Financing Investment: Interim Report

December 11th 2017

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Contents

Executive Summary

UK banks have helped to create a distorted economy. Lending is flowing into unproductive sectors.

Financial stability has been compromised by an economy that is insufficiently geared towards productive lending and investment.

The UK's productivity performance is extremely poor by international standards. The UK runs the risk of being left behind by technological developments, which could and should enrich the whole country. R&D spending is low and not enough companies operate at the scale needed to deliver major increases in research spending. This has longer-term consequences for wages and living standards.

A failure to keep up with the pace of innovation also has direct consequences for banks. Big data should be used to improve decision-making processes for lending. This will allow new lenders to track creditors effectively, providing timely intervention, advice and support to help businesses evolve and grow.

A Strategic Investment Board will be needed to facilitate coordination between the Treasury, the Bank of England and the Department for Business, Energy and Industrial Strategy (BEIS). This will re-establish the link between the real economy and the banking sector.

The Strategic Investment Board will bring together scientists, engineers, entrepreneurs and representatives of industry and trade unions.

The Bank of England mandate should also be reviewed.

Productive sectors are increasingly concentrated in a small part of the country.

There is a risk that the disproportionate number of technology companies in London and the South East will increase, exacerbating regional inequality. Governments have a critical role in addressing these weaknesses, but that will require determined, strategic action.

To drive investment across the country, this interim report makes a number of initial recommendations:

- Locating the National Investment Bank in Birmingham. In the June 2017 manifesto, the Labour Party proposed the creation of a National Investment Bank.
- Locating the Strategic Investment Board secretariat and research department in Birmingham.
- Moving some Bank of England functions to Birmingham.
- Establishing Bank of England offices in Glasgow, Cardiff and Belfast, and two smaller regional offices in Newcastle and Plymouth. In addition, regional offices for the Strategic Investment Board should be created in the same cities.

The regional offices of the Bank of England and the Strategic Investment Board would ensure that productive lending is geared towards the needs of local businesses.

Relocating core economic institutions will provide a clear, visible example of a new government's determination to promote growth and a rebalancing of the economy.

Birmingham is England's second largest city. Relocating institutions to Birmingham should also provide the opportunity to upgrade the regional railway and other transport networks.

Introduction

The pace of technological change is accelerating, threatening established business models and creating an economy characterised by frequent 'disruptive' episodes. As a central bank sitting at the heart of the UK financial system, the Bank of England needs to be playing an active, leading role, ensuring banks are helping UK companies to innovate. Flow of funds analysis shows that banks are diverting resources away from industries vital to the future of this country.

Japan, the US, China, South Korea, Germany and now France are moving ahead of the UK. The UK is falling behind. UK banks have failed to support businesses, focussing on unproductive lending, such as consumer credit borrowing. The predictable failure of this model was recently recognised by the Bank of England and, belatedly, by the lenders themselves.

The Financial Policy Committee at the Bank of England is currently "charged with a primary objective of identifying, monitoring and taking action to remove or reduce systemic risks with a view to protecting and enhancing the resilience of the UK financial system". The Financial Policy Committee is not doing this. It is ignoring investment, which plays a critical role in preventing systemic risks.

The Financial Policy Committee makes no distinction between unproductive and productive lending to companies (specifically to sectors that are technology-intensive and critical to boosting the potential growth path of the UK economy). Financial stability depends on a more desirable balance between unproductive and productive lending.

The Financial Policy Committee is currently focussed on eliminating perceived 'risks' within the financial sector. However, it takes a narrow approach by concentrating on banking resilience (regulatory capital and liquidity), without sufficient regard to the wider second-round impact of its policies. The banking sector should be geared towards stimulating productive investment. Only this will truly reduce the systemic risks currently facing the UK. There is a clear need to re-establish the linkages between the real economy and the UK banks.

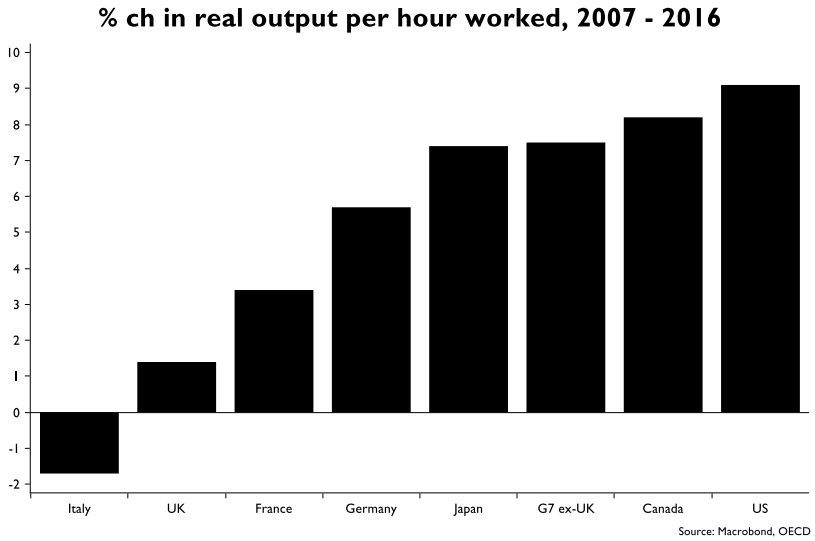
A distorted economy

International and sectoral comparisons of labour productivity

UK productivity has stagnated since the financial crisis of 2007/08. Real output per hour worked rose just 1.4% between 2007 and 2016 (chart 1). Within the G7, only Italy performed worse (-1.7%). Excluding the UK, the G7 countries have experienced a 7.5% productivity increase over this period, led by the US, Canada and Japan.

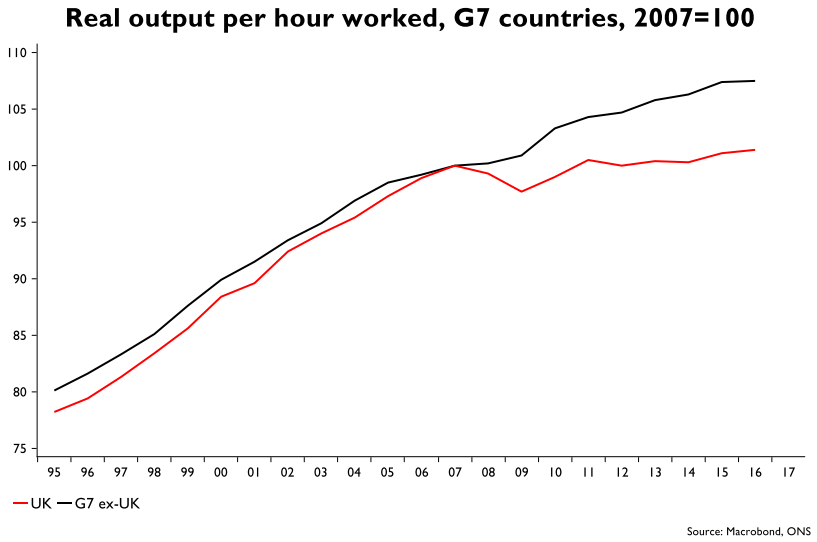
In addition, the 'productivity gap' for the UK – the difference between output per hour in 2016 and its pre-crisis trend – is minus 15.8%. The productivity gap for the G7 ex-UK countries is minus 8.8% (chart 2). Since 2007, real GDP per capita in the UK has lagged both the US and Japan. The UK has been slightly ahead of the Eurozone.

Chart 1



The ONS has also published 'experimental' statistics comparing productivity across countries *and* sectors. The UK's poor productivity performance is not confined to manufacturing. Indeed, the UK underperforms in precisely those areas that are generally considered to be its strengths (see appendix 1 for a full sectoral breakdown). The UK's productivity (output per hour worked) in financial & insurance activities was ranked 23rd out of 29 countries covered by the ONS (EU plus Norway). For 'professional, scientific and technical activities' and 'administrative and support service activities' *combined*, the UK only managed 24th place.

Chart 2



Comparative advantage in services under threat

Despite the weak services productivity data, it appears that the UK still maintains a competitive advantage in this sector. ONS current account data show that the services surplus totalled £99.04bn in the four quarters to Q2 2017, a record high (table 1). The two largest components of the UK's services surplus are financial services (£50.79bn) and 'other' business services (£29.30bn).

Table 1

UK current account balance, services (£bn, 4-quarter moving totals)

Sector	Q4 2007	Q2 2017	Actual change (Q4 2007 - Q2 2017)
Overall services	51.81	99.04	47.23
Financial services	36.25	50.79	14.54
Other business services	18.07	29.30	11.23
Insurance & pension services	9.67	15.72	6.05
Telecomms, computer & information services	3.33	8.67	5.34
Transport	-1.65	4.72	6.37
Intellectual property services	4.33	3.98	-0.35
Manufacturing & maintenance services	0.20	2.71	2.51
Personal, cultural & recreational services	0.25	0.85	0.60
Construction services	0.20	0.53	0.33
Government services, N.I.E	-1.15	-1.07	0.08
Travel	-17.69	-17.15	0.54

Source: ONS

Service sector exports rose to an all-time high of £259.13bn in the four quarters to Q2 2017, a £100.06bn increase since 2007 (table 2). The biggest contribution since 2007 has come from 'other business services', which hit a record £75.37bn in Q2 2017. Other business services are made up of

R&D, 'professional & management consulting services', and 'technical, trade-related & other business services'. Almost half (46.2%) of 'other business services' exports are left uncategorised: they are grouped under a separate 'other business services' subcategory. It is possible that many new digital companies are in this category.

Table 2

UK current account, service sector exports (£bn, 4-quarter moving totals)

Sector	Q4 2007	Q2 2017	Actual change (Q4 2007 - Q2 2017)
Overall services	159.07	259.13	100.06
Other business services	40.25	75.37	35.13
Financial services	45.61	62.32	16.71
Travel	20.56	32.07	11.51
Transport	17.08	27.61	10.53
Telecomms, computer & information services	9.63	19.81	10.18
Insurance & pension services	11.70	15.92	4.22
Intellectual property services	8.92	13.26	4.34
Personal, cultural & recreational services	1.90	4.49	2.58
Manufacturing & maintenance services	0.29	4.10	3.82
Government services, N.I.E	2.13	2.59	0.47
Construction services	1.01	1.59	0.58

Source: ONS

The widening services surplus has not been enough to prevent a deterioration in the current account deficit (chart 3). Furthermore, the competitive advantage of the UK is at risk, if the productivity numbers cited above by the ONS are correct (see appendix 1). The current divergence between the (wider) trade deficit for goods and the (rising) surplus for services may exacerbate the disparity in incomes across the UK.

The biggest increase in the services surplus since 2007 has been in financial services. The UK was home to 10 companies in the KPMG Fintech100 report for 2017, behind the US (19), in line with Australia (10) and ahead of China (9). However, the UK's edge in financial services may be challenged. The UK had only one company in the top 10 (Atom Bank, 8th). Chinese fintech companies, by contrast, occupied the top three spots and accounted for five of the top ten places. China is fast emerging as the leader in fintech.

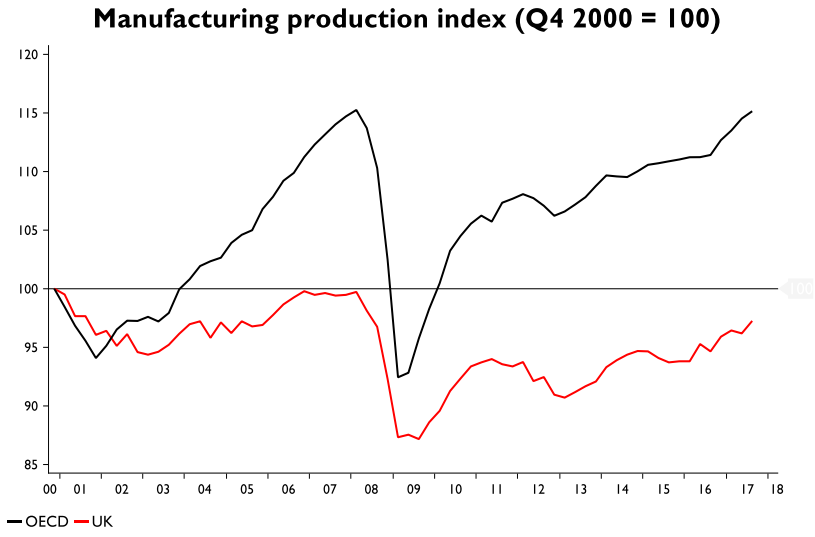
Chart 3

Source: Macrobond, ONS Database

High-technology production falters

UK manufacturing output is currently 3.8% *below* the peak reached over 16 years ago (Q4 2000). The decline in overall industrial production (i.e. manufacturing, mining & energy *combined*) has been even more pronounced over this period (-10.4%). The UK's manufacturing production figures compare unfavourably to the rest of the G7, EU, Eurozone and OECD averages (table 3 and chart 4). Germany and South Korea are racing ahead. German manufacturing production has climbed 25.2% since Q4 2000. South Korea has registered an impressive increase in output of 105.3% over this period. The UK trails the US too. Despite being pulled down by weak production statistics from the peripheral countries and France, total Eurozone manufacturing production has also risen well ahead of the UK.

Chart 4



Source: Macrobond, OECD (Organisation for Economic Co-operation & Development)

Table 3

Industrial production for select countries/regions, percentage change (%) between Q4 2000 - Q2 2017

Country/Economic region	Manufacturing	Overall industrial production (ex-construction)
South Korea	105.3	103.4
Germany	25.2	26.5
OECD	14.5	14.6
EU 28	10.5	7.9
Euro Area	6.7	5.5
US	5.2	9.8
G7	1.9	4.6
UK	-3.8	-10.4
Japan	-4.3	-3.7
Canada	-10.6	2.5
France	-13.5	-11.6
Italy	-21.3	-19.6

Source: OECD

The picture remains the same when looking at the more recent history. The pre-crisis peak of UK manufacturing was in Q4 2006: output today remains 3.6% below this level.[1] Again, the UK trails the OECD, European Union and Eurozone averages.

If the UK was focussing on cutting-edge technology, then the overall decline in industrial production would be less of a concern. However, separate statistics from Eurostat show that the UK's output of high-technology industries has in fact fallen by an average of 0.4% y/y over the past ten years. High technology industries are classified by their "technological intensity", defined as R&D expenditures as a share of value-added.[2] Out of the 20 EU countries for which this data is available, only Sweden has experienced a bigger decline (table 4).[3] Average Eurozone production has increased by 3.3% y/y over the past ten years, while production in the EU has risen 2.4% y/y.

[1] Timelier data from the ONS point to an uptick in industrial production in Q3: excluding construction, output in September climbed to the highest since October 2008. The Markit manufacturing PMI for November hit a 51-month high too: investment goods orders increased at the fastest pace since August 1994. For some companies, the weaker pound continues to boost export competitiveness. A synchronised global economic upswing is providing a tailwind for manufacturers too. Nevertheless, ONS statistics show that output remains 9.2% below the peak of November 2000. IMF Direction of Trade Statistics also show that the UK's share of world exports fell to a low of 2.53% in the year to June 2017, before edging up to 2.56% in the year to August 2017.

[2] See "Glossary: High-tech", Eurostat, http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech. The industries that qualify as "high-technology" are the 'manufacture of basic pharmaceutical products and pharmaceutical preparations'; 'manufacture of computer, electronic and optical products'; and 'manufacture of air and spacecraft and related machinery'.
Similarly, the industries that qualify for "medium-high-technology" classification are: 'manufacture of chemicals and chemical products'; 'manufacture of weapons and ammunition'; 'manufacture of electrical equipment'; 'manufacture of machinery and equipment N.E.C.'; 'manufacture of motor vehicles, trailers and semi-trailers'; 'manufacture of other transport equipment' excluding 'building of ships and boats' and excluding 'manufacture of air and spacecraft and related machinery'; 'manufacture of medical and dental instruments and supplies'.

[3] Data are for EU 28 countries, except for Ireland, Slovakia, Slovenia, Malta, Cyprus, Luxembourg, Finland, and Croatia, for which there was insufficient data.

Table 4

Manufacturing output for select European countries, average annual percentage change (%) between Q2 2007 - Q2 2017

High-tech		Medium high-tech		Medium low-tech		Low-tech	
Estonia	30.1	Romania	15.1	Poland	5.5	Poland	4.5
Lithuania	14.0	Latvia	8.8	Lithuania	2.0	Lithuania	4.1
Latvia	13.8	Czech Rep.	6.2	Austria	1.0	Latvia	1.9
Belgium	8.9	Hungary	6.2	Romania	1.0	Estonia	1.3
Poland	5.6	Poland	6.1	Bulgaria	0.8	Belgium	0.8
Romania	5.3	Lithuania	5.8	Czech Rep.	0.7	Hungary	0.6
Austria	5.3	Bulgaria	4.1	Germany	0.7	Austria	0.1
Czech Rep.	4.9	Estonia	3.9	Latvia	0.6	Romania	-0.1
Bulgaria	4.1	Austria	1.6	Hungary	0.4	UK	-0.2
Denmark	3.6	Denmark	1.5	Belgium	0.4	Portugal	-0.2
Germany	3.4	Netherlands	1.5	Estonia	-0.0	Netherlands	-0.3
Netherlands	2.9	Germany	0.8	Netherlands	-0.1	Germany	-0.5
France	1.3	UK	0.1	Portugal	-0.8	Czech Rep.	-0.8
Hungary	1.2	Belgium	-0.4	UK	-0.9	Sweden	-1.4
Greece	0.6	Sweden	-1.4	Sweden	-1.4	Denmark	-1.7
Italy	0.5	France	-1.4	Denmark	-2.0	France	-1.7
Spain	0.5	Spain	-1.9	France	-2.1	Italy	-1.9
Portugal	0.4	Italy	-2.1	Italy	-2.6	Spain	-2.1
UK	-0.4	Greece	-3.5	Spain	-3.6	Bulgaria	-2.4
Sweden	-2.6	Portugal	-4.1	Greece	-3.7	Greece	-4.0

Source: Eurostat

The UK runs large and rising trade deficits in many strategically important sectors (appendix 2). According to the ONS, the manufacturing trade deficit widened to a record £128.0bn in the year to Q2 2017 (chart 5). Within this, the largest shortfall occurred in 'computer, electronic & optical products' (£22.9bn, chart 6). This includes a £9.4bn deficit in communication equipment, also a record. Other significant trade deficits for high-tech manufactures include 'electrical equipment' (£9.0bn) and 'machinery & equipment N.E.C' (£3.4bn).[4]

[4] N.E.C = Not elsewhere classified.

Chart 5

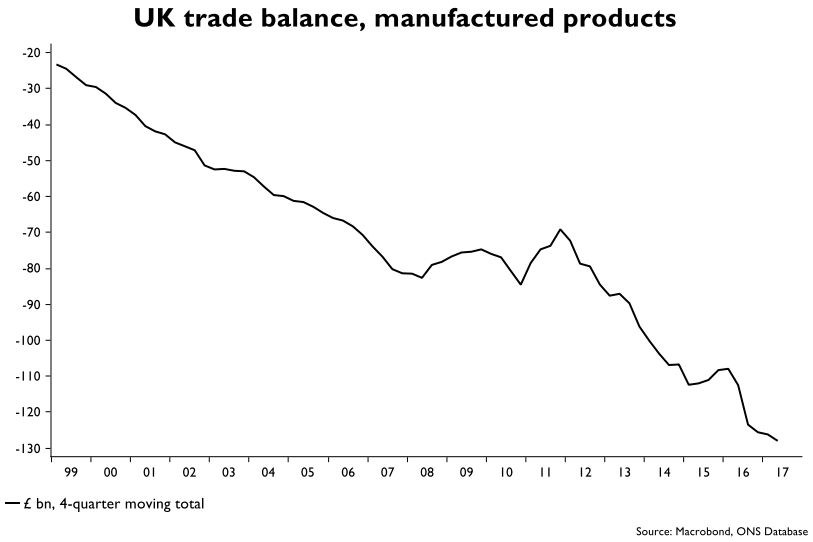
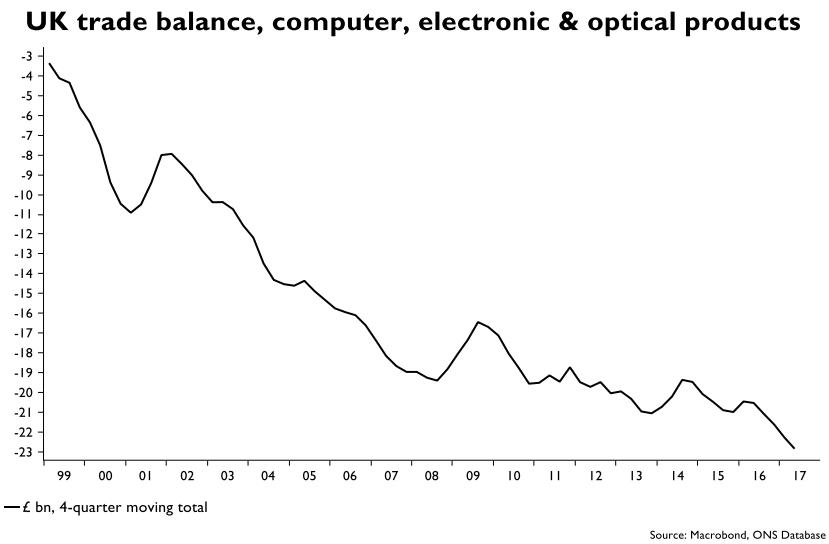


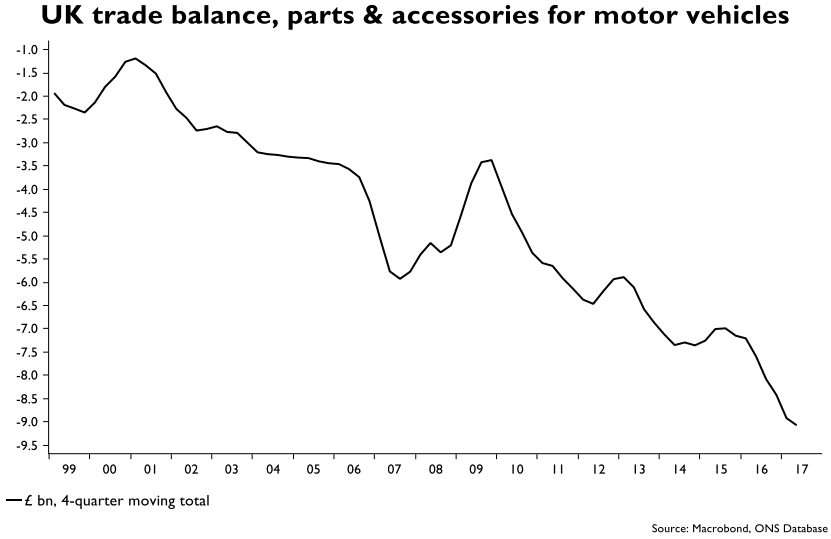
Chart 6



The trade deficit for 'motor vehicles, trailers & semi-trailers' was £15.5bn in the four quarters to Q2 2017. The shortfall in motor vehicles has narrowed from £10.5bn in Q1 2016 to £5.8bn. However, the deficit for 'parts & accessories for motor vehicles' continues to expand, hitting a record £9.1bn in Q2 (chart 7). Locally-sourced parts and components used in vehicle manufacturing are a critical variable: according to the Automotive Council, "much of the sector's value added is created at the start of the production process."[5] The share of parts coming from UK suppliers is rising (up from 36% in 2011 to 44% in 2016). That said, it remains below estimates for Germany and France (around 60%).

[5] See "Growing the Automotive Supply Chain: Local Vehicle Content Analysis", Automotive Council UK, June 2017.

Chart 7



Capital investment remains low

Investment in the UK continues to languish. Out of all the G7 countries, the UK has the lowest share of investment in GDP (16.7%, table 5). The data are in nominal terms, but the patterns seen below hold in real terms too: the UK remains in last place. [6]

Table 5

Gross fixed capital formation (GFCF) for G7 economies in 2016, % of GDP

Gross fixed capital formation		Intellectual property products		Machinery & equipment & weapon systems	
Japan	23.1	Japan	5.6	Japan	7.3
Canada	23.0	France	5.3	Germany	6.5
France	22.0	US	5.1	US	6.4
Germany	20.0	Germany	3.8	Italy	6.2
US	19.5	**UK**	3.6	France	4.9
Italy	17.1	Italy	2.8	Canada	4.5
UK	16.7	Canada	2.6	**UK**	4.0

Source: OECD

This is part of a long-term trend of underinvestment. In the twenty years between 1997 and 2017, the UK's gross fixed capital formation has accounted for an average of just 16.7% of GDP (nominal terms).

[6] Important literature has highlighted the potential mismeasurement issues in high-tech goods and services. See, for example, "ICT Services and their Prices: What do they tell us about Productivity and Technology?", David Byrne and Carol Corrado, Finance and Economics Discussion Series, Federal Reserve, September 2017. There is considerable evidence to suggest that the investment figures are in fact understated: the deflators may be too high, and real investment too low. However, these issues are likely to plague most of the countries in the G7. As such, the numbers provided above should still give a useful insight into the *relative performance* of UK investment.

This is the lowest share out of 34 countries displayed in table 6 (30 OECD countries plus Colombia, Lithuania, Costa Rica and South Africa).

Table 6

Gross fixed capital formation as a share of GDP (%), average between Q1 1997 - Q2 2017

Country	%	Country	%
South Korea	30.8	New Zealand	22.1
Estonia	28.3	Iceland	21.8
Czech Republic	28.0	Portugal	21.7
Australia	26.5	France	21.7
Slovak Republic	25.9	Colombia	21.5
Latvia	25.0	Lithuania	21.0
Japan	24.6	Netherlands	20.9
Spain	24.6	United States	20.8
Switzerland	24.1	Denmark	20.6
Slovenia	24.0	Germany	20.5
Ireland	23.7	Israel	20.2
Austria	23.5	Costa Rica	20.2
Sweden	22.4	South Africa	19.8
Belgium	22.3	Greece	19.7
Finland	22.3	Luxembourg	19.6
Canada	22.2	Italy	19.6
Norway	22.1	UK	16.7

Source: OECD, ONS

Gross fixed capital formation can be broken down further into intellectual property products (IPP), machinery & equipment, dwellings, and 'other buildings & structures'. The UK fares marginally better than Italy and Canada in intellectual property products investment as a share of GDP. Nevertheless, this needs to be put into perspective: both Italy and Canada have notoriously underinvested in technology. Canadian investment in intellectual property products tumbled from a peak of 2.33% of GDP in Q1 2008 to just 1.49% in Q2 this year. The UK is salvaged by its relatively high computer software spending as a share of GDP (4th highest globally, according to the Global Innovation Index 2017[7]): R&D spending – the other part of IPP investment – remains chronically low.

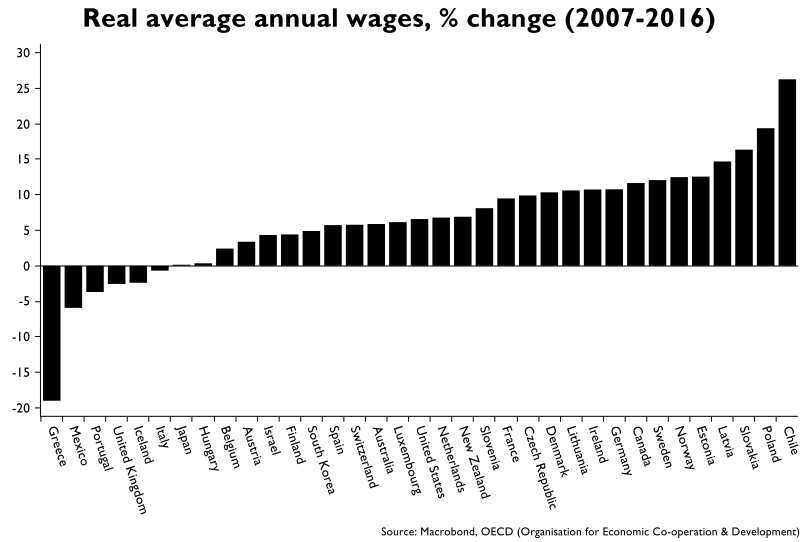
The erosion of the UK's manufacturing capabilities is also evident from the low share of investment spending on machinery & equipment. The UK is last out of all G7 countries (table 5). The UK has

[7] See "The Global Innovation Index 2017", Cornell University, INSEAD and the World Intellectual Property Organisation, WIPO, October 2017, https://www.globalinnovationindex.org/.

slipped into a cycle of low investment and low productivity, which has contributed to the stagnation in real wages.

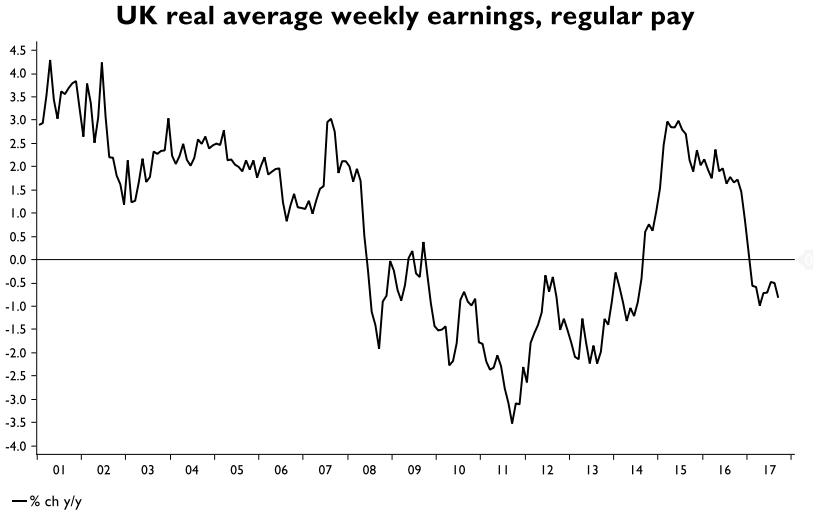
Real average annual wages have fallen 2.6% since 2007, according to the OECD (chart 8). This deterioration in living standards has been amongst the worst in the 35-member group. Sterling's depreciation since the June 2016 referendum has contributed to a further decline in purchasing power: the y/y change in real average weekly earnings (excluding bonuses & arrears) turned negative in February 2017 and was -0.8% in September (chart 9).

