

# **The UK (and Western) Productivity Puzzle: Does Arthur Lewis Hold the Key?**

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## ABSTRACT

I propose a new explanation for the UK productivity puzzle. I graft the Lewis (1954) model onto a standard Solow growth model. What I call the neo-Lewis model is identical to the Solow model in good times. But in bad times foreign demand for a country's exports is constrained below potential supply. This makes labour productivity growth depend negatively on the growth of labour input. I also argue that the neo-Lewis model can explain the fall in TFP growth, in the UK and elsewhere, after 2007. The predictions of the neo-Lewis model are tested on data for 23 advanced countries and also on a larger sample of 52 countries and find support.

JEL codes     E24, O41, O47, J24, F43, F44

Keywords     Productivity, slowdown, TFP, capital, Lewis, immigration

# 1. INTRODUCTION<sup>1</sup>

Labour productivity has barely grown at all in the UK since the last boom ended at the beginning of 2008. The decade of productivity stagnation since then is even more surprising given that before the crisis the UK's productivity growth was one of the highest amongst the advanced economies. The productivity puzzle is the greatest challenge facing UK economic policy, far larger than Brexit. The OECD recently projected that after Brexit the UK's GDP will be 5% lower by 2030 than it would have been if the UK remained in the EU (OECD 2016, their central scenario). But since they also expect migration to fall, the effect on GDP per capita will be smaller, a loss of 3%. This compares with a loss of about 21% in GDP per hour, relative to the pre-crisis trend, which has already been incurred by 2017 (Office for Budget Responsibility, 2017). And this loss is expected to continue and grow: the OBR is now forecasting productivity growth of only 0.9% pa this year, rising to 1.2 % pa in 2022. Even this meagre rate represents a substantial improvement over actual performance since 2007, which has seen effectively zero growth. The real product wage has moved in line with labour productivity. So since 2007 its growth has been close to zero too.

On the other hand the performance of the labour market has been excellent. True, as the Great Recession began unemployment rose rapidly above its pre-crisis level but it has since declined and at 4.3% is now lower than at the peak of the boom. Employment too took a hit during the recession itself, which saw a fall in GDP of over 6% from the peak to the trough quarter, but it has subsequently grown as fast as during the boom. In summary, an excellent labour market performance has accompanied an unprecedentedly poor productivity performance. This is the twofold puzzle of the UK economy since the Great Recession.

The productivity puzzle has been much discussed and much reviewed (Oulton 2016a; Haldane 2017; Tenreyro 2018), but without any consensus so far being reached. Here I propose a new explanation based on insights gained from the work of Arthur Lewis. Briefly,

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<sup>1</sup> An early version of this paper was presented at a seminar in the Department of Economics, University of Queensland, on 20<sup>th</sup> October 2017. I am grateful to participants, particularly to Alicia Rambaldi, for useful comments. A subsequent version was presented at a Centre for Macroeconomics (LSE) seminar on 12th March 2018 where again useful comments were received. The present version has benefited from comments by Bill Martin, Andrew Gurney, Steve Millard, Rebecca Riley, Bob Rowthorn, Martin Weale, Silvana Tenreyro, Jonathan Haskel, Francesco Caselli and Charlie Bean. I am particularly grateful to Bill Martin for a lengthy comment on the previous version (Martin, 2018) as a result of which the paper has been extensively revised and now includes a section on TFP.

the argument is as follows. After the recession began, many countries, particularly in Europe, suffered from a deficiency in foreign demand for their exports. This situation has persisted into the recovery period, after GDP stopped actually falling. The slower growth of exports led to slower growth of GDP. The effect of this on labour productivity depended on the nature of labour market institutions. In the UK for example labour input went on rising at much the same rate after the crisis as it had done before. This was possible because of our flexible labour market which allowed workers to price themselves into jobs. With the same growth of labour input but slower growth of GDP post-crisis, the growth rate of labour productivity necessarily fell. Both before and after the crisis the bulk of the increase in labour input was due to immigration. In continental Europe by contrast labour markets are less flexible. So the growth of labour input was constrained; in fact labour input declined in most countries. Consequently the slowdown in labour productivity was less pronounced in continental Europe than in the UK.

This explanation puts the blame for the slowdown squarely on the Great Recession. However the accepted view now seems to be that continuing low productivity growth has little or nothing to do with the recession. It is instead explained by a decline in the growth rate of TFP which predated the crisis. This decline is partly exogenous, due to the fading effects of the ICT revolution, But it also partly endogenous, due to weaknesses in the competitive process, which again predate the recession (Bergaud et al, 2014; Fernald, 2015; Cette et al., 2016). This has been compounded in some countries by failure to adopt the type of structural reforms long advocated by the OECD. These authors have given good reasons for expecting TFP growth to be lower in future than it was in the US in the glory days of the ICT revolution. And there does seem to be evidence that the competitive process has been weakening; for example, laggard firms seem to have increasing difficulty in catching up to the leading ones (see e.g, Cette et al., 2018). But this is not the whole story. The collapse in TFP growth, particularly in Europe, is too large to be explained by these forces and moreover the timing is suspicious. I argue instead that the Great Recession itself did significant damage to TFP growth through a number of channels. There is industry-based evidence for increasing returns: an industry's TFP growth rate is higher when the economy is expanding more rapidly (Hall, 1988; Caballero and Lyons, 1990; Bartelsman et al., 1994; and Oulton, 1996). So raising the growth rate of GDP would also raise the growth rate of TFP and consequently of labour productivity.

The plan of the paper is as follows. First, I briefly review the UK's performance concentrating on the period since 2000. Next I compare the UK with other EU and non-EU countries (Australia, Canada, and the United States) over the same period. Here I make use of the latest release of the EU KLEMS dataset (September 2017; see [www.EUKLEMS.net](http://www.EUKLEMS.net)). Next in Section 3 I consider whether the standard growth model due to Solow (1956) can explain the data. This is a reasonable question to ask of the model, at least for the UK, since it assumes full employment which is what we now have. I conclude that the Solow model cannot explain the UK experience since 2007. In Section 4 I set out the Lewis (1954) model of growth with unlimited supplies of labour in a dualistic economy. Then in Section 5 I construct what I call the neo-Lewis model in which the spirit of the original model is (I hope) preserved. It turns out that the neo-Lewis model is just the same as the Solow model, except in a "bad regime" when export demand is below potential export supply. In Section 6 I confront the neo-Lewis model with the facts as revealed in the new EU KLEMS dataset. Then in Section 7 I turn to what has become the orthodox view of the productivity slowdown in Britain and elsewhere, namely a slowdown in TFP growth which started before the recession. I argue that the pre-existing slowdown is too small to account for the collapse in TFP growth which has occurred since 2007. I argue instead that the bulk of the slowdown, particularly outside the US, is due to the recession itself. The mechanism is increasing returns, working in reverse. Section 8 contains discussion and justification of the assumptions behind the neo-Lewis model and also some extensions. Section 9 is devoted to the policy implications of the new model and Section 10 concludes.

## 2. THE UK PRODUCTIVITY PUZZLE

### *2.1 The UK economy: the twofold puzzle*

#### *GDP and labour productivity*

GDP peaked in 2008Q1 and then fell for 5 consecutive quarters. The cumulative fall in output from peak to trough in 2009Q2 was 6.1%. From 2009Q3 GDP began to grow again and growth has been positive in nearly every quarter up to now. But in 2017Q3 GDP was only

9.7% higher than at the previous peak nearly ten years earlier, in other words the growth rate of GDP since 2008Q1 was only 0.98% pa.<sup>2</sup>

The course of labour productivity since 1997Q1 is shown in Chart 1. Productivity was growing strongly up till 2008Q1. It fell sharply during the Great Recession which was not surprising given the large fall in GDP and experience in previous recessions. What has come as a great surprise is that though productivity growth has been generally positive since the trough it has been so slow that the productivity level in 2017Q2 was still below the previous peak in 2007Q4. So since the peak nearly ten years earlier productivity growth has been virtually zero, even though the recession proper only lasted for 5 quarters. This is the productivity puzzle.

### *The labour market*

Unemployment was 5.2% at the end of the boom in 2007Q4. It then rose sharply to peak at 8.4% in 2011Q4. But since then it has fallen steadily to stand at 4.3% in 2017Q3 (Chart 2). This fall in unemployment during the recovery from the Great Recession coincided with a rapid rise in employment which rose at 0.95% pa from 2000 to 2007. Employment growth slowed slightly during and after the recession, but still grew at 0.85% pa from 2007 to 2016 (Chart 3 and Table 1). Between 2000 and 2016 an additional 4.2 million people entered employment.

How is it possible for the UK, with its typical Western European demography, to increase employment at such a rapid rate? The answer of course is immigration. From 2000-2007 employment amongst the UK-born grew at only 0.32% pa and this slowed quite sharply to 0.18% afterwards. By contrast employment of the foreign-born grew at 6.67% pa during the boom and at a still impressive 4.85% pa in the subsequent period. If we break down the foreign-born into those born in the EU27 and those born elsewhere we see that since 2007 there has been no slowdown in the growth of those born in the EU but a halving of the growth rate of those born outside the EU. Amongst the EU-born there has been a large change in composition: those born in the accession countries (the A10) now account for 58% of the EU stock. But despite the rapid growth of migrants from the EU, migrants from the rest

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<sup>2</sup> Source: Office for National Statistics, <https://www.ons.gov.uk/economy/grossdomesticproductgdp/timeseries/abmi/pn2>, accessed on 10/12/2017. Seasonally adjusted, CVM, £m. Variable cdid: ABMI.

of the world still constitute 58% of the foreign-born (Table 1). In all the foreign-born accounted for 17% of UK employment in 2016, up from 8% in 2000.<sup>3</sup>

Alongside employment, total hours worked also increased rapidly both before and after 2007. From 2000 to 2007 hours rose at 0.72% pa and from 2007 to 2016 at 0.87% pa. So not only did total hours rise more rapidly after the boom ended but hours worked per worker also increased slightly.<sup>4</sup>

### *2.3 International comparisons*

#### *The data*

Most of the data used here and below come from the latest release of the EU KLEMS dataset (September 2017; available at [www.euklems.net](http://www.euklems.net)). These data go up to 2015 while in previous releases the data ended in 2007. For most countries the data go back to 1995 but I have mostly used data from 2000 as this was a cyclical peak in the US (the end of the dot-com bubble) and a “growth pause” in other countries like the UK. The great advantage of the EU KLEMS dataset is that labour productivity, hours worked, investment, capital services, human capital, and TFP are measured on a consistent basis across countries. In particular capital services (as well as capital stocks) are provided. Capital services is the appropriate measure for productivity analysis (OECD 2009) though unfortunately it is not part of the System of National Accounts and so not provided routinely by national statistical agencies.<sup>5</sup>

29 countries are included in the latest release including (despite the name of the dataset) the US. In previous releases Australia, Canada and Japan were also included but are omitted from the September 2017 release. I have added Australia and Canada to the data used here since these have constructed their own productivity accounts using very similar principles to EU

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<sup>3</sup> These statistics are from the ONS, “Employment by country of birth and nationality”, August 2017 ( a spreadsheet entitled emp06aug2017.xlsx) and are for country of birth. The ONS also publishes a breakdown of employment by nationality which shows substantially lower figures for foreigners. But this is because many of the foreign-born become British citizens. For present purposes, country of birth is the relevant measure.

<sup>4</sup> Office for National Statistics, Labour Force Survey, downloaded on 10/12/2107 from <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/timeseries/ybus/lms>. Variable cdid: YBUS.

<sup>5</sup> The EUKLEMS capital services measure is constructed out of asset stocks in the national accounts of the countries who provided these data. EU KLEMS constructs capital services as a rental-price-weighted aggregate over these stocks. As the website notes, there is a possible inconsistency here as each country uses its own assumptions about depreciation to estimate stocks while EU KLEMS uses a common set of depreciation rates (very similar to the rates used by the BEA in the US) to estimate rental prices.



KLEMS.<sup>6</sup> However for these two countries the unit of analysis is the market or business sector while for the rest it is the whole economy. Japan is still omitted since I was not able to find recent productivity accounts for this country. I have also excluded 6 countries due to their very small size: Cyprus, Estonia, Latvia, Lithuania, Luxembourg and Malta. Most data are missing for Croatia.

