraged labour-saving technical advance, an idea that can be traced back at least to Hicks's theory of wages (Hicks, 1932). The converse role that relatively high wages may have played in economic development has been explored by Habakkuk (1962) for nineteenth-century America and by Allen (2009) for eighteenth-century Britain. Theory does not give clear-cut answers, however. The possible income effect of low wages - increased profits and investment – may outweigh the possible substitution, labour-using, effects. In his theoretical paper, Acemoglu (2013) argues that labour abundance would discourage technological advances were technology naturally labour saving but would encourage technological advances were technology strongly labour complementary, the latter, Acemoglu argues, being a feature of many standard macroeconomic models.

There are related explanations. Martin and Rowthorn (2012) argue that low wages support the relative expansion of labour intensive, low-TFP, activities. Competitive conditions may have changed since the crisis enabling firms to enjoy higher super-normal profits while failing to innovate. Oulton's bad regime may come with less creative destruction and greater X-inefficiency, courtesy of abnormally low wages and interest rates, themselves the result of an underlying demand constraint. At the present time, alas, we lack an encompassing theory that explores the impact on technical advance of effective demand failure and low wages under different technological and competitive regimes.

Measurement error and misinterpretation

A third possibility is that TFP may not be a valid measure of unknown supply-side impediments when output is constrained by weak demand, even if the economy at the same time operates at 'full capacity' with full employment. This thought, not raised by Oulton, is sparked by the capital adjustment process embedded in his neo-Lewis model, which can be explained as follows.

Oulton's model is designed to ensure full employment of the exogenously-driven labour force even in the 'bad regime' when the growth of output is constrained by foreign demand for the country's exports. Oulton assumes investment and capital adjust to ensure the economy is always on its production function. The required growth of capital services can be formally derived from his equations (26) and (28) with the constrained growth of output denoted in bold red font:

$$\widehat{K} = \frac{1}{\propto}\left[\widehat{\mathbf{Y}} - \{\hat{A} + (1-\propto)\hat{L}\}\right] \qquad \text{(A)}$$

Equation (A) defines the growth of capital services that would bring capacity growth, as defined by the production function and equal to the sum of technical progress and the income-share weighted contributions of capital and labour, into equality with demand constrained output growth. Oulton's equilibrium is one in which, it may be said, demand creates its own full-employment supply.[5]

It should be noted that equation (A) is a re-arrangement of the standard growth accounting identity, with the growth of capital services on the left-hand side. The signals that drive investors to act in this fashion are not articulated by the model, however. The possibilities of Harrod-type instability or of the kind of co-ordination failures analysed by, for example, Carlin and Soskice (2018) are not addressed. The adjustment of capital in the bad regime is perhaps better regarded as a requirement that Oulton imposes on his model to deliver the model's definition of full-employment equilibrium.

The proposition that productive capacity has adjusted to weak effective demand raises a question over the standard interpretation of TFP. True TFP may or may not be correctly regarded as exogenous but, as measured, it is simply a residual quantity left over after accounting for the contributions to output growth of the growth of capital services, hours worked and labour quality, $\widehat{H}$:

$$\hat{A} \equiv \widehat{\boldsymbol{Y}} - \left[\propto \widehat{K} + (1{-}\propto)\hat{L} + (1{-}\propto)\widehat{H}\right] \qquad \text{(B)}$$

As the inverted growth accounting identity (B) helps formalise, measured TFP growth would necessarily decline were the contributions of the other factors of production assumed to be fully employed insufficient fully to account for the decline in demand-constrained output growth.

On this interpretation, the fall in the UK's TFP growth between the pre and post crisis periods (0.8 percentage points relative to the international average) would be accounted for by a 0.4 percentage point fall in demand-constrained relative output growth and by a 0.4 percentage point increase in the relative contribution of labour services growth, the latter being predominantly the result of the UK's relative expansion of hours worked (Table A).

If a demand constraint exists and capacity has adjusted to it, preserving full employment, the standard interpretation of growth accounting would be invalidated. In such circumstances, TFP growth would measure the unexplained residual impact on supply growth of the demand shortfall. Or to adapt Moses Abramovitz's famous aphorism (Abramovitz (1956, p11)), TFP would be a 'measure of our ignorance' of the mechanisms that drove productive capacity to align with low aggregate demand.