Chart 8



Source: Macrobond, OECD (Organisation for Economic Co-operation & Development)

Chart 9



Source: Macrobond, U.K. Office for National Statistics (ONS), ONS Database

Regional imbalances in the UK

The recent growth in UK employment has been heavily skewed towards London and the South East. Since 2007, employment across the UK has risen by 2.71m. However, over half (1.38m) of these jobs have been created in London and the South East. Employment in London has jumped 26.0%. The increase in employment has been comparatively modest for most regions (see table 7). A full sectoral breakdown of employment across regions is available in appendix 3 of this document.

Table 7

UK employment by region (millions)

Region	2007	Sep-17	% change between 2007 - Sep 17
UK	29.347	32.059	9.2
England	24.648	27.156	10.2
London	1.160	1.234	26.0
South East	3.211	3.436	10.1
East	2.413	2.539	9.6
South West	2.138	2.237	7.3
North West	2.523	2.674	7.0
North East	2.774	3.040	6.4
West Midlands	3.694	4.657	6.0
Yorkshire & the Humber	4.200	4.623	5.2
East Midlands	2.534	2.719	4.6
Northern Ireland	2.544	2.652	4.5
Scotland	1.365	1.426	4.4
Wales	0.789	0.825	4.2

Source: ONS

The growth in wages (in sterling terms) has been slower in London over this period, due to retrenchment in the financial sector. Nevertheless, average weekly earnings remain well above the national average (table 8). House prices have also risen more quickly in London and the South East since 2007. Faster employment growth in London and the South East is in danger of being choked by deteriorating affordability. The house price-to-salary ratio for London hit a record high in October (14.5 times average earnings).[8] The Silicon Roundabout in London was recently described as the most expensive technology hub in the world.[9] The regions that have seen the fastest employment growth since 2007 have also experienced the biggest increases in house prices (table 9).

[8] See "London's house price ratio has hit a record high", City AM, November 28th 2017, http://www.cityam.com/276507/londons-house-price-salary-ratio-has-hit-record-high.
[9] See "London is home to the world's most expensive technology hub", The Telegraph, September 28th 2017, http://www.telegraph.co.uk/business/2017/09/28/london-home-worlds-expensive-technology-hub/.

Table 8

Average weekly earnings by region (£)

Region	Apr-07	Apr-17	% change between Apr-07 and Apr-17
UK	376.0	448.6	19.3
England	463.6	555.8	19.9
London	586.3	692.5	18.1
South East	481.9	574.9	19.3
East	450.5	545.5	21.1
South West	429.6	520.0	21.0
West Midlands	430.1	514.9	19.7
North West	434.9	514.0	18.2
North East	404.3	504.1	24.7
Yorkshire & the Humber	422.6	502.5	18.9
East Midlands	421.6	499.4	18.5
Scotland	441.7	547.3	23.9
Northern Ireland	400.3	501.2	25.2
Wales	404.3	498.4	23.3

Source: ONS

Table 9

House prices by region (£)

Region	2007	Q3 2017	% change between 2007 - Q3 2017
England			
London	294,907	471,761	60.0
Outer Metropolitan	254,029	365,584	43.9
Outer South East	211,798	277,519	31.0
East Anglia	181,394	222,080	22.4
South West	201,135	240,832	19.7
East Midlands	155,284	177,825	14.5
West Midlands	163,753	183,018	11.8
North West	157,786	156,193	-1.0
Yorkshire & the Humber	154,453	151,482	-1.9
North	132,909	127,213	-4.3
Scotland	148,295	146,022	-1.5
Wales	153,397	149,970	-2.2
Northern Ireland	220,512	133,659	-39.4

Source: Nationwide

A sizeable number of UK households (10%) are still without internet access in their homes (table 10). The North East, North West, Midlands, South West and Wales all have a share above 10%: London and the South East are well below average.

Table 10

Households with internet access (%)				
Region	2006	2011	2016	2017
Great Britain	57	77	89	90
London	63	82	94	94
South East	66	80	94	94
Yorkshire & the Humber	52	74	86	90
Scotland	48	77	87	90
North West	54	78	89	89
West Midlands	53	71	84	89
East of England	64	76	88	89
South West	59	78	88	88
East Midlands	55	77	85	87
Wales	52	71	85	84
North East	54	70	92	82

Source: ONS

Table 11

Average life expectancy* at birth by region, years			
Region	1991-1993	2012 - 2014	Percentage point change
UK	76.1	80.9	4.9
England	76.3	81.2	4.9
London	76.3	82.3	6.0
South East	77.5	82.3	4.8
East	77.6	82.1	4.6
South West	77.6	82.1	4.5
East Midlands	76.4	81.2	4.9
West Midlands	76.0	80.9	5.0
Yorkshire & the Humber	75.9	80.6	4.7
North West	75.2	80.0	4.8
North East	74.7	79.9	5.1
Wales	76.0	80.3	4.3
Northern Ireland	75.6	80.3	4.6
Scotland	74.3	79.1	4.8

Source: Office for National Statistics

** equal-weighted average of females and males*

Regional spread of tech companies

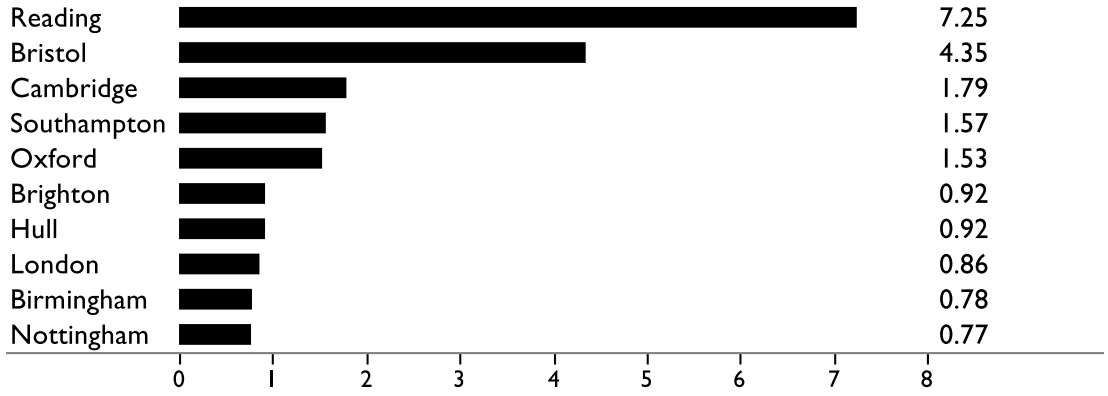
The distribution of technology companies is heavily concentrated in London or cities and towns with proximity to the capital. The KPMG Tech Monitor for December 2015 listed 30 local authorities with

the most technology enterprises. Twelve were in the South East, led by Reading, and eleven were in London. Six were in 'East England' – but all were close to London. There was one in the South West (Swindon – one hour by train from London) and one in the 'West' Midlands (Warwick).[10]

In London, 31 out of the 33 local authorities have a higher proportion of tech enterprises in the local business population than the national average. The Tech Nation 2017 report highlights the dominance of the South East.[11]

Chart 10

Digital tech business concentration by top 10 clusters (LQ - 2015)



Source: BSD, Tech City, 2015

Cambridge and Oxford have benefitted from their respective universities, which rank highly for research. Nevertheless, according to the Tech City 2017 report, average house prices have topped £500,000 in Oxford and Cambridge. Oxford suffers from a chronic lack of homebuilding.[12]

London has benefitted from the proliferation of fintech companies and the headquarters of tech companies. This reflects a multitude of factors – such as talent, culture, political power and transport links. Facebook announced last year that it would boost its London payroll to 1,500 people in 2017. Last week, the tech company pledged to hire an additional 800 employees at its new London office in 2018.[13]

Google has submitted plans for a £1bn facility in Kings Cross. This will form its UK hub and will house 7,000 employees. Chief Executive Sundar Pichai said in November 2016, "Here in the UK, it's clear to

[10] See "Tech Monitor", KPMG, December 2015, https://assets.kpmg.com/content/dam/kpmg/pdf/2015/12/tech-monitor-december-2015.pdf

[11] LQ = location quotient. The higher the LQ, the greater the concentration of tech firms in the local business population relative to the UK average.

[12] See "Oxford encapsulates UK housing challenge", Financial Times, April 27th 2015, https://www.ft.com/content/eaa786ca-ea64-11e4-a701-00144feab7de. See also "Oxford and Cambridge: tale of two cities shows housing disparity", Financial Times, July 1st 2015, https://www.ft.com/content/ddda1eda-1d7c-11e5-aa5a-398b2169cf79.

[13] See "Facebook creates 800 jobs as it opens new London office", BBC News, December 4th 2017, http://www.bbc.co.uk/news/business-42213942.

me that computer science has a great future with the talent, educational institutions, and passion for innovation we see all around us. We are committed to the UK and excited to continue our investment in our new King's Cross campus."

Amazon has a large presence in the UK. Alongside several fulfilment centres dotted around the country, the company boasts three development centres in Cambridge, Edinburgh and London. The centre for UK Amazon Web Services is in London. Amazon's R&D investment in the UK is focussed in the company's development centres. The e-commerce behemoth has recently announced additional R&D staff for London and Cambridge.[14] The centres in Edinburgh and Cambridge are focussed on cutting-edge innovations, including drones and machine learning.

The KPMG Tech Monitor 2015 delved into 16 different areas of technology to ascertain which region has the highest concentration of companies. London, the South East and the East of England were top in twelve of the 16 categories.

Table 12

Concentration of tech companies in the UK, by sector and by region

Sector	Greatest regional concentration	LQ*
All tech sectors	London	1.4
Other financial service activities, ex. Insurance & pension funding, n.e.c.	London	2.2
Other information services n.e.c.	London	1.7
Data processing, hosting & related activities; web portals	London	1.6
Computer programming, consultancy & related activities	London	1.5
Other telecommunications activities	London	1.3
Satellite telecommunications activities	South East	1.6
Software publishing	South East	1.5
Wireless telecommunications activities	South East	1.4
Research & experimental development on biotechnology	East of England	2.0
Manufacture of computer, electronic & optical products	East of England	1.5
Other research & experimental dev. on natural sciences & engineering	East of England	1.4
Manufacture of other parts & accessories for motor vehicles	West Midlands	2.9
Manufacture of electrical & electronic equipment for motor vehicles	West Midlands	2.4
Manufacture of air & spacecraft & related machinery	Northern Ireland	2.1
Engineering design activities for industrial process & production	North East	2.0
Manufacture of electrical equipment	East Midlands	1.3

Source: Markit calculations, based on IDBR snapshot 2015.

** LQ = location quotient. The higher the LQ, the greater the concentration of tech firms in the local business population relative to the UK average*

[14] See "Amazon to double number of R&D staff in London", The Guardian, July 25th 2017, https://www.theguardian.com/technology/2017/jul/25/amazon-double-number-research-development-staff-london. See also "Drone home: Amazon to triple R&D staff at Cambridge base", The Guardian, May 5th 2017, https://www.theguardian.com/technology/2017/may/04/amazon-to-boost-rd-staff-in-cambridge.

Further evidence of the regional disparities can be found in data collected by the Centre for Entrepreneurs. According to their figures, 657,790 start-ups were founded in 2016. Of this, 31.2% were in London (205,325). London's total count for start-ups was more than double the next 19 cities *combined*.

The answer for some – to rebalance the UK – has been to build faster train lines. HS2 was partly conceived for this reason. High Speed 3 (HS3) or the Northern Powerhouse Rail has been advanced for this purpose too. However, without a change in the current economic policy, faster train lines just make it possible to commute further. This has been happening with existing reductions in train times to London.[15]

Clusters

A disproportionate number of the UK's fastest growing technology companies are located in London or towns and cities with relatively close proximity to the capital (e.g. Bristol, Oxford, Cambridge and in Berkshire). The cluster maps in appendix 4 illustrate some of the examples. It is possible that technological change will favour these towns and cities even more in the coming years. This needs to be considered when deciding where to site the National Investment Bank, and by extension the Strategic Investment Board.

The *development* of new software for many companies is an important priority. According to PwC, the software and internet industry (global) recorded by far the biggest increase in R&D in 2016 (15.4% y/y).[16] Indeed, "Companies that reported faster revenue growth than their competitors allocated more R&D investment to software".

This big shift will also favour the South East, which already has the largest concentration of tech enterprises in software publishing. Globally, "The average allocation of R&D spending for software and services increased from 54% to 59% between 2010 - 2015 and is expected to grow to 63% by 2020".[17] The top three reasons given by companies for this shift are: 1) the need to stay competitive, 2) the need to increase revenue generation/growth and 3) a wish to keep up with customer expectations.

R&D spending needs to shift away from London and the South East. In 2015, total government spending on R&D was £1.917bn. London and the South East received just over half (£1.021bn).[18] R&D by higher education was also weighted disproportionately to London and the South East. Total R&D outlays by

[15] See "Infrastructure alone is unlikely to solve all economic ills", Financial Times, August 24th 2017, https://www.ft.com/content/fcfe1ec0-88ae-11e7-afd2-74b8ecd34d3b.
[16] See "2016 Global Innovation Strategy", PwC, p. 20, https://www.strategyand.pwc.com/media/file/2016-Global-Innovation-1000-Fact-Pack.pdf
[17] Ibid, p. 5.
[18] See "UK gross domestic expenditure on research and development: 2015", ONS, March 16th 2017, https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgrossdomesticexpenditureonresearchanddevelopment/2015.

the higher education sector was £8.009bn. London and the South East were responsible for £3.146bn of this spending.

Total R&D in London and the South East – including businesses – was £11.166bn in 2015. This compares with a total of £31.626bn for the UK. The latest estimates by the ONS show that "The South East and East of England continue to dominate where R&D expenditure takes place in the UK. These two regions combined accounted for 41% of UK business R&D expenditure in 2016. These regions combined also employed 79,000 full-time equivalent (FTE) staff, which made up 38% of total R&D employment in 2016."[19]

Technology & concentration

Technology is not creating even economic growth. Recent evidence from the US points to a concentration of well-paid jobs in a small number of cities. According to a report from one leading job-search website (*Indeed*), eight US cities accounted for 27% of job openings in the US technology sector.[20]

Tech jobs with the highest salaries are even more centralised. Among jobs that typically pay over $100,000 per annum, nearly 40% of openings were in Seattle, San Francisco, San Jose, Austin, Washington, Baltimore, Boston and Raleigh.[21] Seven of these cities have been identified by the Brookings Institute as *knowledge capitals.*[22]

The report by *Indeed* added: "Among some of the more specialized and fastest-growing tech occupations, such as engineering program managers, machine learning engineers or database engineers, more than half of the available jobs in the entire country are located in the hub cities". The report concluded that "There's been essentially no dispersion of tech jobs." Technology has reduced communication costs. However, it has not led to more even economic development.

The divergence in labour market participation rates between different US states in 2017 also suggests that the jobs growth across the US has become more unbalanced.[23] The participation rate has dropped in states that voted for President Trump in 2016. These states tend to have a higher proportion of retail and manufacturing jobs. By contrast, the participation rate has risen in states that voted for Hillary Clinton: these states (largely on the coasts) are often stronger in technology and life sciences.

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[19] See "Business enterprise research and development, UK: 2016, ONS, November 21st 2017, https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/businessenterpriseresearchanddevelopment/2016.

[20] See "The Best $100,000+ Tech Jobs Are Increasingly Concentrated in Just 8 Cities", Wall Street Journal, July 26th 2017, https://blogs.wsj.com/economics/2017/07/26/the-best-100000-tech-jobs-are-increasingly-concentrated-in-just-8-cities/

[21] These eight cities account for slightly less than 10% of all US jobs and about 13% of overall job postings.

[22] See "Redefining Global Cities: The Seven Types of Global Metro Economies", 2016, Brookings Institute, p. 30.

[23] https://blogs.wsj.com/economics/2017/11/28/why-are-people-in-red-states-dropping-out-of-the-labor-force/?mod=djemRTE_h

The point was articulated by the Brookings Institute in its 2016 report *Redefining Global Cities*. It described how knowledge capitals benefit from their "significant stock of human capital, innovative universities and entrepreneurs, and relatively sound infrastructure connectivity." They compete in the highest value-added segments of the economy.

London is classified as a *global giant*. These are cities with "extremely large, wealthy metro areas [that] are hubs for financial markets or major corporations, and serve as key nodes in global capital and talent flows".[24] However, the UK does not have any other knowledge capitals to counter the pull of a global city.

The Brookings Institute has also identified a diverse cluster of metro economies that it classifies as *international middleweights*. These have experienced "middling growth". On the whole, these metro areas "have not been able to draw on high-growth entrepreneurs to the same extent as the Knowledge Capitals." These cities suffer from a lack of economic policy that coordinates educated populations, universities and trading clusters. Birmingham is classified as a middleweight. The Brookings Institute warns that for these cities, the challenge is "no longer to find economies of scale or to optimise existing products and services, but rather to create new business models, products and ideas".[25]

Falling behind on R&D

Successive governments have, for many years, failed to invest in the UK's long-term future. R&D performed (i.e. undertaken) by the government (including research councils[26]) declined from 0.46% of GDP in 1981 to 0.11% in 2016 (chart 11).[27] The UK's share of government spending is well below the European Union average (0.23%), for example.

According to ONS data, nominal R&D expenditures performed by government peaked in 2010 (£2.513bn), before falling 16.6% to £2.097bn in 2015. The decline in real terms over this period has been more precipitous (22.4%). Since the start of the data in 1995, public sector R&D spending has experienced a 30.3% cut in real terms.

There is an important distinction between R&D *funded* by government, and R&D performed (i.e. undertaken) directly by the government. R&D funded by government was much higher in 2015 (£6.532bn, or 0.35% of GDP): £1.818bn of this was used by businesses to perform R&D. A further £2.654bn was used to fund higher education, while the government's funding for its own R&D purposes equalled £1.169bn.

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[24] See "Redefining Global Cities", Brookings Institute, p. 2.
[25] Ibid, p. 44.
[26] Both the ONS and Eurostat classify spending by research councils as part of government expenditures. We follow this classification, unless otherwise stated.
[27] Source: Eurostat, Research and development expenditure, http://ec.europa.eu/eurostat/documents/2995521/7752010/9-30112016-BP-EN.pdf/62892517-8c7a-4f23-8380-ce33df016818

Table 13

R&D expenditures as a share of GDP (%)

Overall R&D		Business R&D		Government R&D		Higher Education R&D	
South Korea*	4.23	South Korea*	3.28	South Korea*	0.50	Denmark	0.91
Japan*	3.29	Japan*	2.58	Germany	0.40	Sweden	0.87
Sweden	3.25	Sweden	2.26	Luxembourg	0.37	Switzerland**	0.83
Austria	3.09	Austria	2.20	Russia*	0.34	Austria	0.73
Switzerland**	2.95	Switzerland**	2.05	China*	0.33	Finland	0.69
Germany	2.94	Germany	2.00	United States*	0.31	Iceland	0.67
Denmark	2.87	United States*	1.99	Czech Republic	0.30	Norway	0.66
United States*	2.79	Denmark	1.89	France*	0.29	Netherlands	0.64
Finland	2.75	Finland	1.81	Norway	0.29	Portugal	0.57
Belgium	2.49	Belgium	1.73	Euro Area 19	0.27	Germany	0.54
France*	2.22	China*	1.59	Slovenia	0.27	Belgium	0.50
Euro Area 19	2.12	Slovenia	1.51	Japan*	0.26	Euro Area 19	0.46
Iceland	2.08	France*	1.44	Greece	0.25	Estonia	0.46
China*	2.07	Euro Area 19	1.37	Belgium	0.24	EU 28	0.46
Norway	2.04	EU 28	1.32	EU 28	0.23	France*	0.45
EU 28	2.03	Iceland	1.31	Netherlands	0.23	**United Kingdom**	0.42
Netherlands	2.03	Netherlands	1.16	Serbia	0.23	Japan*	0.40
Slovenia	2.00	**United Kingdom**	1.13	Spain	0.22	South Korea*	0.38
United Kingdom	1.69	Norway	1.09	Finland	0.22	United States*	0.37
Czech Republic	1.68	Czech Republic	1.03	Croatia	0.18	Turkey*	0.35
Italy	1.29	Hungary	0.89	Bulgaria	0.17	Czech Republic	0.34
Estonia	1.28	Ireland	0.83	Italy	0.17	Greece	0.33
Portugal	1.27	Italy	0.75	Slovakia	0.17	Spain	0.33
Luxembourg	1.24	Estonia	0.66	Hungary	0.16	Italy	0.33
Hungary	1.21	Russia*	0.65	Romania	0.16	Lithuania	0.33
Spain	1.19	Spain	0.64	Estonia	0.15	Serbia	0.32
Ireland	1.18	Luxembourg	0.64	Austria	0.14	Ireland	0.30
Russia*	1.10	Poland	0.63	Lithuania	0.14	Macedonia*	0.30
Greece	0.99	Portugal	0.61	Latvia	0.14	Poland	0.30
Poland	0.97	Bulgaria	0.57	Sweden	0.11	Croatia	0.28
Serbia	0.89	Turkey*	0.44	**United Kingdom**	0.11	Luxembourg	0.23
Turkey*	0.88	Greece	0.42	Iceland	0.10	Malta	0.22
Croatia	0.84	Slovakia	0.40	Turkey*	0.09	Slovenia	0.22
Slovakia	0.79	Malta	0.39	Montenegro*	0.07	Slovakia	0.22
Bulgaria	0.78	Croatia	0.37	Portugal	0.07	Cyprus	0.21
Lithuania	0.74	Serbia	0.33	Cyprus	0.06	Latvia	0.19
Malta	0.61	Lithuania	0.27	Denmark	0.06	Montenegro*	0.18
Cyprus	0.50	Romania	0.27	Macedonia*	0.06	China*	0.15
Romania	0.48	Cyprus	0.17	Ireland	0.05	Hungary	0.13
Latvia	0.44	Latvia	0.11	Switzerland**	0.02	Russia*	0.11
Macedonia*	0.44	Montenegro*	0.11	Poland	0.02	Romania	0.05
Montenegro*	0.38	Macedonia*	0.08	Malta	0.01	Bulgaria	0.04

Source: Eurostat. Note: Private non-profit R&D expenditures not shown

** 2015*

*** 2012*

Chart 11

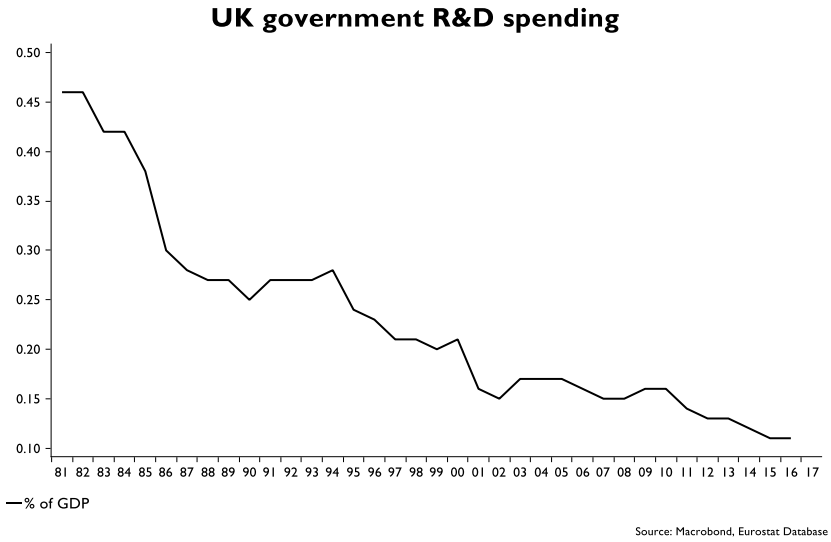
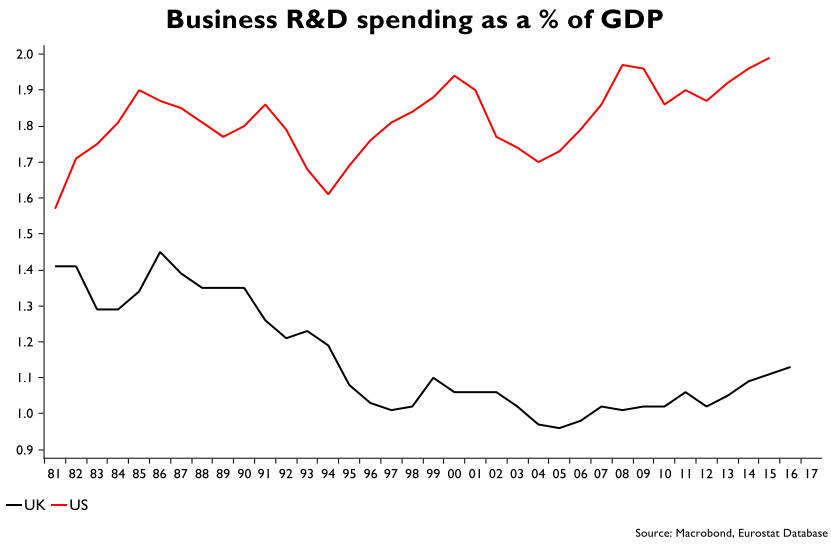


Chart 12



Based on these numbers, it could be argued that the state continues to provide support for innovation. Nevertheless, as a share of GDP, government-*funded* R&D has also been trending lower, falling by seven basis points from a high of 0.42% in 1995 (the start of the data series). This is less than the decline in government-*performed* R&D (-13 basis points to 0.11% over this period), but still significant. In addition, the ONS argues that "R&D performed is regarded as a more accurate measure than funding received by an organisation, as not all funds received may be used on R&D as intended."[28]

[28] See "UK gross domestic expenditure on research and development: 2015", ONS, March 16th 2017, https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgrossdomesticexpenditureonresearchanddevelopment/2015.

The private sector has not compensated for the state's retrenchment as hoped. Business enterprise R&D also experienced a secular decline relative to GDP during the 1980s and 1990s, dropping from 1.41% in 1981 to a low of 0.96% in 2005 (chart 12). The public sector, it turns out, was not crowding out entrepreneurs: rather, the two forms of investment are complementary.[29] Government-backed research in the US has driven the development of core technologies subsequently commercialised by Apple and Google. The emergence of technology giants in the US highlights the importance of basic research and 'blue-sky thinking'.

This model is being replicated by China today (see *Global Technology Trends*). According to R&D Magazine, "China's R&D is mostly funded by the government" and is "managed and directed by the Chinese Academy of Sciences (CAS)."[30] Formed in 1928, "CAS has 124 direct-report institutions consisting of 104 research institutes, five universities and supporting organizations and 12 management organizations. There also are 25 legal affiliations and 22 CAS-invested holding enterprises."

In mitigation, ONS data for 2016 reveal a 5.6% y/y increase in private R&D spending. This was ahead of the average annual growth rate of 4.3% since 1992. Business enterprise R&D is steadily creeping higher as a share of GDP too (from 1.02% in 2012 to 1.13% last year).[31] This nudged total R&D expenditure in the UK to 1.69% of GDP in 2016, the highest since 2009. However, some perspective is required: the latest figure remains well down from the high of 2.24% of GDP in 1981, and even further below the current OECD average (2.38%, table 13).

There is another worrying trend: businesses are increasingly outsourcing their R&D. R&D funded by UK businesses, but performed overseas, surged to a record £7.423bn in 2015, up from £2.164bn in 2012. This would be less of a concern if businesses were investing at home at an equal rate. However, the rise in overseas R&D (£5.259bn) has been much larger than the increase in R&D funded and performed by businesses in the UK (£2.860bn) over this three-year period.

It is vital that the right incentives are put in place for companies to invest domestically. The latest tax incentives announced in the 2017 budget may potentially have a positive impact: the Government will increase the rate of the R&D expenditure credit for large businesses from 11% to 12% starting January 1st next year, as well as introduce an Advanced Clearance Service for R&D expenditure credit claims.

This is part of the Government's new Industrial Strategy, unveiled on November 27th 2017. The paper focusses on four "Grand Challenges" that the UK economy faces, and need prioritising. These are 1)

[29] See *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*, M. Mazzucato, 2013, Anthem Press.
[30] See "2017 Global R&D Funding Forecast, R&D Magazine, Winter 2017, http://digital.rdmag.com/researchanddevelopment/2017_global_r_d_funding_forecast?pg=22#pg22
[31] Source: Eurostat, Research and development expenditure in the EU Member States by performing sector, 2016, Business enterprise sector, http://ec.europa.eu/eurostat/documents/2995521/8493770/9-01122017-AP-EN.pdf/94cc03d5-693b-4c1d-b5ca-8d32703591e7.