In summary, for the countries included here, 24 have data on GDP, 23 on labour productivity and hours worked, and 16 have data on capital intensity and TFP.

### *Results*

Table 2 shows the pattern of growth before and after the crisis. GDP growth declined in all 24 countries post-crisis by on average 2.69 percentage points. Greece, Finland, Italy, Portugal and Slovenia had negative growth in GDP post-crisis, i.e. in 2015 their GDP was still below the 2007 level. GDP growth in the UK was above the mean post-crisis: better than in France, and a bit less than in Germany and the US.

Before the crisis, the growth of hours in the UK was below the cross-country mean though faster than in France, Germany, Italy and the US. After the crisis hours declined in all countries except Denmark, Germany, Romania and Sweden. In the UK hours grew slightly faster after 2007 than before. Hours grew at a faster rate in the UK post-crisis than in any other country except Canada and Sweden.

Before the crisis labour productivity was growing more rapidly in the UK than in most of the advanced countries, faster than in Canada, France, Denmark, Germany, Ireland, Italy, the Netherlands and the US, though slower than in Australia, Finland and Sweden. Some emerging markets like Bulgaria, Czech Republic, Romania, Slovakia, Slovenia and even Greece did better which likely reflects their catch-up potential. After the crisis labour productivity growth fell in 18 out of 22 countries, on average by 1.34 percentage points. In the UK growth was slower than in any other country except Finland and Greece where growth was negative. In these two countries GDP growth was also negative.

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<sup>6</sup> Data for Canada are from Statistics Canada, downloaded on 17/11/2017 from <http://www.statcan.gc.ca/eng/start>, a spreadsheet named cansim-3830021.xls. For Australia they are from Australian Bureau of Statistics, downloaded on 17/11/2017 from <http://www.abs.gov.au/AusStats/ABS@.nsf/MF/5260.0.55.002>, a spreadsheet named 52600550022016.xls.

The growth of capital intensity fell in 9 out of 15 countries after the crisis. In the UK it grew at only 0.22 % pa after 2007. This compares with 1.04% pa in Germany, 1.27% in France and 0.96% in the US.

In summary, there is no striking difference between the UK and these other countries in GDP growth post-crisis. What is striking about the UK though is labour productivity growth (close to zero) and the growth of hours (comparatively rapid). The UK also saw the largest decline in the growth of capital intensity of any country here.

One other feature stands out in Table 2. After 2007 TFP growth fell in 12 out of 14 countries including in the UK. The only exceptions were Canada and Italy where TFP growth has been negative since 2000. TFP levels actually fell in 13 countries. In TFP the US performed best after 2007 but even here the growth rate declined by 0.54 percentage points; the level of TFP in the US was only a bit over 1% higher in 2015 than it had been in 2007. In the UK the growth rate fell by 1.3 percentage points.

### 3. CAN THE SOLOW MODEL EXPLAIN THE PUZZLE?

Let us consider whether the textbook model of economic growth due to Solow (1956), still the workhorse model in many applications, can help to explain what has been happening in the UK in the boom, the Great Recession and the subsequent recovery. I first set out the theory briefly and then discuss its application to the UK.

#### 3.1 Theory

The aggregate production function, assumed to be constant returns to scale and for simplicity to take the Cobb-Douglas form, is

$$Y = AK^\alpha L^{1-\alpha} \quad 0 < \alpha < 1$$

or

$$y = Ak^\alpha \quad y := Y / L; \quad k := K / L \tag{1}$$

Here  $Y$  is output (GDP),  $A$  is the level of TFP,  $L$  is labour (hours), assumed to be growing at the rate  $n$ ,  $K$  is capital,  $y$  is output per unit of labour (productivity),  $k$  is the capital-labour

ratio (capital intensity) and the parameter  $\alpha$  can be identified with the share of capital.

Capital accumulates in accordance with the following law:

$$\dot{K} = sY - \delta K \quad (2)$$

Here  $s (= I/Y)$  is the investment ratio and  $\delta$  is the depreciation rate, both assumed constant.

Using (1) we can rewrite this as

$$\hat{k} = sAk^{\alpha-1} - \delta - \hat{L} \quad (3)$$

where a hat (^) denote a growth rate. e.g.  $\hat{y} = \dot{y}/y$ . The growth rate of productivity is

$$\hat{y} = \hat{A} + \alpha\hat{k} \quad (4)$$

Equations (3) and (4) constitute the short run dynamics of the model. We can use them to solve for the paths of  $y$  and  $k$ , given the initial level of  $k$  and the path of  $L$ .

As Solow showed, the model possesses a steady state where the steady state growth rate of GDP is:

$$\hat{Y}^* = \frac{\hat{A}}{1-\alpha} + n$$

Here  $n$  is the growth rate of labour, assumed to be constant in the steady state, and a star (\*) denotes the steady state. The steady state growth rate of GDP per hour (productivity), denoted by  $g$ , which is also the steady state growth rate of capital intensity ( $k$ ), is therefore

$$g := \hat{y}^* = \hat{k}^* = \frac{\hat{A}}{1-\alpha} \quad (5)$$

Note that the growth rate of hours ( $n$ ) has no effect on the long run growth rate of productivity or of capital intensity.

### 3.2 Application to the UK

Suppose now we consider an economy in a long run steady state as described by equation (5) which is now subject to a labour supply shock, an unexpected one-off rise in the labour supply with no change in any of the parameters. This is a standard exercise in the manipulation of the Solow growth model where we seek to characterise the transition path from one equilibrium to another. The increase in the labour supply lowers the capital-labour ratio. So the marginal product of labour falls as does the real wage; the latter change is necessary to maintain full employment. The steady state growth rate and level of productivity are unchanged. So after the (instantaneous) fall in the capital-labour ratio the capital stock

must grow more rapidly than before for a while, in order to restore the capital-labour ratio to its long run level; there is an incentive to do this because the marginal product of capital has risen. Productivity and the real wage must also grow more rapidly for a while.

This process does not sound very like what has been happening in the UK since 2007. It is possible however that what we are observing is a *sequence* of labour supply shocks, each of which reduces the real wage below its equilibrium path. When the sequence of shocks comes to an end, an investment boom will be unleashed driving the economy back up to equilibrium, though in the UK this has yet to be observed. But it is difficult to see the evolution of labour supply as a sequence of shocks given that it is a continuation of the pre-crisis trend. We could of course save the Solow model by applying the capital accumulation equation (3) in a tautological way, using the lower investment ratio and lower TFP growth rate observed after 2007. But this would not be very convincing. I therefore turn now to an alternative model of growth due to Arthur Lewis.

#### 4. THE LEWIS MODEL OF DEVELOPMENT IN A DUAL ECONOMY

In 1954 Arthur Lewis published a seminal article on economic development in a dual economy (Lewis, 1954); see Gollin (2014) for a modern assessment.<sup>7</sup> His vision was based on the colonial economies of his own day in which a small modern, capitalist sector is embedded in a larger economy which uses pre-modern technology, the subsistence sector. The capitalist sector uses modern technology and has high average labour productivity while in the subsistence sector average productivity is low. The subsistence sector can be identified with agriculture though Lewis argued it could be extended to include petty traders and the servants of the well-to-do. He argued that in the subsistence sector the marginal product of

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<sup>7</sup> W. Arthur Lewis (1915-1991) was awarded the Nobel Prize in Economics in 1979. He has fallen out of fashion in modern discussions of economic growth. Acemoglu (2009, chapter 21, section 21.3.1) presents a model of dualistic growth based on Lewis (1954). But it formalises only the closed economy version of the Lewis model and lacks the crucial element of foreign demand. He takes the essential element of the model to be a barrier preventing free migration between urban and rural areas whereas Lewis emphasises the ease of migration. In Barro and Sala-i-Martin (2004) Lewis's 1954 article appears in the list of references but he is not mentioned in the text. Lewis does not appear at all in Jones (2002).

labour is zero so there is surplus labour. People in the subsistence sector can be attracted to work in the capitalist sector by paying a wage which gives a (probably small) premium over the subsistence level of income; the latter is determined either by the average productivity of labour in the subsistence sector or by convention. This process can continue and the capitalist sector can expand till the surplus labour is exhausted.

We can formalise the Lewis model by assuming that in the capitalist sector a production function of the Solow type applies: see equation (1). Technical progress is assumed to be zero in the subsistence sector. The real wage ( $w$ ) in the capitalist sector is a constant, determined by the subsistence level of income plus some premium necessary to cover the costs of migration out of the subsistence sector. Capitalists set the real wage equal to the marginal product of labour:

$$w = (1 - \alpha)AK^\alpha L^{-\alpha} = (1 - \alpha)Ak^\alpha$$

Migration from the subsistence sector keeps the real wage constant:

$$w = \hat{A} + \alpha k^\alpha = 0$$

which implies that

$$\hat{k} = -\hat{A} / \alpha \leq 0 \text{ if } \hat{A} \geq 0$$

(Lewis (1954) generally takes  $\hat{A} = 0$  though he certainly envisaged the possibility of technical progress). Consequently in the capitalist sector

$$\hat{y} = \hat{A} + \alpha \hat{k} = \hat{A} - \hat{A} = 0 \quad (6)$$

i.e. productivity growth is zero: any technical progress is offset by falling capital intensity.

In the Lewis model, as long as unlimited supplies of labour last, growth in the capitalist sector is driven by demand for the products of this sector. Lewis is not very explicit about this, but one interpretation is that the capitalist sector is producing for export, e.g. the products of mines, plantations, or labour-intensive manufacturing, as in the export-processing zones later established by many developing countries, for which domestic demand is insignificant. So the model can be completed by adding an equation for demand and a market-clearing condition:

$$Y^d = g(Z) = \gamma Z^\theta \quad \gamma > 0, \theta > 0 \quad (7)$$

where  $Y^d$  is foreign demand for the country's exports and  $Z$  is world demand. I have picked a convenient functional form which will be useful below. The market-clearing condition is

$$Y = Y^d \quad (8)$$

Then the long run growth rate of output in the capitalist sector, as long as labour supplies last, is given by  $\theta\hat{Z}$  and this equals the growth rate of the capitalist labour force :

$$\hat{Y} = \hat{A} + \alpha\hat{k} + \hat{L} = \hat{L} = \theta\hat{Z}$$

using (6).

The Lewis model unlike the Solow model does not make truly long run predictions about growth, since the surplus labour which drives the model will eventually be exhausted. After that point Lewis expected growth to be determined by what he called the “neo-classical” model, by which he meant I suppose something like the Solow model though the latter was not to be published till two years after his own. If the Solow model applies after surplus labour is exhausted, then technical progress has to be the driver of growth in the long run.

If despite this caveat we compare the predictions of the two models we can note the following contrasts:

1. In Lewis growth is the opposite of “inclusive”. Due to the expansion of the capitalist sector GDP and profits rise but the workers get no benefit: their real wages are constant. In Solow the rising tide lifts all boats.
2. This difference in the conclusions is driven by the different assumptions about labour. In Solow growth of the labour force is exogenous, in Lewis it is endogenous (at least in the capitalist sector) and driven entirely by the demand of employers which in turn is driven by foreign demand.

## 5. THE NEO-LEWIS MODEL

How can the Lewis model, whatever its merits as a model of growth in a dual economy, have any application to a developed economy like the UK? The answer is that we can consider the whole UK economy as like the capitalist sector of the Lewis model. The “subsistence” sector is now the rest of the world. The UK economy can draw on the rest of the world to augment its own home-grown labour.<sup>8</sup>

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<sup>8</sup> Interestingly, Lewis himself foresaw this application of his model. He writes: “When capital accumulation catches up with the labour supply, wages begin to rise above the subsistence level, and the capitalist surplus is

The Lewis model, at least in my interpretation, has two essential elements. First, demand for exports is driven by demand in the rest of the world; second, labour input is endogenous and driven by the demands of employers. In what follows, which I call the neo-Lewis model, I maintain the first element but then have to explain how export demand determines demand for the remainder of UK output. I drop the second element since it seems to me unrealistic to claim that labour input is determined entirely by employers. It is true that UK employers nowadays actively recruit overseas but immigration has its own dynamic, driven by conditions in the sending countries as well as differences in the receptivity of the possible destination countries (more on this below).