4 Demand deficiency: the role of exports

Oulton makes a novel contribution by attributing the demand constraint to flagging export demand. As he notes, the causal role played by export demand has received little attention in the literature on economic growth. This omission is even more surprising in view of the coincidence of the international productivity slowdown and the sharp post-crisis deceleration in world trade.[6]

Oulton hypothesises that the shock to trade growth led to a situation in which countries' export demand fell short of supply, which adjusted to the lower demand. The impact on output was amplified by a balance of trade constraint on domestic demand that was binding on both trade surplus and trade deficit economies.[7] Oulton's demand-side approach is distinct from supply-side theories, such as that of Melitz (2003), that link productivity enhancement to the world-trade led expansion of naturally high-productivity exporting firms, the resulting displacement of low-productivity domestic-orientated firms, and exporters' gains from increased specialisation and economies of scale and scope.

Chart B: Export market growth decline from 2000-2007 to 2007-2015

Source: Oulton (2017), Table 2 for individual economies and page 19 for cross-country mean.

Chart C: Export market growth decline weighted by exports-to-GDP share

Source: Oulton (2017), Table 2; Australian Bureau of Statistics, Bureau of Economic Analysis, Eurostat, ONS, Statistics Canada. Note: Export-to-GDP shares are calculated as an average for the periods 2000-2007 and 2008-2015 with the exceptions of Ireland (2015 omitted) and Poland (2000-2002 omitted) for the reasons noted in Oulton (2017).

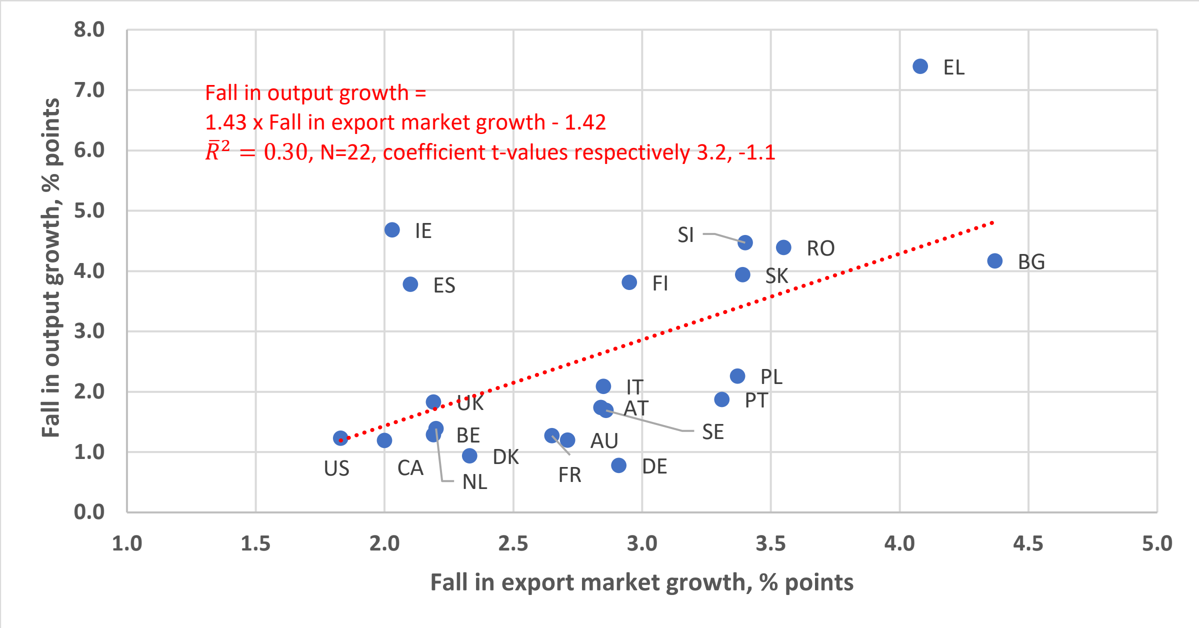
Oulton does not note that his empirical measure of export demand shock – the slowdown, after the crisis, in export market growth facing individual economies – cannot explain the UK's relative output performance. According to Oulton's measure, the fall in the UK's export market growth after the crisis was less than that seen in most overseas countries (Chart B) and similar to the average overseas experience (GDP weighted). On this basis, the UK should have experienced a similar output growth outcome, but in fact experienced a worse one (Table A). The divergence between the UK output growth outcome and prediction is not closed if allowance is made for the relative openness of economies. As Oulton argues, smaller, more open economies are likely to be more susceptible to export market shocks than larger, more closed economies. Chart C shows the UK's not unfavourable relative position once Oulton's export shock variable is weighted by a measure of openness.

