UK Economic Outlook

Special features on:

- UK housing market outlook

- A machine learning approach to estimating current GDP growth

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Highlights and key messages for business and public policy

Key projections

	2017	2018
Real GDP growth	1.5%	1.4%
Consumer spending growth	1.9%	1.5%
Inflation (CPI)	2.8%	2.9%

Source: PwC main scenario projections

- UK economic growth held up better than expected in the six months following the Brexit vote, particularly as regards consumer spending. But growth slowed in the first half of 2017 as inflation rose sharply, squeezing household spending power.

- In our main scenario, we project UK growth to slow from 1.8% in 2016 to around 1.5% in 2017 and 1.4% in 2018. This is due to slower consumer spending growth and the drag on business investment from ongoing political and economic uncertainty relating to the outcome of the Brexit negotiations.

- The weaker pound could also boost net exports, however, which should offer some support for overall GDP growth and reduce the current account deficit relative to 2016. The recent pick-up in the Eurozone economy should also help here.

- Service sector growth will slow but remain positive in 2017-18. Some manufacturing exporters will benefit from the weaker pound, but businesses serving domestic consumers are likely to see some slowdown in growth.

- The Bank of England will probably keep interest rates on hold in the short term, but the case for a rate rise could build later this year or, more likely, in 2018 if growth and inflation evolve broadly as we project.

- The government is under considerable political pressure to ease austerity, but we would not expect any significant tax and spending changes until the Autumn Budget.

Housing market set to slow, with strongest growth now in the commuter belt around London

- House price growth has already slowed since the Brexit vote, with transaction volumes well down. We expect house price growth to slow further in the short term, but in the longer term lack of supply could still see property prices rise faster than average earnings.

- Until 2014, central London saw the most rapid house price growth, but momentum has now rippled out first to the outer London boroughs and now to commuter belt towns and cities outside London. Our research shows this is typical of patterns seen in past house price cycles.

- While house prices in London and the South East have risen well above 2007 pre-crisis peaks, there are wide variations here across the country. We find that around a quarter of UK local authorities still have average house prices lower than their mid-2007 peak levels.

Machine learning techniques can help to estimate current economic growth

- New research published in this report shows how machine learning techniques (a form of AI) can produce estimates of current GDP growth that are more timely, and not significantly less accurate, than preliminary ONS estimates that are published several weeks later. But these techniques still require significant expert human input – we are some way yet from a fully automated AI system for economic forecasting.

- Based on data available up to 7th July, our "nowcasting" model estimates UK GDP growth at around 0.3% in the second quarter of 2017. This would be up very slightly on the first quarter (0.2%), but still some way below the long term historical UK trend of around 0.5% growth per quarter.

1 – Summary

Recent developments

The UK economy held up well in the six months after the EU referendum, particularly as regards consumer spending. But growth then slowed markedly in the first quarter of 2017 as both consumer spending and services growth moderated.

A key factor behind this recent moderation has been an increase in the rate of consumer price inflation (CPI) from around zero on average in 2015 to 2.9% in the year to May 2017, as global commodity prices have picked up somewhat from lows in early 2016, and the effects of the weak pound after the Brexit vote have fed through supply chains. Higher inflation has squeezed real household incomes and, despite a falling savings ratio, this has taken the edge off consumer-led growth.

On the more positive side, investment has held up reasonably well since the Brexit vote, while exports should be boosted by an upturn in global growth, notably in the Eurozone. The weaker pound, although bad for UK consumers, has been helpful to exporters and inbound tourism.

Table 1.1: Summary of UK economic growth and inflation prospects

Indicator (% change on previous year)	OBR forecasts (March 2017)		Independent forecasts (June 2017)		PwC Main scenario (July 2017)	
	2017	2018	2017	2018	2017	2018
GDP	2.0	1.6	1.6	1.4	1.5	1.4
Consumer spending	1.8	0.9	1.7	1.0	1.9	1.5
Inflation (CPI)	2.4	2.3	2.7	2.7	2.8	2.9

Source: Office for Budget Responsibility (March 2017), HM Treasury survey of independent forecasters (average value of new forecasts made in June 2017 survey) and latest PwC main scenario.

Future prospects

As shown in Table 1.1, our main scenario is for UK GDP growth to slow gradually from 1.8% in 2016 to around 1.5% in 2017 and 1.4% in 2018 as the effects of the weaker pound on inflation and continued Brexit-related uncertainty feed through. Our views on growth are similar to the latest consensus forecasts but slightly lower than the last OBR forecasts in the March 2017 Budget (see Table 1.1). However, the broad pattern of gradually slowing growth in 2017-18 is common to most forecasts at present. Our views on inflation are also similar to the consensus forecast, but higher than the OBR since we can take account of more recent data.