AI & Data Economy; 2) Future of Mobility; 3) Clean Growth; 4) Ageing Society. There are some positives in the Government's latest proposed framework to tackle these issues.

For a start, there is an acknowledgment that the public sector has a role to play in directing the economy towards productive sectors, when private enterprise is failing to do so. The Government has committed to reach 2.4% of GDP investment in R&D by 2027 and to achieve 3% of GDP over the long run. This follows the firm recommendation of the House of Commons Science and Technology Committee who, back in 2016, were clear about the path the Government should take:

> *[The Government] should use the opportunity of the Autumn Statement later this month to commit, as we have previously recommended, to raising the UK's expenditure on science R&D to 3% of GDP. This would demonstrate a determination not only to negotiating a post-Brexit relationship with the EU that is good for science but also to secure opportunities for science collaboration with markets beyond Europe.*[32]

In a bid to meet these targets, the Autumn Budget 2017 confirmed an increase in public R&D spending per annum to £12.5bn by 2021/22, up from approximately £9.5bn in 2015/16. The money will come from the National Productivity and Investment Fund (NPIF). Extra R&D funding had already been pledged in the Autumn Statement 2016: R&D increases would accelerate from £425m in 2017/18 to £820m in 2018/19, £1,500m in 2019/20, and £2,000m in 2020/21. An additional (newly announced) £2.345bn will be spent in 2021/22 (out of a total budget for the NPIF of £6.475bn for that year). The NPIF was also granted an extra £7bn in 2022/23, although this money is yet to be allocated between different initiatives.

In summary, an extra £7.090bn will be invested over the next five years on R&D, *over and above* current departmental spending plans. Public R&D spending will total £12.5bn in 2021/22, £2.345bn more than previously projected.

The Industrial Strategy claims that public investment in R&D was "around £9.5bn last year (2016/17)".[33] The figure for public R&D spending differs significantly from that provided by Eurostat, which calculates government R&D spending to have been £2.104bn in 2016. It is likely that the £9.5bn figure relates to government-*funded*, not government-*performed* R&D. Even so, the ONS calculated government-funded R&D (including research councils) as £6.532bn in 2015: a £3bn jump over one year is implausible. The Industrial Strategy paper, in all probability, uses a broader definition of government-funded R&D that

[32] See "Leaving the EU: implications and opportunities for science and research: Government Response to the Committee's Seventh Report", Parliament, February 1st 2017, https://publications.parliament.uk/pa/cm201617/cmselect/cmsctech/1015/101502.htm
[33] See "Industrial Strategy: Building a Britain fit for the future", HM Government, November 2017.

includes higher education councils as well, bringing the total to £8.750bn in 2015, much closer to the £9.5bn figure provided by the Government for 2015/16.

Nominal GDP is projected to grow by an annualised 3.0% over the next five years to £2.2756tr by 2021, according to the latest (downwardly revised) growth forecasts provided by the OBR. Converting fiscal year estimates into calendar years (i.e. assuming £9.5bn was spent by the public sector on R&D in *2016*, *not 2016/17*) we can estimate that public sector R&D spending will rise from 0.48% to 0.55% of GDP in 2021 (a 7-basis point rise). The Government is clearly relying on a significant increase in R&D outlays by the private sector to meet its targets.

The Industrial Strategy figures imply that £23.65bn in R&D was funded by the business, private non-profit, or overseas sectors last year. Assuming 1) public R&D expenditures remain at 0.55% of GDP until 2027; and 2) nominal GDP continues to grow by 3% per annum, then private sector funded R&D will have to grow by an annualised 7.1% over the next eleven years for the Government to reach its target (of 2.40%). This would represent a significant acceleration on the average y/y rise over the past 30 years (5.6%).

There are some positive signs. Business spending on R&D (using their own funds) expanded 9.5% y/y in 2016, following a 9.6% y/y rise in 2015 (note: this does not include funding from overseas and non-profits, which are growing at a slower rate).

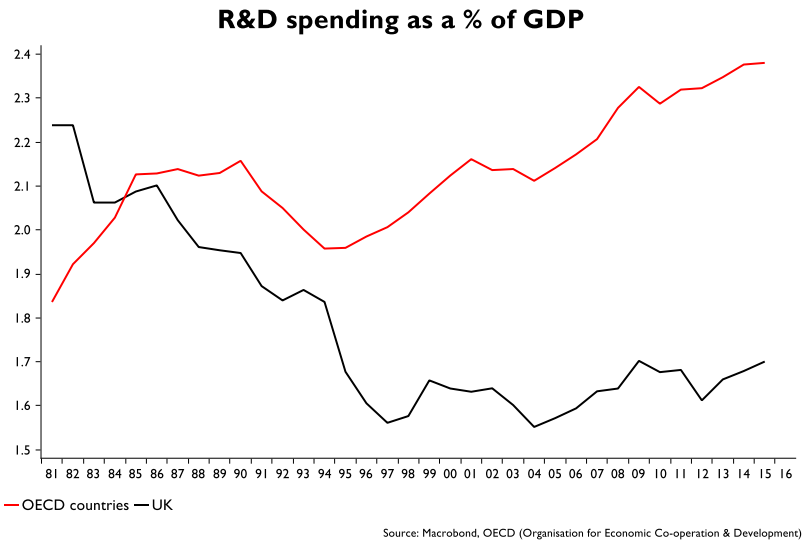
It remains to be seen whether the recent acceleration above the long-term average will be sustained. Investment intentions have recovered somewhat from the post-referendum low of August last year.[34] Spending on intellectual property products grew 2.3% q/q and y/y in real terms in Q3 2017 (not broken out between R&D and software). However, overall business investment slowed to 1.3% y/y in Q3, the lowest since Q2 2016.

The Government's ambition to reach the OECD average for R&D spend is admirable. However, aside from the overly optimistic forecasts for private sector spending, they are trying to hit a moving target. It is conceivable that by 2027, the OECD average will have risen further. In the ten years to 2015, OECD R&D investment as a share of GDP climbed from 2.14% of GDP in 2005 to 2.38% in 2015, and is likely to keep on rising as the global competition intensifies (chart 13). Direct competitors are not standing still: South Korea (4.23%); Japan (3.29%); Germany (2.93%); US (2.79%) and China (2.07%) are already ahead and will continue to move up the innovation curve. The CDU in Germany pledged

[34] See "Agents' summary of business conditions – November 2017 update", Bank of England, November 8th 2017, http://www.bankofengland.co.uk/publications/Documents/agentssummary/2017/nov.pdf.

to boost total R&D spending to 3.5% of GDP by 2025 in the most recent elections.[35] The Europe 2020 goals include a target of 3% of EU GDP to be invested in R&D (currently 2.03%).[36]

Chart 13



Ironically, the US government is cutting back on R&D. The recent increase in R&D spending in the US has been driven by the private sector instead. Nevertheless, the US is reaping the rewards of higher R&D outlays undertaken by its government in earlier decades. The emergence of large, profitable technology companies is partly responsible for the sizeable rise in private sector spending on R&D reported by the Bureau of Economic Analysis.[37]

Indeed, according to the latest PwC Global Innovation 1000 report for 2017, 13 out of the top 20 companies for spending on R&D were headquartered in the US (table 14).[38] Eight out of the top ten global innovators were US companies too: a Chinese company (Alibaba) made the top 10 for the first time since the inception of the survey (table 15).[39] No UK companies made the top 10 global innovators, or the top 20 R&D spenders: AstraZeneca (18th in 2016) dropped to 21st place. Just three of the top 100 global R&D spenders were headquartered in Britain (AstraZeneca, GlaxoSmithKline and Fiat Chrysler Automobiles N.V.).

[35] See "Merkel's party pledges to push Germany into R&D spending lead", Times Higher Education, July 6th 2017, https://www.timeshighereducation.com/news/merkels-party-pledges-push-germany-rd-spending-lead
[36] See "The Europe 2020 Strategy", Eurostat, http://ec.europa.eu/eurostat/statistics-explained/index.php/Europe_2020_headline_indicators.
[37] Source: US Bureau of Economic Analysis (BEA). Real investment in research & development hit a record of 1.71% of real GDP in Q2 2016, but has since slipped to 1.69% (Q3 2017).
[38] See "2017 Global Innovation Strategy", PwC, p. 26, https://www.strategy-business.com/media/file/sb89_17407_Will_Stronger_Borders_Weaken_Innovation.pdf
[39] Ibid, p. 28.

Table 14

Top 20 global R&D spenders ($ bn)

Rank	Company	Country	Industry	2016	2017	Annual percentage change
1	Amazon.com, Inc.	US	Consumer Discretionary	12.54	16.09	28.3
2	Alphabet Inc.	US	Information Technology	12.28	13.95	13.6
3	Intel Corporation	US	Information Technology	12.13	12.74	5.0
4	Samsung Electronics Co., Ltd.	South Korea	Information Technology	11.95	12.72	6.4
5	Volkswagen Aktiengesellschaft	Germany	Consumer Discretionary	12.51	12.15	-2.9
6	Microsoft Corporation	US	Information Technology	12.05	11.99	-0.5
7	Roche Holding AG	Switzerland	Healthcare	9.43	11.35	20.4
8	Merck & Co., Inc.	US	Healthcare	6.70	10.12	51.0
9	Apple Inc.	US	Information Technology	8.07	10.05	24.5
10	Novartis AG	Switzerland	Healthcare	9.47	9.57	1.1
11	Toyota Motor Corporation	Japan	Consumer Discretionary	9.47	9.31	-1.7
12	Johnson & Johnson	US	Healthcare	9.05	9.10	0.5
13	General Motors Company	US	Consumer Discretionary	7.50	8.10	8.0
14	Pfizer Inc.	US	Healthcare	7.69	7.87	2.4
15	Ford Motor Company	US	Consumer Discretionary	6.70	7.30	9.0
16	Daimler AG	Germany	Consumer Discretionary	6.31	6.86	8.7
17	Oracle Corporation	US	Information Technology	5.79	6.82	17.8
18	Cisco Systems, Inc.	US	Information Technology	6.21	6.30	1.4
19	Honda Motor Co., Ltd.	Japan	Consumer Discretionary	5.89	6.20	5.3
20	Facebook, Inc.	US	Information Technology	4.82	5.92	22.9

Source: PwC 2017 Global Innovation 1000

The top US companies are pulling even further ahead. Amazon and Alphabet (the top two) have both ratcheted up their R&D so far in 2017 by 28.3% y/y and 13.6% y/y, respectively. Amazon, Alphabet and Intel's combined R&D expenditures totalled $36.95bn last year, well above the total R&D performed by UK businesses in the whole of 2016 ($27.76bn, 2016 exchange rates). Apple was not in the top 20 R&D spenders in 2014: by 2017, it was 6th.

The absence of large companies able, or willing, to undertake large-scale R&D suggests government spending on R&D needs to rise more quickly in the UK, to compensate for a weak private sector (table 16). Indeed, the Industrial Strategy's optimistic forecast of a rapid increase in business investment needs to be put into context: the UK currently lacks the technology companies with the scale to compete globally and deliver the requisite growth.

The UK must contend with the rise of China too. The latest data from the Chinese National Bureau of Statistics suggest that R&D spending hit a new record of 2.11% of GDP in 2016. R&D Magazine estimates that "at its current rate of growth for R&D, China's total R&D is expected to surpass that

of the U.S. by 2026. China's R&D has already surpassed that of all 34 countries of Europe combined in 2016."[40]

Table 15

Top 10 global innovators

Rank	Company	Country	Industry
1	Alphabet Inc.	US	Information Technology
2	Apple Inc.	US	Information Technology
3	Amazon.com, Inc.	US	Consumer Discretionary
4	Tesla, Inc.	US	Consumer Discretionary
5	Microsoft Corporation	US	Information Technology
6	Samsung Electronics Co., Ltd	South Korea	Information Technology
7	General Electrics Company	US	Industrials
8	Facebook, Inc.	US	Information Technology
9	IBM	US	Information Technology
10	Alibaba Group Holding	China	Information Technology

Source: PwC 2017 Global Innovation 1000

According to the PwC Global Innovation 1000 survey for 2017, R&D spending in China fell 3.3% y/y. However, the decline was concentrated in industrials (-11.4% y/y). Excluding industrials, R&D spending rose 16.0% y/y to $29.58bn. Alibaba increased R&D expenditures by 24% y/y to $2.48bn, Tencent by 32% to $1.71bn and JD.com by 54% to $0.77bn. Huawei is not included in the PwC survey because it is a private company, but its R&D expenses totalled RMB 76.39bn in 2016 ($11.77bn), putting it on a par with the world's top R&D spenders. Huawei is aggressively investing in the development of 5G.[41] Alibaba is looking to spend $15bn on R&D over the next three years, a 134% increase on the $6.4bn spent over the previous three years.

The UK Government is moving in the right direction, but there is a danger that their ambitions do not match the scale of the task in hand. The bulk of the public-sector R&D funding will be delivered from 2019/20 onwards: by this time, China and the US will have moved even further ahead in the fields of AI and big data. Furthermore, it takes time for "crowding-in" effects to work: there will be an inevitable lag between initial public-sector investment and private sector spending.

[40] See "2017 Global R&D Funding Forecast", R&D Magazine, Winter 2017, http://digital.rdmag.com/researchanddevelopment/2017_global_r_d_funding_forecast?pg=22#pg22.

[41] See p. 6 of accompanying Global Technology Trends. See also "China's Huawei Battles to Own the Next Generation of Wireless Technology", Wall Street Journal, February 26th 2017, https://www.wsj.com/articles/chinas-huawei-battles-to-own-the-next-generation-of-wireless-technology-1488114002?mg=prod/accounts-wsj. To develop 5G, Huawei has deployed an R&D staff of 80,000.

Table 16

Top UK R&D spenders in the Global Innovation 1000 ($ bn)

Rank	Company	Industry	2016	2017	Annual percentage change
21	AstraZeneca PLC	Healthcare	6.00	5.89	-1.8
35	GlaxoSmithKline plc	Healthcare	4.40	4.48	1.9
44	Fiat Chrysler Automobiles N.V.	Consumer Discretionary	3.02	3.46	14.3
121	Delphi Automotive PLC	Consumer Discretionary	1.20	1.20	0.0
124	Rolls-Royce Holdings plc	Industrials	1.01	1.13	12.2
167	CNH Industrial N.V.	Industrials	0.86	0.86	0.5
182	BT Group plc	Telecommunication Services	0.72	0.80	11.1
288	Travelport Worldwide Limited	Information Technology	n/a	0.43	n/a
304	BP p.l.c.	Energy	0.42	0.40	-4.3
432	Micro Focus International plc	Information Technology	0.16	0.28	71.8
439	BAE Systems plc	Industrials	0.21	0.25	22.6
457	Dialog Semiconductor Plc	Information Technology	0.22	0.24	8.1
466	Johnson Matthey Plc	Materials	0.24	0.24	-2.0
480	Smith & Nephew plc	Healthcare	0.22	0.23	3.6
481	GKN plc	Consumer Discretionary	0.19	0.23	18.5
514	Atlassian Corporation Plc	Information Technology	0.14	0.21	47.9
568	The Sage Group plc	Information Technology	0.18	0.19	2.0
577	Reckitt Benckiser Group plc	Consumer Staples	0.17	0.18	6.4
590	British American Tobacco p.l.c.	Consumer Staples	0.18	0.18	-2.7
638	Cobham plc	Industrials	0.17	0.16	-5.7
677	Sky plc	Consumer Discretionary	0.11	0.15	34.5
678	Smiths Group plc	Industrials	0.14	0.15	5.6
743	Axovant Sciences Ltd.	Healthcare	0.08	0.13	75.8
755	Pentair plc	Industrials	0.12	0.13	10.6
765	GW Pharmaceuticals plc	Healthcare	0.10	0.13	30.0
786	Hikma Pharmaceuticals PLC	Healthcare	0.04	0.13	250.0
812	LivaNova PLC	Healthcare	0.08	0.12	58.8
817	Spectris plc	Information Technology	0.11	0.12	11.0
834	Indivior PLC	Healthcare	0.15	0.12	-19.6
840	Sophos Group plc	Information Technology	0.10	0.12	18.3
877	Spirent Communications plc	Information Technology	0.12	0.11	-5.6
887	BTG plc	Healthcare	0.10	0.11	13.7
924	Wm Morrison Supermarkets PLC	Consumer Staples	0.11	0.10	-4.6
925	Renishaw plc	Information Technology	0.08	0.10	23.6
929	Imagination Technologies Group Plc	Information Technology	0.18	0.11	-36.8
993	TechnipFMC plc	Energy	0.09	0.10	10.7

Source: PwC 2017 Global Innovation 1000

Creating value

The UK fares much better when it comes to the application of existing technologies. In this regard, the UK is a 'leader' in innovation, ranking 5th in the 2017 Global Innovation Index (GII), an annual report tracking the performance of countries globally.[42] That said, the UK has slipped down the rankings in recent years, falling from 2nd place in 2015. It is unclear whether this is the start of a longer-term decline.

The UK's biggest strengths are in creative outputs (4th), infrastructure (5th) and market sophistication (5th).[43] Within creative outputs, the UK performed exceptionally in ICTs & business model creation (1st) and ICTs & organisational model creation (2nd). The UK is adept at applying existing technologies to create new business models and streamline operations. Computer software spending as a share of GDP (4th) was another notable strength. The willingness and ability of UK companies to use ICT is a big positive.

However, the decline in real wages in the UK since 2007 shows there is a danger that ICT simply becomes a tool to cut costs. The UK requires a stronger R&D base. This is critical for the country's long-run economic performance and the development of domestic industries.[44] Real value can only be generated through innovation. An important study by the Enterprise Research Centre concluded that the multiplier effect of R&D – the boost to real GDP – was "more than five".[45]

Low R&D spending has also contributed to the drop in the proportion of knowledge workers in the UK. According to the GII, the number of researchers as a share of the population has been in steady decline since 2013, falling from 10th in the global rankings to 18th in 2017. Employment in knowledge-intensive industries – a subcomponent of 'business sophistication' – has fallen gradually since 2013, from 2nd place to 8th.

Education

In this context, the UK needs to do more to raise education attainment. The PISA education rankings are based on a triennial survey of 15-year-olds. Students are asked to complete a two-hour test, assessing mathematics, science and reading skills.[46] The latest survey was conducted in 2015 and the

[42] See "The Global Innovation Index 2017", Cornell University, INSEAD and the World Intellectual Property Organisation, WIPO, October 2017, https://www.globalinnovationindex.org/.
[43] The GII is broken down into 7 major sub-pillars: institutions, human capital & research, infrastructure, market sophistication, business sophistication, knowledge & technology outputs and creative outputs.
[44] Note also that the development of new software is classified within R&D spending, not software spending.
[45] See "The taxpayer tech dividend: R&D grants provide £43bn economic boost, study finds", Economic & Social Research Council, September 7th 2017, http://www.esrc.ac.uk/news-events-and-publications/news/news-items/the-taxpayer-tech-dividend-r-d-grants-provide-43bn-economic-boost-study-finds/.
[46] See "What is PISA?", OECD, http://www.oecd.org/pisa/aboutpisa/.

results were published in December 2016. The survey covered all 35 OECD countries, as well as 'partner' countries, and some city-states such as Singapore and autonomous regions such as Macao.[47]

The UK was ranked 9th in the OECD for science, 19th for reading and 20th for mathematics. The UK performed above the OECD average in science (scoring 509 points) and reading (498 points), but roughly in line with the OECD average for mathematics (table 17).

Out of all the participants (73), the UK was ranked 27th in mathematics (down one place from three years ago). The UK was ranked 22nd for reading, up one place from 2012. The UK jumped six places to 15th in science, despite recording a much lower score.

Singapore topped the rankings for reading, mathematics and science amongst the 73 countries/regions. Hong Kong, Macao and Taiwan performed strongly too: Hong Kong scored 2nd place in reading and mathematics. Japan scored 2nd place in science, and 5th in mathematics. Indeed, the Asian economies of Singapore, Hong Kong, South Korea, and Macao ranked above the UK on all three scores. Taiwan and the Chinese provinces of Beijing, Shanghai, Jiangsu, and Guangdong were ahead of the UK in mathematics and science too, but not in reading.

It should be noted that there are many criticisms of PISA.[48] There are inherent difficulties in cross-country education comparisons. Others have argued that these rankings shift attention to short-term fixes, and away from longer-term enduring changes in education practice that can take decades to have a positive effect.[49]

Nevertheless, the rankings may be used to get a sense of where the UK is falling behind. In particular, the rankings are better suited to measuring performances *within* the UK, given the cultural similarities of England, Scotland, Wales and Northern Ireland and comparable education systems.[50]

For example, Wales lags behind the rest of the UK in the PISA rankings, while England ranks first on all three measures (science, mathematics, reading). The disparity in science education between Wales and the rest of the UK has been widening.

Scotland's performance in the rankings has deteriorated sharply too. In 2012, it was ranked 1st in the UK on scores of mathematics and reading. However, it slipped to 3rd in 2015 in both subjects. It also fell from 2nd to 3rd in science. Addressing regional disparities in education outcomes will be critical to addressing the uneven economic performance across the UK.

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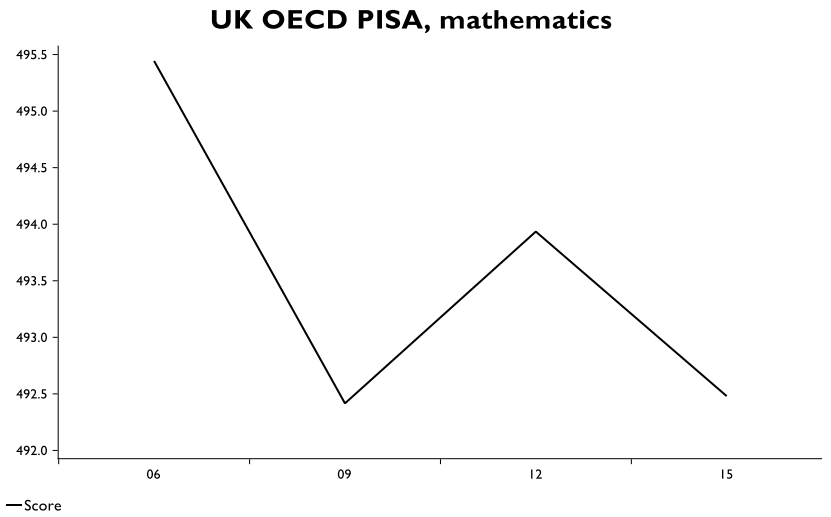
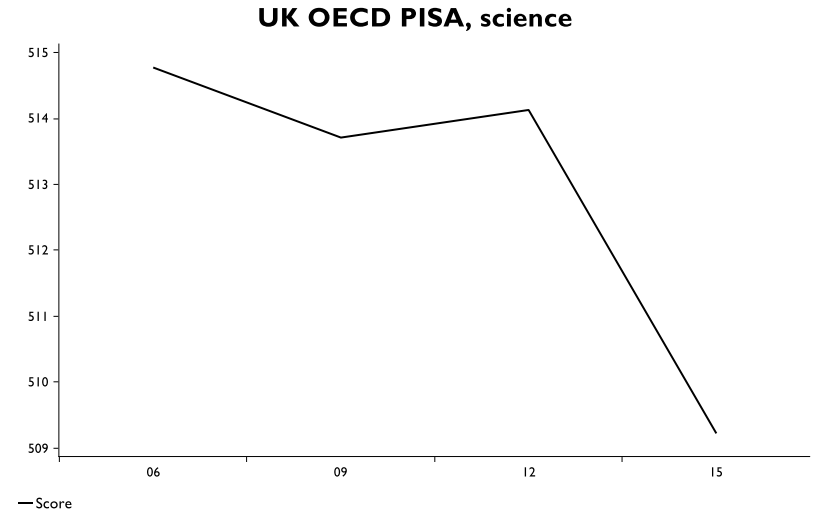
[47] A full list of 2015 participants is available here: http://www.oecd.org/pisa/aboutpisa/pisa-2015-participants.htm
[48] See "The Pisa methodology: do its education claims stack up?", The Guardian, December 3rd 2013, https://www.theguardian.com/news/2013/dec/03/pisa-methodology-education-oecd-student-performance.
[49] See "OECD and Pisa tests are damaging education worldwide – academics", The Guardian, May 6th 2014, https://www.theguardian.com/education/2014/may/06/oecd-pisa-tests-damaging-education-academics.
[50] See "Pisa tests: UK lags behind in global school rankings", BBC News, December 6th 2016, http://www.bbc.co.uk/news/education-38157811.

Chart 14



Source: Macrobond, OECD (Organisation for Economic Co-operation & Development)

Chart 15



Source: Macrobond, OECD (Organisation for Economic Co-operation & Development)

Table 17

2015 PISA Rankings, OECD Countries

Reading			Mathematics			Science		
Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
1	Canada	526.7	1	Japan	532.4	1	Japan	538.4
2	Finland	526.4	2	South Korea	524.1	2	Estonia	534.2
3	Ireland	520.8	3	Switzerland	521.3	3	Finland	530.7
4	Estonia	519.1	4	Estonia	519.5	4	Canada	527.7
5	South Korea	517.4	5	Canada	515.6	5	South Korea	515.8
6	Japan	516.0	6	Netherlands	512.3	6	New Zealand	513.3
7	Norway	513.2	7	Denmark	511.1	7	Slovenia	512.9
8	New Zealand	509.3	8	Finland	511.1	8	Australia	510.0
9	Germany	509.1	9	Slovenia	509.9	9	**United Kingdom**	509.2
10	Poland	505.7	10	Belgium	507.0	10	Germany	509.1
11	Slovenia	505.2	11	Germany	506.0	11	Netherlands	508.6
12	Netherlands	503.0	12	Poland	504.5	12	Switzerland	505.5
13	Australia	502.9	13	Ireland	503.7	13	Ireland	502.6
14	Sweden	500.2	14	Norway	501.7	14	Belgium	502.0
15	Denmark	499.8	15	Austria	496.7	15	Denmark	501.9
16	France	499.3	16	New Zealand	495.2	16	Poland	501.4
17	Belgium	498.5	17	Sweden	493.9	17	Portugal	501.1
18	Portugal	498.1	18	Australia	493.9	18	Norway	498.5
19	**United Kingdom**	498.0	19	France	492.9	19	United States	496.2
20	United States	496.9	20	**United Kingdom**	492.5	20	Austria	495.0
21	Spain	495.6	21	Czech Republic	492.3	21	France	495.0
-	OECD average	492.7	22	Portugal	491.6	22	Sweden	493.4
22	Switzerland	492.2	-	OECD average	490.2	-	OECD average	493.2
23	Latvia	487.8	23	Italy	489.7	23	Czech Republic	492.8
24	Czech Republic	487.3	24	Iceland	488.0	24	Spain	492.8
25	Austria	484.9	25	Spain	485.8	25	Latvia	490.2
26	Italy	484.8	26	Luxembourg	485.8	26	Luxembourg	482.8
27	Iceland	481.5	27	Latvia	482.3	27	Italy	480.5
28	Luxembourg	481.4	28	Hungary	476.8	28	Hungary	476.7
29	Israel	479.0	29	Slovakia	475.2	29	Iceland	473.2
30	Hungary	469.5	30	Israel	469.7	30	Israel	466.6
31	Greece	467.0	31	United States	469.6	31	Slovakia	460.8
32	Chile	458.6	32	Greece	453.6	32	Greece	454.8
33	Slovakia	452.5	33	Chile	422.7	33	Chile	447.0
34	Turkey	428.3	34	Turkey	420.5	34	Turkey	425.5
35	Mexico	423.3	35	Mexico	408.0	35	Mexico	415.7

Source: Programme for International Student Assessment (PISA)

The UK has a comparative advantage in universities. Tech City 2017 argues that: "Universities are essential to all digital economies. They generate skills and innovation while attracting investment and talent".[51]

[51] See "Tech Nation 2017: At the forefront of global digital innovation", TechCity, 2017, p. 19, http://technation.techcityuk.com/.

According to the Times Higher Education Varsity Rankings for 2016-17, the UK has eight out of the top 20 universities in Europe. However, academic activity is also highly concentrated: four are in London, while the top two are Oxford and Cambridge.

The QS ranking of universities paints a similar picture. Of the top 20 universities in the world, 3 are in the UK (Oxford, Cambridge and UCL). The highest ranked university outside of the 'golden triangle' is Edinburgh, at 28. Manchester follows on 33. Birmingham was 97th, while Leeds was 100th.

The RUR Research Performance world rankings follow this tune. Of the top 20, four are in the UK and all are in the South. Edinburgh and Manchester are 56th and 66th, respectively. Birmingham is 100th.

Universities are enjoying more success in leveraging their intellectual property. Income from intellectual property amongst UK universities increased 18.5% y/y during 2014-15, according to data from the Higher Education Funding Council for England. In many cases, the different skill sets of academia and industry are highly complementary. Closer collaboration between the two sectors will generate significant value by transferring world-class research into practical applications. This has positive commercial, social and economic benefits.

Dissecting bank lending

However, sectors that are critical to the potential growth path of the UK economy are not being supported by the banks. These include manufacturing, professional scientific & technical activities, information & communication and administrative & support services. Administrative & support services cover many digital companies that the ONS has struggled to classify correctly in the past.[52] Deposits from these four sectors – and many others – are effectively being recycled into lending that damages the long-run growth prospects of the UK economy.