Oulton nevertheless presents interesting, albeit small sample, cross-country regressions that appear to establish a relationship between changes, over the pre and post crisis periods, in productivity growth and in export market growth. Oulton's regression (3) assigns a coefficient of 1.27 to the change in export market growth and of -0.43 to the change in the growth of hours worked. Like Oulton, Rowthorn (2017) notes that the coefficient on hours worked should be -1. Rowthorn also argues that the regression may be a proxy test of a relationship between the change in export market growth and the change in output growth, rather than of the relationship, posited by Oulton, between the change in export market growth and the change in productivity growth (Annex D).

The output relationship suggested by Rowthorn, shown in Chart D, is instructive. The fit is worse than Oulton's regression (3) but the fall in export market growth remains statistically significant. There are several puzzles. The coefficient on the export market variable at 1.43 is well above that implied by the share of exports in gross domestic product. There are very large outliers: actual falls in output growth greatly exceed those predicted for Greece, Ireland and Spain. Substitution as the regressor of the export-to-GDP weighted fall in export market growth does not, as it should, improve the fit. The fit is worse and the weighted export market growth variable statistically insignificant (Chart E).
One possible explanation is that Oulton's export market growth variable is acting as a proxy for a variety of other financial-crisis related demand shocks. Candidates include insolvency and resulting austerity in Greece and the type of austerity-inducing, pathological bond market liquidity shocks in open Euro-zone economies notably identified by Paul de Grauwe (de Grauwe and Ji (2013)).

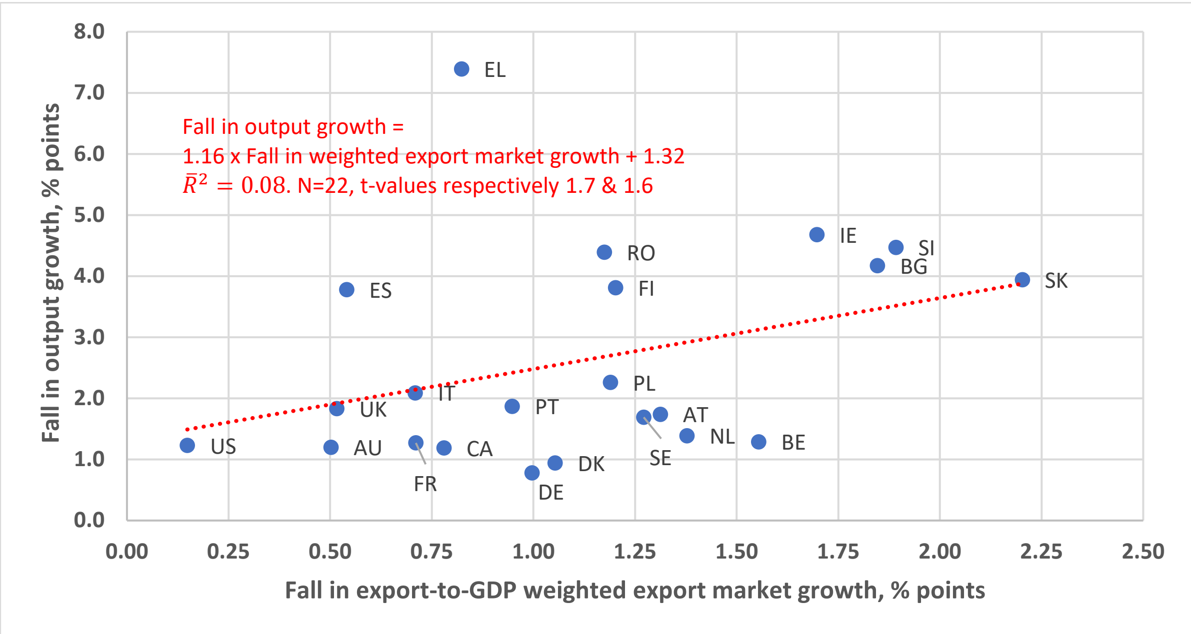
Despite my reservations about the true role played by export demand, Oulton's broader insight that the demand constraint exists and applies at the developed world level thus feels like ringing common sense and warrants much closer investigation by analysts whose productivity research specialisation too frequently invites supply-side tunnel vision.