Consumer spending growth is expected to moderate in 2017-18 as inflation bites into real spending power. So far, consumers have offset this in part through higher borrowing, but there are limits to how much further this can go with the household savings ratio having already fallen to very low levels.

On the other hand, the weak pound should also have some offsetting benefits for net exports as will a somewhat stronger global economy. Brexit-related uncertainty may hold back business investment, but this should be partly offset by planned rises in public investment (as announced in the Autumn Statement last November). Fiscal policy could also be further relaxed in the 2017 Autumn Budget, although we have not factored this into our main scenario projection at this stage.

There are always uncertainties surrounding our growth projections and these are particularly marked following the vote to leave the EU, as illustrated by the alternative scenarios in Figure 1.1. There are still considerable downside risks relating to international developments (notably a possible US-led rise in global protectionism in the longer term) and the fallout from Brexit, but there are also upside possibilities if these problems can be contained. In our main scenario, we expect the UK to suffer a moderate slowdown not a recession, but businesses need to monitor and make contingency plans for potential downside risks.

Inflation could rebound to well over 3% by early 2018 assuming the pound remains relatively weak and there is no repeat of past falls in global energy and food prices. Despite this, we expect monetary policy to remain on hold in the short term. In our main scenario, official interest rates are assumed to remain at current levels throughout 2017, but this will depend on how events develop. By early 2018, the case for a gradual rate rise could grow stronger if UK growth and inflation evolve broadly as projected in our main scenario.

Figure 1.1 – Alternative UK GDP growth scenarios
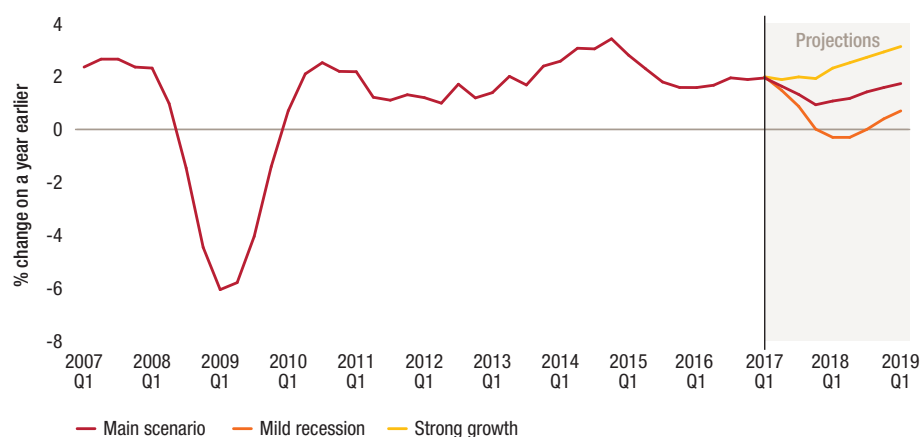
Sources: ONS, PwC scenarios

Housing market set to slow, while momentum ripples out from London to the commuter belt

House prices were not impacted by the UK's decision to leave the EU as quickly as some expected, but price growth has been weak in 2017 so far. Transaction volumes appear to have suffered more, but these effects are compounded by other factors such as stamp duty reform.

As discussed in detail in Section 3 of this report, we expect that the slowdown in the housing market will continue, yielding annual house price growth of around 3.7% in 2017, down from 7% in 2016. In our main scenario, house price inflation will pick up slightly again in later years averaging around 4% until 2025. Figure 1.2 shows this main scenario together with alternative high and low variants with plausible alternative sets of model projections on income growth, interest rates, credit conditions and housing supply.

We find that housebuilding at the level proposed by the government, although welcome, will only have a relatively small effect in constraining this further rise in house prices given the backlog of under-supply that has built up over many decades.

London has been most severely impacted by economic and policy uncertainty and the recent policy changes related to stamp duty. Price inflation in London in the first four months of 2017 was only 4.1% compared with 13.2% in the same months in 2016. We project that London house price inflation will continue to slow with average growth of below 3% in 2017 as a whole.