### *5.1 The model*

The economy produces a single good which can be consumed, invested or exported. A different consumer good can be imported. The size and growth rate of the labour force are exogenous. Goods and labour markets always clear (full employment). I make the small economy assumption that the terms of trade and foreign demand for domestic output are exogenous.

#### *Production, investment and capital*

The production and capital accumulation side of the model are just as before in the Solow model and are given by equations (1)-(5). As before the domestic production function is:

$$Y = Ak^\alpha L \quad (9)$$

whence

$$\hat{Y} = \hat{A} + \alpha\hat{k} + \hat{L} \quad (10)$$

#### *Investment and capital accumulation*

I make the Solovian (and Keynesian) assumption that investment is proportional to output:

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adversely affected. However, if there is still surplus labour in other countries, the capitalists can avoid this in one of two ways, by encouraging immigration or by exporting their capital to countries where there is still abundant labour at a subsistence wage. ... If there were free immigration from India and China to the U.S.A., the wage level of the U.S.A. would certainly be pulled down towards the Indian and Chinese levels. ... This is one of the reasons why, in every country where the wage level is relatively high, the trade unions are bitterly hostile to immigration, except of people in special categories, and take steps to have it restricted. The result is that real wages are higher than they would otherwise be, while profits, capital resources, and total output are smaller than they would otherwise be." Lewis has correctly predicted that business interests would be strongly in favour of immigration in the UK today but so far he has been wrong about the attitude of the trade unions.

$$I = sY \quad 0 < s < 1 \quad (11)$$

From this and equations (2) and (9) we get the capital accumulation equation:

$$\hat{k} = sAk^{\alpha-1} - \delta - \hat{L} \quad (12)$$

This equation always holds but as we shall see in a moment the assumption that  $s$  is a constant may have to be dropped.

### *Household demand*

Let  $C$  be consumption, measured in units of domestic output, let  $D$  be consumers' expenditure on domestic output, let  $M$  be the quantity of imports purchased by consumers, and let  $p$  be the relative price of imports in terms of domestic output:  $p := P_M / P$  where  $P$  is the domestic price and  $P_M$  the import price. Then

$$C = D + pM \quad (13)$$

The national income identity is:

$$\begin{aligned} \text{Real GDP(E)} &= C + I + X - pM \\ &= D + I + X = Y = \text{Real GDP(O)} \end{aligned} \quad (14)$$

and using (11)

$$D + X = (1-s)Y \quad (15)$$

Consumers maximise utility  $U$  which depends on domestic goods and imports

$$U = D^\omega M^{1-\omega} \quad 0 < \omega < 1 \quad (16)$$

subject to the budget constraint:

$$D + pM = C$$

The first order conditions of this problem yield

$$\frac{D}{M} = \frac{\omega}{1-\omega} p \quad (17)$$

Hence, differentiating with respect to time,

$$\hat{D} = \hat{M} + \hat{p} \quad (18)$$

(A somewhat more sophisticated assumption is that (17) holds only as a long run relationship:

$$\frac{D^*}{M^*} = \frac{\omega}{1-\omega} p$$

There is a short run adjustment mechanism taking the form

$$\hat{D} - \hat{M} = -\psi_1 \ln[(D/M) / (\omega p / (1-\omega))] \quad 0 < \psi_1 < 1$$



where  $\psi_1$  is the speed of adjustment. To avoid distracting from the main message, I stick with the simpler formulation.)

### *Balance of trade*

The balance of trade, in units of domestic output, is  $X - pM$ . I assume that there is some mechanism, ultimately the intertemporal budget constraint, which prevents the balance moving from its equilibrium value given by:

$$X = \phi pM \quad \phi > 0 \quad (19)$$

Some countries (e.g. Germany, the Netherlands) seem to be able to run a positive balance of trade indefinitely ( $\phi > 1$ ) while others (e.g. the US, Australia) have a negative balance for decades ( $\phi < 1$ ). So no assumption as to the size of  $\phi$  is made except that it is positive. The parameter  $\phi$  presumably depends on demography and other factors such as preferences which I prefer to leave in the background.

(A somewhat more sophisticated and empirically realistic assumption is that (19) holds only as a long run relationship:

$$X^* = \phi pM^* \quad \phi > 0$$

There is a short run adjustment mechanism taking the form

$$\hat{X} - (\hat{p} + \hat{M}) = -\psi_2 [\ln(X / \phi pM)] \quad 0 < \psi_2 < 1$$

where  $\psi_2$  is the speed of adjustment. Again, to avoid distracting from the main message, I stick with the simpler formulation.)

Differentiating (19) with respect to time,

$$\hat{X} = \hat{M} + \hat{p} \quad (20)$$

From (18) and (20)

$$\hat{D} = \hat{X} \quad (21)$$

That is, domestic demand for domestic output grows in line with exports.

### *Foreign demand for exports*

Foreign demand for exports is

$$X^d = \gamma Z^\theta \quad \gamma > 0, \theta > 0 \quad (22)$$

Hence

$$\hat{X}^d = \theta \hat{Z} \quad (23)$$

Now we reach the key assumption. The supply of exports,  $X$ , cannot exceed demand but may not equal it either:

$$X \leq X^d \quad (24)$$

In good conditions the weak inequality (24) does not bind as an equality ( $X < X^d$ ), in other words the home country can export as much as it likes. But after a sufficiently large shock to foreign demand the inequality may bind ( $X = X^d$ ) — the country's exports are constrained by foreign demand.<sup>9</sup> So now we have two regimes to analyse, a good one and a bad one.

*The two regimes*

(a) *good regime:  $X < X^d$*

Weak inequality (24) is not binding as an equality so the solution is the same as that of the Solow model: the short run dynamics are given by equations (10) and (12).

(b) *bad regime:  $X = X^d$*

Equation (24) binds as an equality, so from (21) and (23)

$$\hat{D} = \hat{X} = \theta \hat{Z} \quad (25)$$

Implicit in the bad regime is that the economy cannot grow as fast as in the good regime. In the good regime the economy is assumed to be in a steady state where

$$\hat{I} = \hat{K} = \hat{Y} = g + n$$

Now in the bad regime by assumption we have

$$\theta \hat{Z} < g + n \quad (26)$$

It is straightforward to show that this implies that in the bad regime

$$\hat{Y} < g + n \quad (27)$$

*Proposition*      Assume that in the good regime the economy was in a steady state in which output ( $Y$ ), investment ( $I$ ) and capital ( $K$ ) were growing at the same rate  $g + n$ , i.e. labour productivity ( $y$ ) and capital intensity ( $k$ ) were growing at rate  $g$ . Then in the bad regime, with a constant investment ratio, and given the same growth of labour supply in the

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<sup>9</sup> The idea that growth might be limited by foreign demand is also found in Houthakker and Magee (1969) and Thirlwall (1979), though the idea there is applied to long run development.

two regimes, labour productivity and capital intensity grow more slowly than in the good regime.

*Proof* Let  $s_{bad}$  be the investment ratio in the bad regime, for the moment taken to be constant. I assume

$$0 < s_{bad} \leq s$$

i.e. the “bad” investment ratio cannot exceed the old (“good”) one which prevailed in the previous steady state. Equation (15) now becomes

$$D + X = (1 - s_{bad})Y$$

whence using equation (25)

$$\hat{Y} = \theta \hat{Z} < g + n \quad (28)$$

or

$$\hat{y} < g \quad (29)$$

Putting (25) and (14) together we also have:

$$\hat{Y} = (1 - s_{bad})\theta \hat{Z} + s_{bad} \hat{I} \quad (30)$$

whence

$$\hat{I} = \theta \hat{Z} < g + n \quad (31)$$

It then follows from the capital accumulation equation  $\hat{K} = (I / K) - \delta$  that the growth of capital must fall too below its steady state level:

$$\hat{K} < g + n \quad (32)$$

or

$$\hat{k} < g \quad (33)$$

which proves the Proposition. ■

*Remark* Suppose  $s_{bad} < s$  (which is what we find in the data). Then there must have been a period in which the investment ratio ( $I/Y$ ) was falling, i.e. when  $I$  was growing less rapidly than  $Y$ . So at the onset of the bad regime investment and capital grow even less rapidly for a period while the bad regime “beds in”.

In summary, in the bad regime foreign demand drives the growth of output. Investment and capital intensity then respond to ensure that the exogenously-given labour force is fully employed. So from (28) labour productivity growth in the bad regime is

$$\hat{y} = \theta \hat{Z} - \hat{L} \quad (34)$$

Using (34) and solving for  $\hat{k}$  from (10):

$$\hat{k} = \frac{1}{\alpha} [\theta \hat{Z} - \hat{A} - \hat{L}] \quad (35)$$

So an increase in the growth rate of foreign demand raises the growth rate of capital intensity while an increase in the growth rate of labour supply lowers it, as does an increase in the TFP growth rate. The second and third of these predictions are exactly the opposite of the Solow model's: in the latter TFP growth and capital deepening are positively related and capital deepening is independent of labour supply growth, at least in the steady state.

Note too that the capital accumulation equation (12) continues to hold even in the bad regime but the investment ratio  $s_{bad}$  can no longer be assumed to be constant.<sup>10</sup> We can solve for the investment ratio in the bad regime using equations (12) and (35):

$$s_{bad} = \frac{(\theta / \alpha) \hat{Z} - (1 / \alpha) \hat{A} + \delta - [(1 - \alpha) / \alpha] \hat{L}}{A k^{\alpha-1}} \quad (36)$$

So in the bad regime the impact effect on the investment ratio of a rise in the growth rate of foreign demand, or a fall in the growth rate of labour supply, is positive.<sup>11</sup>

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<sup>10</sup> One caveat is that the model should not be pressed too hard. Equation (35) could have a solution in which capital is actually destroyed; this occurs if  $\hat{K} < -\delta$ . If so, the model might cease to apply: it is unreasonable for firms to destroy capital unless they expect the bad regime to persist indefinitely.

<sup>11</sup> The dynamics of the model may be more complicated than the account in the text implies. To satisfy all the equations some jumps in the investment ratio may be required.

## 6. TESTING THE NEO-LEWIS MODEL

To test the neo-Lewis model empirically I assume that equation (34) applies in both periods, before and after the crisis, i.e. 2000-2007 and 2007-2015, denoted by superscript B and A respectively, but with a shift factor which is expected to be larger before the crisis. So for the  $i$ -th country

$$\begin{aligned}\hat{y}_i^B &= \mu_i^B + \pi_Z \hat{Z}_i^B + \pi_L \hat{L}_i^B + \varepsilon_i^B \\ \hat{y}_i^A &= \mu_i^A + \pi_Z \hat{Z}_i^A + \pi_L \hat{L}_i^A + \varepsilon_i^A\end{aligned}\quad (37)$$

Here  $\varepsilon_i^B$  and  $\varepsilon_i^A$  are error terms and we expect  $\mu_i^B > \mu_i^A$ ,  $\pi_Z > 0$ , and  $\pi_L < 0$ . Then taking differences (growth after minus growth before) we get the equation to be used for testing the hypothesis:

$$\Delta \hat{y}_i = (\mu_i^A - \mu_i^B) + \pi_Z \Delta \hat{Z}_i + \pi_L \Delta \hat{L}_i + (\varepsilon_i^A - \varepsilon_i^B) \quad (38)$$

An analogous equation for testing predictions about capital intensity can be based on equation (35).

Now we need an empirical proxy for world demand,  $Z$ . This is measured for each country by the export-weighted imports (EWI) of its trading partners, which indicates the potential for a country to expand its exports. For the  $i$ th country the EWI is defined as

$$EWI_i = \frac{\sum_j X_{ij} M_j}{\sum_j X_{ij}} \quad (39)$$

where the  $X_{ij}$  are country  $i$ 's exports to country  $j$  and  $M_j$  is total imports of country  $j$ . So if country  $i$  tends to export to countries whose imports are growing rapidly then  $EWI_i$  will be growing more rapidly than if its exports are concentrated on slow-growing countries. This variable is initially nominal and measured in US dollars.<sup>12</sup> I convert it to real by deflating by the GDP deflator for the US. The growth rate of real EWI before and after the crisis appears in Table 2. There has been a substantial decline in all countries. The cross-country average is a fall of 2.85 percentage points, with a considerable range around this average (standard deviation: 0.69).

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<sup>12</sup> This variable is part of the database of the National Institute Global Econometric Model (NiGEM). I am grateful to Garry Young and Yanitsa Kazalova for making it available to me.