Chart D: Falls in output growth & export market growth



Source: Oulton (2017), Table 2. Note (1) Czech Republic and Hungary omitted from Oulton's 24 country dataset due to missing observations on export market growth (Czech Republic) and productivity (Hungary). Note (2) Legend: AT (Austria), AU (Australia), BE (Belgium), BG (Bulgaria), CA (Canada), DE (Germany), DK (Denmark), EL (Greece), ES (Spain), FI (Finland), FR (France), IE (Ireland), IT (Italy), NL (Netherlands), PL (Poland), PT (Portugal), RO (Romania), SE (Sweden), SI (Slovenia), SK (Slovakia), UK (United Kingdom), US (United States).

Chart E: Falls in output growth & weighted export market growth



Sources: Oulton (2017), Table 2. Australian Bureau of Statistics, Bureau of Economic Analysis, Eurostat, Office for National Statistics, Statistics Canada. Notes (1) See notes to Chart D. (2): Export-to-GDP weights are calculated as averages for each of the periods 2000-2007 and 2008-2015.

Notes

1 References as in Oulton (2017).

2 Oulton (2017), p20.

3 The apparent anomaly does not affect Oulton's econometric results.

4 Oulton (2017) p.29.

5 The capital adjustment condition is expressed in growth rate terms; the model does not have formal integral control that would eliminate an initial output gap or unemployment that may result from a foreign demand shock.

6 World trade growth fell from 6.5 per cent p.a. to 2.9 per cent p.a. between 2000-2007 and 2007-2015. (Source: International Monetary Fund, World Economic Outlook Database, October 2017.)

7 There is an inconsistency in the derivation of the link between export market growth and output growth. Oulton's equation (26) relies on the constancy of the share '*s*' of investment in GDP. Equation (29) shows bad regime '*s*' is not constant.

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Annexes

Annex A: EU KLEMS UK productivity growth decomposition discrepancy

There exists a discrepancy in the published EU KLEMS data between the basic series for the growth of UK whole economy productivity, on the one hand, and the equivalent growth accounting series, on the other hand. The growth accounting data are used in the decomposition of productivity growth into component parts: the contributions of changes in labour quality (labour composition), capital intensity (capital services per hour worked) and the residual total factor productivity (TFP).

The basic, non-growth accounting series for value added per hour worked for the whole economy yields average logarithmic rates of growth over the periods 2000-2007 and 2007-2015 of respectively 1.91 per cent and 0.08 per cent per annum, as Table A1 shows. These figures concur exactly with Oulton (2017, Table 2) and are approximately the same as those derived from the more up-to-date Office for National Statistics productivity release (1.82 per cent and 0.09 per cent). By contrast, the EU KLEMS growth accounting series for hourly productivity growth records growth rates of respectively 1.37 per cent and -0.03 per cent.

Table A1: EU KLEMS UK labour productivity data discrepancy

UK data from EU KLEMS (EU KLEMS identifiers)	Logarithmic per cent change, p.a. 2000-2007	2007-2015
Gross value added per hour worked, calculated from basic series		
EU KLEMS index (LP_I)	1.91	0.08
GDP divided by hours worked (VA_QI ÷ H_EMP)	1.91	0.08
EU KLEMS growth accounting series (excludes sectors T and U)		
Gross value added per hour worked (LPI_Q)	1.37	-0.03
of which contributions of:		
Labour composition (LPIConLC)	0.31	0.37
IT capital (LPIConKIT)	0.22	0.08
Non-IT capital (LPIConKNIT)	-0.17	-0.17
Sum of IT and non-IT capital	0.05	-0.10
TFP (LPIConTFP)	1.01	-0.30
Sum of contributions	1.37	-0.03
Memo:		
Capital services per hour worked (CAP_QI ÷ H_EMP)	1.86	0.22
ONS data for whole economy output per hour worked	1.82	0.09