Table 17 shows all the sectors where lending is less than deposits (i.e. 'deposit surplus').[53] The combined deposit surplus of the first four 'productive' sectors in table 18 is £115.19bn. This nearly matches the deficit in deposits for the four sectors listed in table 19 (£115.52bn).[54]

The most notable sector with a deposit deficit – buying, selling & renting of real estate – attracts the lion's share (£84.79bn, chart 16). Note: the pressure on banks to reduce their reliance on wholesale

[52] See "Measuring the UK's digital economy with big data", National Institute of Economic and Social Research, July 2013, https://www.niesr.ac.uk/publications/measuring-uk%E2%80%99s-digital-economy-big-data

[53] The lending numbers include all sterling and foreign currency loans.
The Bank of England provides lending data extending back to 1987 for the majority (but not all) industries.
However, these 'long-run' lending numbers relate to sterling lending *only* (i.e. exclude foreign currency lending).
http://www.bankofengland.co.uk/boeapps/iadb/index.asp?Travel=&levels=1&XNotes=Y&B6951XBMX6815X6937X6948.x=1&B6951XBMX6815X6937X6948.y=8&XNotes2=Y&Nodes=X6937X6948X6951X6952X6953X6232X6267X32089X32097X6255X6259X6010X6012X6013X6014X6815&SectionRequired=C&HideNums=1&ExtraInfo=#BM.

[54] For total non-financial corporations, there is a deposit surplus. In short, the banks take in more deposits than they lend: the gap is £85.30bn. This gap has widened in recent years. Overall, the gap between deposits and lending for all UK residents (financial & non-financial business and individuals & individual trusts) has widened to £163.1bn in Q3 2017.

funding and increase liquidity ratios partly explains why, on an aggregate basis, deposits have risen relative to lending (see chart 17).

Table 18

Sectors with a deposit surplus / lending deficit

Sector	£ bn, Q3 2017
Total	206.63
Professional, scientific & technical activities	68.54
Information & communication	23.55
Manufacturing	15.75
Administrative & support services	7.35
Public administration & defence	21.89
Personal & community activities	16.36
Mining & quarrying	15.91
Education	12.41
Recreational, cultural & sporting activities	8.48
Construction	6.93
Wholesale & retail trade	3.89
Transport & storage	3.18
Human health & social work	2.29
Fishing	0.12

Source: Bank of England. A positive number implies lending is lower than deposits in this sector.

Table 19

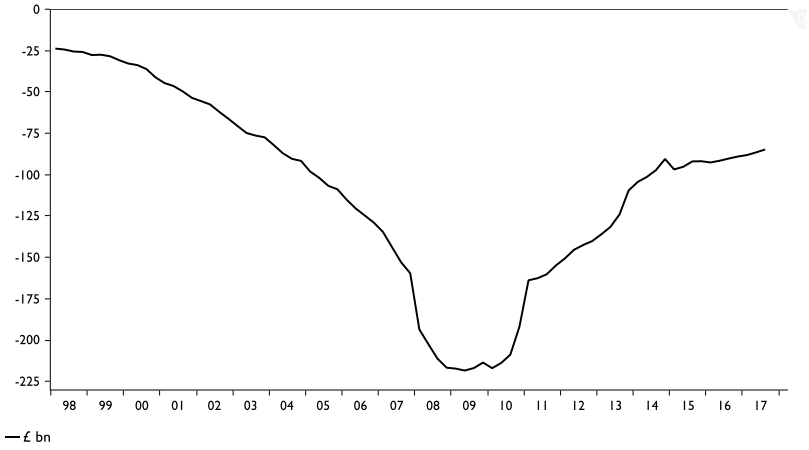
Sectors with a deposit deficit / lending surplus

Sector	£ bn, Q3 2017
Total	-115.52
Buying, selling & renting of real estate	-84.79
Agriculture, forestry & fishing	-11.44
Electricity, gas & water supply	-4.97
Accommodation & food service activities	-14.32

Source: Bank of England. A negative number implies lending is higher than deposits in this sector.

Chart 16

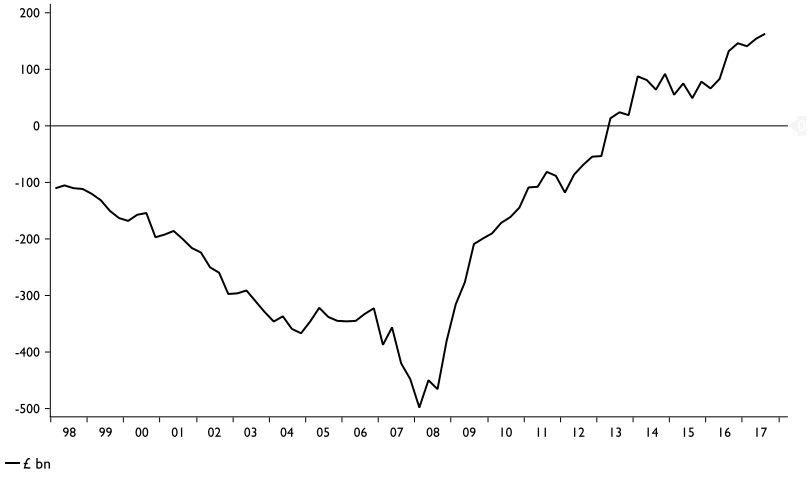
UK buying, selling & renting of real estate, deposits minus lending



Source: Macrobond, Bank of England

Chart 17

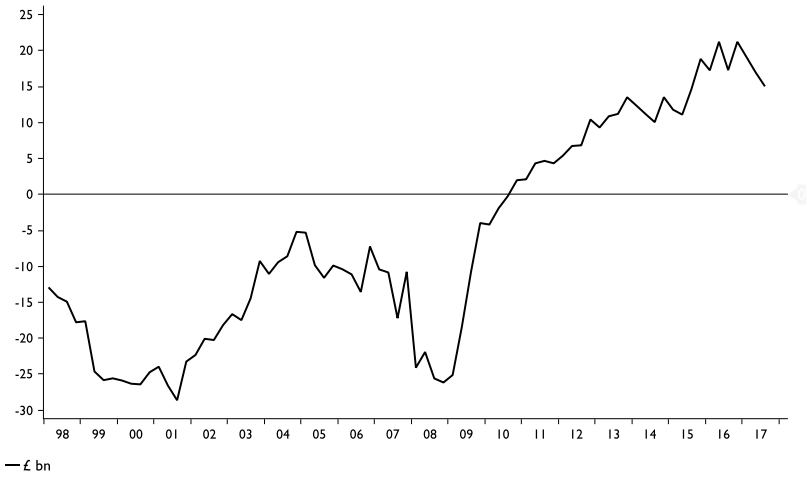
UK all residents, deposits minus lending



Source: Macrobond, Bank of England

Chart 18

UK manufacturing, deposits minus lending



Source: Macrobond, Bank of England

In total, there are 14 sectors (in table 18) that are generating deposits over and above lending. In strict accounting terms, they all contributed to a deposit surplus. A proportion of this is effectively used to lend on to sectors listed in table 19.[55]

Manufacturing, professional scientific & technical activities, information & communication and administrative & support services are emphasised because, globally, these sectors have been at the forefront of rapid technological change.

Of course, companies that are growing quickly could experience a strong rise in deposits and may have less requirement for lending. Lending has fallen in manufacturing, professional scientific & technical activities and information & communication, while deposits have risen.

In administrative & support services, lending has risen, but this has been outstripped by faster growth in deposits. Furthermore, professional scientific & technical activities, information & communication and administrative & support services have seen strong jobs growth since the crisis of 2007/08.[56] From this perspective, it appears that banks are not starving companies of the required funds to invest and expand.

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[55] Examining the gap between deposits and lending should not be confused with the concept of a 'funding gap'. For example, a report by the *Business, Energy and Industrial Strategy Committee* defined the funding gap for SMEs as "The difference between the funding required by SMEs and the funding available". See "House of Commons, Business Energy and Industrial Strategy Committee, Access to finance", Business, Energy and Industrial Strategy Committee, October 25th 2016, p. 5, https://publications.parliament.uk/pa/cm201617/cmselect/cmbeis/84/84.pdf.
The funding gap is difficult to calculate in practice. The funding needs of a business are subjective and can be endogenous. Surveys may be unreliable. For example, if a company realised that it could acquire more cost-effective funding, then it would alter its aspirations accordingly, which would in turn change the financing it requires.

[56] Source: ONS. Employment has risen strongly in professional scientific & technical activities (25.2%), administrative & support services (22.6%) and information & communication (21.5%) since Q1 2009. Jobs growth in these sectors has outpaced the overall increase in workforce jobs over this period (9.4%). Together, these three sectors account for 21.3% of total workforce jobs in the UK (table 19).

Table 20

Employment by industry

Industry	% change since Q1 2009	Employment, millions (Q2 2017)	Share of total employment (%)
Total	9.44	34.95	100.00
Professional, scientific & technical activities	25.24	3.00	8.58
Administrative & support service activities	22.58	2.99	8.54
Information & communication	21.48	1.48	4.24

Source: ONS

However, productivity across these three industries remains weak by international standards (see appendix 1). A dearth of lending to critical industries indicates that banks are failing to help UK businesses to invest. In a competitive global environment, it is imperative that small companies have sufficient access to finance to enable them to scale-up.[57]. The outstanding stock of loans to SMEs has dropped from £197.8bn in April 2011 (start of data) to £165.4bn in October 2017. Even if company balance sheets appear healthy, a lack of investment in key technologies will compromise their performance and ability to compete over the long run. It will undermine the potential growth path of the economy, damage productivity and reduce the ability of companies to increase salaries.

Table 21

Manufacturing deposits and lending, Q3 2017

Sector	Deposits (£ bn)	Lending (£ bn)	Deposits minus lending (£ bn)	Lending as a share of deposits	% change in lending since Q1 2009
Manufacturing	58.2	43.0	15.2	73.9	-26.6
Food, beverages and tobacco	5.7	10.6	-4.9	186.6	-25.6
Textiles, wearing apparel and leather	1.7	1.3	0.3	80.9	-10.9
Pulp, paper, and printing	2.0	2.3	-0.4	117.8	-74.5
Chemicals, pharmaceuticals, rubber and plastics	11.1	9.2	1.8	83.3	48.1
Non-metallic mineral products and metals	7.5	4.9	2.6	65.7	-39.6
Machinery, equipment and transport equipment	15.6	8.0	7.6	51.2	-18.9
Electrical, medical and optical equipment	8.4	3.0	5.4	36.2	-20.9
Other manufacturing	6.4	3.6	2.8	56.5	-36.6

Source: Bank of England

Indeed, real wages have still fallen across the economy since 2007. The Bank of England has recognised the risk that jobs will be lost to robotics, a trend that could increase the downward pressure on

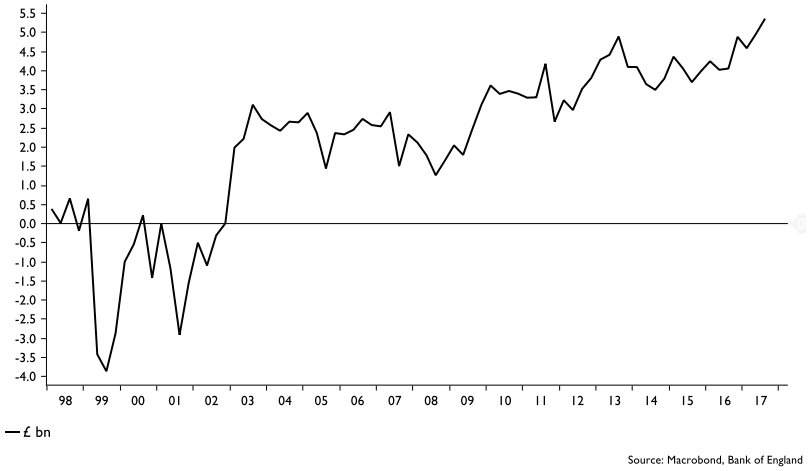
[57] See "The Scale-Up Report", Sherry Coutu, November 2014, p. 32, http://www.scaleupreport.org/scaleup-report.pdf.

wages.[58] In this context, banks need to be channelling funds into sectors that offer the best chance of combatting these big shifts. They should be recycling deposits into areas that offer growth opportunities: instead, they are doing the opposite.

The reduction in lending to manufacturing companies is an indictment of the banks' skewed priorities (table 21). One of the biggest declines has been in electrical, medical & optical equipment: lending has fallen from a high of £9.58bn in Q2 1999 to £3.04bn in Q3 2017. Deposits exceeded lending by £5.36bn in this sector by Q3 2017 (chart 19). This sector includes industries that, globally, have seen big innovations in recent years. The failure of banks to support companies in this sector should be a major consideration for the Bank of England. The gap between lending and deposits for electrical, medical & optical equipment companies is the largest in relative terms within manufacturing (see table 21).

Chart 19

UK manufacturing, electrical, medical & optical equipment, deposits minus lending



Source: Macrobond, Bank of England

The banks also have a deposit surplus of £7.59bn with machinery, equipment & transport equipment (appendix 5). This is the largest surplus within manufacturing in absolute terms. Along with electrical, medical & optical equipment, these two sectors account for well over half of the deposit surplus within manufacturing. One other sector with a surplus – non-metallic minerals & metals (£2.58bn) – is significant given the difficulties faced by this industry in recent years (appendix 5).

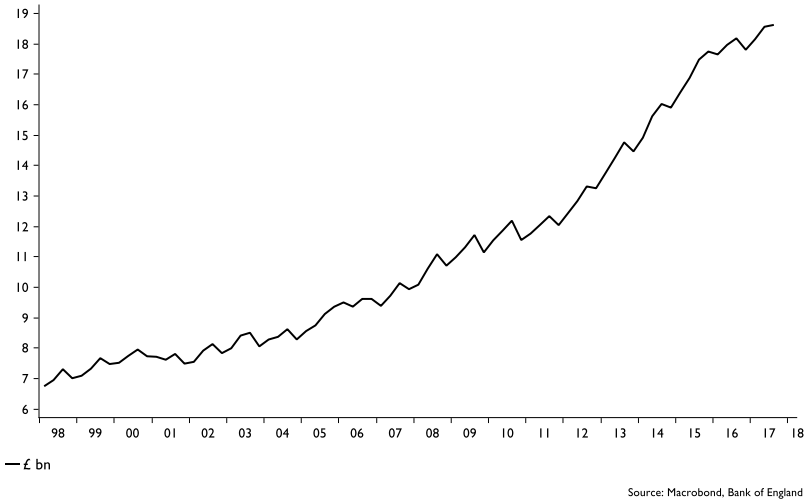
Loans outstanding to agriculture, hunting & fishing have risen from £6.48bn in Q4 1997 to £18.63bn in Q3 2017 (chart 20). This has resulted in a big rise in the deposit deficit for this sector (£11.44bn, appendix 5). The growth in lending could be viewed as a positive if it was being used for investment to raise productivity in agriculture.

[58] See "Labour's Share", Andrew Haldane, Bank of England, November 12th 2015, http://www.bankofengland.co.uk/publications/Documents/speeches/2015/speech864.pdf. "…rarely a week passes without evidence of jobs and industries being fundamentally reshaped by globalisation and technology, be it the digital economy, the sharing economy or even the Second Machine Age."

However, it is possible that this increase in lending has simply been deployed for buying agricultural land. The deterioration in the trade deficit for food, beverages & tobacco since 1997 – despite the increase in lending to agriculture over this period – is also striking (chart 21).[59] Indeed, lending to the food, beverage & tobacco industry has dropped from a high of £21.3bn to £10.6bn. It is hard to avoid the conclusion that banks have been happy to help investors acquire agricultural land, but not to invest in food production.

Chart 20

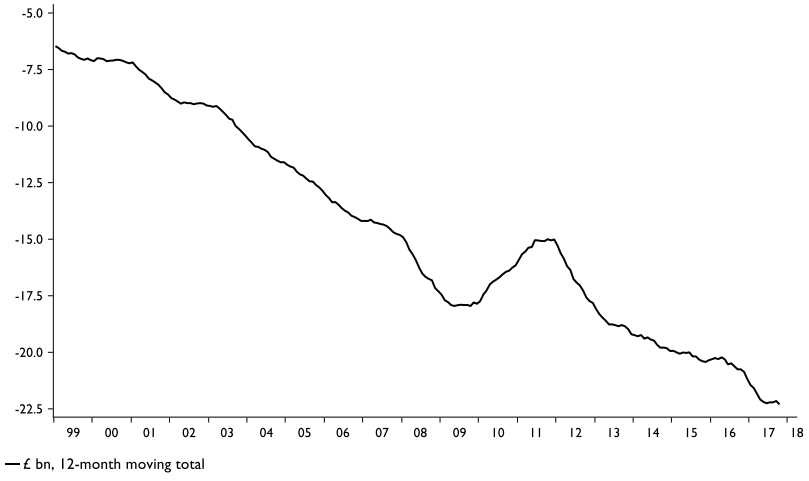
UK agriculture, hunting & forestry, lending



Source: Macrobond, Bank of England

Chart 21

UK trade balance, food, beverages & tobacco



Source: Macrobond, U.K. Office for National Statistics (ONS)

[59] Source: Bank of England. Bank Stats (Monetary and Financial Statistics), Table C1.2, Industrial analysis of monetary financial institutions' lending to UK residents.

The price of agricultural land in the UK has risen by over 270%, from approximately £2,000 per acre in Q4 2004 to £7,311 per acre in Q3 2017.[60] Over the past ten years, farmland has consistently outperformed major assets such as the FTSE100 Index and the Knight Frank UK House Price Index, which includes prime central London properties.[61]

The surplus of lending for electricity, gas & water supply (£4.97bn) is a concern too. This is not the best use of the banks' lending capacity: loans for critical infrastructure in utilities can and should be provided through the government. Gilt issuance is cheaper than bank lending.

The last sector to enjoy a surplus of lending over deposits is accommodation & food services (£14.32bn). To emphasise, this relates to food services, not production. A further breakdown of lending in this sector is required. It is possible that the rise in lending has been skewed towards accommodation, which may be property-related. Alternatively, it could be tied to the expansion in student accommodation, which has helped the UK generate a surplus on tuition fees within the current account.[62]

Bloated real estate sector?

Manufacturing, professional scientific & technical activities, information & communication and administrative & support services account for 28.7% of real GDP. Loans outstanding to these four sectors total just £108.82bn, or 5.5% of GDP.

This is less than the total of loans outstanding to companies engaged in the buying, selling & renting of real estate (£135.97bn or 6.9% of GDP). The priorities of the banks are inconsistent with securing a higher potential growth path for the UK economy.

Companies engaged in the 'buying, selling & renting of real estate' are separate from the £1,189bn of lending secured on dwellings (i.e. mortgage loans, including bridging finance) on the books of UK banks. With 'other loans' included (£134.3m), UK banks have a total of £1,323.8bn of loans outstanding to households. However, the deposits that banks take from UK individuals is £1,252.6bn. This deficit (£71.2bn) is covered by the surplus generated from non-financial corporations. Again, it is hard not to conclude that banks are borrowing from sectors critical to UK economic growth to fund consumer spending or borrowing for house purchases.

[60] Source: Knight Frank Farmland Index. The latest figure marks a drop of 11.98% on the September 2015 peak of £8,306. The Knight Frank farmland market index is an opinion-based index, compiled quarterly by Knight Frank's farms & estates and valuations offices in the UK. It tracks the price performance of bare agricultural land without dwellings or buildings.
[61] See "Knight Frank Farmland Index", Q3 2017, http://content.knightfrank.com/research/157/documents/en/english-farmland-index-q3-2017-5013.pdf.
[62] See "UK Balance of Payments, The Pink Book: 2017", ONS, October 31st 2017, https://www.ons.gov.uk/releases/unitedkingdombalanceofpaymentsthepinkbook2017. The education travel surplus more than doubled from £3.73bn in 2005 to £8.91bn in 2015, before falling back to £6.54bn in 2016.

Table 22

Real GDP and lending

Sector	Share of output in real GDP (%)	Lending (£ bn, Q3 2017)	Share of total lending (%)
Manufacturing	10.3%	43.02	3.5%
Professional, scientific & technical activities	7.3%	19.83	1.6%
Information & communication	6.5%	14.73	1.2%
Administrative & support services	4.6%	31.24	2.5%
Buying, selling & renting of real estate	12.3%	135.56	10.9%

Source: Bank of England, ONS

Critics will argue that it is not within the Bank of England's remit to intervene in the direction of lending. This, they claim, would impede the smooth functioning of markets, and distort the 'efficient' allocation of capital.

However, financial stability risks will emerge if an economy loses its competitiveness. Private finance cannot always be relied upon to guarantee the optimal allocation of capital, as the subprime crisis clearly showed. Bank lending is one channel through which the Bank of England can promote strategic industries that have a critical role to play in improving the long-run growth prospects of the UK economy.

Recent uptick in manufacturing lending

It should be noted that lending to the manufacturing sector has spiked in the May to July period, from £38.2bn to £49.7bn. This has been driven by loans in foreign currency, up from £13.3bn to £22.9bn. This jump in foreign currency lending is primarily found in two industries: 'chemicals, pharmaceuticals, rubber & plastic' and 'food, beverages & tobacco'. The Bank of England confirmed that the spike in the manufacturing lending in June/July was "because of a couple of large businesses driving the aggregates." This could be due to M&A deals.

Foreign currency loans to the manufacturing sector have since dropped back to £14.69bn in October. Sterling loans to the industry have begun to grind higher, rising steadily from £24.92bn in May to a high of £28.52bn in September, before slipping to £28.47bn in October. The September figure was the highest since February 2010. Nevertheless, one sector – the food, beverages & tobacco industry – has accounted for approximately two-thirds (65.9%) of the rise in total sterling loans between May and

October. Some of the major food retailers have expressed concerns over food shortages that may follow once the UK leaves the EU, prompting a rise in stockpiling at warehouses.[63]

Commercial real estate, collateral and intangibles

The dependency on foreign direct investment inflows to fund the current account deficit implies the UK is acutely vulnerable to capital outflows, which could trigger wider economic disruption.[64] Overseas investors, for example, account for around 80% of total investment in the London commercial real estate market in 2017, up from 55% in 2007. There has been an increased concentration, with Asian investors accounting for almost two-thirds of foreign purchases in London this year.

Banks have reduced their direct exposure to the commercial real estate market. Commercial real estate lending by UK banks has fallen from around £160bn at the end of 2008 to around £77bn by the end of H1 2017. Nevertheless, the importance of commercial real estate for collateral in bank lending renders the UK economy particularly vulnerable to a sudden reversal of these capital inflows. A 2015 review by the Bank of England of bank lending to small and medium-sized companies suggested that 75% of companies borrowing from banks use commercial real estate as collateral. As the Financial Policy Committee warns, "an amplified downturn in the commercial real estate market could be transmitted to the real economy by reducing companies access to bank loans and their ability to undertake new loans".[65] Every 10% fall in UK commercial real estate prices would lead to a 1% decline in investment.

The reliance upon commercial real estate to collateralise lending is also a big constraint for companies in fast growing technology sectors. The importance of intangibles (e.g. software) to the development of new products and services makes it hard for small companies to borrow.

[63] See "Brexit fears spur businesses to stockpile goods", Financial Times, November 23rd 2017, https://www.ft.com/content/9492bd32-c959-11e7-aa33-c63fdc9b8c6c

[64] In mitigation, a recent article by Bank of England staff argues that "Looking at *gross*, rather than *net* capital flows since 2012 suggests inflows have been extremely subdued relative to past levels. Instead, the UK has benefitted from increasing capital gains on past foreign investments and used these to fund its spending. We argue this carries lower financial stability risks than relying on gross inflows to cover the current account deficit." See "A prince not a pauper: the truth behind the UK's current account deficit", Bank Underground, December 7th 2017, https://bankunderground.co.uk/2017/12/07/a-prince-not-a-pauper-the-truth-behind-the-uks-current-account-deficit/.

[65] See Financial Stability Report November 2017, pp. 28-29.

Strategic Investment Board

The Strategic Investment Board will sit at the heart of the economy, coordinating R&D, commercialisation and information flows (see attached flow charts *Industrial Strategy* and *Strategic Investment Board and Research* at the end of this report).

1. The Strategic Investment Board will be charged with boosting productive investment across the economy. Investment is critical to achieving strong growth alongside low inflation.

2. The Strategic Investment Board will facilitate coordination between the Treasury, the Bank of England and the Department for Business, Energy and Industrial Strategy (BEIS). This will re-establish the link between the real economy and the banking sector.

3. The Strategic Investment Board will draw on science and technology to devise comprehensive policy proposals for investment. There will be an emphasis on R&D investment. Private sector R&D will not be crowded out. It will be encouraged.

4. The Strategic Investment Board will need to absorb information and expertise from a spectrum of sources and act as a national hub for data and expertise in fast-changing parts of the economy.

5. Scientists and researchers at the cutting edge of their fields[66] will be appointed to senior advisory positions. The Strategic Investment Board will also seek the advice of trade unionists, businesses and leading industrialists.

6. The Strategic Investment Board will track the commercialisation of R&D and the wider adoption of existing technologies.[67] Both are crucial for improving the UK's productivity levels.

7. A preliminary[68], non-exhaustive list of specialist areas based on technology trends could include:

    - Agricultural technology
    - Education technology
    - Medical technology, digital healthcare and pharmaceuticals

[66] The current Council for Science and Technology (appointed by and reporting directly to the PM) would be subsumed into the Strategic Investment Board.

[67] Despite scoring high on the World Economic Forum's survey for adoption of ICT (Information and Communications Technology), the UK lags other developed economies when it comes to the adoption of other productive technologies. According to the Council for Science and Technology, "the UK has missed the opportunity to play a significant role in designing and deploying industrial robots." (See "Letter to the Prime Minister", Council for Science and Technology, October 21st 2016, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/592423/Robotics_automation_and_artificial_intelligence_-_cst_letter.pdf).

[68] This list is not comprehensive and will inevitably evolve.

- Communications technology
- Aerospace
- Space
- Other transport – autos/railways/marine
- Fintech
- Regulatory technology (regtech)
- Construction technology
- Renewables
- Internet of things
- Artificial Intelligence
- Semiconductors
- Robotics
- Mechanical engineering
- Electronics/electrical equipment (semiconductor chips)
- Optical
- Iron, steel and metals fabrication
- Composite materials

The Strategic Investment Board will need to develop a series of metrics for judging the impact of monetary and financial policies on investment, innovation jobs and wages. The Strategic Investment Board will work alongside the ONS to collect data that accurately captures the dynamics of today's economy.

The Strategic Investment Board will need a detailed view of how technology is changing the economy across different industries and sectors. The monetary and financial policy authorities will need to overlay this analysis with the data on bank lending. There needs to be a clear map of how much bank lending is directed to various productive sectors of the economy.

Productivity data can be used to assess the investment multiplier effect of bank lending across sectors. It can also be used to assess the impact on exports and the trade balance for individual sectors. In addition, it can be compared with labour market data to assess the impact on job creation and wages.

Innovations can be highly disruptive. Jobs may be lost in some sectors, but opportunities will arise in new industries. It will be the job of the Strategic Investment Board to examine the all-important second-round effects on growth and jobs (i.e. complementarities).

The Financial Policy Committee currently lacks a clear understanding of how technology is changing, and how it will affect the UK financial system. The Financial Policy Committee is unprepared for technology-led deflation, notably the risks to both jobs and wages and the possible credit losses. Detailed analysis will be required to understand the potential disruption to old business models from tech-led deflation.

The Strategic Investment Board will scrutinise and advise the monetary and financial policy authorities as banks shift from unproductive lending to innovative companies. It will help identify opportunities as well as systemic risks from technological change.

We suggest that the Strategic Investment Board has six permanent committee members plus two representatives, one each from the National Investment Bank and the publicly-controlled RBS. This will ensure a consistency between the polices of the National Investment Bank/RBS and the Bank of England.

We also propose that the Strategic Investment Board builds a network of formal contacts, across business, universities and research institutes, both in the UK and abroad (see flow chart: *Strategic Investment Board and Research*).

The Strategic Investment Board will provide a monthly report, bringing together research from other sources. This will be made available for free to all businesses in the UK as well as the banks.

The case for relocation

There is a strong case for placing the National Investment Bank away from London and the South East, to encourage faster and more balanced economic growth.

We also recommend moving some of the Bank of England functions away from London.

Basing national institutions instrumental to economic policy in London increases the risks of concentration.

Putting productive lending and R&D at the heart of economic policy offers an opportunity to rebalance the country geographically. The boost to economic growth may be greater if there is an explicit regional policy. Businesses in London have cited rising costs as a major constraint. This is damaging the potential growth path of the UK economy.

Proposals

We recommend putting the National Investment Bank in Birmingham.

We would also recommend putting the Strategic Investment Board in Birmingham, preferably next door or close to the National Investment Bank.

We would move some Bank of England functions to Birmingham, into a third building, again either next door or close to the National Investment Bank.

All three, side-by-side, would constitute a new 'economic policy' hub, possibly close to the main train station (Birmingham New Street).

Relocating institutions to Birmingham should provide the opportunity to upgrade the regional railway networks.

Birmingham has a population of 1.124m. According to the 2011 Census, the population of the West Midlands metropolitan area was 5.602m.

Restructuring core Bank of England responsibilities will help to provide a counterweight to the dominance of London.

We also propose establishing Bank of England offices in Glasgow, Cardiff and Belfast, and two smaller regional offices in Newcastle and Plymouth.

In addition, we propose that the next government establishes regional offices for the Strategic Investment Board in the same six cities.

Their function would be to ensure that productive lending is geared towards the needs of local businesses.