The results of estimating equation (38) are in Table 3. Consider first column (3) where the change in productivity growth is the left-hand-side variable. Both the independent variables, export demand and hours, are highly significant (at the 1% level) and have the correct sign. Given that this is a difference between two cross sections the level of explanatory power is quite high (R-squared = 0.513). However the neo-Lewis model predicts that the coefficient on hours should be -1 while the estimated coefficient is smaller in absolute value, -0.433. The upper panel of Chart 4 shows the added variable plots for this regression from which it is clear that no single country is driving the results. The specification in column (3) in effect assumes that the same constant applies to all countries which could lead to biased estimates. One way to deal with this is fixed effects but there are not enough observations for this. So instead the growth rate of GDP over 2000-2007 ( $\hat{Y}^B$ ) is added in column (4) to proxy for country-specific effects. The coefficient on this variable is negative and significant at the 10% level, indicating that countries which did well before the crisis did worse after it. The coefficient on export demand is now smaller and less significant but hours remains highly significant and somewhat larger in absolute value. The lower panel of Chart 4 shows the added variable plots for this regression. Even more than the upper panel, this shows that the results are not being distorted by outliers.

Columns (5)-(8) have the same specification as columns (1)-(4) except that the dependent variable is now the change in the growth rate of capital intensity. The hours variable is highly significant again but export demand is not. However there are only 14 countries now.

So the facts are broadly consistent with the neo-Lewis model put forward here. But this of course is no guarantee that it is true: any set of facts is consistent with an unlimited number of theories. The problem is that the sort of facts discussed here will only be observed on very rare occasions, most recently the Great Recession. The only previous event in the twentieth century comparable to this in scale was the Great Depression of the 1930s. Hence it is difficult for conventional econometric techniques to achieve empirically rigorous results.

## 7. IS IT ALL ABOUT TFP?

### *7.1 Did the TFP slowdown precede the Great Recession?*

TFP growth has fallen dramatically since the crisis as we have seen (Table 2). In the UK's case, the slowdown in TFP accounts for 71% of the slowdown in labour productivity growth, in a growth accounting sense. And this finding survives untouched when a longer list of intangible assets is included under capital (Goodrich et al. 2016). So isn't the TFP slowdown the main story, eclipsing the role of any slowdown in the growth of capital intensity?

Furthermore it is often asserted nowadays that the slowdown in TFP growth preceded the financial crisis, suggesting that a micro-based explanation should be sought and implying that the policy remedy is "structural reforms" (Bergaud et al, 2014; Fernald, 2015; Cetto et al., 2016).<sup>13</sup>

However, if one just considers the period up till 2007, it is very difficult to find evidence of a TFP slowdown in most countries. Chart 5, reproduced from Oulton (2016b), shows TFP growth in the market sector in 18 countries; data are from the earlier release of the EUKLEMS database which fortuitously stops in 2007.<sup>14</sup> Two simple measures of the trend are shown: the mean over the data period for each country (dashed line) and a Hodrick-Prescott trend (red line). In most cases the country's actual TFP growth rate is at or near its mean level at the end of the period; exceptions are Australia and Ireland. In most cases too the HP trend is flat or rising in the years leading up to the financial crisis. This suggests that the collapse exhibited since 2007 must be somehow related to the crisis and the subsequent Great Recession and not to pre-existing adverse micro factors.

A more sophisticated analysis is available for the US. Crafts and Mills (2017) estimate trend TFP growth in the US, 1967-2016. They apply a time series model to Fernald's quarterly series for TFP growth in the business sector (Fernald, 2014). TFP growth is modelled as a

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<sup>13</sup> Micro studies have thrown light on the evolution of productivity. For example, using French firm-level data Cetto et al (2018) exhibit a number of adverse trends which could impact TFP growth. But the timing is problematic for explaining the post-2007 collapse. For example, they find that the speed of convergence of laggard firms to leading firms actually rose in the period 2007-2012, though it fell sharply in 2014 (their latest year).

<sup>14</sup> This is the March 2011 update of the November 2009 release which includes more countries than the later release. Also the capital services measure is better since unlike in the later release asset stocks are estimated using a common set of geometric depreciation rates.

random walk (the trend) plus a zero-mean, auto correlated “noise” process. Using Fernald’s series for the whole period 1947-2015, Crafts and Mills find that the trend has been slowing continuously since 1967, from around 1.5% pa in that year to around 1.0% pa in 2016 (see their Figure 3). The actual outturn according to Fernald’s data over 2007-2015 was 0.56% pa (0.63% pa adjusted for utilisation). In other words the outturn was substantially lower than the trend as estimated by Crafts and Mills. Another way to look at it is to note that in 2016 the Crafts-Mills trend growth rate was about 0.1% pa lower than in 2000, so the slowdown in trend growth is quite modest in relation to what actually occurred, about 0.6%.<sup>15</sup> So the slump in US TFP growth since 2007 is not correctly described as a decline in the trend rate. It was also not foreseeable using just the data up to 2007 since Crafts and Mills find a rising trend if only the 25 years of data up to 2007 are used (see their Figures 3 and 4) .

## *7.2 An alternative explanation: the externality hypothesis*

On the face of it, it seems very implausible that a fortuitous and exogenous decline in the rate of innovation could account for slow productivity growth after 2007 in any of the countries studied here. The alternative explanation is that the recession itself has somehow adversely affected TFP growth. Four channels suggest themselves.

First, the amount of innovation taking place in the economy may be temporarily reduced, due to a loss of business confidence (Oulton and Sebastián-Barriol, 2017). Innovation is implemented through or accompanied by investment in intangibles (e.g. R&D, in-firm training, or expenditure of management time on corporate restructuring) or it could take the form of new entrants into an industry bringing new products, new technology or new business methods. All this is (arguably) what lies behind TFP growth as conventionally measured. Now innovation is a cumulative process and the supply of workers and entrepreneurs capable of innovating is likely to be inelastic. So unlike with physical capital a reduction in innovation in one period cannot easily be made up in a subsequent one: in other words, less innovation today means that the future *level* of TFP is permanently lower. For illustration, suppose that prior to a crisis, assumed to last  $h$  years, the economy is capable of generating a stream of innovations  $a, b, c, \dots$  from the current year  $t$  onwards. As a result of

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<sup>15</sup> From the spreadsheet accompanying Fernald (2014), dated 1 February 2018, it can be calculated that comparing 2007-2015 with 2000-2007, unadjusted TFP growth slowed down by 0.63 pppa; adjusted for utilisation the slowdown was 0.57 pppa. This is very similar to the slowdown of 0.54 pppa in Table 1 which is for the whole economy.



the crisis the first innovation  $a$  is now delayed to year  $t+h$ ; the subsequent innovations  $b, c, \dots$  are now also delayed  $h$  years to years  $t+h+1, t+h+2, \dots$ . Though all innovations are eventually introduced the level of TFP will clearly be lower in every year after the crisis is over than it would have been in the absence of the crisis. And for  $h$  years the growth rate of TFP will be below its pre-recession rate, even if after this period it recovers. A reduction in the TFP level will also lead to a secondary effect, a reduction in the desired level of capital, again reducing labour productivity. In short, more rapidly expanding output might raise animal spirits leading to a greater willingness to experiment with new business methods.

The second and third channels involve capital. They posit a (positive) connection between the growth of capital intensity and the growth of TFP. If capital growth is generally underestimated due to inadequate allowance for quality change or new capital goods, or if there is a positive externality associated with capital accumulation (as suggested by Romer (1987)), then the growth accounting approach will overstate the contribution of TFP growth to labour productivity growth and understate that of capital. If capital accumulation slows down it will appear that TFP growth has slowed down too. The second channel operates if the elasticity of output with respect to capital is higher than capital's share (the latter being the standard growth accounting measure). I examined these channels in Oulton (2016a) and did not find them to be likely to be quantitatively large, particularly at the whole economy level where any error in measuring capital services will be partially balanced by an offsetting error in measuring GDP.<sup>16</sup>

The fourth channel posits a positive connection between the growth of output and the growth of TFP. The starting point here is Fabricant's Law. In panel data on US manufacturing industries over the period 1899-1939 Fabricant (1942) observed a positive correlation between the growth of output and the growth of labour productivity. In my earlier work with Mary O'Mahony (Oulton and O'Mahony 1994) we observed the same pattern for 124 UK manufacturing industries over 9 sub-periods within the overall span 1954-1986. We also observed a positive correlation between output growth and TFP growth. But which way does the causation run, from output to TFP or the reverse? The usual argument is that this correlation is uninteresting. TFP growth happens to be higher in some industries which initially leads to higher profits. This attracts entry leading to higher output which the market

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<sup>16</sup> A qualification is that some types of intangible investment may generate externalities since their output elasticity is estimated to be higher than their share (Corrado et al., 2017).

absorbs by lower prices. So causation runs from TFP growth to output growth via lower relative prices. We found however that the correlation between output growth and relative price growth was much weaker than that between output growth and TFP growth, which casts doubt on this explanation (Oulton and O'Mahony (1994), chapter 7).

The alternative view is that some form of increasing returns is involved. Hall (1988) and Bartelsman et al (1994) found support for increasing returns on US data, Caballero and Lyons (1990) on European data, and Oulton (1996) found support on the same UK manufacturing data just described (in the latter the externality seemed to be at the manufacturing sector level rather than the industry level). Hall (1988) had invoked a “thick market externality” to explain the phenomenon: an example is the delivery van which travels as many miles on average in good times as bad but delivers more packages when times are good. This suggests the effect operates at business cycle frequencies and is just due to varying utilisation, hence the term “short run increasing returns”. But this is not the only possibility. Oulton (1996) found that the externalities seem to apply peak-to-peak as well as over the course of the business cycle, which is not consistent with the thick market story. A second possible type of externality is a learning effect: knowledge of new techniques and methods diffuses faster through the economy, the faster the rate of overall expansion. This type of effect would be expected to operate peak-to-peak, Another possibility is under monopolistic competition when fixed costs give rise to increasing returns.

It is difficult to test these ideas using just macro data and particularly using the latest release of the EU KLEMS dataset since there are only 14 countries for which TFP growth rates are available. So I use instead the latest release (version 9.0) of the Penn World Table, described in Feenstra et al. (2015) and freely downloadable from <https://www.rug.nl/ggdc/productivity/pwt>. After eliminating countries with populations of less than 2 million and countries with no data on hours worked there remain 52 countries for which TFP is available. I use the PWT's “national accounts” variables: *rgdpna*, *rkna* and *rtfpna* for indices of real GDP, real capital stock and TFP respectively; total hours worked is calculated as average hours per worker times the number of workers (*avh x emp*). Two drawbacks of the Penn World Table should be noted. First, the capital variable is the aggregate capital stock, not the superior capital services measure. Second, the terminal year is 2014, not 2015. On average in these 52 countries TFP growth slowed down by 1.29 percentage points per annum (pppa), GDP by 1.92 pppa, capital by 0.26 pppa, and hours by 1.00 pppa.

The externality hypothesis suggests that, on cross-country data, the bigger the slowdown in GDP, the bigger the slowdown in TFP. Table 4 shows how the change in the TFP growth rate between the periods 2007-2014 and 2000-2007 relates to the change in the growth rate of GDP, the change in the growth rate of capital, and the change in the growth of hours between the same two period (columns 1-3). Much the strongest relationship is with GDP and it is positive: the bigger the slowdown in GDP, the bigger the slowdown in TFP (Chart 6). The coefficient on GDP is highly significant ( $t = 6.6$ ). Taken literally, this says that a slowdown of one percentage point in GDP causes a slowdown of 0.53 percentage points in TFP. The coefficients on the other variables, capital and labour, are not significant. The pattern of the correlations is interesting. Each is between TFP and a component of TFP so it might be objected that any relationship is just mechanical. But why then is it much stronger with GDP than with capital or labour?

Columns 4 of Table 4 is a test of the Solow model's predictions about the effect of a slowdown in TFP growth which that model takes to be exogenous. The Solow model predicts that a slowdown in TFP growth will cause a slowdown in the growth rate of capital intensity. But the coefficient on the latter, 0.28, is much smaller than the model predicts: with a capital share of about one third the coefficient should be about 1.5 (see equation (5)). It is also insignificant.