Source: EU KLEMS, September 2017 release (www.euklems.net); Office for National Statistics, release 5th January 2018 (CDID: LZVB) https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity ,

The discrepancy cannot be attributed to the exclusion from the growth accounting data of the minor industry sectors covering the activities of households and exterritorial organisations (Standard Industrial Classification industry sections T and U). The impact on overall average productivity growth rates of these exclusions is of second order (second decimal point) significance.
The discrepancy is reflected in the self-evidently too low EU KLEMS estimates of the contribution to productivity growth of capital intensity. Whole economy capital intensity – capital services per hour worked - grew by 1.86 per cent per annum in the 2000-2007 interval and by 0.22 per cent per annum in the 2007-2015 interval. Using a crude method rather than the exact Törnqvist weighting procedure and taking a capital income share of approximately 35%, the contributions of capital intensity to annual productivity growth should be closer to 0.65 per cent (c.f. 0.05 per cent) in the first period and 0.08 per cent (c.f. -0.10) in the second period.

Corrected estimate of the contribution of capital intensity can be derived from the EU KLEMS output growth accounting data. As Table A2 shows, the growth accounting contributions sum to estimates of the growth of the chained-volume measure of value added which, unlike the productivity data, do not differ significantly from the EU KLEMS basic series. The minor difference in the growth rates of overall output recorded by the basic and growth accounting series is attributable to the exclusion from the growth accounting data of the two minor industry sectors, T and U.

Table A2: EU KLEMS UK output growth decomposition

UK data from EU KLEMS (EU KLEMS identifiers)	Logarithmic per cent change, p.a. 2000-2007	2007-2015
Gross value added calculated from EU KLEMS:		
Basic series VA_QI	2.61	0.78
Growth accounting series VA_Q (excludes sectors T and U)	2.63	0.79
of which contributions of:		
Hours worked (VAConH)	0.40	0.41
Labour composition (VAConLC)	0.31	0.37
IT capital (VAConKIT)	0.23	0.09
Non-IT capital (VAConKNIT)	0.67	0.22
Sum of IT and non-IT capital	0.91	0.31
TFP (VAConTFP)	1.01	-0.30
Sum of contributions	2.63	0.79
Memo:		
Capital services excluding sectors T and U (CAP_QI)	2.56	0.92

Source: EU KLEMS, September 2017 release (www.euklems.net)

The estimated output growth contributions pass a simple test for coherence. As they should be, the contributions of labour composition and TFP are the same for output and for productivity. The output contributions of capital services are approximately equal to the growth rates of capital services weighted by a capital income share of 35%.

The output growth decomposition estimates offer a means to derive corrected estimates of the contribution of capital intensity to productivity growth. Consider the standard growth accounting equations for the growth of output and productivity:

$$\hat{Y} \equiv (1-\alpha)\hat{L} + (1-\alpha)\hat{H} + \alpha\hat{K} + \hat{A} \quad \text{(A1)}$$

$$\hat{y} \equiv (1-\alpha)\hat{H} + \alpha\hat{k} + \hat{A} \quad \text{(A2)}$$

Variables are defined as in Oulton (2017) with the addition of $\hat{H}$ designating the growth of labour quality, the result of changes in labour composition.

The EU KLEMS data error arises in the term $\alpha\hat{k}$ in equation (A2). A corrected estimate can be derived from the output growth equation (A1) and the growth of hours worked, noting that:

$$\alpha\hat{L} \equiv \hat{L} - (1-\alpha)\hat{L} \quad \text{(A3)}$$

$$\alpha\hat{k} \equiv \alpha\hat{K} - \alpha\hat{L} \quad \text{(A4)}$$

To be consistent with the growth accounting series, hours worked refer here to the whole economy less hours worked in sectors T and U.

Table A3 shows the detail of these re-calculations. The contribution of capital intensity to annual average productivity growth over the two periods 2000-2007 and 2007-2015 is put at 0.61 per cent and -0.01 respectively. These estimates are close to, but more precise than, the back-of-envelope calculations assuming fixed income shares and are coherent with the recorded growth in national productivity, as Table A4 shows.