Currently, the Bank of England relies upon a network of economic agents across the country to feed back to Threadneedle Street, London. This is unsatisfactory and leads to the regions being underweighted in policy decisions.

We will consult ahead of more detailed recommendations made in our final report.

Bank of England mandate

In a recent letter to the Bank of England governor, the Chancellor Philip Hammond reminded Mr Carney that "monetary policy has a critical role to play in supporting the economy". It remains, he argued, "a central element of the government's macroeconomic strategy, alongside credible fiscal policy, investment to raise productivity and financial stability."[69]

However, it could be argued that these goals are incompatible with the operational target for monetary policy: "an inflation rate of 2 per cent, measured by the 12-month increase in the Consumer Prices Index (CPI). The inflation target of 2 per cent applies at all times. This reflects the primacy of price stability and the inflation target in the UK monetary policy framework."

One indicator alone does not capture the complexity of a modern, dynamic, 21st century economy. The consumer price index does not reflect the big shifts in the distribution of income that may occur due to technology. The singular focus on an inflation target may be out-of-date.

Indeed, the biggest challenge facing the UK economy over the coming years is the prospect of technology-led disruption putting downward pressure on wages. By failing to pay sufficient attention to technology, the Monetary Policy Committee has consistently overestimated how quickly wages would rise.[70]

Inflation of 2% should not be the sole target. Other variables could be included, such as wages, productivity and investment. Under the current framework, no consideration is given to how the inflation target is fulfilled. The 2% inflation target can be hit without wages rising, for example, through rising import costs (as seen during much of 2017), increases in administered prices (utilities) or higher taxes. Equally important, the Bank of England may need other policy tools at its disposal.

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[69] See *Remit for the Monetary Policy Committee*, Letter from the Chancellor to the Governor, November 22nd 2017. https://www.bankofengland.co.uk/letter/2017/mpc-remit-november-2017

[70] See "The labour market", Michael Saunders, external MPC member, Bank of England, January 13th 2017, https://www.bankofengland.co.uk/-/media/boe/files/speech/2017/the-labour-market.pdf?la=en&hash=07ECB5918F175BD259B87F8EAB6A568B6A3860B6. "In recent years, pay growth has repeatedly undershot consensus expectations, OECD forecasts and BoE forecasts despite falling unemployment."

Banking resilience

The core problem for the banks is one of low retained earnings and a focus on low margin and unproductive lending. This is compounded by poor IT infrastructure and a lack of reinvestment[71], which reduces the ability of banks to monitor the development of new markets and seek out opportunities for more productive lending.

High capital ratios *per se* are not indicative of the healthy, vibrant banking system needed to create a strong economy. Much of the Bank of England's focus since the 2008 financial crisis has been on resolution, increasing the capital ratios of the banks and ensuring their funding or liquidity positions are "robust".[72] The Bank of England talks of a "comprehensive and effective bank resolution regime" and the "wide toolkit, including the power to 'bail in' the shareholders and creditors of failed banks".[73]

In the June 2017 Financial Stability Report, the Bank of England cited £70bn of debt issuance by the banks "over the past two years, which can be readily bailed in".[74] If the banks lose money and their capital ratios fall, this debt can be converted into equity to protect the bank.

However, this debt issuance does not change the net assets of banks. Indeed, it is a curious proposition – the way to make banks safer is through more borrowing. Debt was the core problem in the run-up to the financial crisis of 2007/08.

> *"The presence of debt in capital requirements is, of course, really odd, at least to a run-of-the-mill corporate lawyer. Taking on debt increases assets, of course, but to an equivalent amount it increases liabilities. So, the net asset position of the bank is not improved".*[75]

The Bank of England argues that if the banks fail, but have higher capital ratios, the taxpayer will be protected. This seems to be a limited ambition – making sure the banks have enough money to pay out losses in the event of default. Successful businesses invest and innovate. The imperative to stay ahead is even more acute in an era of rapid technological change.

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[71] See Financial Stability Report November 2016, p. 21. "UK banks are also targeting significant cost savings through, for example, cutting staff and IT costs."
[72] See Financial Stability Report June 2017, p. 29. "UK banks' liquidity and funding positions are also robust. For major UK banks, the aggregate ratio of liquid assets to potential net outflows under stressed conditions (known as the Liquidity Coverage Ratio) was 128% in March 2017."
[73] See Financial Stability Report June 2017, p. 29. "The United Kingdom now has a comprehensive and effective bank resolution regime, under which the Bank has a wide toolkit, including the power to 'bail in' the shareholders and creditors of failed banks. This requires banks to maintain a minimum amount of loss-absorbing resources known as 'minimum requirements for own funds and eligible liabilities' (MREL)".
[74] See Financial Stability Report June 2017, p. 29.
[75] See "The Fall and Rise of Debt in Bank Capital Structures", Paul Davies QC(hon), October 18th 2015.

Since 2008, the banks have been shrinking.[76] The regulators have applauded this trend as it reduces the capital banks are required to hold. The reduction in risk-weighted assets accounts for the lion's share of the rise in common equity tier 1 capital ratios (CET1).[77]

The Bank of England implies that, in boosting a bank's capital ratio, increasing retained earnings and attracting extra equity investment are equivalent or carry the same weight. However, attracting additional equity investment – at least in the context of the UK banking sector – is typically linked to the need to fund dividend pay-outs.[78] Without an accompanying material rise in underlying profitability, such a hike in dividends paid would automatically result in lower retained earnings.

Bank share prices have continued to languish despite the rise in capital ratios. In some notable cases, the reduction in bank assets has also reduced long-term profitability. Indeed, the Bank of England has admitted that it would take four years at current levels of profitability and dividend pay-outs for banks (on average) to raise their CET1 ratio by 1% using retained earnings.[79]

In its November 2016 Financial Stability Report, the Bank of England also warned that "A prolonged period of low profitability would threaten banks' ability to rebuild capital following future shocks to their balance sheets."[80] Despite the reliance on AT1[81] instruments to boost regulatory capital ratios, the Bank of England acknowledges that this avenue may be closed in the event of another systemic crisis. In response to a crisis, "As the sale or closure of non-core businesses is completed, UK banks are likely to be increasingly reliant on their ability to retain earnings, **or** attract equity investment [author's emphasis]."[82]

Disposing of assets to raise capital ratios is a short-term solution. Borrowing to raise capital ratios is also fraught with risks if a number of banks are forced to 'bail in'. It may prove impossible or prohibitive for banks to return to the market following write-offs.

Relying on retained earnings to boost capital ratios is a more effective medium- to long-term strategy. However, banks have failed to articulate to shareholders the importance of productive investment and

[76] According to the Bank of England, (Table B1.4.1.1), the assets of all UK-owned MFIs has shrunk by 3.37% since January 2010, from £7.13tr to £6.89tr in October 2017. See http://www.bankofengland.co.uk/statistics/Pages/bankstats/2017/oct.aspx.
[77] See Financial Stability Report November 2016, p. 26, Chart B.3. Based on a limited sample of six major UK banks. According to the Bank of England, the reduction in risk-weighted assets boosted the average CET1 ratio by 4.22 percentage points between 2009 and 2015. By contrast, retained earnings raised the average CET1 ratio by 1.02 percentage points. Equity contributed an additional 0.45 percentage points.
[78] The recently announced 'special dividend' by Lloyds is a case in point. See "Lloyds unveils special dividend after highest profit since crisis", Financial Times, February 22nd 2017, https://www.ft.com/content/c3386d46-f8ce-11e6-bd4e-68d53499ed71?mhq5j=e2. It is interesting that the largest tech companies do not seem to have the same problem. Amazon is famous for not paying dividends, but reinvesting its profits instead.
[79] See Financial Stability Report November 2016, p. 28.
[80] Ibid.
[81] Additional Tier 1.
[82] See Financial Stability Report November 2016, p. 28.

organic growth. The point is underlined by the success of large technology companies where growth potential has been recognised by their shareholders, even in the absence of any dividend pay-outs.

The Bank of England highlights misconduct charges, weak returns for the investment banks and small trading income for the "persistently" low share prices.[83] Ring-fencing is another potential cost that will make the banks 'safer', but will also reduce profitability in the short-run.[84] By January 2019, UK banks will be required to separate their domestic retail banking from international activities and investment banking. 'Brexit' is another major short-term cost for UK banks.

Nevertheless, the Bank of England cites credit default swap premia to show investors are not fretting over the risk of banks defaulting: it argues that low share prices are not a reflection of market concerns over asset quality.[85] Other indicators cited by the Bank of England include 'fair value deductions', which have "fallen materially for UK banks since the crisis".[86] Non-performing loans have also fallen "substantially".[87]

The Bank of England did concede in November 2016 that wider concerns over 'franchise value' and the banks' perceived "ability to generate returns for shareholders over the medium term" had played a part.[88] Weak underlying profitability of banks has depressed their share prices. The Bank of England also acknowledged that this "poses challenges for the banks to generate capital internally and, at the margin, reduces their resilience to shocks".[89]

That said, there is very little, if any, analysis of new business models that banks need to pursue. 'Restructuring' is related to shifts in the balance sheet or sources of funds, or the need to cut operating

[83] See Financial Stability Report June 2017, p. 31. "Price to book ratios, which measure the market value of equity relative to the value of equity recorded on banks' balance sheets, remain persistently below one. The FPC continues to judge that the low equity prices of UK banks can likely be explained by anticipated misconduct redress costs and weak expected operating profitability of investment banking services in particular, rather than by market concerns about asset quality".
[84] See Financial Stability Report June 2017, p. 29. "The largest UK banks are in the process of separating their core retail banking activities into 'ring-fenced banks' (RFBs), with investment and international banking activities situated outside the ring-fence. Ring-fencing will deliver significant financial stability benefits, by protecting core retail banking activities from risks associated with activities such as investment banking, and by enhancing the resolvability of large banking groups".
[85] See Financial Stability Report November 2016, p. 27. "Reflecting the overall resilience of the UK banking sector, bank funding costs have remained low since the November *Report* (Table B.1). Credit default swap (CDS) premia, which measure the cost of insuring against bank default, are now close to post-crisis lows, at just under 60 basis points. And spreads on additional Tier 1 (AT1) instruments — bonds that convert to equity if a bank's capital ratio falls below a certain level — are at their lowest level on record".
[86] See Financial Stability Report November 2016, p. 27. "Indicators of the quality of banks' assets have improved in recent years. For example, 'fair value deductions' — which indicate how the book value of banks' equity would be affected if they were required to take account of losses on customer loans not covered in the current accounting framework — have fallen materially for UK banks since the crisis."
[87] See Financial Stability Report November 2016, p. 27. "Similarly, measures of non-performing loans have improved substantially. UK banks have much lower 'Texas ratios' — the ratio of non-performing loans to total equity capital and loan-loss reserves — than many European counterparts with similar price to book ratios".
[88] See Financial Stability Report November 2016, p. 27.
[89] See Financial Stability Report November 2016, p. 20. "Persistently weak profitability poses challenges for the ability of banks to generate capital internally and, at the margin, reduces their resilience to shocks".

costs.[90] It is not connected to the investment in core technology required to compete with alternative lenders and to support productive lending.

Furthermore, the quote in footnote 89 is instructive: the use of the words "at the margin" reflects the emphasis on debt (and equity issuance) to bolster the balance sheets of banks. Retained earnings are not seen as the primary driver of new capital for banks. This quote also illustrates the Bank of England's main concern – securing capital to reduce the risk of taxpayer-funded bailouts. As highlighted above, there are flaws to this approach.

This belies the lack of ambition or vision, that ultimately renders the banks unable to fulfil their role of supporting economic growth. There is no reference here – or elsewhere – to the impact of low profitability on the banks' ability to invest in their core business model.

IBM is an example of how well-established companies can lose out by not reinvesting in core products. In the ten years to 2015, the US tech company ploughed "more than $120bn of its free cash into repurchasing its shares".[91] IBM has been forced to change tack: the US company has fallen behind Amazon and Microsoft in cloud computing. IBM has "embarked on a period of investment" after it "acknowledged that it will not meet its previous profit goals". In a market where scale counts, the failure to invest has put IBM "uncomfortably close to the borderline".

Successful productive lending requires detailed analysis of companies and their potential growth markets. This can only be achieved with a relentless focus on gathering information and data to scrutinise changes in consumer demand, supply, prices, revenues, costs and profits. It will also allow lenders to monitor 'disruptor' products and services, and gauge future market trends. Instead, by focussing on mortgage lending and consumer credit, the banks have been engaged in a race to the bottom reminiscent of the years preceding 2008.[92]

Many of today's larger technology firms have the data to make superior credit judgments. They have the core capabilities to garner crucial information on businesses across a range of industries. Google and Amazon have a strong advantage. Google is already in the credit analysis game and Amazon is lending money. Google captures around 70% of the credit and debit card transactions in the U.S. from

[90] See Financial Stability Report November 2016, p. 21. "UK banks plan to improve their profitability partly by exiting businesses with lower returns. That includes further shrinkage of their global investment banking activities, where exposures have already been reduced considerably since the crisis. UK banks are also targeting significant cost savings through, for example, cutting staff and IT costs. Any further reductions in returns due to economic conditions would increase the scale of the challenge that UK banks face in restructuring their business models".
[91] See "IBM is in a fight to keep up with big spending rivals in the cloud", Financial Times, May 24th 2017, https://www.ft.com/content/290e2936-4054-11e7-9d56-25f963e998b2
[92] See Financial Stability Report November 2017, pp. 14-15.

third parties. Alongside its vast data on internet users (combined with location data), it can gain further insights into individual behaviour and the profitability of stores where they shop.[93]

Chinese companies like Alibaba have developed world-leading skills in this field. Alibaba has also taken a lead in adopting big data and dynamic credit risk management to manage arrears. The delinquency ratio at Ant Financial's Small Loan Unit (90+ days) was 0.48% in April 2017. According to the China Banking Regulatory Commission, the comparable delinquency rate for state-owned banks was 1.74% in Q3. The disparity in delinquency rates provides an added incentive for regulators to take a hard line: backed with stronger business models (and limited debt), the technology companies are well-placed to challenge the hegemony of incumbent lenders.

Nonetheless, it also offers an important opportunity to create a new banking system, one that can help raise productivity in the UK economy. The UK has seen the emergence of peer-to-peer lenders using new platforms to link savers with businesses seeking alternative sources of funding.[94] The UK has one of the largest P2P lending sectors in Europe.[95]

Peer-to-peer lenders provide one alternative to the existing banks, but they do not have the large-scale information that many of the larger technology companies possess. In addition, serious questions have been raised about insufficient credit controls and, at times, inadequate representations to the end lenders.[96]

Indeed, the real catalyst for growth lies with the big data created from online transactions, allied with the growth in sensors and the internet of things.[97] This provides technology companies with the chance to make detailed, daily assessments of business opportunities, to build more successful lending models. Big data will allow new lenders to track borrowers effectively, providing timely intervention, advice and support to help businesses evolve and grow.

The emergence of challenger banks based around the model of unproductive lending – consumer credit, buy-to-let mortgages – is not the answer. Partnerships between technology companies and indigenous lenders will need to be geared towards raising productive lending. The Bank of England will

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[93] See "Google plans to track credit card spending", BBC News, May 26th 2017, http://www.bbc.co.uk/news/technology-40027706.

[94] According to data from the P2P Finance Association, outstanding loans by P2P lenders totalled £3.442bn in Q2 2017, of which £1.827bn were business loans and £1.615bn were loans to individuals. Total cumulative lending by P2P lenders hit £8.387bn in Q1. Source: Peer-to-Peer Finance, http://p2pfa.info/data.

[95] See "UK regulator signals tougher peer-to-peer lending rules", Financial Times, December 9th 2016, https://www.ft.com/content/fcc36bde-bde0-11e6-8b45-b8b81dd5d080.

[96] See "Peer-to-peer loan groups told to stop lending to each other", Financial Times, February 28th 2017, https://www.ft.com/content/a6562dd6-fdb4-11e6-8d8e-a5e3738f9ae4. "Andrew Bailey, chief executive of the FCA, told the Financial Times in December that he was concerned about the lenders' use of "provision funds" — pots of cash designed to protect investors from losses. Mr Bailey said the protection seemingly offered to investors could "trend towards being misleading" and made buying loans appear as low risk as depositing money in a bank account. The watchdog also said it would look into the "risk of regulatory arbitrage" with banks."

[97] See, for example, "Pushing manufacturing productivity to the max", McKinsey, May 2017, http://www.mckinsey.com/business-functions/operations/our-insights/pushing-manufacturing-productivity-to-the-max.

need to be uncompromising in its scrutiny of new lenders, whatever their structure – standalone, technology-driven banks or recalibrated existing lenders ('partnerships').

Existing banks left to their own devices may struggle to change. Politicians and regulators have failed to prepare the existing banks for the challenge posed by a new era of technology. They have not ensured that banks play their part in supporting the growth of new businesses. Instead, banks have entrenched their focus on unproductive lending.

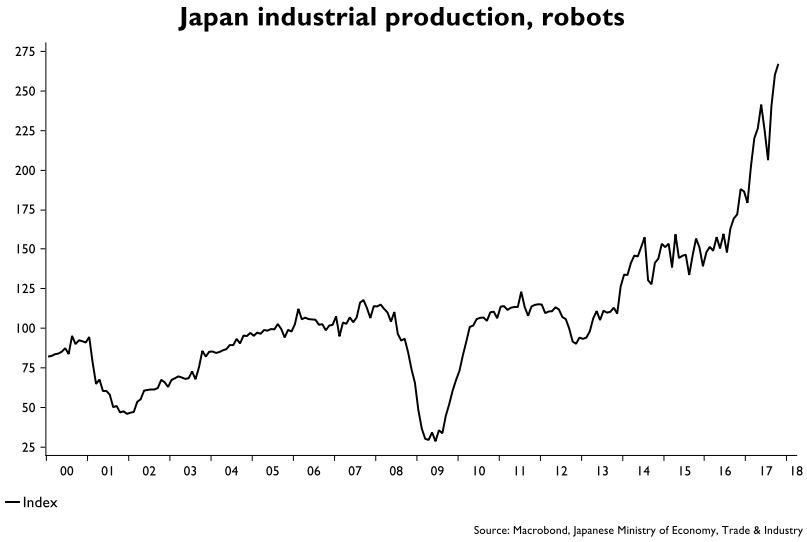
Technology – the challenge for the UK

The UK's ARM has been at the forefront of some impressive developments in the chip industry, prior to its sale to Japanese telecoms giant Softbank. Consolidation in the semiconductor industry shows competition is intensifying. Scale matters: if successful, Broadcom's audacious bid for Qualcomm would be the sector's biggest deal to date, arguably putting the companies in a better position to compete with giants such as Intel and Samsung.

Chipmakers have found new ways to boost performance, such as stacking chips one on top of the other (appendix 7).[98] There is a new arms race among chipmakers: the battle to develop artificial intelligence products to tap into the market for AI hardware and software. Estimates from International Data Corp. show that this market is expanding 50% y/y, and that global spending on AI-related hardware and software could rise from $12.0bn this year to $57.6bn by 2021.[99]

The rapid changes in the semiconductor industry and the growth of more powerful specialist chips will open enormous opportunities. Nevertheless, countries with larger technology companies will benefit disproportionately. The *Global Technology Trends* report (attached) highlights some of the important developments over the past year that underline the challenges facing the UK.

Chart 22



In critical sectors, the UK is lagging: robotics is an obvious example. Japanese industrial production of robots jumped 55.3% y/y in October to a record high in seasonally adjusted terms (chart 22). The

[98] See "The Secret to Tech's Next Big Breakthroughs? Stacking Chips", Wall Street Journal, November 19th 2017, https://www.wsj.com/articles/the-secret-to-techs-next-big-breakthroughs-stacking-chips-1511034248

[99] See "IDC Spending Guide Forecasts Worldwide Spending on Cognitive and Artificial Intelligence Systems to Reach $57.6 Billion in 2021", International Data Corporation, September 25th 2017, https://www.idc.com/getdoc.jsp?containerId=prUS43095417.

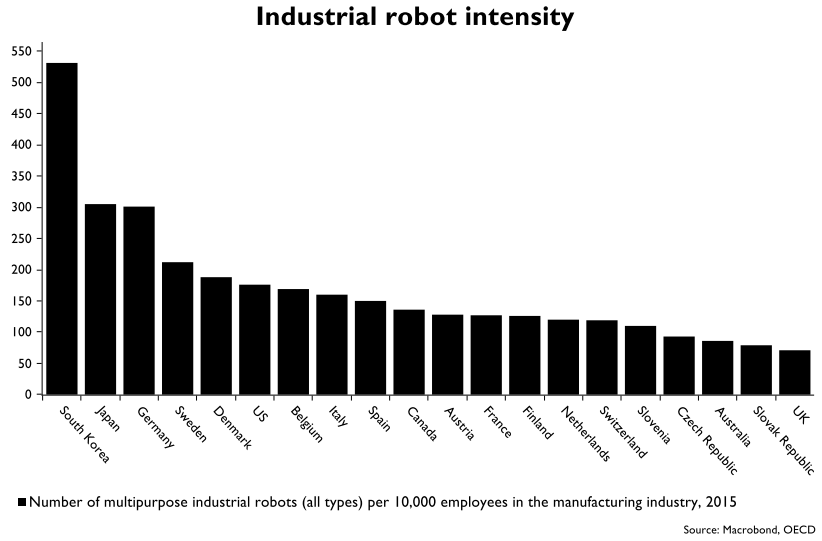
surge in output of 'intelligent robots' (59.4% y/y in September, year-to-date) provides an indication of the productivity benefits that automation could bring to early adopters.

Japan has benefitted from China's push to automate: China accounted for 29.6% of the global robotics market in 2016, according to the International Federation of Robotics. This share is projected to rise to 40.3% by 2020. China is fast developing its domestic capabilities in robotics: the National Bureau of Statistics estimates that output of industrial robots jumped 68.9% y/y (year-to-date) in October.

There remains a real danger that the pace of automation will accelerate for some of the UK's biggest competitors, leading to a further deterioration in the country's trade balance. Industrial robot intensity in the UK is very low by international standards (chart 23). Japan shows that automation need not take jobs. The level of employment has risen strongly; the unemployment rate has fallen to 2.80%.[100] Germany has seen strong jobs growth despite highly automated production processes.

For the Strategic Investment Board, a detailed analysis of the UK trade deficit will be an important starting point to understanding the structural problems that need to be addressed. The UK is running record trade deficits in technology-related industries. Policymakers need to engage with a variety of advisors to understand how the economy is changing and to provide an effective industrial strategy. This will need to be overseen by the Strategic Investment Board. This will improve the flow of information and funding for critical R&D. Industrial strategies will only work if the ideas and contributions of scientists, engineers, researchers and company executives are absorbed and disseminated quickly and methodically. Fragmentation will impair the ability of the UK to capitalise and commercialise upon its undoubted strengths in research.

Chart 23



[100] Source: Japan Statistics Bureau.