Figure 1.2 – Alternative house price inflation scenarios
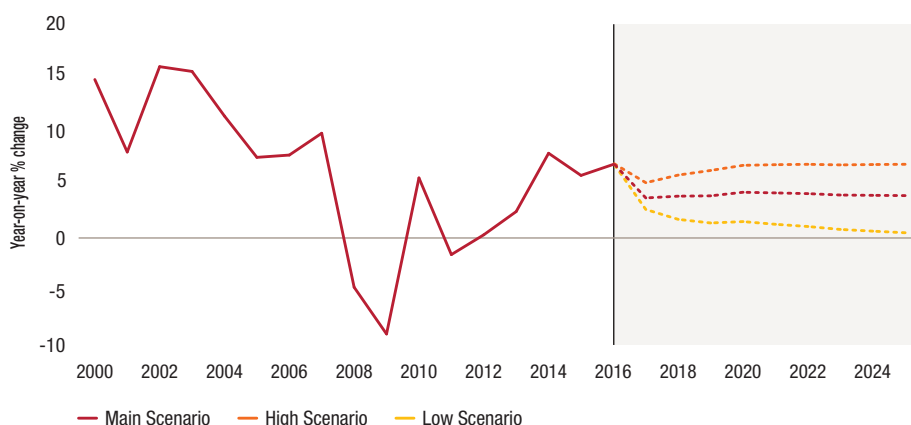
Sources: PwC analysis based on ONS house price index

Elsewhere in UK, we project that house prices in the East and Southern regions of England will continue to rise faster than the UK average rate, but Northern Ireland and the North East will continue to lag behind.

There is a huge disparity across the country in how house prices at a local level have performed since their 2007 pre-crisis peak. Whilst the average house price across the UK has grown by 17% since mid-2007, over a quarter of all local authorities are still 'under water' with average house prices below their 2007 peak levels. The region that has seen the greatest decline is Northern Ireland, where on average house prices are more than 40% below their pre-recession peak.

There has also been a structural shift in London's housing market recently, as house price growth has moved outward from the capital. Growing unaffordability within London, coupled with policy reform, has seen house prices in prime central London boroughs slow while prices in the outer boroughs and the commuter belt have risen. Over the last two years, house prices in the outer boroughs have risen 9 percentage points faster than in the inner boroughs, whilst house price growth in the fastest growing cities within the commuter belt exceeded the average rate of increase in London by 4 percentage points in 2016.

## Machine learning techniques can help to estimate current GDP growth

Businesses, financial markets and policy makers need to keep a constant watch on the UK economy. But the preliminary ONS estimate of GDP growth is released with a significant lag and can often be materially different to later final estimates of GDP growth. This creates a potential need for alternative indicators of current economic activity.

"Nowcasting" models can meet this need by utilising frequently released information to assess current economic activity. They are used across the globe, most notably by central banks in advance of the release of official GDP statistics. Over certain periods in the UK (e.g. 2001-8) such models have been able to outperform preliminary GDP estimates, though the latter have become more reliable in recent years. But nowcasting models can still give more timely estimates of broadly similar accuracy.

We have therefore developed our own nowcasting model for UK GDP, which utilises machine learning techniques (a form of AI) as described in detail in Section 4 of this report. We use machine learning to augment human expertise and judgement here, not to replace it.

Our analysis shows that output indices used by the ONS when forming their preliminary estimates are strong predictors of final GDP. However, the inclusion of other indicators, such as house prices, materially improves our ability to estimate the latest quarterly movements in GDP. For the last four years, we find that our nowcasts are somewhat more accurate on average than the median estimates from the widely quoted Reuters poll of forecasters and only slightly less accurate than preliminary GDP growth estimates published several weeks later.

Figure 1.3 – UK GDP growth (% QoQ) Q2 2013 - Q2 2017
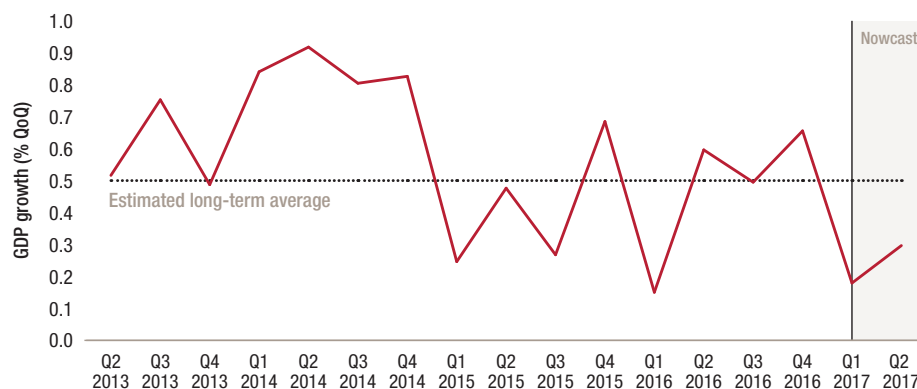
Sources: ONS, PwC

Based on data available up to 7th July, our nowcasting model suggests that GDP growth in the second quarter of 2017 will continue to be sluggish at around 0.3% relative to the previous quarter (see Figure 1.3). This is up very slightly from the ONS estimate of 0.2% growth in the first quarter of 2017 due to somewhat stronger estimated growth in the services sector, offset in part by weaker production and construction sector growth than in the first quarter. If correct, this would mean that the first half of 2017 would represent the weakest six month period for UK GDP growth since 2012.