These correlations do not of course prove that a GDP slowdown causes a TFP slowdown. But they are certainly consistent with the industry-based studies cited above. They are also consistent with the neo-Lewis model which sees the GDP slowdown as caused by constrained demand for exports. The model now works through the TFP channel as well as the capital-deepening one to explain the labour productivity slowdown.

## 8. DISCUSSION AND EXTENSIONS

### *8.1 Previous explanations*

Here is a partial list of explanations for the productivity puzzle which have so far been put forward.

1. Distortion due to hard-to-measure or otherwise problematic sectors
2. Reallocation of labour to sectors where productivity is lower
3. Mis-measurement of GDP due to mis-measurement of banking output and of the digital economy
4. Overheating in the boom (so output was growing more rapidly than was sustainable)
5. Labour hoarding
6. The impact of austerity
7. Lower human capital (skill)
8. Flat or falling capital intensity
9. Crippled banks and zombie firms

I have reviewed these explanations extensively elsewhere (Oulton 2016a). Suffice it to say that I did not find any of them plausible by themselves though one at least, flat or falling capital intensity, has formed part of my own explanation. Of the other explanations, some did not fit the facts (reallocation, lower human capital, austerity), one has been rendered implausible by the length of time that productivity has stagnated (labour hoarding), and another fails to understand how GDP is measured in practice (banking output). It may well be that the digital economy is mis-measured. But first, this affects only a small part of the economy, some of which drops out of GDP as it is intermediate consumption; second, outside the digital sector the productivity puzzle will remain; third, mis-measurement of digital products has been with us for a long time so to explain the productivity puzzle one needs to show that mis-measurement has got worse since 2007, for which there is no evidence (Byrne et al. 2016).

Any explanation based around the banking crisis has to grapple with four facts: (1) while there is evidence that a banking crisis has a permanent adverse effect on the *levels* of GDP, employment and productivity, it is much harder to argue that it has a long run effect on their growth rates (Oulton and Sebastiá-Barriel 2017); (2) Banks in the UK unlike in Europe lend

predominantly to smaller firms, while larger firms rely on corporate bonds (where interest rates are low) and on retaining profits which have been very healthy;<sup>17</sup> (4) most observers think that the UK banking system is now functioning normally again.<sup>18</sup>

Firm-level studies are potentially valuable in distinguishing between alternative explanations. For example, one might hypothesize that smaller, independent firms which have no access to the bond market would be particularly affected by restrictions on bank lending. But despite many interesting findings no such smoking gun has yet been identified (Barnett et al. 2014; Riley et al. 2017).

Finally, as a general comment on all candidate explanations, 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 among developed economies.

## 8.2 Aggregate demand shocks or export demand shocks?

The thesis of this paper has some resemblance to Pessoa and Van Reenen (2015) who argued that wage flexibility explains both puzzles (low or zero productivity growth accompanied by full employment). Their analysis is framed around the growth accounting equation which in my notation is

$$\Delta \ln(Y / L) = \Delta \ln TFP + \alpha \Delta \ln(K / L)$$

They then argue that a “demand shock” which lowers  $Y$  will, given TFP growth, lead to a fall in capital intensity if wages are sufficiently flexible. They do not refer to export demand and do not mention immigration. The latter omission is bit surprising given that with real wage flexibility a positive labour supply shock would also lower both  $Y/L$  and  $K/L$ . Their approach suggests that the solution to the problem is a fiscal and/or monetary expansion sufficient to compensate for the adverse demand shock. By contrast my approach relies on shocks to

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<sup>17</sup> To quote Martin and Rowthorn (2012): “The emphasis placed on the impact of a sclerotic banking system on the pace of innovation by credit-constrained small and medium-sized enterprises belies the quantitatively small role of SMEs in explaining innovation and productivity growth. Independent SMEs account for just 3½% of business R&D spending.”

<sup>18</sup> Tenreyro (2018) is also sceptical about explanations based on the banking crisis. But she does argue that productivity is likely to rise in finance once the deleveraging process is completed.

export demand. And in the bad regime an expansionary fiscal or monetary policy would not solve the problem since it would not increase export demand.<sup>19</sup>

### 8.3 *Export demand shocks*

Demand for a country's exports as a cause of growth has received surprisingly little attention in the literature on economic growth, as opposed to the literature on economic development. It plays no role for example in the influential study of Mankiw et al. (1992) which tested the Solow model on 98, mostly open, countries. The case for export demand shocks as an important cause of recessions and subsequent slow growth, or even slumps, is strengthened by considering the example of smaller countries or sub-national units (regions and cities). Consider Finland for example. Between 1990 and 1993 Finland's GDP fell by 9%. It did not surpass its 1990 level till 1996. This had little to do with anything happening in Finland itself but was due rather to the collapse of Finland's then principal trading partner, the Soviet Union. This was followed by a favourable export demand shock when Finland joined the EU in 1995. Finland has undergone a major depression after 2007, with GDP falling nearly 9% in 2009. Since then GDP has largely stagnated; in 2015 it was still over 7% below its 2008 level (source: EU KLEMS, September 2017 release). It seems likely that a bad situation has been made worse by the loss of comparative advantage suffered by Finland's largest company, Nokia. As the Nokia Annual Report for 2016, "Rebalancing for growth", delicately puts it : "By 1998 Nokia was the world leader in mobile phones, a position it enjoyed for more than a decade."<sup>20</sup> At its peak in 2007 Nokia accounted for 70% of the total market capitalisation of firms quoted on the Helsinki stock exchange when its market cap was 106 billion euros. This fell to some 6 billion euros in 2012, though it recovered somewhat to 26 billion euros in 2015 (information from Wikipedia). So on top of the effects of the financial crisis Finland has suffered an additional, Nokia-related, shock as world demand has shifted towards non-Finnish companies such as Apple and Samsung. The case for export demand shocks is even stronger if one looks at cities and regions. It would be odd to discuss the decline of Detroit without mentioning the problems of its main export industry, cars.

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<sup>19</sup> Other papers emphasising the role of aggregate demand in accounting for the productivity puzzle include Martin and Rowthorn (2012) and Carlin and Soskice (2018). The latter is a model of a closed economy.

<sup>20</sup> [https://www.nokia.com/sites/default/files/files/nokia\\_ar16\\_full\\_report\\_english\\_3.pdf](https://www.nokia.com/sites/default/files/files/nokia_ar16_full_report_english_3.pdf), accessed on 01/12/2107.

It seems likely that these idiosyncratic shocks affecting small countries are not fully captured by the EWI index. The latter shows a substantial fall for Finland after 2007 but nothing exceptional (Table 2).

If the effect of export demand shocks is easier to spot in the case of smaller countries, it may be that they are less important usually for larger ones. In the model the imported good cannot be produced at home. This is clearly less realistic for larger countries as evidenced by the fact that the imports-GDP ratio falls with country size. So for a large country a fall in exports could still lead to a parallel fall in imports but this may have only a small effect on domestic production and demand since import-competing industries can expand; in the limit when domestic products are perfect substitutes for foreign ones the effect of a foreign demand shock is zero. This may help to explain why the US has done better than even the large European countries since 2007.

#### *8.4 What is different about the UK labour market?*

By comparison at least with continental EU countries the UK is very attractive to migrants for several reasons. First, when eight new countries (the A8), consisting of Poland, Hungary, Slovakia, Slovenia, the Czech Republic and the three Baltic states, joined the EU in 2004, the UK government immediately opened the UK labour market to citizens of these countries; it followed the same policy when Bulgaria and Romania joined the EU in 2007 and when Croatia joined in 2013. Other EU countries required a transition period before opening their labour markets. Second, potential migrants, whether from the EU or elsewhere, are more likely to speak at least some English rather than say French, German or Italian, which makes the UK more attractive as a destination. Third, the UK labour market is very flexible, in several relevant ways. For a great many jobs, particularly unskilled ones, no formal qualifications are necessary and occupational licensing is comparatively rare. Firing costs are low (employment protection legislation is weak), which makes firms more willing to offer employment. Trade unions are weak, except in the public sector. And the UK has never adopted any of the continental versions of the European Social Model.<sup>21</sup> The latter gives a

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<sup>21</sup> The European Social Model comes in four varieties: Nordic, Continental (as in e.g. Austria, Belgium, France, and Germany), Mediterranean (Greece, Italy, Portugal and Spain) and Anglo-Saxon, the latter applying only to the UK and Ireland. (Perhaps after Brexit it will be renamed the Celtic model). The Continental version is characterised by strong “employment protection” legislation and an important role for trade unions (Sapir 2005).

very important role to the “social partners” — unions, employers and government — in setting wages and working conditions at the industry level. The aim here is to prevent “social dumping”, which would allow firms to undercut the wages of indigenous workers by importing cheaper foreign labour.<sup>22</sup> Finally, in the case of illegal migrants or overstayers, it is comparatively easy to escape the attention of the authorities since the UK has no system of national identity cards.<sup>23</sup>

A striking demonstration of the advantages of the UK as perceived by migrants themselves is the illegal encampment known as the “jungle” erected outside Calais. Until its demolition by the French authorities in October 2016 it held many thousands of migrants who had often been living there for months or even years in squalid conditions. The one aim of these migrants was to smuggle themselves into Britain where they confidently expected to find work. The point here is that these migrants had already reached safety on the territory of the European Union. But they clearly felt that their chances of finding work in France (or any other continental EU country to which they could have travelled) were greatly inferior to their chances in Britain.

### *8.5 Benefits and costs of immigration to natives*

There is a large literature which mostly claims that the impact of immigration on the wages of natives is negligibly small. One strand was started by Card (1990) who studied the Mariel boatlift. His results have been disputed by Borjas (2015) and (2016). These studies attempt to identify the short run elasticity of wages to a labour supply shock. So they are of doubtful relevance to the UK productivity puzzle where the issue is the failure of capital accumulation to respond to additional labour. For the UK Nickell and Saleheen (2008) also found small

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Sapir notes: “Although their membership is on the decline, unions remain strong as regulations extend the coverage of collective bargaining to non-union situations.”

<sup>22</sup> The hostility to social dumping in Europe is exemplified by the opposition of President Macron to the Posted Workers Directive which allows firms in (say) France to import workers from (say) Romania and pay them at Romanian not French rates, thus doing an end run round French wage policy. Macron has recently (October 2017) succeeded in getting his fellow heads of government to agree to water down this directive (*Financial Times*, “Poland warns migrant worker curbs will hit competitiveness”, 4<sup>th</sup> December 2017). An earlier example of opposition to social dumping is the process of German reunification. This initially threatened a large influx of workers from the East into the West and also greater competition for Western workers if firms moved in the opposite direction to take advantage of cheap Eastern labour. The German trade unions were successful in preventing this by obliging the East to adopt the West’s wages and other conditions, at the cost initially of high unemployment in the East (Carlin et al. 2014).

<sup>23</sup> David Wood, former head of immigration enforcement at the Home Office, told the House of Commons home affairs committee recently that he believes that there are about a million illegal migrants currently in the UK



effects of immigration on native wages. But their study used data from the boom period, so again is not evidence against the hypothesis of this paper.

Standard growth theory suggests another way in which native living standards can be damaged by immigration, which so far as I am aware has not been discussed in the literature on immigration (it is not mentioned in Borjas (2014) for example). In the Solow model the long run growth rate of labour ( $n$ ) has no effect on the long run growth rate of productivity. It does however affect the long run *level* of productivity and capital intensity at each point in time: the higher is  $n$ , the lower is  $y$  and  $k$ . The long run steady state level of output per hour at time  $t$  is given by

$$y^*(t) = A(t)^{1/(1-\alpha)} \left[ \frac{s}{n + g + d} \right]^{\alpha/(1-\alpha)}$$

So the ratio of long run output per hour in an economy with fast growing labour to an otherwise identical economy with slow growing labour is

$$\left[ \frac{n_{slow} + g + \delta}{n_{fast} + g + \delta} \right]^{\alpha/(1-\alpha)}$$

Parameters values appropriate for the UK are  $\alpha = 0.35$ ,  $g = 2\%$ ,  $\delta = 7\%$ ,  $n_{slow} = 0.32\%$ , and  $n_{fast} = 0.95\%$ . The value for  $n_{slow}$  is the growth rate of native-born employment in the UK while that for  $n_{fast}$  is the growth rate of total (native- and foreign-born) employment, both over 2000-2007 (see Table 1). Then the level of productivity and hence of the standard of living (consumption per hour worked) in the economy with fast growth of labour will be only 97% of that in the other economy. In other words at any moment in time the standard of living in the fast-labour-growth country will always be about 3% less than in the slow-labour-growth one, a significant effect, in fact comparable to the per capita cost of Brexit according to the OECD's projection quoted earlier (OECD 2016).