Appendices

Appendix 1: Sectoral productivity

Chart A1

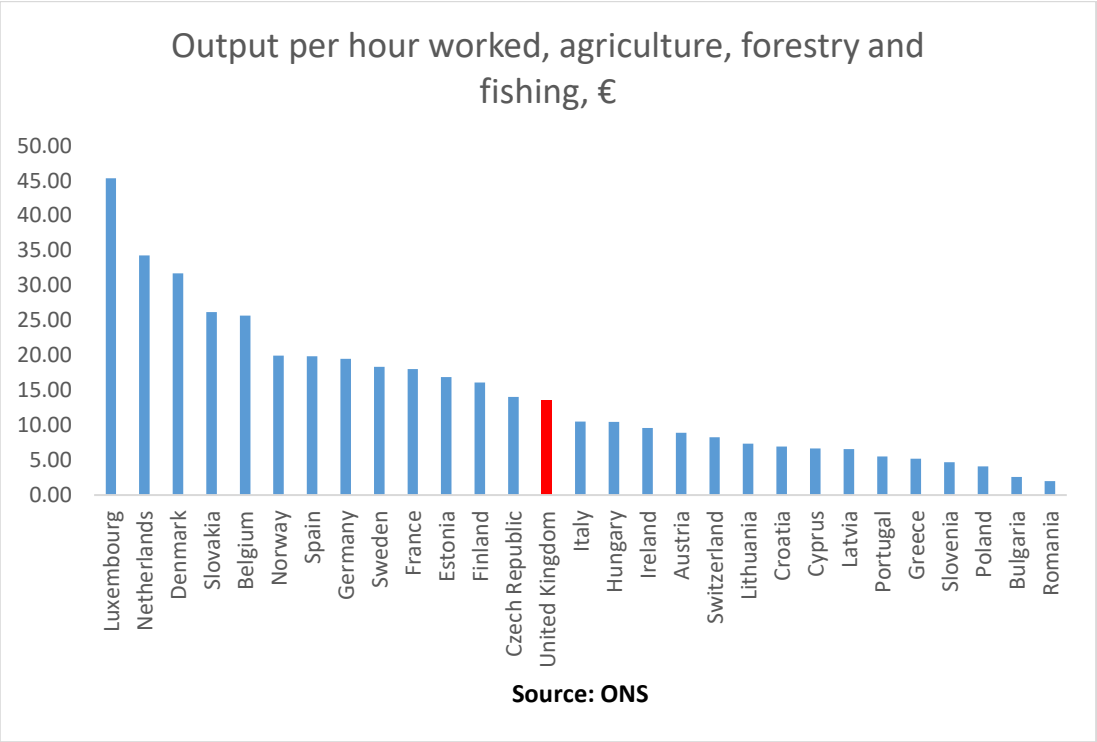


Chart A2

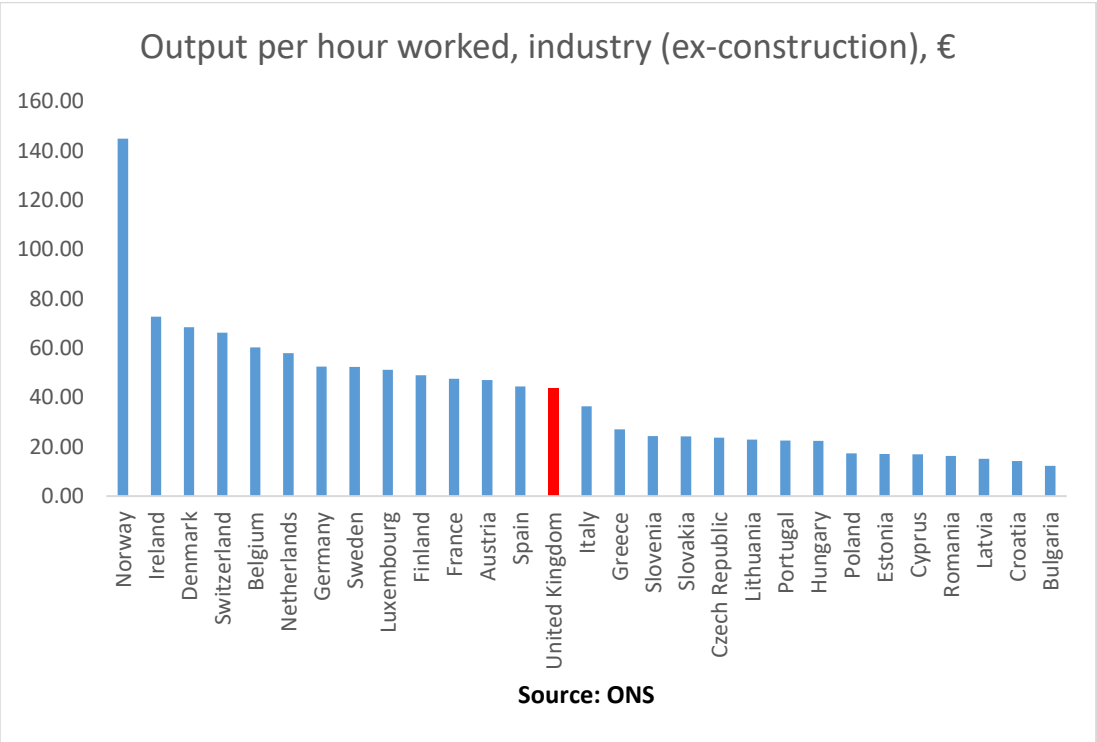


Chart A3

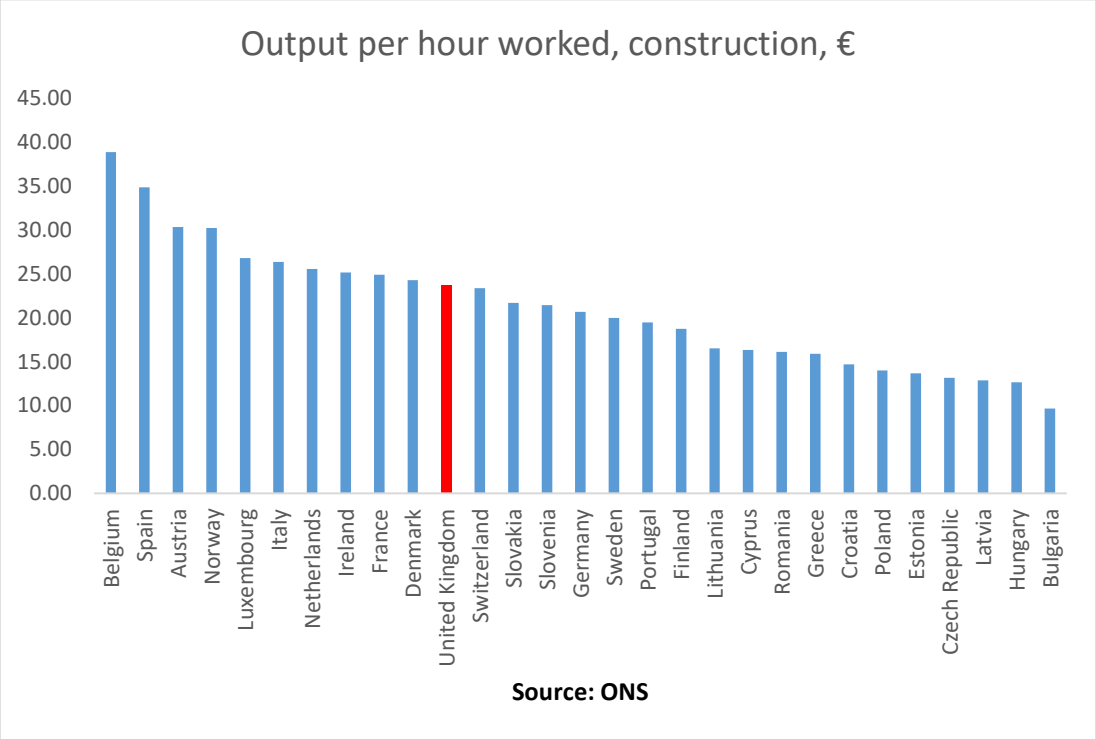


Chart A4

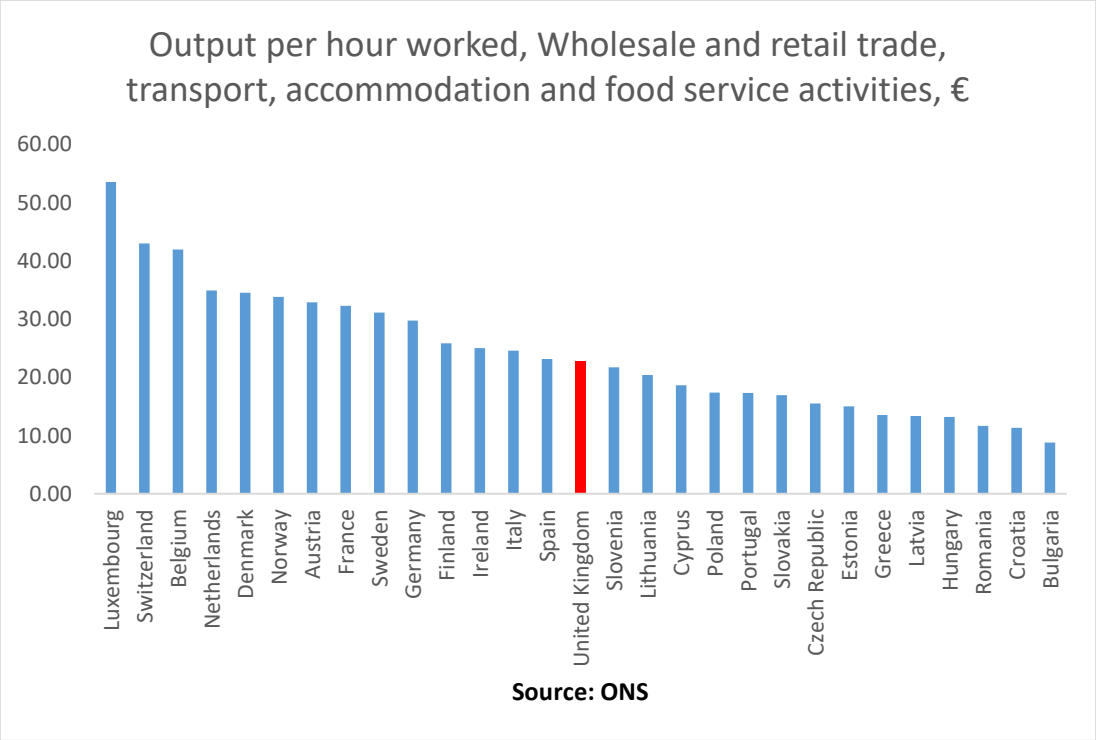
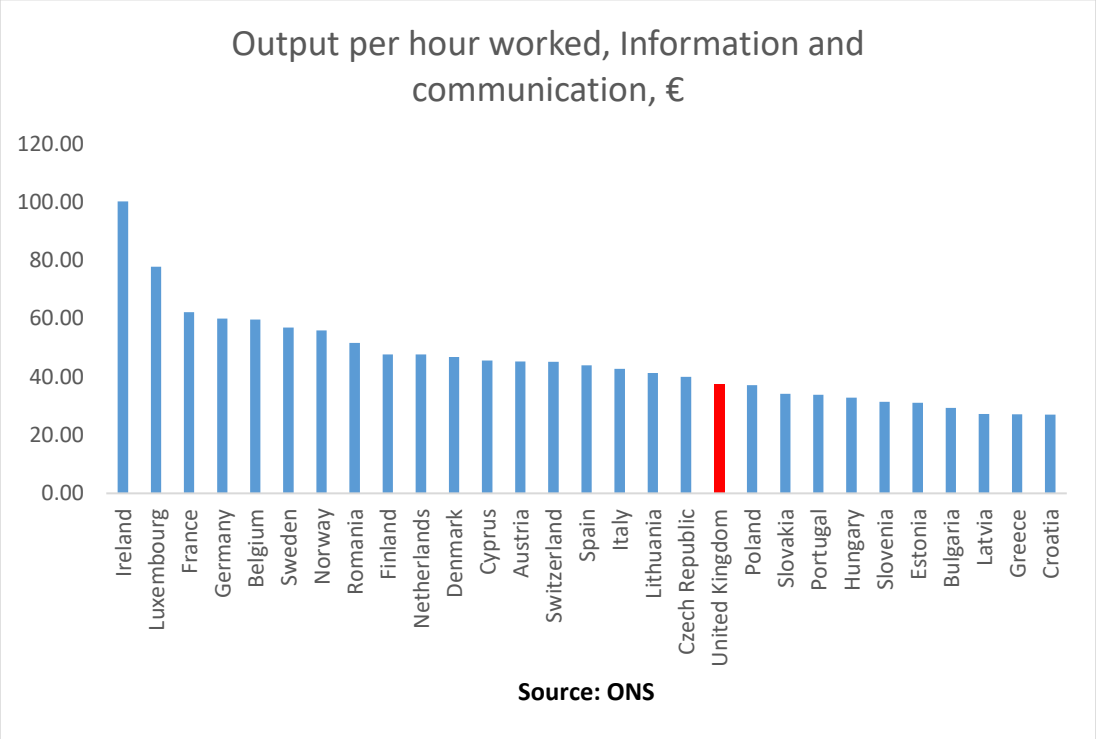
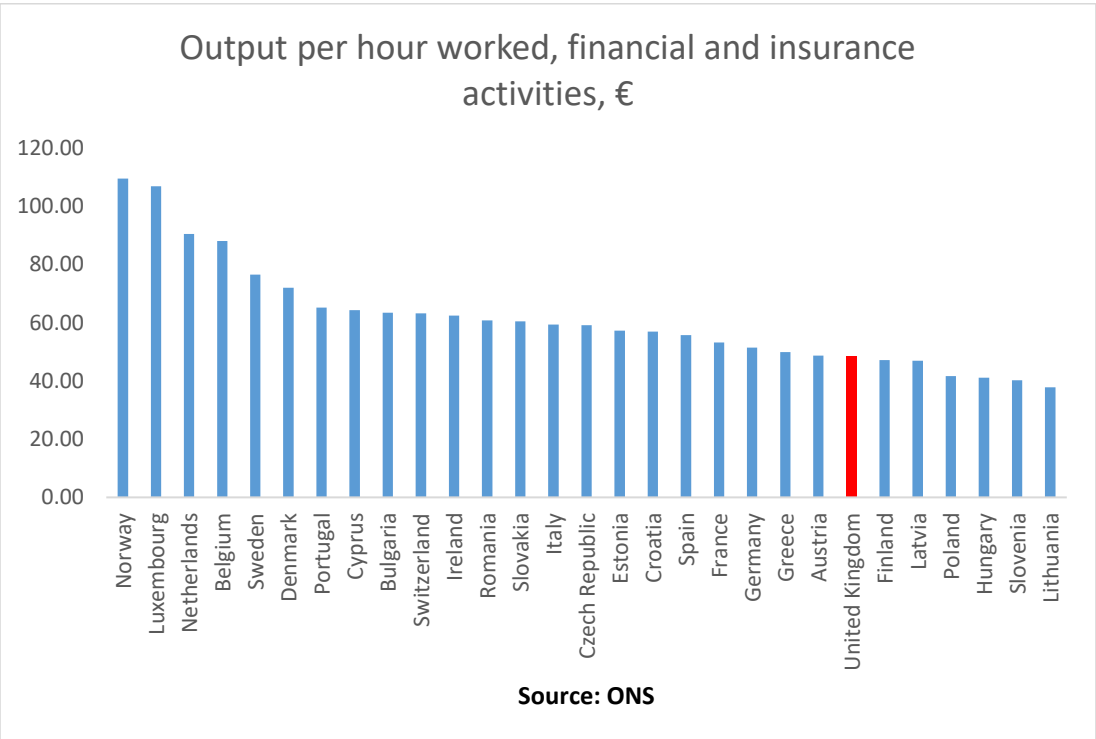


Chart A5



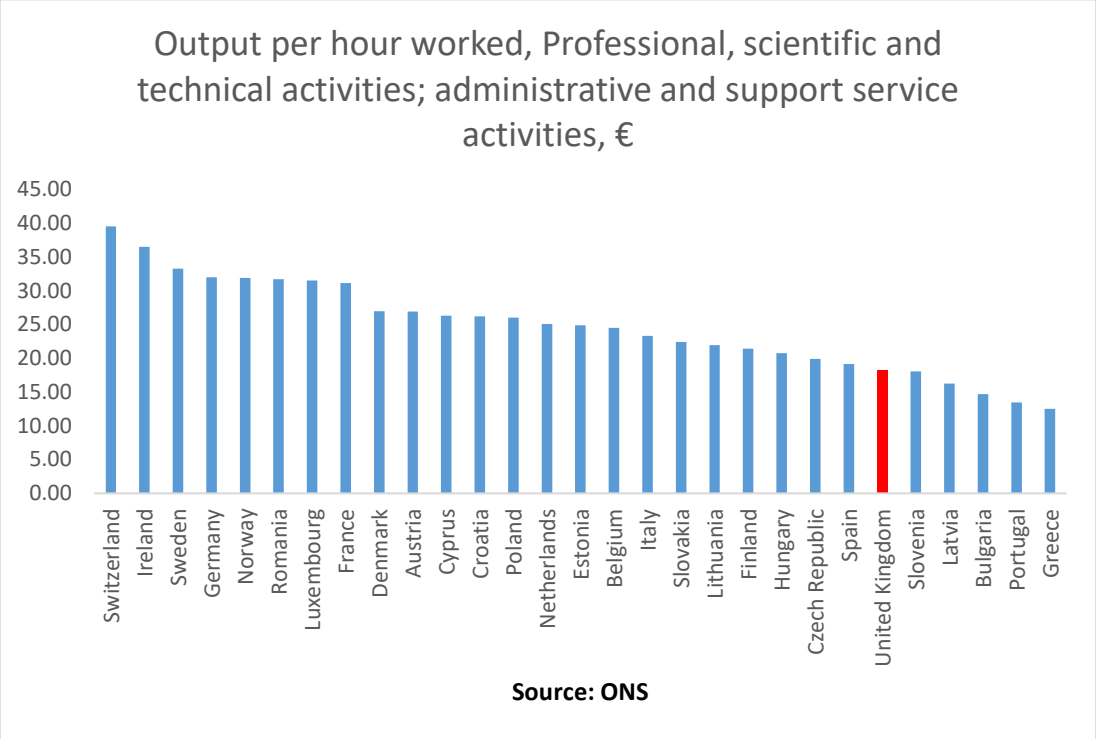
Source: ONS

Chart A6



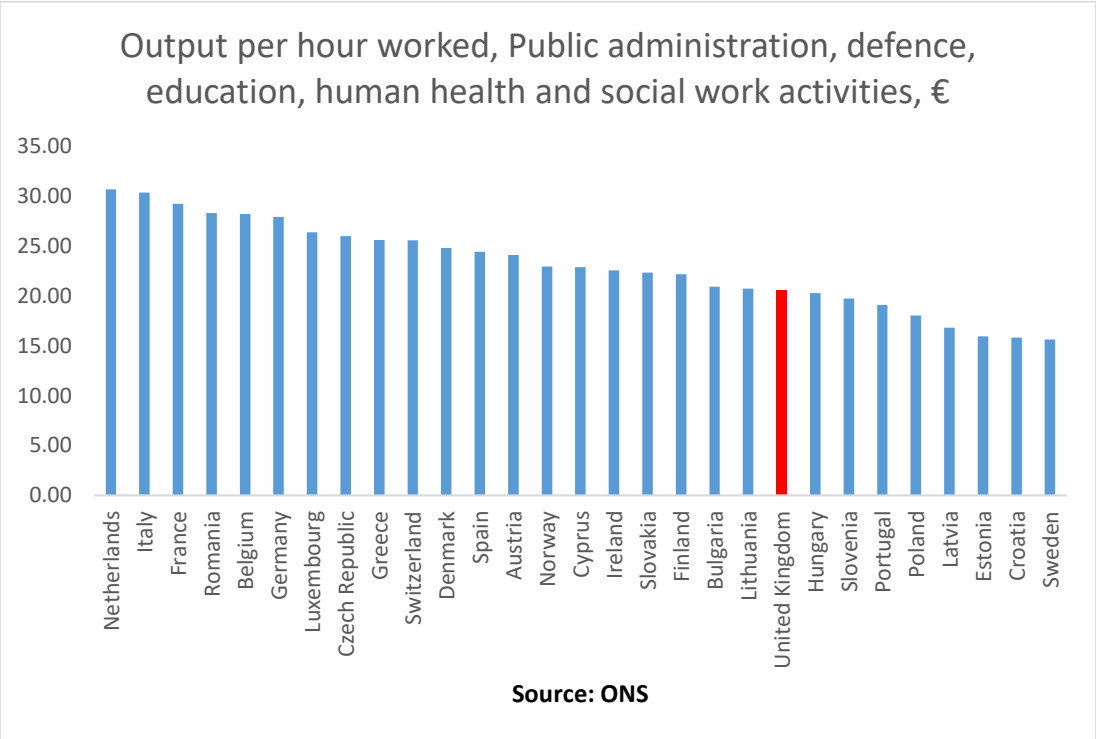
Source: ONS

Chart A7



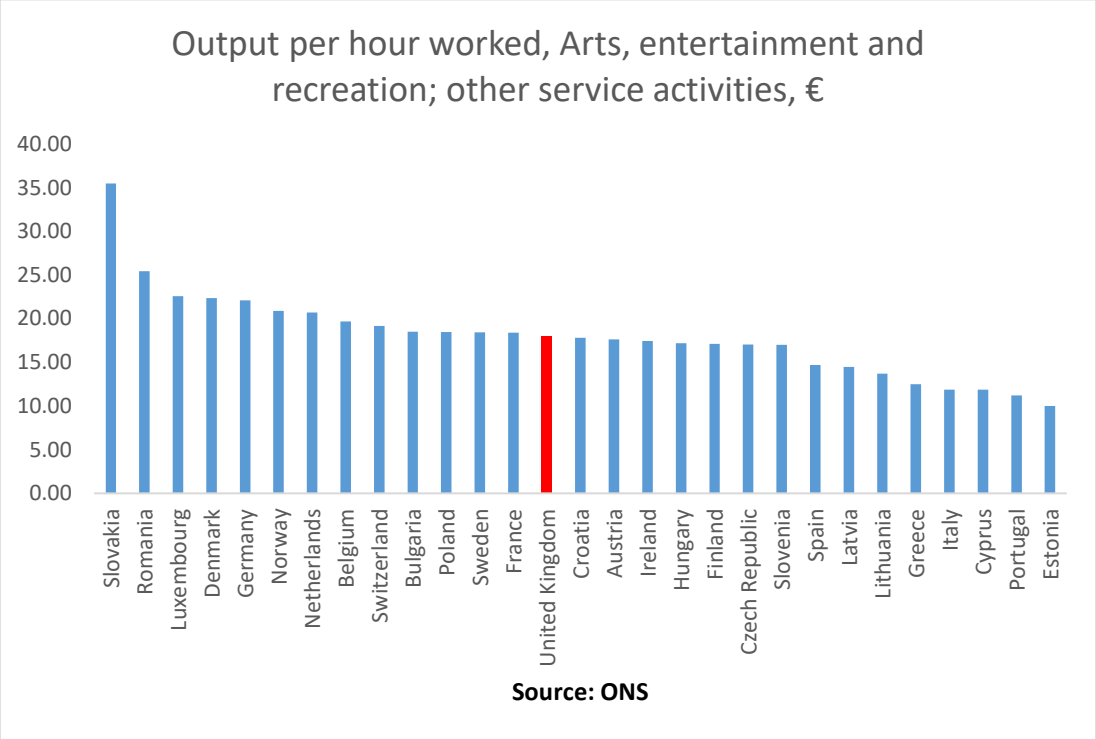
Source: ONS

Chart A8



Source: ONS

Chart A9



Source: ONS

Appendix 2: UK trade by goods

Table A1

Trade balance by good, Q2 2017

Good	£ bn, 4-quarter moving total
Total	-138.32
Agriculture, forestry & fishing	-7.69
Mining & quarrying	-8.20
Coal & lignite	-0.75
Crude petroleum & natural gas	-4.97
Natural gas	-5.64
Metal ores	-1.50
Other mining & quarrying products	-0.99
Manufactured products	-127.97
Food products	-16.64
Beverages	0.87
Distilled alcoholic beverages	4.74
Wine	-3.38
Other beverages	-0.10
Tobacco products	-1.33
Textiles	-2.82
Clothing	-12.35
Leather & related products	-5.14
Wood & prod of wood, cork, straw & plaiting mat	-3.85
Paper & paper products	-3.97
Printing & recording services	0.01
Coke & refined petroleum products	-7.44
Chemical & chemical products	-1.15
Pharmaceutical products & preparations	-2.36
Rubber & plastic products	-4.43
Rubber products	-1.73
Plastic products	-2.70
Other non-metallic mineral products	-2.52
Glass & glass products	-0.95
Other	-1.27
Basic metals	-3.52
Basic iron steel & ferro-alloys	-1.06
Non-cast steel tubes, pipes & hollow profiles	-0.55
Other products of the first processing of steel	-0.31
Basic precious & other non-ferrous metals	-1.57
Cast iron & steel tubes & pipes	-0.03
Fabricated metal products	-4.02
Structural metal products	-0.62
Steam generators & nuclear reactors	-0.62
Tanks, reservoirs & containers of metal	-0.10
Weapons & ammunition	0.49
Cutlery, tools & general hardware	-1.72

Other fabricated metal products	-1.46
Computer, electronic & optical products	-22.85
Electronic components & boards	-2.18
Computers & peripherals	-8.25
Communication equipment	-9.41
Consumer electronics	-3.73
Measuring, testing & navigating equip; watches & clocks	0.72
Irradation, electromedical & electrotherapeutic	0.22
Optical instruments & photographic equipment	-0.20
Magnetic & optical media	-0.01
Electrical equipment	-9.02
Electric motors, & electricity distrib & control	-0.87
Batteries & accumulators	-0.73
Wiring & wiring devices	-1.65
Electric lighting equipment	-1.82
Domestic appliances	-4.08
Other electrical equipment	0.12
Machinery & equipment N.E.C	-3.42
General-purpose machinery	-1.95
Other general-purpose machinery	-2.28
Agriculture & forestry machinery	-0.15
Metal forming machinery & machine tools	-0.37
Other special-purpose machinery	1.34
Motor vehicles, trailers & semi-trailers	-15.52
Motor vehicles	-5.80
Bodies for motor vehicles, trailers & semi-trailers	-0.64
Parts & accessories for motor vehicles	-9.07
Other transport equipment	2.86
Ships, boats & floating structures	-0.16
Railway locomotives & rolling stock	-1.30
Air & spacecraft & related machinery	5.54
Military fighting vehicles	0.05
Transport equipment N.E.C	-1.27
Furniture	-4.87
Other manufactured goods	-4.51
Jewellery, bijouterie & related articles	0.94
Musical instruments	-0.18
Sports goods	-0.60
Games & toys	-1.68
Medical & dental instruments & supplies	-1.95
Manufactured goods N.E.C	-1.05
Electricity, gas, steam & air conditioning	-0.63
Waste	2.22
Information & communication services	1.01
Professional, scientific & technical services	0.06
Arts, entertainment & recreation services	2.88

Source: ONS

Appendix 3: UK workforce

UK workforce jobs by region, by sector

Table A2

Total employment	Average in 2007 (000s)	Q2 2017 (000s)	% change	Average weekly earnings, 2016 (£)
UK	32140.5	34949.0	8.74	464.00
London	4831.3	5796.0	19.97	
South East	4469.3	4963.0	11.05	
South West	2721.0	2990.0	9.89	
East	2887.5	3138.0	8.68	
West Midlands	2722.5	2951.0	8.39	
Wales	1396.0	1505.0	7.81	
East Midlands	2239.0	2375.0	6.07	
Yorkshire & the Humber	2580.0	2732.0	5.89	
North West	3463.0	3606.0	4.13	
Northern Ireland	856.0	879.0	2.69	
Scotland	2748.8	2804.0	2.01	
North East	1199.0	1202.0	0.25	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

Table A3

Manufacturing	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	2969.5	2666.0	-10.22	7.63	553.00
Northern Ireland	89.5	92.0	2.79	10.47	
East Midlands	297.5	295.0	-0.84	12.42	
Yorkshire & the Humber	300.5	292.0	-2.83	10.69	
Wales	169.0	158.0	-6.51	10.50	
West Midlands	351.0	327.0	-6.84	11.08	
South West	260.3	241.0	-7.40	8.06	
North East	134.5	122.0	-9.29	10.15	
South East	325.0	285.0	-12.31	5.74	
East	265.5	224.0	-15.63	7.14	
North West	380.8	319.0	-16.22	8.85	
Scotland	227.5	184.0	-19.12	6.56	
London	168.7	126.1	-25.24	2.18	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region. For example, 12.42% of total jobs in the East Midlands are in manufacturing.*

Table A4

Construction	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	2330.5	2286.0	-1.91	6.54	555.00
London	268.2	313.5	16.89	5.41	
East	236.5	270.0	14.16	8.60	
South East	324.5	350.0	7.86	7.05	
South West	193.8	207.0	6.84	6.92	
East Midlands	167.5	160.0	-4.48	6.74	
West Midlands	202.8	192.0	-5.30	6.51	
Yorkshire & the Humber	198.0	180.0	-9.09	6.59	
North West	249.0	220.0	-11.65	6.10	
Wales	103.8	91.0	-12.29	6.05	
Scotland	207.0	171.0	-17.39	6.10	
North East	99.8	76.0	-23.81	6.32	
Northern Ireland	79.3	56.0	-29.34	6.37	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A5

Electricity, gas, steam & air condition supply	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	85.8	150.0	74.93	0.43	635.00
North West	5.3	14.0	166.67	0.39	
Wales	5.0	12.0	140.00	0.80	
South East	10.8	22.0	104.65	0.44	
West Midlands	7.0	14.0	100.00	0.47	
East Midlands	10.8	19.0	76.74	0.80	
Northern Ireland	1.8	3.0	71.43	0.34	
Scotland	13.0	22.0	69.23	0.78	
East	4.8	8.0	68.42	0.25	
Yorkshire & the Humber	6.0	10.0	66.67	0.37	
North East	4.0	6.0	50.00	0.50	
South West	10.0	13.0	30.00	0.43	
London	7.0	6.0	-14.65	0.10	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A6

Services	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	26150.8	29175.0	11.56	83.48	449.00
London	4363.2	5327.7	22.11	91.92	
South East	3737.5	4230.0	13.18	85.23	
West Midlands	2114.3	2368.0	12.00	80.24	
South West	2196.0	2438.0	11.02	81.54	
East	2324.8	2580.0	10.98	82.22	
Wales	1073.8	1169.0	8.87	77.67	
Yorkshire & the Humber	2036.0	2214.0	8.74	81.04	
North West	2775.0	3005.0	8.29	83.33	
East Midlands	1717.5	1849.0	7.66	77.85	
Northern Ireland	643.0	685.0	6.53	77.93	
Scotland	2198.0	2317.0	5.41	82.63	
North East	944.5	982.0	3.97	81.70	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A7

Education	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	2591.5	2980.0	14.99	8.53	425.00
London	314.0	411.6	31.11	7.10	
South East	379.0	494.0	30.34	9.95	
North East	102.0	121.0	18.63	10.07	
Yorkshire & the Humber	230.3	265.0	15.09	9.70	
East Midlands	179.5	205.0	14.21	8.63	
Wales	122.5	139.0	13.47	9.24	
East	236.8	267.0	12.78	8.51	
West Midlands	232.8	261.0	12.14	8.84	
South West	228.8	243.0	6.23	8.13	
North West	289.8	298.0	2.85	8.26	
Scotland	202.3	202.0	-0.12	7.20	
Northern Ireland	74.3	73.0	-1.68	8.30	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A8

Finance & insurance activities	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	1180.0	1094.0	-7.29	3.13	880.00
London	353.2	367.3	4.00	6.34	
South East	132.8	127.0	-4.33	2.56	
Yorkshire & the Humber	90.3	86.0	-4.71	3.15	
Northern Ireland	20.3	19.0	-6.17	2.16	
South West	86.0	80.0	-6.98	2.68	
Wales	35.5	33.0	-7.04	2.19	
West Midlands	79.5	72.0	-9.43	2.44	
East Midlands	49.8	44.0	-11.56	1.85	
Scotland	101.3	88.0	-13.09	3.14	
North East	32.3	27.0	-16.28	2.25	
North West	111.8	90.0	-19.46	2.50	
East	87.5	60.0	-31.43	1.91	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A9

Human health	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	3620.8	4382.0	21.02	12.54	411.00
London	390.1	590.3	51.33	10.19	
South West	328.3	411.0	25.21	13.75	
West Midlands	291.5	358.0	22.81	12.13	
East	306.3	370.0	20.82	11.79	
Wales	189.8	229.0	20.69	15.22	
South East	483.5	577.0	19.34	11.63	
Yorkshire & the Humber	305.0	361.0	18.36	13.21	
North West	410.8	474.0	15.40	13.14	
East Midlands	245.5	279.0	13.65	11.75	
Northern Ireland	121.5	136.0	11.93	15.47	
North East	164.0	183.0	11.59	15.22	
Scotland	384.5	414.0	7.67	14.76	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A10

Information & communication	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	1243.8	1482.0	19.16	4.24	716.00
London	352.5	461.0	30.79	7.95	
South East	233.0	299.0	28.33	6.02	
East	106.3	135.0	27.06	4.30	
North East	32.3	40.0	24.03	3.33	
Northern Ireland	18.5	22.0	18.92	2.50	
North West	103.8	121.0	16.63	3.36	
South West	80.8	94.0	16.41	3.14	
East Midlands	60.0	66.0	10.00	2.78	
Scotland	78.5	81.0	3.18	2.89	
Yorkshire & the Humber	67.8	68.0	0.37	2.49	
Wales	30.5	28.0	-8.20	1.86	
West Midlands	79.5	67.0	-15.72	2.27	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A11

Professional scientific & technical activities	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	2285.3	2997.0	31.15	8.58	631.00
Yorkshire & the Humber	130.8	193.0	47.61	7.06	
South West	173.8	243.0	39.86	8.13	
London	577.3	800.1	38.59	13.80	
East Midlands	120.5	164.0	36.10	6.91	
East	218.8	292.0	33.49	9.31	
South East	362.5	457.0	26.07	9.21	
Scotland	166.5	207.0	24.32	7.38	
West Midlands	151.0	186.0	23.18	6.30	
North West	221.5	268.0	20.99	7.43	
North East	59.3	71.0	19.83	5.91	
Northern Ireland	34.0	40.0	17.65	4.55	
Wales	69.0	74.0	7.25	4.92	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A12

Public administration & defence	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	1773.3	1489.0	-16.03	4.26	559.00
London	239.6	230.4	-3.83	3.98	
Scotland	181.3	167.0	-7.86	5.96	
Wales	98.0	86.0	-12.24	5.71	
South West	156.8	137.0	-12.60	4.58	
Northern Ireland	63.8	55.0	-13.73	6.26	
South East	212.5	179.0	-15.76	3.61	
East	128.3	104.0	-18.91	3.31	
Yorkshire & the Humber	141.0	113.0	-19.86	4.14	
North West	185.5	148.0	-20.22	4.10	
West Midlands	132.3	105.0	-20.60	3.56	
North East	89.0	69.0	-22.47	5.74	
East Midlands	119.3	86.0	-27.88	3.62	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A13

Real estate activities	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	452.8	550.0	21.48	1.57	449.00
Wales	13.5	24.0	77.78	1.59	
South East	58.0	82.0	41.38	1.65	
London	86.9	121.2	39.46	2.09	
North East	14.3	19.0	33.33	1.58	
West Midlands	39.8	51.0	28.30	1.73	
North West	51.5	64.0	24.27	1.77	
Yorkshire & the Humber	28.8	35.0	21.74	1.28	
East	40.0	45.0	12.50	1.43	
South West	49.0	48.0	-2.04	1.61	
Northern Ireland	7.3	7.0	-3.45	0.80	
Scotland	33.3	32.0	-3.76	1.14	
East Midlands	30.3	23.0	-23.97	0.97	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A14