Table A3: Re-calculation of capital intensity contribution to productivity growth

UK data from EU KLEMS (EU KLEMS identifiers)	Logarithmic per cent change, p.a. 2000-2007	2007-2015
Hours worked:		
Whole economy (H_EMP)	0.69	0.70
$\hat{L}$ whole economy excluding sectors T and U (EU KLEMS data)	0.70	0.72
From contributions to output growth EU KLEMS accounting:		
$(1-\alpha)\hat{L}$	0.40	0.41
$\alpha\hat{K}$	0.91	0.31
Calculation of:		
$\alpha\hat{L} \equiv \hat{L} - (1-\alpha)\hat{L}$	0.30	0.32
$\alpha\hat{k} \equiv \alpha\hat{K} - \alpha\hat{L}$	0.61	-0.01

Source: EU KLEMS, September 2017 release (www.euklems.net)

Table A4: EU KLEMS UK labour productivity data corrected

UK data from EU KLEMS (EU KLEMS identifiers)	Logarithmic per cent change, p.a. 2000-2007	2007-2015
Gross value added per hour, whole economy		
EU KLEMS index (LP_I)	1.91	0.08
EU KLEMS growth accounting series (excludes sectors T and U)		
Gross value added per hour, (VA_Q and EU KLEMS hours data)	1.93	0.07
of which contributions of:		
Labour composition (LPIConLC)	0.31	0.37
Capital intensity derived from output growth accounting	0.61	-0.01
TFP (LPIConTFP)	1.01	-0.30
Sum of contributions (correctly rounded)	1.93	0.07

Source: EU KLEMS, September 2017 release (www.euklems.net)

Annex B: UK growth accounting before and after the financial crisis

Table B1: UK growth accounting pre- and post-crisis: alternative periods and sources

United Kingdom	Logarithmic growth, p.a. %			Change from 2000-2007	
Data sources and sector	**2000-2007**	**2007-2015**	**2009-2015**	**2007-2015**	**2009-2015**
KLEMS Whole economy					
Productivity	1.9	0.1	0.5	-1.9	-1.4
of which, contributions of:					
Labour quality	0.3	0.4	0.4	0.1	0.1
Capital intensity	0.6	0.0	0.0	-0.6	-0.6
TFP	1.0	-0.3	0.1	-1.3	-0.9
KLEMS Market sector					
Productivity	2.7	0.1	0.8	-2.7	-2.0
of which, contributions of:					
Labour quality	0.4	0.3	0.4	-0.1	0.0
Capital intensity	0.8	0.1	0.1	-0.6	-0.7
TFP	1.5	-0.4	0.3	-1.9	-1.2
ONS Market sector					
Productivity	2.3	-0.3	0.2	-2.6	-2.1
of which, contributions of:					
Labour quality	0.2	0.4	0.4	0.2	0.2
Capital intensity	0.6	0.1	-0.3	-0.5	-0.8
TFP	1.5	-0.8	0.1	-2.4	-1.4
Tenreyro Market sector					
Productivity	2.0	n.a.	0.4	n.a.	-1.5
of which, contributions of:					
Labour quality	0.4	n.a.	0.5	n.a.	0.1
Capital intensity	1.1	n.a.	0.1	n.a.	-1.0
TFP	0.6	n.a.	-0.2	n.a.	-0.8
Labour reallocation, other	-0.1	n.a.	0.1	n.a.	0.2

Sources: EU KLEMS, September 2017 release; Office for National Statistics, Multi-factor productivity estimates, April 2017 release, Tenreyro (2018).

Annex C: Lewis model reduced-form production function

Oulton takes for simplicity a Cobb-Douglas production function of the form:

$$Y = AK^{\alpha}L^{1-\alpha} \qquad \text{(B1)}$$

In the Lewis model with a perfectly elastic supply of labour, labour is hired to the point at which the marginal product of labour is equal to the exogenous wage ($\boldsymbol{w}$):

$$(1-\alpha)AK^{\alpha}L^{-\alpha} = \boldsymbol{w} \qquad \text{(B2)}$$

Re-arrangement of equation B2 gives the level of labour demand:

$$L = \left(\frac{1-\alpha}{\boldsymbol{w}}\right)^{\frac{1}{\alpha}} A^{\frac{1}{\alpha}}\,\mathrm{K} \qquad \text{(B3)}$$

The substitution for L in equation (B1) using equation (B3) yields a reduced form *AK*-type production function:

$$Y = \tau A^{\frac{1}{\alpha}}\,K \qquad \text{(B4)}$$

where $\tau = \left(\frac{1-\alpha}{\boldsymbol{w}}\right)^{\frac{1-\alpha}{\alpha}}$, a constant if the wage is constant, as Oulton assumes.