### 8.6 Skilled or unskilled immigrants?

I have assumed so far that labour is homogeneous. The case for large-scale immigration is often made on the grounds that migrants bring valuable skills lacking in the native population. No doubt some do but is this true on average? The evidence would suggest not.

The OECD skills study (Kuczera et al., 2016) recently measured basic skill levels amongst adults in England on two dimensions, literacy and numeracy:

*Literacy*: the ability to read and understand the label on a bottle of Aspirin. To pass you need to be able to answer a question like “What is the maximum number of days you should take this medicine? List 3 situations for which you should consult a doctor”

*Numeracy*: the ability to read the petrol gauge on a truck and calculate how much fuel remains in the tank. To pass, you need to be able to see that the tank is three quarters full and to calculate that 36 gallons remain if you are told that the tank holds 48 gallons.

They found that more than a quarter of adults aged 16-65 in England (and 10% of university graduates!) have low basic skills: they fail one or both of these tests, which is worrying enough. But the more relevant finding in the present context is that the skill levels of migrants are *lower* than those of the native born. (Note: a migrant was defined as someone born abroad, at least one of whose parents was also born abroad. Thus this definition excludes the children born to British parents temporarily working abroad. Migrants so defined made up 13% of the population aged 16-65).

## 9. POLICY IMPLICATIONS

I have made the case that rapid rates of immigration since the Great Recession began in 2008, along with slow growth rates of export demand, have caused the UK’s productivity problem. Since Great Recessions fortunately happen rarely it is very difficult to establish this hypothesis at a fully rigorous empirical level. But policy makers are frequently (always?) in the position of having to make decisions without the economics profession having reached a full consensus. So I list here some policy alternatives which merit consideration if the hypothesis is accepted.

1. *Do nothing*. Doing nothing is a possible response. Immigration after all raises GDP and a larger GDP enables the UK to have larger armed forces and to play a bigger role in world affairs (“punching above our weight”). However at the moment the British people show little appetite for any more foreign interventions, even so-called

humanitarian ones. They seem much more concerned with raising living standards which means raising productivity. Hence doing nothing is not a democratic response, provided that there is some alternative with a chance of success.

2. *Wait for the world economy to revive.* At the time of writing there is much optimism amongst international organisations and commentators about growth prospects in Western countries, particularly in Europe. But these hopes may turn out to be misplaced or exaggerated as have earlier ones. So waiting is not a riskless strategy.
3. *Revive the world economy.* According to the estimates in Table 3, columns (3) and (4), raising the growth rate of demand for UK exports by one percentage point would raise productivity growth by between 0.87 and 1.27 per cent per year. The problem here is that it is not clear what policy tools are available to achieve this. What the UK needs is a rise in demand for exports which will in turn lead to a revival of investment, with the growth of labour supply held at something like its current rate or below. So just “ending austerity” in the UK will not do the trick. The effect would be just to worsen further the balance of trade, increase debt, and possibly raise inflation above target. The benefit of higher UK imports would spill over to our suppliers but the consequent second round effect on UK exports would be minimal. One theoretical possibility is a coordinated fiscal and/or monetary expansion across the Western world, combined with incentives to raise investment. To state it in these terms merely emphasises how implausible such a policy sounds. But it is possible that a single, large country or a bloc of smaller ones could adopt such policies in an uncoordinated way, which might have something of the desired effect.
4. *Adopt the European Social Model.* The aim here would be to make inward migration unattractive to potential migrants (whether from the EU or elsewhere) by setting wages and other conditions at levels which lower the demand for labour, via dialogue between the social partners. This is a very unattractive alternative. First, higher wages would attract more migrants so the policy would have to incorporate mechanisms to discriminate in favour of natives (“British jobs for British workers”). Second, in practice the European Social Model (at least as practiced outside the Nordic countries) discriminates against the disadvantaged amongst the native population: consider for example the very high unemployment and low employment rates in the Parisian *banlieues*. Third, the flexible labour market has arguably been at the root of the UK’s success prior to the Great Recession (Aghion et al., 2013; Oulton, 2016a). To revert to

something like the labour market institutions of the pre-Thatcher era would be a very retrograde step.

5. *Restructure UK trade towards faster growing areas.* There are no doubt numerous micro interventions which could help in this aim. And Brexit may well provide a considerable negative incentive for firms to develop new markets outside the EU, helped by new trade deals. How much effect such policies can be expected to have remains controversial.
6. *New incentives for investment.* A policy which the UK could adopt on its own is to give radical new incentives for investment, for example allowing full expensing of all types of investment in the year in which they are made (100% depreciation for tax purposes). This could even be accompanied by an *increase* in corporation tax. The motivation for an increase is that a low tax rate reduces the incentive to invest since it reduces the value of existing depreciation allowances.
7. *Control immigration.* According to the estimates in Table 3, columns (3) and (4), reducing the growth rate of labour by one percentage point would raise productivity growth by between 0.43 and 0.51 per cent per year. Following Brexit in March 2019 free movement of labour from the EU can come to an end (at least after the transition period has expired, supposedly at the end of 2020) but as emphasised earlier migrants from the EU constitute less than half the total foreign-born stock. In theory it should have been easy to reduce migration from the rest of the world, which after all has been the stated policy of the government since 2010, but in practice this has proved not to be the case; since 2010 and up to mid-2017 EU-born workers rose by a million while non-EU ones rose by “only” 700 thousand (Table 1). Perhaps there are countervailing pressures, either from business interests or from the ethnic minority communities already settled here, which make it difficult. Nevertheless if the basic hypothesis of this paper is accepted then the case for an immigration policy which responds to the needs of the economy is a strong one. The ten years of stagnating productivity could have been avoided had an “emergency brake” on immigration (from all sources) been imposed. This does not mean no immigrants at all. Rather it suggests varying the total in accordance with the state of the economy and severely limiting unskilled immigration. The examples of Canada and Australia both of whom

ban unskilled immigrants (except under humanitarian and family reunion programmes) suggest that such a policy is perfectly feasible.<sup>24</sup>

Finally, none of the discussion above should be taken to imply that export demand or immigration are the only things holding back productivity growth in the UK and preventing us from closing the long-standing productivity gap between us and other developed countries like France, Germany and the US.. To list just a few widely-cited and discussed problems, the low investment ratio, particularly in R&D, inadequate infrastructure, and poor levels of intermediate and even basic skills have contributed. All these issues are to be addressed we must hope by the government's new Industrial Strategy (HM Government 2017).

## 10. CONCLUSIONS

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. Labour market flexibility can explain why we have also had low unemployment and high employment. The reason why the UK was not able to have fast labour productivity growth after the crisis even though immigration rates were similar to those of the pre-crisis period is that after the crisis the growth of foreign demand for UK exports fell. This has led to low rates of capital accumulation and consequently low rates of productivity growth. This has been compounded by virtually zero growth rates of TFP, but this last is a factor common to virtually all the countries studied here; indeed in some countries like Sweden the *level* of TFP has fallen substantially.

Due to the nature of their labour markets and social policies, most EU countries have had much less rapid growth rates of labour after the crisis. Consequently they have had better productivity growth but worse labour market outcomes than the UK.

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<sup>24</sup> The policies discussed here are focused entirely on productivity effects. There are many other social and economic consequences of large-scale immigration which are beyond the scope of this paper. For discussion of the economic, demographic and fiscal implications see Rowthorn (2015) and for the wider social implications see Goodhart (2013).

The factors leading to people from all over the world coming to the UK to work are of course complex. Much must depend on conditions in the migrants' countries of origin. But by the nature of its flexible labour market and other institutions the UK has been much more welcoming to migrants as workers than have most other EU countries.

That the facts are consistent with this explanation has been demonstrated by a simple modification of the workhorse Solow growth model. Taking inspiration from the early work of Arthur Lewis I adapt the Solow model to make the growth of demand for a country's exports depend on the growth of foreign demand. In normal times this constraint does not bind. In abnormal times, like the Great Recession and its aftermath, foreign demand acts as a constraint on the home economy. If labour supply is rising sufficiently rapidly in this situation due to immigration while output is constrained by foreign demand, then capital intensity will rise less rapidly or even fall, leading to stagnant or falling labour productivity, a situation which might be described as "growth with unlimited supplies of labour". Other countries' outputs are also constrained by foreign demand but their inflexible labour markets plus their adherence to the European Social Model mean that the effects show up as higher unemployment and lower job creation, accompanied by lower immigration.

Slow growth of capital intensity is not however the whole story. The UK and the other countries studied here have seen a large fall in TFP growth as well. I argue that this is a consequence of slow growth in GDP since 2007, in turn due to constrained demand for exports as emphasised by the neo-Lewis model. The countries with the largest falls in GDP growth also had the largest falls in TFP growth. Based on earlier industry-based studies, I argue that this relationship is causal, due to a form of increasing returns but working here in reverse.

## TABLES

**Table 1**  
**UK employment by country of birth, millions**

	Total	UK-born	Foreign-born	of which:	
				EU27	non-EU
1997	26.523	24.547	1.975	0.651	1.324
1998	26.794	24.712	2.080	0.700	1.380
1999	27.167	25.050	2.116	0.697	1.419
2000	27.483	25.272	2.210	0.710	1.500
2001	27.711	25.397	2.311	0.725	1.586
2002	27.944	25.484	2.457	0.738	1.719
2003	28.223	25.656	2.565	0.752	1.813
2004	28.533	25.825	2.707	0.784	1.923
2005	28.853	25.940	2.911	0.884	2.027
2006	29.140	25.899	3.238	1.017	2.221
2007	29.379	25.846	3.525	1.174	2.351
2008	29.628	25.843	3.780	1.288	2.492
2009	29.154	25.358	3.788	1.288	2.501
2010	29.227	25.336	3.886	1.354	2.532
2011	29.375	25.218	4.147	1.498	2.649
2012	29.695	25.419	4.268	1.570	2.698
2013	30.042	25.591	4.437	1.652	2.785
2014	30.752	25.992	4.749	1.834	2.915
2015	31.281	26.214	5.050	2.061	2.989
2016	31.725	26.266	5.453	2.303	3.150
2017 (Jan-June)	31.931	26.267	5.660	2.366	3.294
<i>Growth rates,</i>					
<i>% pa</i>					
2000-2007	0.95	0.32	6.67	7.18	6.42
2007-2016	0.85	0.18	4.85	7.49	3.25

Source: ONS, "Employment by country of birth and nationality", August 2017 [emp06aug2017.xlsx]

Note: Annual averages of quarterly levels.