Accommodation & food service activities	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	2017.5	2376.0	17.77	6.80	240.00
Scotland	195.0	263.0	34.87	9.38	
London	316.0	392.1	24.06	6.76	
Wales	98.3	121.0	23.16	8.04	
South East	266.8	327.0	22.59	6.59	
South West	190.3	233.0	22.47	7.79	
Northern Ireland	46.5	55.0	18.28	6.26	
West Midlands	158.0	180.0	13.92	6.10	
North West	219.5	250.0	13.90	6.93	
North East	75.0	85.0	13.33	7.07	
East	159.0	176.0	10.69	5.61	
Yorkshire & the Humber	163.8	172.0	5.04	6.30	
East Midlands	130.0	122.0	-6.15	5.14	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A15

Administrative & support service activities	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	2563.5	2986.0	16.48	8.54	383.00
East Midlands	172.3	231.0	34.11	9.73	
Yorkshire & the Humber	185.8	240.0	29.21	8.78	
Northern Ireland	45.5	58.0	27.47	6.60	
West Midlands	221.0	271.0	22.62	9.18	
London	504.5	614.1	21.72	10.59	
North West	259.5	315.0	21.39	8.74	
North East	84.5	97.0	14.79	8.07	
Wales	80.3	91.0	13.40	6.05	
East	246.5	277.0	12.37	8.83	
South East	382.8	401.0	4.77	8.08	
South West	188.3	197.0	4.65	6.59	
Scotland	193.5	195.0	0.78	6.95	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A16

Arts, entertainment & recreation	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	864.0	973.0	12.62	2.78	361.00
Wales	37.5	48.0	28.00	3.19	
Scotland	75.3	95.0	26.25	3.39	
South East	127.5	150.0	17.65	3.02	
Yorkshire & the Humber	66.3	76.0	14.72	2.78	
North West	85.8	98.0	14.29	2.72	
East	69.3	79.0	14.08	2.52	
West Midlands	64.0	72.0	12.50	2.44	
Northern Ireland	17.5	19.0	8.57	2.16	
London	161.5	173.9	7.67	3.00	
East Midlands	57.8	60.0	3.90	2.53	
South West	71.8	74.0	3.14	2.47	
North East	29.8	28.0	-5.88	2.33	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A17

Transport & storage	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	1514.3	1748.0	15.44	5.00	538.00
West Midlands	135.3	188.0	39.00	6.37	
South West	106.5	135.0	26.76	4.52	
North East	45.3	56.0	23.76	4.66	
South East	195.8	230.0	17.50	4.63	
East	141.0	164.0	16.31	5.23	
London	267.5	306.0	14.38	5.28	
East Midlands	114.8	127.0	10.68	5.35	
Northern Ireland	30.0	33.0	10.00	3.75	
Yorkshire & the Humber	130.0	142.0	9.23	5.20	
Scotland	121.5	129.0	6.17	4.60	
North West	177.5	187.0	5.35	5.19	
Wales	49.3	50.0	1.52	3.32	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A18

Water supply, sewerage, waste & remediation activities	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	158.8	208.0	31.02	0.60	N/A
Yorkshire & the Humber	8.5	18.0	111.76	0.66	
East	12.5	25.0	100.00	0.80	
South West	11.3	18.0	60.00	0.60	
West Midlands	14.0	20.0	42.86	0.68	
Wales	9.0	12.0	33.33	0.80	
East Midlands	10.0	13.0	30.00	0.55	
Northern Ireland	5.0	6.0	20.00	0.68	
North West	21.5	25.0	16.28	0.69	
South East	26.3	30.0	14.29	0.60	
Scotland	17.5	19.0	8.57	0.68	
London	15.0	15.3	2.13	0.26	
North East	8.0	7.0	-12.50	0.58	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A19

Wholesale & retail trade, repair of motor vehicles & motorcycles	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	5056.5	5112.0	1.10	14.63	409.00
London	633.8	687.8	8.53	11.87	
West Midlands	444.8	466.0	4.78	15.79	
East	494.8	516.0	4.30	16.44	
South West	443.3	456.0	2.88	15.25	
South East	741.3	756.0	1.99	15.23	
North West	564.5	575.0	1.86	15.95	
East Midlands	371.5	371.0	-0.13	15.62	
Scotland	389.5	382.0	-1.93	13.62	
Wales	215.5	207.0	-3.94	13.75	
Northern Ireland	146.0	140.0	-4.11	15.93	
Yorkshire & the Humber	429.3	401.0	-6.58	14.68	
North East	182.5	155.0	-15.07	12.90	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A20

Other service activities	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	831.8	940.0	13.01	2.69	365.00
Northern Ireland	18.3	27.0	47.95	3.07	
North West	83.0	113.0	36.14	3.13	
Wales	30.5	40.0	31.15	2.66	
East Midlands	54.3	69.0	27.19	2.91	
East	73.5	87.0	18.37	2.77	
South West	71.8	82.0	14.29	2.74	
West Midlands	75.3	85.0	12.96	2.88	
London	140.5	157.6	12.17	2.72	
Yorkshire & the Humber	57.5	60.0	4.35	2.20	
South East	127.0	131.0	3.15	2.64	
North East	31.5	30.0	-4.76	2.50	
Scotland	68.5	58.0	-15.33	2.07	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A21

Agriculture & forestry	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	376.5	402.0	6.77	1.15	379.00
Wales	33.3	60.0	80.45	3.99	
South West	44.3	69.0	55.93	2.31	
London	2.4	3.6	52.16	0.06	
North East	5.5	8.0	45.45	0.67	
East Midlands	29.8	32.0	7.56	1.35	
Scotland	56.5	59.0	4.42	2.10	
South East	41.8	42.0	0.60	0.85	
Northern Ireland	34.3	34.0	-0.73	3.87	
West Midlands	31.0	29.0	-6.45	0.98	
North West	29.3	22.0	-24.79	0.61	
East	41.3	28.0	-32.12	0.89	
Yorkshire & the Humber	27.8	15.0	-45.95	0.55	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Table A22

People employed by households	Average in 2007 (000s)	Q2 2017 (000s)	% change	Share of total (%)*	Average weekly earnings, 2016 (£)
UK	155.3	66.0	-57.49	0.19	N/A
South East	35.0	21.0	-40.00	0.42	
London	25.7	14.2	-44.77	0.25	
East	16.8	9.0	-46.27	0.29	
West Midlands	10.0	5.0	-50.00	0.17	
Scotland	7.8	3.0	-61.29	0.11	
North West	11.3	4.0	-64.44	0.11	
Wales	3.0	1.0	-66.67	0.07	
South West	20.5	5.0	-75.61	0.17	
Yorkshire & the Humber	9.8	2.0	-79.49	0.07	
East Midlands	11.8	1.0	-91.49	0.04	
North East	3.5	0.0	-100.00	0.00	
Northern Ireland	0.5	0.0	-100.00	0.00	

Source: ONS. Average weekly earnings exclude bonuses & arrears (i.e. 'regular pay').

** = "Share of total" is the percentage of jobs in the sector as a share of all jobs in that region.*

Appendix 4: Cluster maps

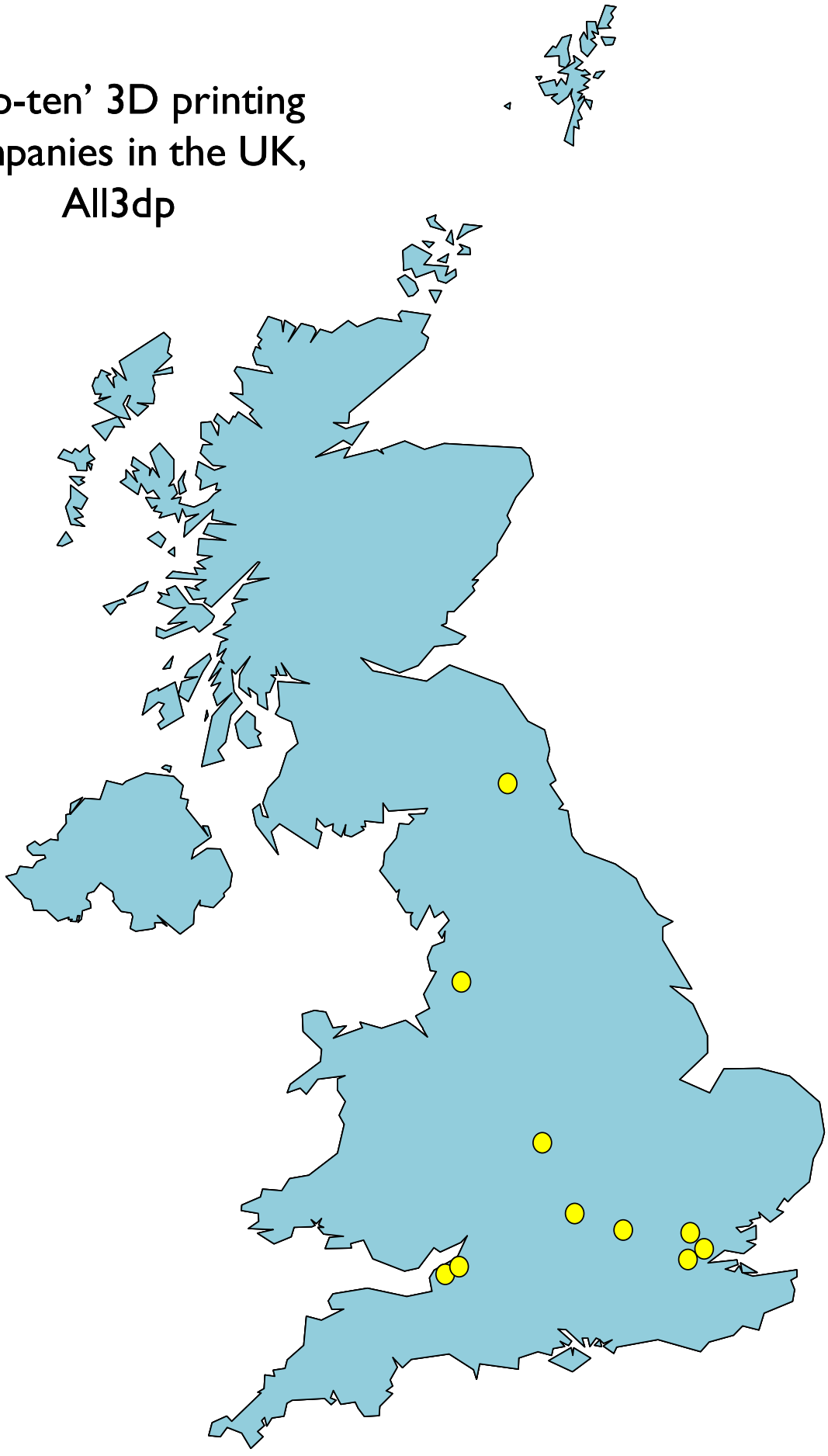
The following are a series of cluster maps that highlight the concentration of technology companies around London and the South East.

AI companies

Company	Location	Description
DeepMind	London	The company is seeking to combine the best techniques from "machine learning and systems neuroscience to build powerful general-purpose learning algorithms."
Magic Pony Technology	London	Uses machine learning to create high-quality videos from grainy footage
Status Today	London	A security firm that employs AI to monitor employee behaviour patterns, in order to assess whether they become a risk
Rainbird	London/Norwich	A platform that allows businesses to automate decision-making
Tractable	London	Tractable "creates a propiertary AI algorithm that attempts to learn and perform visual tasks in the same way a human would – helping businesses streamline certain manual tasks."
Synap	Leeds	Synap is a mobile and web app that allows students and professionals to prepare for exams by taking quizzes that are developed by other members of the Synap community. It uses AI algorithms to tailor lessons and revision schedules for individual students.
Onfido	London	Onfido allows companies to carry out remote background checks. It uses AI and machine learning, in addition to basic info such as name and DOB, to build up sophisticated fraud protection.
Weave.ai	London	A start-up that is looking to make smartphone assistants more human-like, by analysing files on different platforms and return answers
Seldon	London	Uses behavourial data to predict future actions of media and e-commerce consumers
Improbable	London	Created an operating system that sits in the cloud, and allows anyone to build simulations in virtual worlds

Source: Business Insider, "10 British AI companies to look out for in 2016", January 5 2016

‘Top-ten’ 3D printing companies in the UK, All3dp



3D printing companies

Company	Location	Description
E3D	Oxford	E3D are specialists in FDM 3D printing, and considered the best company in this class.
Open Bionics	Bristol	This company prints prosthetic and robotic limbs
iMakr	London/New York	Boast the world's largest 3D printing stores, and provide on-demand printing, services and training to customers.
Andiamo 3D	London	Scan and print affordable external braces for the spine or limbs. Using 3D printers reduces manufacturing time from 13 weeks to one.
Fuel 3D	Chinnor, Oxfordshire	Work with companies who wish to develop new 3D applications.
Formworx	Rothbury	Produce high-quality, custom prints of 3D models produced by artists, designers, architects and engineers.
3D Quick Printing	Coventry	Specialise in quick turnaround of products.
Heita Technologies	Bristol	One of the older companies on the list, Heita provide 3D printing services as well as a range of products.
Printtopeer	London	Aims to make 3D printing easier for enterprises, by using an online dashboard that can control 3D printers remotely.
COLLABORAT3D	Chorley	Seller of 3D printers, consumables and services

Source: All3dp, "Best 3D Printing Companies 2017 - The 40 Most Innovative", June 2017

‘Top-ten’ software companies in the UK, Clutch

Software companies

Company	Location	Description
Intellectsoft	London	Full service software partner, capable of developing, marketing, and maintaining both web and mobile applications
DCSL Software	Farnborough	Bespoke software development company
BJSS	Leeds	IT consultancy with over 20 years experience in software delivery and advice
Bright Interactive	Brighton	A web software development company
Innovify	London	Software development, mainly in mobiles, but also web and custom
Audacia	Leeds	Bespoke software development company
Atlas	Wickford	Bespoke software development company
VTS Software	Manchester	Bespoke software development company
51zero	London	Use big data to develop software
Applify	London	Mobile app developer

Source: Clutch, "Top 75 UK Software Development Firms", September 25 2017

‘Top-ten’ big data companies in the UK, efinancialcareers, TechBullion & Techworld

Big data companies

Company	Location	Description
DataSift	Reading	Tracks what is popular among social media users
Knowsis	London	"Social intelligence for the capital markets" - Knowsis is a web intelligence company that extracts data from social media to help investors with their decisions
Push Technology	London	"We make the internet work for our mobile-obsessed, everything-connected world."
Mastodon C	London	Real-time data interpreter, modelling and analysing for businesses
Qubit	London	offers a product suite that collects and processes big data sets to detect and execute the main levers for improving online profitability via machine learning, high-performance computing and statistical analysis
TUMRA	London	Using large-scale data analysis, visualization and machine learning, the company helps other companies to solve complex problems
Brandwatch	Brighton	Brandwatch analyse people's activity, social media data and audience across many topics from multiple channels (Facebook, Quora, Twitter, etc.). The company helps other businesses to understand consumer insights and to identify and engage with the right people.
Spend Network	London	Tool for analysing public sector spending
Kognitio	Bracknell	Provides cloud based data analytics for data science and business intelligence companies.
Adzuna	London	Search engine that aggregates job adverts from over a hundred online sources

Sources: efinancialcareers, "43 of the top big data companies to work for, by J.P.Morgan", June 1 2017
See also: TechBullion, "10 Big Data Technologies to Watch in The UK in 2017, October 29 2016
See also: Techworld, "19 innovative UK companies using open data | UK open data businesses", November 1 2016

‘Top-15’ robotics start-ups in the UK, Techworld

Robotics

Company	Location	Description
Botskill	London	Introduces firms to chatbots, which can be used to deal with routine customer enquiries
Generic Robotics	Reading	Allows users to manipulate, create and feel 3D objects in a virtual environment. Used to help dentists and doctors in training
Cambridge Medical Robotics	Cambridge	Developing a robot capable of performing keyhole surgery
Automata	London	Manufacturer of robots for use in production lines, and even classrooms
Consequential Robotics	Sheffield	Develop companion and assistive robots to enhance quality of life as people age
Ai Build	London	Want to integrate robotics into 3D printing processes
Reach Robotics	Bristol	Creating 'monster' robots that be controlled by mobile devices and used to play video games
Open Bionics	Bristol	Create low-cost prosthetic arms and hands for amputees
Animal Dynamics	Yarnton	Developing vehicles that are inspired by movements of animals, to improve efficiency
Moley Robotics	London	Created the first robotic kitchen
Primo Toys	London	Manufacture toys for children to introduce them to technology, such as coding
Emotech	London	Created an artificially intelligent robot that "adapts" to the user's personality over time
Q-bot	London	Q-bot is a small robot that can be used to help insulate homes
Starship Technologies	London	Develops small self-driving robots capable of delivering goods locally within 30 minutes
Robotical	Edinburgh	Created 'Marty', a small robot that can help teach users about programming

Source: Techworld, "Who are the hottest robotics startups in the UK? Meet 15 of the country's best", October 3 2017

UK fintech firms in the FinTechCity top 50 global rankings

Fintech companies

Company	Location
Action.ai	London
Aire	London
Algomi	London
Atom Bank	London
Azimo	London
Clearmatics	London
Clearscore	London
ComplyAdvantage	London
Contego	London
Credit Benchmark	London
Curve	London
DarkTrace	Cambridge
Digital Shadows	London
FeatureSpace	London
FundApps	London
Iwoca	London
Kantox	London
LendInvest	London
MarketInvoice	London
Monzo	London
Onfido	London
OpenGamma	London
Privitar	London
Railsbank	London
RateSetter	London
Revolut	London
Seedrs	London
SETL	London
Suade	London
Thought Machine	London
Trussle	London

Source: FinTechCity, "The FinTech50 2017", June 6 2017

‘Top-ten’ insurtech start-ups in the UK, Techworld

Insurtech companies

Company	Location	Description
Cuvva	London	Aims to make insuring cars easier. You can get quick quotes by entering reg data, approx value.
InMyBag	London	Insurance for devices like laptops, phones & cameras. If device is lost/stolen, InMyBag, working with Amazon and Apple, will guarantee replacement within the same day
Brolly	London	App which uses AI to give users a mobile insurance locker, advisor and shop. Using stored documents, Brolly will scan market to see if you are over/under insured.
Buzzmove	London	Uses existing database of removal companies, Buzzmove is building up a database of what people own. Aim is to provide more appropriate insurance policies
Digital Fineprint	London	Machine learning tech that aims to provide smarter insurance policies by incorporating users' social media data
Digital Risks	London	Insurance specialist for tech companies that offers monthly model. Also allows for development in policy as business grows.
Neos	London	Customers can look at dashboards or camera feeds at their homes and assess if issues require a specialist. For example, a leak could be detected and the user can request a plumber to be called out.
Guevara	London	P2P car insurance app. Customers pay an amount based on their age, car, location experience. You then 'pool' with other similar users - if the group keeps claims down, the pot stays there year on year, and you can save on renewal
Insly	London	Cloud based platform for insurance brokers. You can search and manage clients, policies, objects and payments in one place
Worry+Peace	Buckinghamshire	Customers can purchase insurance and manage policies in its Pouch platform. Offers range of products, looks to emulate Amazon approach but for insurance

Source: Techworld, "15 UK insurtech startups to watch", August 2 2017

Major UK semiconductor companies

Semiconductor companies

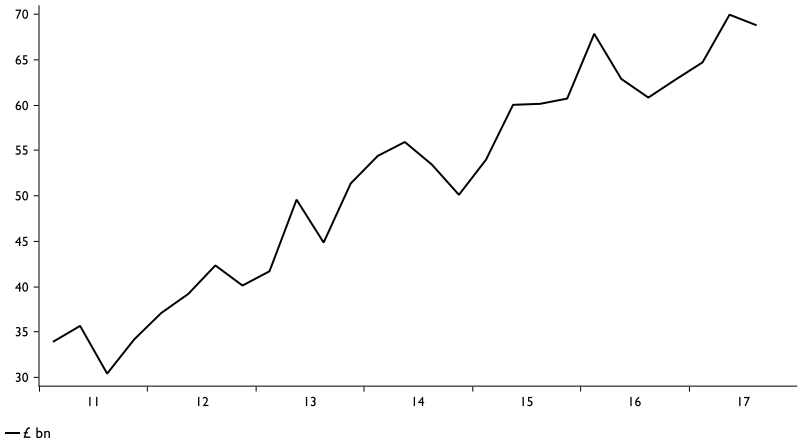
Company	Location	Description
IQE	Cardiff	Advanced semiconductor wafer manufacturers based in Cardiff. Used by tech companies in high end devices. Focus on wireless, photonics, InfraRed, CPV (advanced solar), power switching, LEDs and advanced electronics.
ARM	Cambridge	Develops and licenses microprocessors
Imagination Technologies	Kings Langley, Hertfordshire	Produce semiconductor hardware and software for a range of consumer goods
Graphcore	Bristol	Developed an intelligence processing unit designed for machine learning.
Frontier Smart Technologies	London	London-based semiconductor company Frontier specialises in chips for digital radios and smart audio devices, having found its niche as a key technology provider for the connected home
CML Microsystems	Langford, Essex	CML Microsystems Plc designs, manufactures and markets mixed-signal and Radio Frequency (RF) semiconductors, primarily for global communication and solid state storage markets
Dialog Semiconductor	Reading	Dialog creates highly integrated standard (ASSP) and custom (ASIC) mixed-signal integrated circuits (ICs), optimised for smartphones, computing, IoT, LED Solid State Lighting (SSL) and smart home applications. Dialog operates a fabless business model, but maintains its own test and physical laboratories at its office in Kirchheim
Compound Semiconductor Technologies	Glasgow	CST Global is an independent manufacturer of III-V photonic devices. Provide custom, foundry services in wafer, coated bar, chip device and die on tape formats

Source: These companies have been sourced from newspaper articles

Appendix 5: Dissecting bank lending

Chart A10

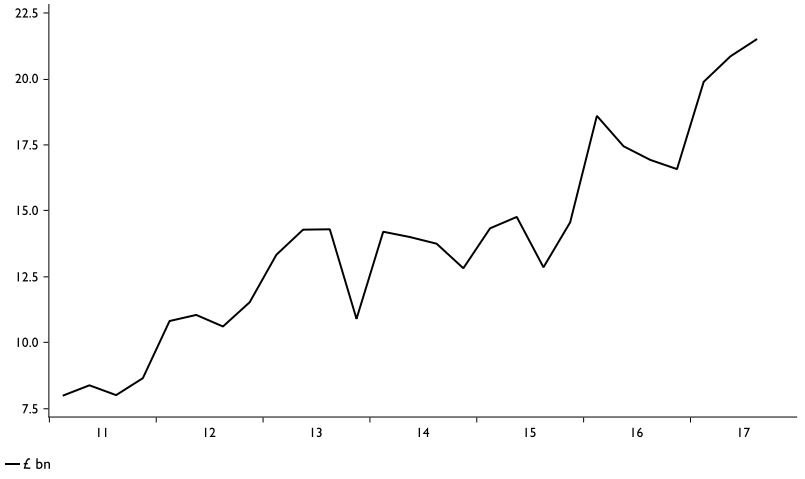
UK professional scientific & technical activities, deposits minus lending



Source: Macrobond, Bank of England

Chart A11

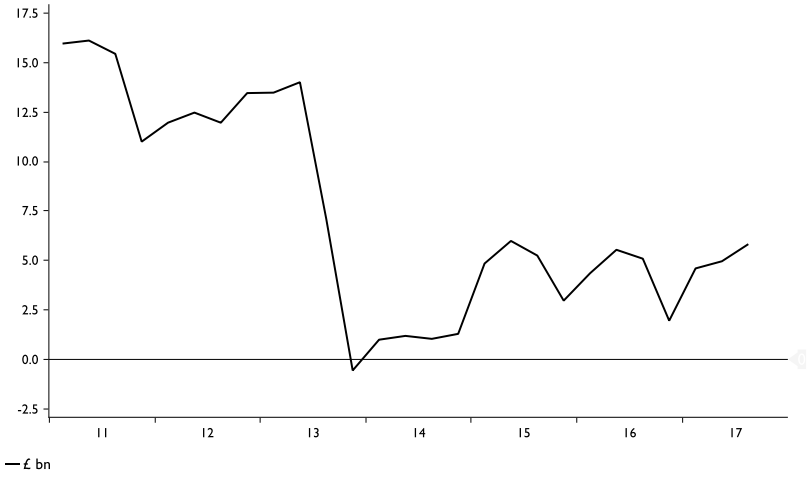
UK information & communication, deposits minus lending



Source: Macrobond, Bank of England

Chart A12

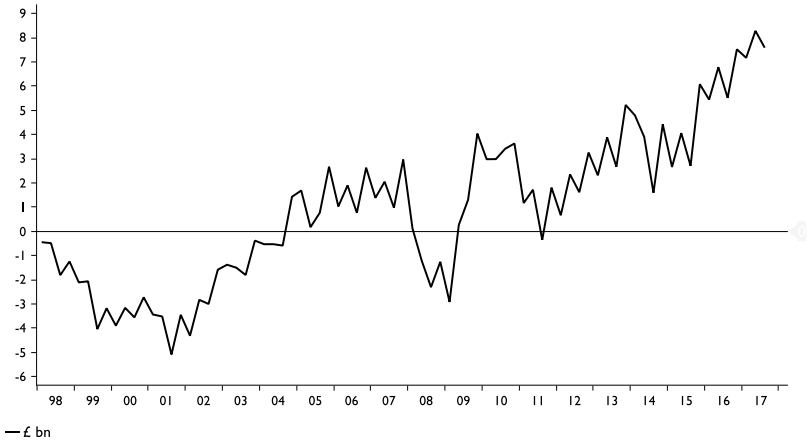
UK administrative & support services, deposits minus lending



Source: Macrobond, Bank of England

Chart A13

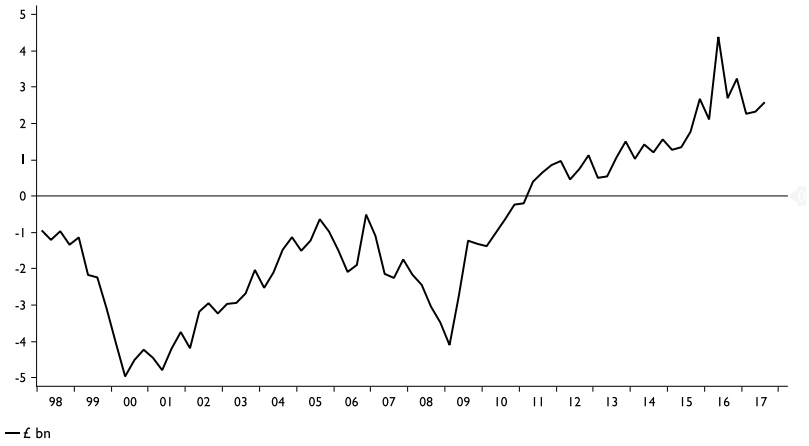
UK manufacturing, machinery, equipment & transport equipment, deposits minus lending



Source: Macrobond, Bank of England

Chart A14

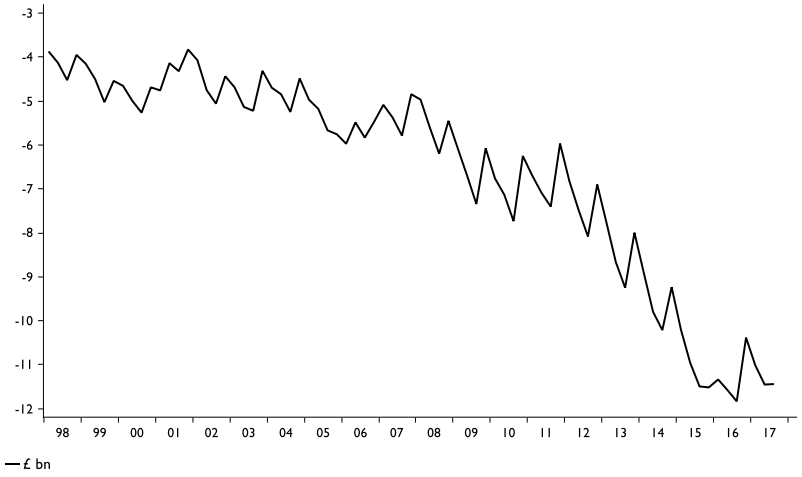
UK manufacturing, non-metallic mineral products & metals, deposits minus lending



Source: Macrobond, Bank of England

Chart A15

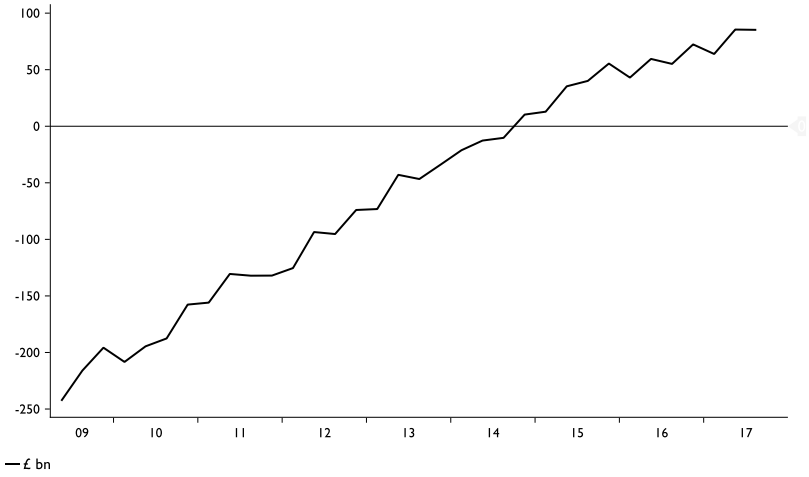
UK agriculture, hunting & forestry, deposits minus lending



Source: Macrobond, Bank of England

Chart A16

UK non-financial corporations, deposits minus lending



Source: Macrobond, Bank of England

Appendix 6: Banking resilience

Background

The immediate post-crisis focus was on the Basel II minimum requirements. Pre-2007/08, the ratio of common equity to risk-weighted assets – before regulatory adjustments such as the deduction of goodwill – could be as low as 2%.[101] In 2007/08, banks did not have enough quality capital (i.e. common equity and reserves) and were forced to go to the markets in the middle of a crisis.