The growth rates of output and labour productivity are respectively given by:

$$\hat{Y} = \frac{1}{\alpha}\hat{A} + \hat{K} \qquad \text{(B5)}$$

$$\hat{y} = \frac{1}{\alpha}\hat{A} + \hat{k} \qquad \text{(B6)}$$

Capital services and capital intensity growth enter respectively with unit coefficients in contrast to the conventional factor-income share weighted structural forms:

$$\hat{Y} = \hat{A} + \alpha\hat{K} + (1-\alpha)\hat{L} \qquad \text{(B7)}$$

$$\hat{y} = \hat{A} + \alpha\hat{k} \qquad \text{(B8)}$$

Annex D: Note on Oulton (2017) by Bob Rowthorn, 30th December 2017

Oulton regresses $\Delta\hat{y}$ on $\Delta\hat{Z}$ and $\Delta\hat{L}$. Z is Oulton's proxy for world demand, calculated as the export-share weighted sum of trading partners' imports. The coefficients on each variable are highly significant, and when both variables are included are equal to 1.27 and -0.43 respectively. They are equal to 1.15 and -0.37 when included separately.

How are these results to be interpreted?

Oulton's regression (3) is based on the following equation:

$$\Delta\hat{y}_i = \left(\mu_i^A - \mu_i^B\right) + \pi_z \Delta\hat{Z}_i + \pi_L \Delta\hat{L}_i + \left(\varepsilon_i^A - \varepsilon_i^B\right)$$

If $\Delta\hat{Z}$ and $\Delta\hat{Y}$ were perfectly correlated across countries, there would be an exact relationship of the form $\Delta\hat{Y} = b + \theta\Delta\hat{Z}$ for some constant b. Since $\Delta\hat{y} = \Delta\hat{Y} - \Delta\hat{L}$ there would then be an exact relationship of the form $\Delta\hat{y} = b + \theta\Delta\hat{Z} - \Delta\hat{L}$. The estimated values of π_z and π_L would then be exactly equal to θ and -1 respectively, no matter what the causal link (if any) between $\Delta\hat{y}$ and $\Delta\hat{Y}$ or between $\Delta\hat{y}$ and $\Delta\hat{Z}$. In fact, the estimated value of π_L in regression (3) is -0.43 instead of -1. This divergence must be due entirely to the imperfect correlation between $\Delta\hat{Z}$ and $\Delta\hat{Y}$.

I am not sure how far regressions (1) to (4) can be interpreted as an explanation for the behaviour of $\Delta\hat{y}$. They may, in fact, be proxy tests of the equation $\Delta\hat{Y} = b + \theta\Delta\hat{Z}$. It would be useful to see this equation estimated directly.

In equation (7) Oulton regresses $\Delta\hat{k}$ on $\Delta\hat{Z}$ and $\Delta\hat{L}$. The coefficient on $\Delta\hat{Z}$ is statistically insignificant and the coefficient on $\Delta\hat{L}$ is eight times its standard error and equal to -0.61. Results are similar in regressions (5), (6) and (8). These results might be explained as follows. Suppose that $\Delta\hat{K}$ has a low correlation with $\Delta\hat{L}$. Since $\Delta\hat{k} = \Delta\hat{K} - \Delta\hat{L}$ there will then be a high negative correlation between $\Delta\hat{k}$ and $\Delta\hat{L}$, which is what we observe. It would be useful to see the result of regressing $\Delta\hat{K}$ on $\Delta\hat{L}$.

More generally, it would be useful to see a correlation matrix of all the variables $\Delta\hat{Z}, \Delta\hat{Y}, \Delta\hat{K}, \Delta\hat{L}, \Delta\hat{y}; \Delta\hat{k}$.