**Table 2**  
**Mean growth rates by country, 2000-2007 and 2007-2015 (% p.a.)**

Country	Code	GDP (Y)		Hours (L)		Labour productivity (y)		Capital intensity (k)		TFP (A)		Foreign demand (Z)	
		2000-2007	2007-2015	2000-2007	2007-2015	2000-2007	2007-2015	2000-2007	2007-2015	2000-2007	2007-2015	2000-2007	2007-2015
Austria	AT	2.31	0.57	0.37	-0.12	1.94	0.70	2.12	1.54	0.89	-0.02	3.34	0.50
Australia	AU	3.71	2.51	1.79	0.60	1.92	1.91	3.55	3.76	0.21	-0.01	5.34	2.63
Belgium	BE	2.11	0.82	0.73	0.43	1.38	0.39	2.03	0.69	0.47	-0.10	2.63	0.44
Bulgaria	BG	5.73	1.56	2.13	-1.06	3.61	2.62	.	.	.	.	3.92	-0.45
Canada	CA	2.47	1.28	1.81	0.81	0.66	0.47	2.12	1.46	-0.23	-0.13	2.17	0.17
Czech Rep.	CZ	4.38	0.59	-0.19	0.01	4.58	0.61	4.10	4.32	2.20	-1.67	.	.
Germany	DE	1.57	0.79	-0.13	0.31	1.70	0.48	2.45	1.04	0.87	-0.07	3.40	0.49
Denmark	DK	1.31	0.37	0.47	-0.54	0.84	0.91	1.58	2.43	0.01	-0.39	2.86	0.53
Greece	EL	3.74	-3.65	1.54	-2.67	2.20	-0.97	.	.	.	.	5.00	0.92
Spain	ES	3.37	-0.41	3.07	-1.79	0.30	1.38	1.44	2.91	-0.39	-0.44	2.37	0.27
Finland	FI	2.97	-0.84	0.82	-0.42	2.15	-0.42	0.84	0.94	1.66	-0.94	3.35	0.40
France	FR	1.82	0.55	0.55	0.01	1.27	0.54	2.30	1.27	0.23	-0.35	2.94	0.29
Hungary	HU	3.51	0.46	.	.	.	.	.	.	.	.	3.83	0.38
Ireland*	IE	4.72	0.04	2.83	-2.48	1.89	2.52	.	.	.	.	2.22	0.19
Italy	IT	1.13	-0.96	1.09	-1.08	0.04	0.12	1.46	1.66	-0.70	-0.51	3.28	0.43
Netherlands	NL	1.96	0.57	0.63	0.00	1.34	0.57	0.82	0.80	.	0.10	2.66	0.46
Poland**	PL	5.40	3.14	2.62	0.48	2.78	2.66	.	.	.	.	3.57	0.20
Portugal	PT	1.38	-0.49	-0.07	-1.47	1.45	0.98	.	.	.	.	3.02	-0.29
Romania	RO	6.03	1.64	-1.81	-1.61	7.84	3.25	.	.	.	.	3.52	-0.03
Sweden	SE	2.94	1.25	0.46	0.76	2.49	0.49	2.85	1.80	-0.14	-0.73	3.22	0.36
Slovenia	SI	4.43	-0.04	0.46	-0.20	3.97	0.16	.	.	.	.	3.61	0.21
Slovakia	SK	6.03	2.09	0.84	0.25	5.19	1.84	.	3.36	.	0.07	3.79	0.40
United Kingdom	UK	2.61	0.78	0.69	0.70	1.91	0.08	1.86	0.22	1.01	-0.30	2.78	0.59
United States	US	2.08	0.85	0.37	0.23	1.70	0.63	2.30	0.96	0.69	0.15	3.08	1.25
<i>Mean</i>		<i>3.14</i>	<i>0.56</i>	<i>0.83</i>	<i>-0.38</i>	<i>2.29</i>	<i>0.95</i>	<i>2.12</i>	<i>1.82</i>	<i>0.48</i>	<i>-0.33</i>	<i>3.38</i>	<i>0.44</i>
<i>Min</i>		<i>1.13</i>	<i>-3.65</i>	<i>-1.81</i>	<i>-2.67</i>	<i>0.04</i>	<i>-0.97</i>	<i>0.82</i>	<i>0.22</i>	<i>-0.70</i>	<i>-1.67</i>	<i>2.17</i>	<i>-0.45</i>
<i>Max</i>		<i>6.03</i>	<i>3.14</i>	<i>3.07</i>	<i>0.81</i>	<i>7.84</i>	<i>3.25</i>	<i>4.10</i>	<i>4.32</i>	<i>2.20</i>	<i>0.15</i>	<i>5.47</i>	<i>2.63</i>

Source: For all countries except Canada and Australia: EU KLEMS, September 2017 release ([www.euklems.net](http://www.euklems.net)). Data for Canada are from Statistics Canada, downloaded on 17/11/2017 from <http://www.statcan.gc.ca/eng/start>, a spreadsheet named cansim-3830021.xls. Australian data are from Australian Bureau of Statistics, downloaded on 17/11/2017 from <http://www.abs.gov.au/AusStats/ABS@.nsf/MF/5260.0.55.002>, a spreadsheet named 52600550022016.xls. Foreign demand: Export-Weighted Imports from NIESR's NiGEM database.

Note: For Canada and Australia, figures are for the market sector. For all other countries, figures are for the whole economy.

\* Ireland: 2007-2014, not 2007-2015, since Irish GDP in 2015 was distorted by tax manipulation by multinationals.

\*\* Poland: 2003-2007, not 2000-2007, due to missing values in 2000, 2001 and 2002.



**Table 3****Tests of the neo-Lewis model:****dependent variables are the change in the growth of labour productivity ( $\Delta\hat{y}$ ) and the change in the growth of capital intensity ( $\Delta\hat{k}$ )**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\Delta\hat{y}$	$\Delta\hat{y}$	$\Delta\hat{y}$	$\Delta\hat{y}$	$\Delta\hat{k}$	$\Delta\hat{k}$	$\Delta\hat{k}$	$\Delta\hat{k}$
$\Delta\hat{Z}$	–	1.146** (0.474)	1.270*** (0.395)	0.868* (0.471)	–	-0.05032 (0.669)	-0.398 (0.255)	-0.402 (0.276)
$\Delta\hat{L}$	-0.369* (0.200)	–	-0.433*** (0.135)	-0.507*** (0.146)	-0.586*** (0.0834)	–	-0.606*** (0.0766)	-0.618*** (0.0903)
$\hat{Y}^B$	–	–	–	-0.343* (0.168)	–	–	–	-0.0750 (0.270)
Constant	-1.745*** (0.377)	1.995 (1.231)	1.751 (1.024)	1.602 (1.150)	-0.983*** (0.167)	-0.577 (1.782)	-1.985** (0.737)	-1.833 (1.088)
Observations	22	22	22	22	14	14	14	14
R-squared	0.168	0.285	0.513	0.603	0.686	0.000	0.713	0.716

Source: Data from Table 2.

Note: \*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1. OLS estimates; robust standard errors in parentheses.

**Table 4**  
**Testing the externality hypothesis in 52 countries**

Independent variables	Dependent variable			Change in <i>K/L</i> growth (4)
	(1)	Change in TFP growth		
		(2)	(3)	
Change in GDP growth	0.527*** (0.0803)			
Change in capital growth		0.135 (0.151)		
Change in hours growth			-0.118 (0.152)	
Change in TFP growth				0.283 (0.194)
Constant	-0.281 (0.168)	-1.259*** (0.221)	-1.412*** (0.218)	1.105*** (0.363)
<i>N</i>	52	52	52	52
R-squared	0.514	0.018	0.018	0.058

Note: Changes are measured as annual average growth over 2007-2014 minus annual average growth over 2000-2007. Robust standard errors in parentheses.

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Penn World Table, version 9.0, and own calculations.

# CHARTS

## Chart 1



Chart 2

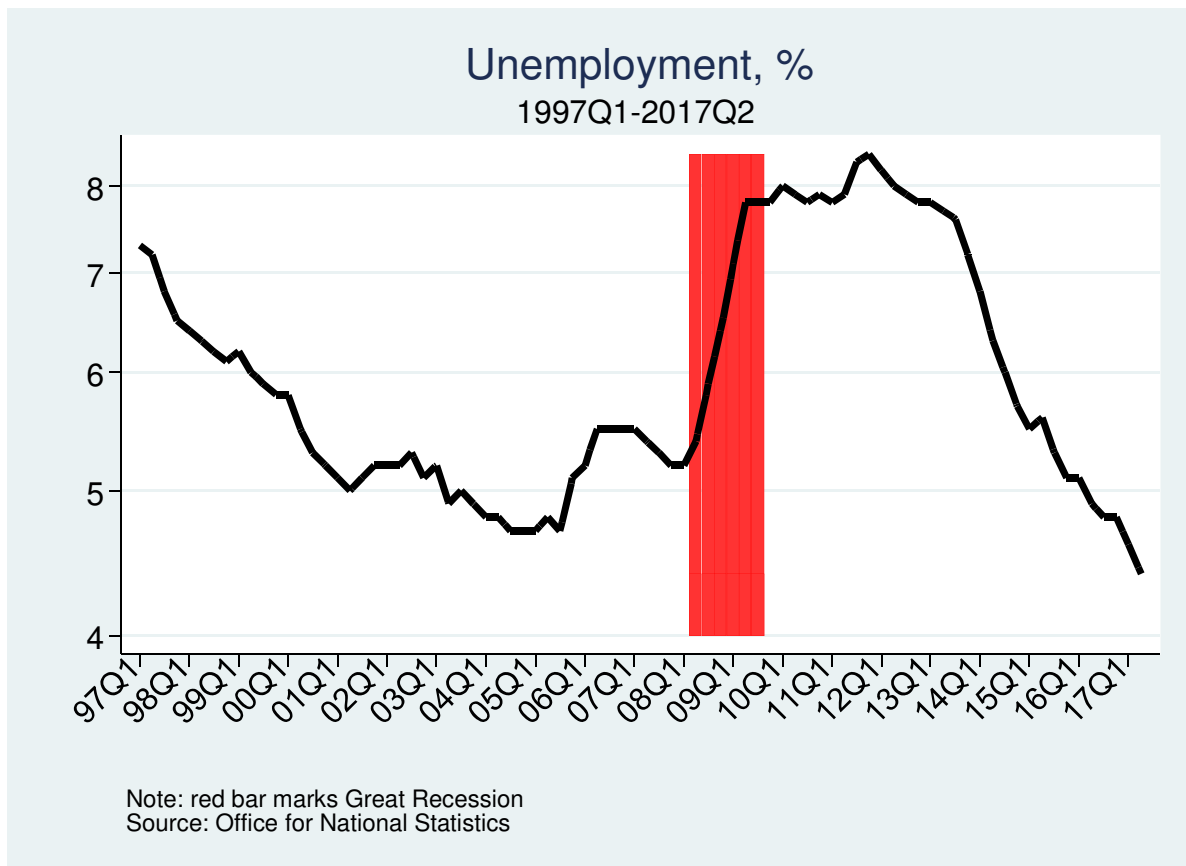
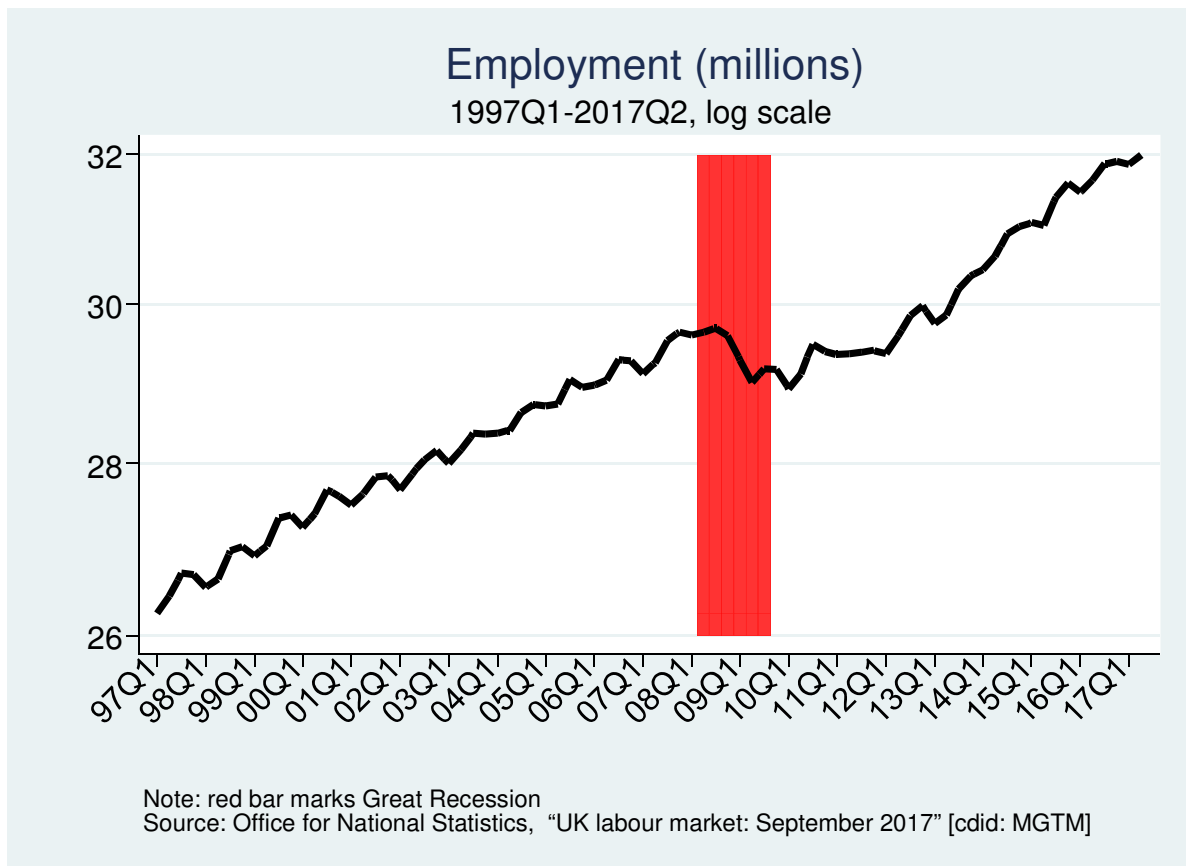
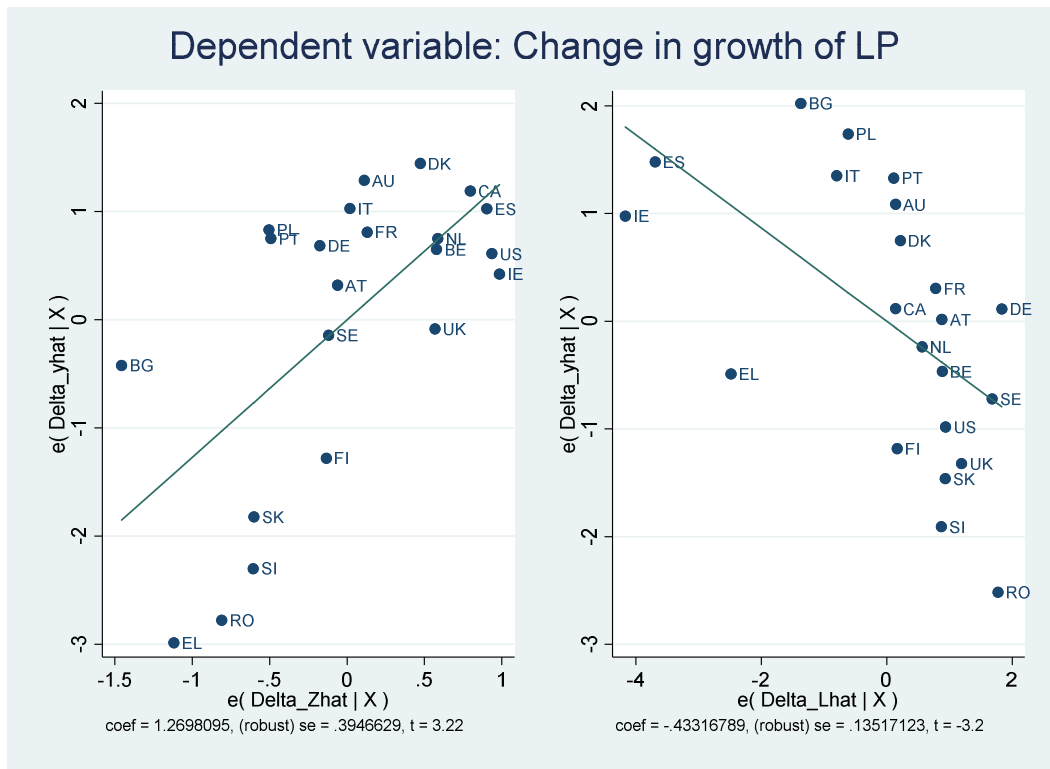