Banks were able to report Tier 1 ratios that consisted of low levels of common equity. With losses and write-downs, this directly affected the retained earnings component of common equity. A better definition would have been to use tangible common equity (netting out goodwill).

In the post-financial crisis era, total regulatory capital now consists of a) Tier 1 Capital – made up of Common Equity Tier 1 (CET1) and Additional Tier 1 Capital (AT1) – and b) Tier 2 Capital. The regulators insist that AT1 and Tier 2 must be classified at a minimum as contingent capital. This can be converted to ordinary equity or written down at the discretion of the regulator for the bank to remain a going concern or if public funds are still required to keep the bank viable.

Additional discretionary capital may also be required by the regulator. The Bank of England has various powers to raise CET1 levels, for example, to protect against excessive credit growth, by setting the capital conservation buffer (currently set at 2.5% CET1). Further powers allow for the use of the countercyclical capital buffer and systemic risk buffer to provide additional Tier 1 capital, as determined by the Financial Policy Committee and the Prudential Regulation Authority, respectively. Systemically important banks (G-SIBs)[102] will be required to hold up to a further 2.5% CET1 to be phased in by 2019, pursuant to international standards. UK bank regulators have more discretionary powers to increase CET1 capital to risk weighted assets through regulatory determined capital buffers (Pillar 2A and 2B) and additional supervisory requirements determined by the PRA.

Subordinated debt as capital

Of the 8% minimum required capital, 3.5% can still be made up of contingent capital. As noted by Paul Davies QC, the presence of debt in capital requirements is counterintuitive. Taking on debt increases both assets and liabilities and does not improve a bank's net capital position.

[101] See "Strengthening the resilience of the banking sector", Basel Committee on Banking Supervision, December 2009, p. 4, paragraph 13.
[102] Also called G-SIIs.

The current capital rules are an improvement on Basel II. Under Basel II, subordinated debt could be written off if a bank became insolvent (but not before), to protect bank depositors. Public rescues of banks shielded subordinated debt holders from losses.

The Basel III rules are still not ideal. The rules offer two pre-insolvency options: 'bail-in' to keep the bank operating as a 'going concern' or a pre-insolvency trigger on any bank-issued contingent convertible bonds. Both have practical problems.

What is bail-in?

The aim of bail-in[103] is to absorb losses and recapitalise a financial institution by firstly using the bank's own resources. The central banks of EU-member states have the powers to make special bail-in provisions that write down or convert the claims of shareholders and unsecured creditors into equity. These powers ensure ordinary taxpayers, who otherwise have no connection and no previous liability to the failing institution, do not find themselves exposed to the cost of a rescue.

Bail-in is already happening in practice. In April 2016, the Austrian Financial Market Authority (FMA) became the first EU-member state to use the new law to shore up an €8 billion ($9.1 billion) deficit in the balance sheet of Heta Asset Resolution AG (the "bad bank" residual asset of Hypo Alpe-Adria-Bank International AG). The FMA did this by (amongst other things) insisting on a 54% bail-in for all eligible preferential liabilities, cutting Heta's senior liabilities by 54% and extending the maturities of all eligible debt to the end of 2023. Veneto Banca and Banca Popolare di Vicenza in Italy received state funding in April 2016 rather than a 'bail-in', partly for political considerations.[104]

Further state funding was granted to Banca Popolare di Vicenza in June 2017 rather than activating the resolution rules set out in the Banking Recovery and Resolution Directive (BRRD). This then gave the Italian government the ability to use their own national insolvency laws to deal with failing banks and the practical and political issues idiosyncratic to Italy.[105]

In a systemic crisis, the BRRD is less likely to work because domestic banks must, if required, offer contributions of funds to their ailing counterparts. When Banca Popolare di Vicenza ran into difficulty,

[103] The banking recovery & resolution Directive (2014/59/EU). Brought into national legislation by the amendments to the Banking Act 2009 and the Financial Services and Markets Act 2000.
[104] The Italian government wanted to calm investor fears over the Italian banking sector. See "Italy agrees €5bn fund to rescue weaker lenders", Financial Times, April 12th 2016, https://www.ft.com/content/bae1eff2-003e-11e6-ac98-3c15a1aa2e62.
[105] See "Why Italy's €17bn bank rescue deal is making waves across Europe", Financial Times, June 26th 2017, https://www.ft.com/content/03a1c7d0-5a61-11e7-b553-e2df1b0c3220.

the Italian government decided not to test markets to raise further capital.[106] In 2016, institutional investors had already pulled back from providing bank capital.[107]

What is the contractual recognition of bail-in powers?

Financial institutions established in EU-member states are bound by the BRRD and its provisions. Member states are obliged to implement the directive into national legislation.

Outside the EU, however, the BRRD does not automatically apply. There is a risk that a counterparty may challenge (and the courts may fail to give effect to) a subsequent bail-in. Since January 1st 2016, article 55 of the BRRD requires financial institutions established in EU-member states to include terms in any agreements governed by non-EU laws, which specify that the payment and other liabilities in those agreements may be subject to bail-in under the BRRD. The type of liabilities covered may be quite broad. They could include contractual and non-contractual liabilities, but may extend to loan agreements, hedging arrangements, guarantees, inter-creditor arrangements and security documents, amongst others.

Contingent convertible bonds (CCBs)

CCBs have re-emerged as a means of dealing with the bail-out risk to the public while still giving banks the advantage of issuing cheaper capital, rather than ordinary equity. These fixed-income instruments are convertible to equity if a pre-specified trigger event occurs. As a result of this feature, and others, it can also be used as a component of AT1 regulatory capital. Some better designed CCBs have a trigger event linked to a CET1 capital ratio figure that, if breached by the issuing bank, transforms the debt into equity prior to the bank formally entering any form of administration or insolvency. CCB bond holders bear the pre-insolvency risk upon the trigger event occurring. This is called a 'bail-in'.

Even without a trigger, bail-in can still occur for the CCBs if the resolution authorities determine that the bank has reached a point of non-viability. Writing down or converting the CCB at this earlier stage means it will bear losses before the taxpayer injects funds into the bank.

CCBs do not come without criticism:

- The trigger must be designed to avoid accounting manipulation, and any conversion of a CCB to equity must be automatic and inviolable.[108] It is noted that the Lloyds Bank CCB in 2009

[106] See articles 103 and 104 of EU Directive 2014/59/EU.
[107] See "AT1: Banks suffer a fundamental sell-off", Euromoney, February 24th 2016, https://www.euromoney.com/article/b12kp62qkqxxhp/at1-banks-suffer-a-fundamental-sell-off.
[108] See "Contingent Convertible Bonds and Capital Structure Decisions, Abul B, Jaffee DM and Tchistyi A, April 25th 2010, https://www.frbatlanta.org/-/media/documents/news/conferences/2010/fmc/papers/Tchistyi.pdf.

has an accounting trigger that risks being manipulated[109], with the potential for the CCB to not operate as expected.

- The equity conversion terms must be fully specified or there is further risk of manipulation or litigation.
- CCBs offer lesser protection compared to more robust use of countercyclical buffers, Pillar 2A and 2B buffers and the further use of the leverage ratio, which by contrast must be met with CET1 only.
- There are additional risks of perverse incentives and gaming by the various capital holders and the banks themselves. In fact, the best use of CCBs would be to allow their issuance, but not to in any way count towards AT1 Capital: there are still incentives for such use by banks while helping with the protection against a bail-out.[110]

A further review of the rules should be considered given the risks to the UK economy. As outlined by Paul Davies QC[111], the minimum equity figure at this level has been criticised as too low by the Vickers Commission in the UK, policy advisers and independent academics. Most have proposed minimum equity requirements around double the new Basel III minimum with buffers.

Gaming risk weighted asset capital

Capital ratios and risk-weighted assets are the core means by which bank regulators assess the solvency and stability of a bank. Risk-weighted assets (RWAs) allow for a degree of subjectivity. Basel III enables financial institutions to determine RWAs using either the standard approach, the foundation rating-based approach (F-IRB) or the internal rating-based approach (A-IRB or IRBA). The simplicity of the standardised method produces significantly different results (higher RWAs) than the internal rating models, which are more complex and nuanced. This difference already means that there is capital arbitrage between the smaller challenger banks (holding higher levels of capital on their RWA calculations) and the big, nationally systemic banks (holding less capital based on their RWA calculations). The large banks have an economic incentive to lower the reported value of RWAs so as not to increase their costs of issuing further Tier 1 capital. Internal rating models must be signed off by the Financial Conduct Authority/Prudential Regulation Authority (FCA/PRA).

However, it is not clear whether the FCA/PRA fully understand the implications of these models or how they reconcile the differences between each bank's approach to credit risk, risk management policies and practices:

[109] Ibid, p. 3.
[110] Ibid, p. 7.
[111] See "The Fall and Rise of Debt in Bank Capital Structures", Paul Davies QC(hon), October 18th 2015.

> *"An extensive review of modelling practices by the Institute of International Finance (IIF) RWA Task Force in 2014 indicated that, while variances in RWA outcomes can indeed be large, there are numerous potential explanatory factors, including risk management policies and practices, as well as differences between banks' portfolios. For example, differences in recovery strategy with the same counterparty would result in different Loss Given Default, and hence differences in the value of risk-weighted assets. Hence, variation in credit management practice can give rise to legitimate variance in RWAs."*[112]

The Prudential Regulation Authority is charged with checking that the RWAs are correct. However, the complexity and variance of outcomes noted by some researchers is problematic. Although these may be legitimately explainable[113], systemically important banks may have risk weighted analysis models that are significantly less optimal than others.

An additional approach mooted to shore up the validity of RWA calculations suggests auditors either fully test or at least conduct a level of 'assurance' on the RWA numbers submitted by banks to the regulator. Given such complexities, auditor assurance of RWAs is not likely to work and will add significant costs to banks with perhaps only limited upside. The better option is to simplify the models used by the big banks in a way that increases RWAs, perhaps using 'adjusted' capital ratios that impose floors and caps on risk weights used by banks. The Bank of England has adopted the leverage ratio (3%) under Basel III. The leverage ratio is simple and less open to manipulation.[114]

RWA variations

The different methodologies (standardised, foundation and advanced) used to measure risk allows for significant variation in the complexity of the businesses run by banks. Larger, more complex banks hold significantly higher levels of credit risk because of the number and size of their clients. They operate a more sophisticated business model requiring further complex credit and counterparty risk analysis. These firms also have the capability to run credit modelling that is accepted and approved by the regulator. The complexity implies there is room for different interpretations by each bank of the CRR rules and different 'assessments' of risk. This allows for divergent outcomes on RWA assessments and a favourable implementation of the rules.

[112] See "The uses (and abuses) of modelling adjustments", Europe Economics, March 2016.
[113] Ibid, p. 31.
[114] The Basel III leverage ratio is defined as the capital measure (the numerator) divided by the exposure measure (the denominator), with this ratio expressed as a percentage: Leverage ratio = Tier 1 Capital measure/Exposure measure. The Exposure Measure = (a) on-balance sheet exposures; (b) derivative exposures; (c) securities financing transaction (SFT) exposures; and (d) off-balance sheet (OBS) items. See "Basel III leverage ratio framework and disclosure requirements", Basel Committee on Banking Supervision, January 2014.

A uniform methodology for all assets may not be appropriate given the differences between banks.[115] The value of risk-sensitivity in capital regulation, which gives banks better knowledge and control of risk, should be recognised. Nevertheless, in the retail customer sector and SME lending, a more transparent model open to all banks should be considered. This would create a level regulatory capital playing field and a clearer understanding by the Prudential Regulation Authority of bank risk. This is likely to lead to a convergence with a lower regulatory capital requirement for the smaller banks and an increase in regulatory capital for the large banks. The use of big data for enhancing the methodology, increasing transparency and driving down costs to produce RWAs, should also be considered.

This may reduce the already divergent risk rates between home mortgages and SME lending. The regulators provide very limited support in the interpretation of rules and methodologies, placing the onus fully on the banks. A more active role would reduce the risk of regulatory arbitrage.

Other model issues

Iain Coke of Financial Services Faculty at the Institute of Chartered Accountants in England and Wales ("ICAEW") notes that banks do not have to use their internal models consistently over time. There are no requirements for independent checks of the model:

> *"Auditing capital ratios or risk-weighted asset calculations is not necessarily straightforward. The process needs to be subject to cost benefit assessment. But given the importance of the numbers, they merit robust scrutiny and controls."*[116]

The problem, explains Juergen Pelz, a chartered accountant and partner at Capco, is that the Basel III recommendations for F-IRB and especially A-IRB are principle rather than rule-based. As a result, there is limited guidance on how to apply these principles, which contributes to inconsistency across institutions.[117]

The ECB risk measurement programme – while consistent among EU banks – does not mean it is any more adequate:

> *"there is no industry-wide standard process for calculating capital ratio because banks have differing levels of risk management sophistication depending on their scale and business model complexity"*[118]

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[115] See "The uses (and abuses) of modelling adjustments", Europe Economics, March 2016, p.8.
[116] See "Risk Weighted Assets: Weighing the odds", Iain Coke, Economia, The Institute of Chartered Accountants in England and Wales, December 2nd 2015.
[117] Ibid.
[118] Vincent Papa, Director of financial reporting at the CFA Institute, quoted in "Risk Weighted Assets: Weighing the odds", Iain Coke, Economia, The Institute of Chartered Accountants in England and Wales, December 2nd 2015.

Gaming of the rules is, therefore, quite easy under the existing regulatory structure. The Association for Financial Markets in Europe (AFME) acknowledges that there may be some elements of 'gaming'. This is most likely due to the subjectivity of the scope and significance of risk factors that each bank uses.[119]

As noted in the Economist, the ever-declining RWA density (i.e. RWA%) suggests bankers are getting savvier about 'optimising' their models:

> *"Repeated studies have found that putting the same pool of loans and securities through different banks' formulae lead to wildly different outcomes."*[120]

Brunella Bruno of Bocconi University, Italy, argues that:

> *"The level of complexity of the internal rating models is very high, so maybe the rules should change (and eventually become simpler to reduce the incentive to manipulate info) and bank authorities' supervision powers should become more comprehensive and pervasive"*[121]

As noted earlier, the Prudential Regulation Authority does have other powers that could be used to even out regulatory risk issues not currently captured, which could create the right incentives.

The Prudential Regulation Authority issued a consultation paper (CP12/17) in July 2017, setting out a new Pillar 2A that will give the Prudential Regulation Authority more scope to increase risk weighing requirements.[122] This, along with the Prudential Regulation Authority buffer (also known as Pillar 2B), incentivises banks to reduce their mortgage book as a percentage of their lending and promote SME lending.[123]

Prudential Regulation Authority Powers

The Bank of England and the Prudential Regulation Authority in July 2017 proposed amendments in the Consultation Paper CP12/17 'Pillar 2A capital requirements and disclosure'. This contained proposed draft amendments to the Supervisory Statement 31/15 'The Internal Capital Adequacy Assessment Process (ICAAP) and the Supervisory Review and Evaluation Process (SREP)':

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[119] See European Banking Authority Exercise – Notes.
[120] See "Whose model is it anyway? – Risk-weighted capital", The Economist, September 17th 2015, https://www.economist.com/news/finance-and-economics/21665039-regulators-are-taking-firmer-stand-how-banks-gauge-risk-whose-model-it.
[121] Brunella Bruno quoted in "Risk Weighted Assets: Weighing the odds", Iain Coke, Economia, The Institute of Chartered Accountants in England and Wales, December 2nd 2015. She is also a co-author of "The credibility of European banks' risk-weighted capital: structural differences or national segmentations?", June 2015, BAFFI CAREFIN Centre.
[122] See "Pillar 2A capital requirements and disclosure", Consultation Paper CP12/17, Bank of England Prudential Regulation Authority, July 2017, http://www.bankofengland.co.uk/pra/Documents/publications/cp/2017/cp1217.pdf.
[123] See Prudential Regulation Authority Powers.

"2.8 To reflect the change from guidance to requirement of Pillar 2A, the PRA proposes to update its Capital Buffers and Pillar 2 Model Requirements by adding a requirement that firms should maintain Pillar 2A capital and meet that requirement with at least 56% of CET1 capital and not more than 44% additional Tier 1 (AT1) capital or 25% Tier 2 capital. A firm would then be invited to apply for the imposition of such a requirement at the same time as it is informed about the outcome of the SREP."

Powers of PRA to set the 'PRA buffer'

"5.21 In setting a PRA buffer for a firm the PRA will not just consider whether the firm would meet its CET1 capital requirements under the CRR and its ICG Pillar 2A capital requirement in the stress scenario. Other factors informing the size of the PRA buffer include but are not limited to: the maximum change in capital resources and requirements under the stress; the firm's leverage ratio; the extent to which the firm has used up its CRD IV buffers (eg the systemically important financial institution (SIFI) and capital conservation buffers); Tier 1 and total capital ratios; and the extent to which potentially significant risks are not captured fully as part of the stress."

"5.22 Where the PRA assesses a firm's risk management and governance (RM&G) to be significantly weak, it may set the PRA buffer to include an amount of capital to cover the risks posed by those weaknesses until they are addressed. This will generally be calibrated in the form of a scalar applied to the amount of CET1 required to meet the firm's Pillar 1 plus Pillar 2ATCR. Depending on the severity of the weaknesses identified, the scalar could range from 10% to 40%. If the PRA sets the PRA buffer to cover the risk posed by significant weaknesses in risk management or governance it will identify those weaknesses to the firm and expect the firm to address those weaknesses within an appropriate timeframe."

Proposals

- A uniform methodology for retail home mortgage lending and SMEs. This could assist with SME lending for smaller banks.
- Better regulation and oversight required through uses of big data and data analytics.
- Make more use of the regulatory powers such as Pillar 2A and 2B (PRA buffer rules): banks will be asked to provide additional capital for mortgage lending as an incentive to boost SME lending growth.[124]

[124] See "The PRA's methodologies for setting Pillar 2 capital", Statement of Policy, Bank of England, February 2017. Note that the PRA has the power to set Pillar 2A and Pillar 2B through a discretion. See also "Pillar 2A capital requirements and disclosure", Consultation Paper CP12/17, Bank of England Prudential Regulation Authority, July 2017. This is a proposal to widen the powers set out in "PRA Powers". Note that the FPC has the power to set the countercyclical capital buffer, which could also be used as a lever.

- The Financial Policy Committee must use their power to vary risk weights for specific sectors to achieve stated goals:

  "In addition, sectoral capital requirements provide the FPC with a means for varying the risk weights on banks' exposures to three specific sectors: residential property, commercial property and other parts of the financial sector. The FPC expects to apply this tool if exuberant lending conditions in one of these sectors pose risks to financial stability. The FPC's strategy for deploying sectoral capital requirements is described in 'The FPC's powers to supplement capital requirements: a policy statement', January 2014."[125]

[125] See "Supplement to the December 2015 Financial Stability Report: The framework of capital requirements for UK banks", Bank of England, https://www.bankofengland.co.uk/-/media/boe/files/financial-stability-report/2015/supplement-december-2015.pdf?la=en&hash=61C9D1CFFC64D5E5A2C2B3595E508921B5953AB3.

"Studies by the BCBS and the European Banking Authority (EBA) indicated that up to three quarters of the variability in risk weights for credit risk is driven by differences in underlying risk arising from banks' asset composition. Thus, divergent levels of RWAs can be justified when attributable to different levels of exposure to risks across institutions; i.e. natural — and desirable — differences in business models and portfolios would be expected to result in observable RWA differences. Therefore, RWA variation of this type is consistent with the greater risk sensitivity intended by the Basel II framework.

However, different national implementations of the Basel agreement, firms' risk management practices and divergent supervisory practices along with the banks' modelling choices also contribute (although to a lesser extent) to the observed variation of RWAs across banks. In particular, the choice of IRB approaches (i.e. foundation versus advanced IRB) as well as risk parameter changes and other modelling choices have been portrayed as the most prominent aspects of methodological influences on the calculation of RWAs across banks.

An extensive review of modelling practices by the Institute of International Finance (IIF) RWA Task Force in 2014 indicated that, while variances in RWA outcomes can indeed be large, there are numerous potential explanatory factors, including risk management policies and practices, as well as differences between banks' portfolios. For example, differences in recovery strategy with the same counterparty would result in different Loss Given Default, and hence differences in the value of risk-weighted assets. Hence, variation in credit management practice can give rise to legitimate variance in RWAs.

Nevertheless, additional convergence could be helpful. Within this context, it is suggested that there is still scope for further harmonisation of modelling approaches, for instance through closer coordination among supervisors when validating IRB models."[126]

[126] See "The uses (and abuses) of modelling adjustments", Europe Economics, March 2016, p. 5. See also "Analysis of risk-weighted assets for credit risk in the banking book" Basel Committee on Banking Supervision (2013b) and "Results from the 2014 low default portfolio (LDP) exercise", European Banking Authority, (2015).

Appendix 7: Technology trends

Capturing the impact of technology

Official price indices for semiconductors showed that quality-adjusted semiconductor prices were not falling nearly as rapidly as they did prior to the mid-2000s. This implied that the pace of technological progress in the semiconductor industry had slowed: the "technological revolution" that occurred in the run-up to the dotcom boom and during the early 2000s, was apparently over.

It also cast doubt on Moore's Law, the well-established rule of thumb that predicts computing power approximately doubles every 18 to 24 months. There are physical limits to the number of transistors that can be crammed into a chip: it appeared that science was fast approaching this limit. In the scenario, the outlook for productivity would worsen. GDP per capita growth would falter, and living standards would increase at a far slower rate.

The severity of the 2007/08 economic downturn propagated fears that the world economy could no longer grow at pre-crisis trends. The "secular stagnation" camp, it appeared, had won the argument.

In March 2013, an important paper was published by the Federal Reserve, asking the question: *Is the Information Technology Revolution Over?*[127] The slowing rate of decline in the Producer Price Index (PPI) for MPUs – which barely fell at all in 2012 – was, at face value, disconcerting. Advances in semiconductor technology had previously driven down constant-quality prices for MPUs at a rapid rate, lowering the price of information technology goods, and facilitating their diffusion throughout the economy.

This appeared at odds with the sustained pace of *miniaturisation* (i.e. scaling reductions) achieved in the semiconductor industry. The average technology cycle – the amount of time required to achieve a 30% reduction in the width of the smallest feature on a chip – remained substantially shorter than the three-year cycle in effect before the 1990s. Manufacturers were finding novel solutions to circumvent problems associated with squeezing ever more transistors on a chip.

More appropriate statistical techniques – hedonic regressions – were used to estimate a new price index for MPUs. The authors found that the semiconductor technology had in fact "continued to advance at a rapid pace and that the BLS price index for microprocessors may have substantially understated the rate of decline in prices in recent years." The pace of innovation was not slowing.

This paper has since been updated and revised on several occasions. The latest version was published in January 2017, entitled: *How Fast are Semiconductor Prices Falling?* The authors again concluded that MPU prices were being significantly mismeasured. From 2004 to 2009, their hedonic index fell faster

[127] See "Is the Information Technology Revolution Over?", David Byrne, Stephen Oliner & Daniel Sichel, Federal Reserve, March 2013, https://www.federalreserve.gov/pubs/feds/2013/201336/201336pap.pdf

than the official PPI. From 2009 to 2013, this gap widened further, with the authors' hedonic index "falling at an average annual rate of 42 percent, while the PPI declined at only a 6 percent rate. Given that MPUs currently represent about half of U.S. shipments of semiconductors, this difference has important implications for gauging the rate of innovation in the semiconductor sector."

Technology Timeline – data issues

March 2013 – *Is the Information Technology Revolution Over?* is published, casting doubt on the Producer Price Index (PPI) data that showed a slower decline in prices for microprocessor units (MPUs).[128]

September 2014 – GFC Economics publish a paper entitled *US investment & productivity*. Contrary to assertions that the information technology revolution is nearing its end, GFC Economics offer an 'optimistic' assessment of the technology cycle. In real terms, investment in intellectual property products (software and R&D) is at record highs as a share of GDP. GFC Economics reference the Federal Reserve paper *Is the Information Technology Revolution Over?*, arguing that the potential mismeasurement of prices is not confined to semiconductors. If the deflators for a variety of IT goods & services are also wrong, then real spending on software and R&D may be much higher too.

March 2015 – An update of the March 2013 paper is published by the same authors in the NBER, titled: *How Fast are Semiconductor Prices Falling?*[129] The paper is more detailed, but comes to the same conclusion.

March 2015 – GFC Economics publish a paper entitled *Measuring the US economy*. It examines the efforts that the statistical authorities have made in a bid to accurately capture a modern, 21st century economy. However, it also underscores the inherent challenges statisticians face in keeping up with the pace of technological progress.

June 2015 – GFC Economics publish a follow-up article to their September 2014 paper. This takes a closer look at the details of price indices, examining potential biases to the deflators. It is argued that hedonic methods may provide a better indication of the true extent of price declines in semiconductors. GFC Economics revisit the argument that the official PPI for MPUs is wrong.

January 2017 – The latest version of *How Fast are Semiconductor Prices Falling?* is published by the Federal Reserve.[130] The same authors find that from 2004 to 2009: "our preferred hedonic index fell faster than the PPI, and from 2009 to 2013 the gap widened further, with our preferred index falling at an average annual rate of 42 percent, while the PPI declined at only a 6 percent rate."

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[128] See "Is the Information Technology Revolution Over?", David Byrne, Stephen Oliner & Daniel Sichel, Federal Reserve, March 2013, https://www.federalreserve.gov/pubs/feds/2013/201336/201336pap.pdf.
[129] See "How Fast are Semiconductor Prices Falling?", David Byrne, Stephen Oliner & Daniel Sichel, National Bureau of Economic Research, April 2015, http://www.nber.org/papers/w21074.
[130] See "How Fast are Semiconductor Prices Falling?", David Byrne, Stephen Oliner & Daniel Sichel, Federal Reserve, January 2017, https://www.federalreserve.gov/econresdata/feds/2017/files/2017005pap.pdf.

April 2017 – GFC Economics publish a commentary: *Why statisticians may be overestimating inflation globally*.[131] "The pace of technological change is accelerating due to the rapid growth in specialised semiconductor chips. Chip designers are circumventing many of the physical challenges that pointed to the end of Moore's Law. This has ramifications for economic growth and productivity, globally. Faster chips were instrumental to the investment in information technology (IT) that drove the dotcom boom (1996 – 2000). The current IT cycle may last longer and provide a bigger boost to growth. It will also affect more countries. Many emerging market economies are benefitting from today's new technologies." Furthermore, "It may also mean that core inflation will remain below target in the developed world despite further declines in unemployment rates. More sophisticated, idiosyncratic semiconductor chips underpin many of the innovations that are disrupting old business models."

July 2017 – GFC Economics publish a commentary: *Does the rally in semiconductor prices signal a new wave of disinflation?*[132] Chip prices are accelerating higher; demand for semiconductors is surging. GFC Economics argue that "the depth of the current rally in chip prices underlines the potential disruption that lies in store for many established businesses. More powerful smartphones are playing their part, but the rise in chip prices has also been propelled by a big shift in demand from the Internet of Things, driverless cars and the growth of AI applications. In short, the growth in specialist chips suggests the secular decline in core inflation now underway in the US will accelerate, and spread to other countries."

September 2017 – Latest GFC Economics piece on semiconductors: *Innovation cycle trumps geopolitics.*[133] It suggested that the dynamics in the technology sector would outweigh geopolitical risks in the short run: equity markets could hit new highs. Indeed, "The semiconductor cycle has taken another upward turn. Chip sales are accelerating sharply, as a host of new high-tech industries boost demand. This is positive for the global economy and should help to underpin the low inflation dynamics seen in many countries." Chip prices may eventually turn in 2018, according to GFC Economics: capacity utilisation in the US semiconductor manufacturing industry had been steadily declining over the past few years. "A reversal in chip prices will cause equity values to correct for semiconductor companies, possibly in 2018. However, this need not be a trigger for a decline in stock markets per se. On the contrary, the increasing power of many chips – Moore's Law may even be accelerating – combined with lower prices will be a catalyst for further improvements in technology. The unemployment-inflation trade-off may continue to flatten."

[131] See "Why statisticians may be overestimating inflation globally", GFC Economics, April 27th 2017.
[132] See "Does the rally in semiconductor prices signal a new wave of disinflation?", GFC Economics, May 7th 2017
[133] See "Innovation cycle trumps geopolitics", GFC Economics, September 12th 2017