Chart 3

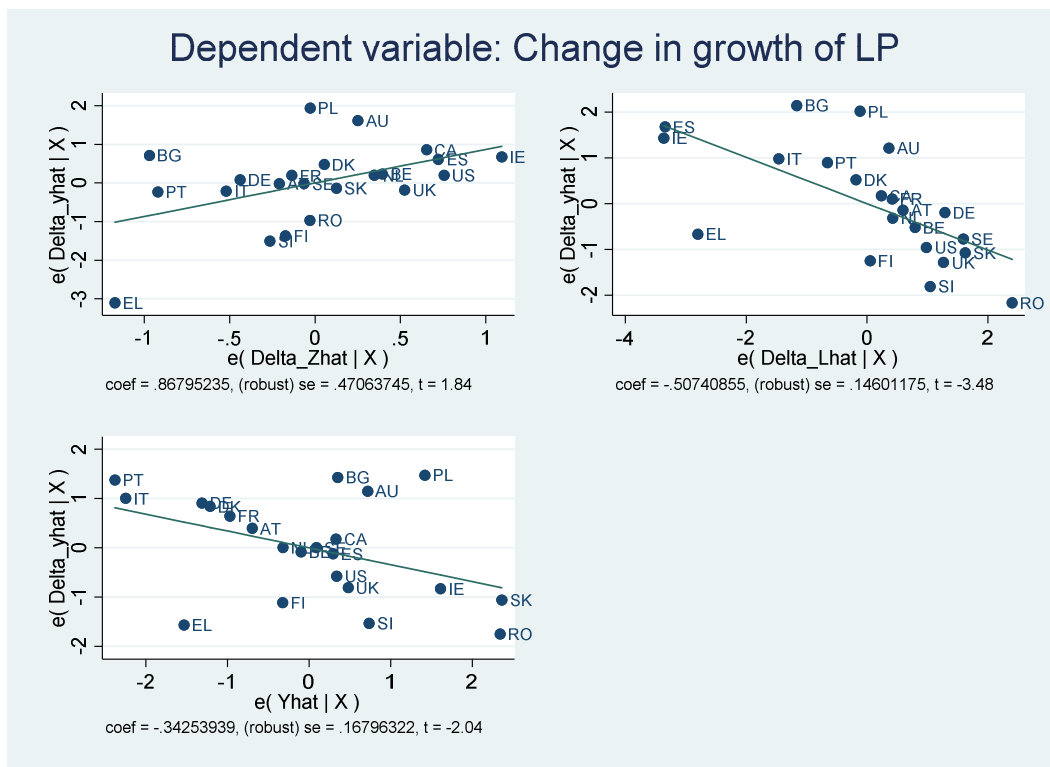


### Chart 4

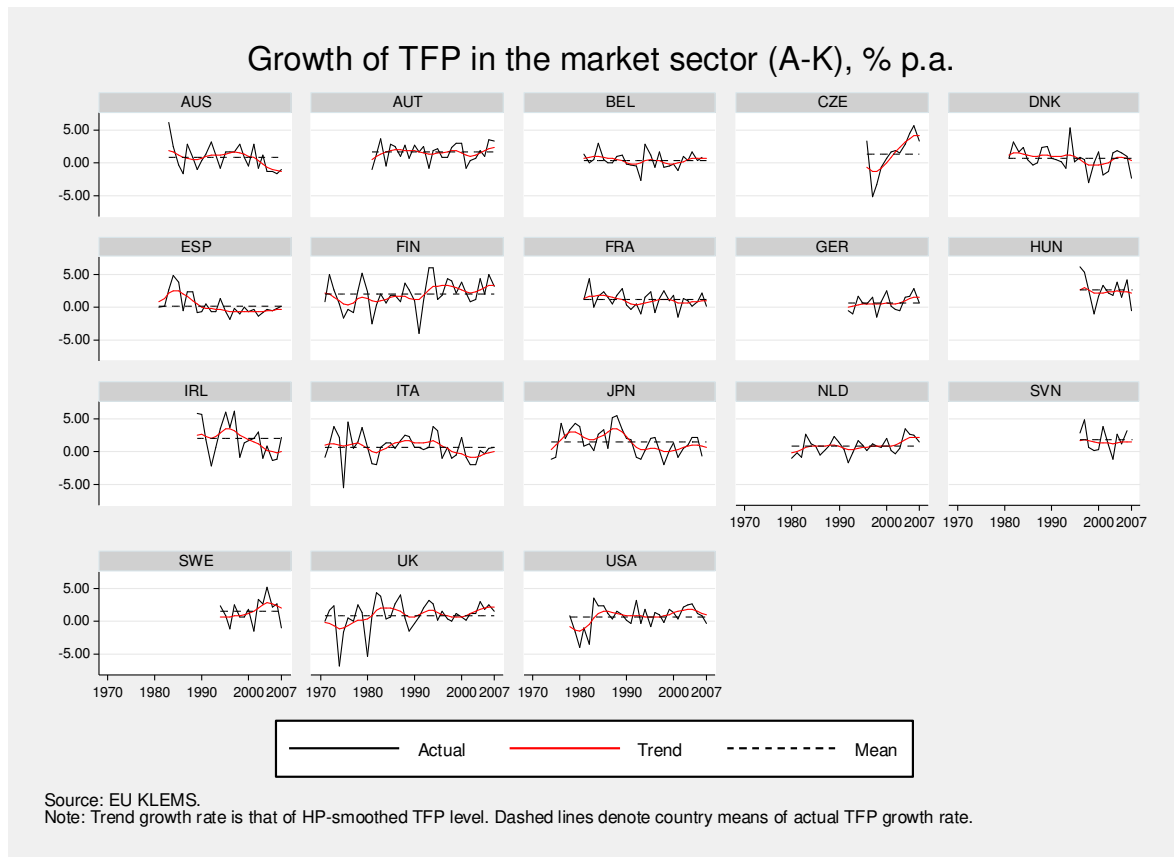
Added variable plots for column (3) of Table 3 (see Table 2 for country codes)



Added variable plots for column (4) of Table 3 (see Table 2 for country codes)

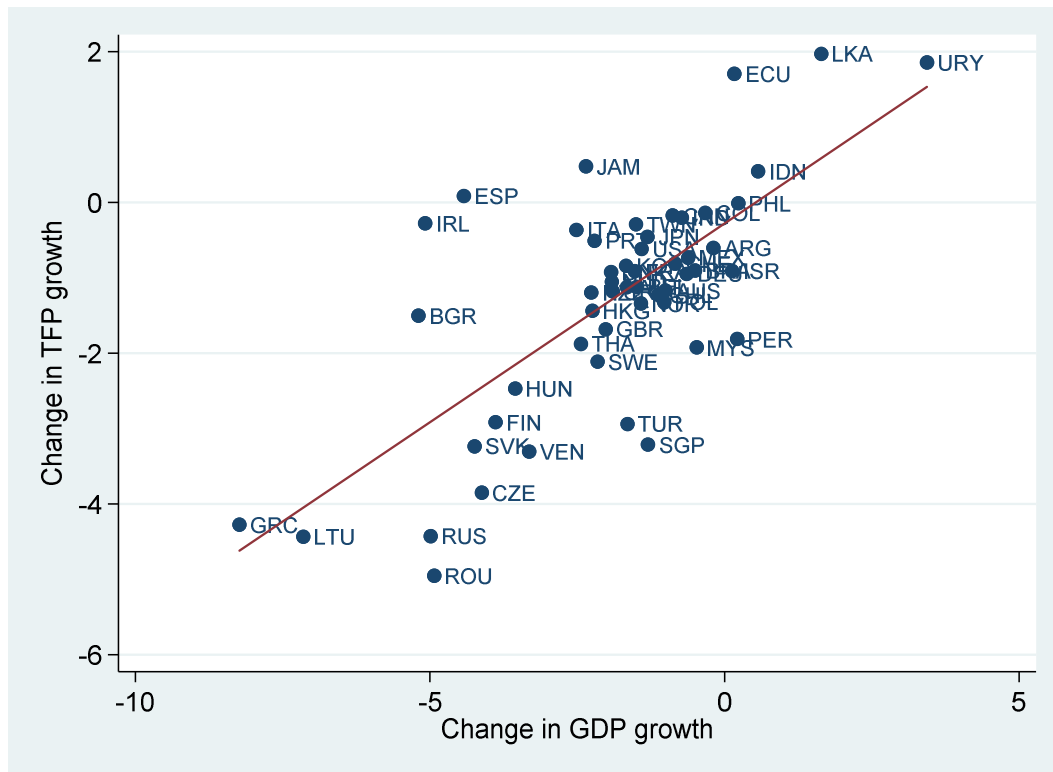


**Chart 5**  
**TFP growth in the market sector in 18 countries up till 2007**



Source: Oulton (2016b), derived using EU KLEMS (the March 2011 update of the November 2009 release).

**Chart 6**  
**Change in TFP growth versus change in GDP growth (52 countries)**



Source: Penn World Table, version 9.0. Average annual growth rates over 2007-2014 minus annual average growth rates over 2000-2007.



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