As well as estimating GDP, nowcasting models can also be used in a variety of other policy and business contexts such as predicting industry sales or firm revenues. Such wide applicability allows policy makers and businesses to understand the present better, so that they can plan more effectively for the future.

2 – UK economic prospects

Key points

- The UK economy grew by 2% in the year to Q1 2017, but the quarterly rate fell to 0.2%, primarily as a result of a softening in consumer expenditure and the services sector.

- In our main scenario, we forecast UK growth to slow to 1.5% in 2017 and 1.4% in 2018. The UK would avoid recession in this scenario, although risks to growth are still weighted somewhat to the downside given the uncertainties associated with Brexit.

- A key factor behind the overall slowdown is a moderation in consumer spending growth to around 2% in 2017 and 1.5% in 2018. This reflects a squeeze on household spending power from higher inflation and sluggish wage growth.

- Wage growth continues to be low despite the lowest unemployment rate since 1975. This suggests that the traditionally negative relationship between these two variables, as described in the Phillips Curve, may have broken down – a view supported by our analysis in this report.

- Investment held up relatively well in the first quarter, but uncertainty surrounding Brexit may weigh on this going forward.

- We project that London could remain the fastest growing UK region in 2017-18, but its pace of expansion is expected to slow significantly from earlier rapid rates. Other regions are projected to see average real growth in 2017-18 of around 1-1.5%, but we do not predict negative growth in any region in our main scenario.

- Consumer price inflation is likely to rise above 3% later this year. This continues to be driven by the exchange rate depreciation since the Brexit vote, although this effect could start to fade later in 2018 if wage growth remains subdued.

- The Bank of England voted to hold interest rates at 0.25% in June, but three MPC members voted for an increase and we do expect a very gradual increase in rates to begin sometime over the next year unless there is a sharp deceleration of growth over this period.

Introduction

In this section of the report we describe recent developments in the UK economy and review future prospects. The discussion covers:

## 2.1 – Recent developments and the initial impact of Brexit

The UK economy has now grown for 17 consecutive quarters and remained resilient in the second half of 2016 despite headwinds from the vote for the UK to leave the European Union ('Brexit'). However, the first quarter of 2017 has seen a softening of growth as higher inflation squeezed consumers.

During the last decade, as shown in Figure 2.1, growth in the manufacturing sector has been relatively weak, with output remaining below pre-financial crisis levels. Growth in the construction sector has been volatile, but with a generally improving outlook since the beginning of 2013.

In contrast, the services sector has grown consistently and relatively strongly since the financial crisis. However, as shown in Figure 2.2, the rate of growth in the sector slowed sharply in the first quarter of 2017, pulling down overall GDP growth (in which services has a near 80% weight).

There has been a broadly similar trend in consumer expenditure, with a marked decline in growth to around 0.4% in the first quarter of 2017, after holding up well throughout 2016. This reflects the rise in inflation, due in large part to the weak pound since the Brexit vote, which has squeezed real incomes.

Figure 2.1 – Sectoral output and GDP trends
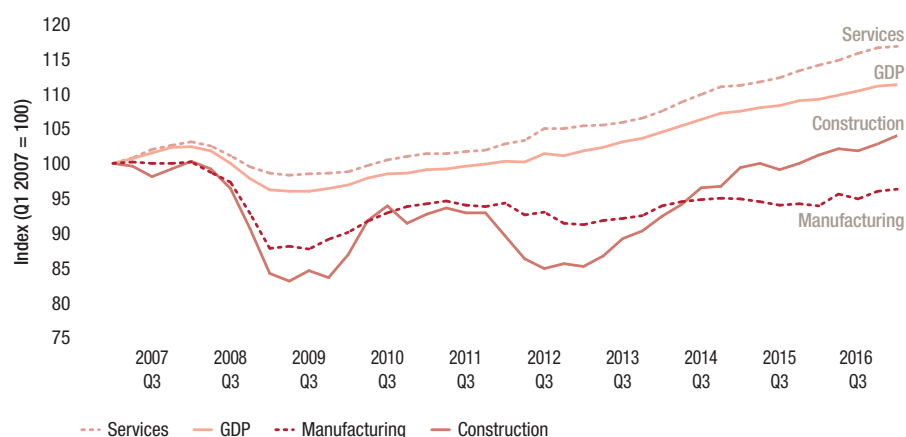
Source: ONS

**Figure 2.2 – Trends in GDP, consumer spending and the services sector**
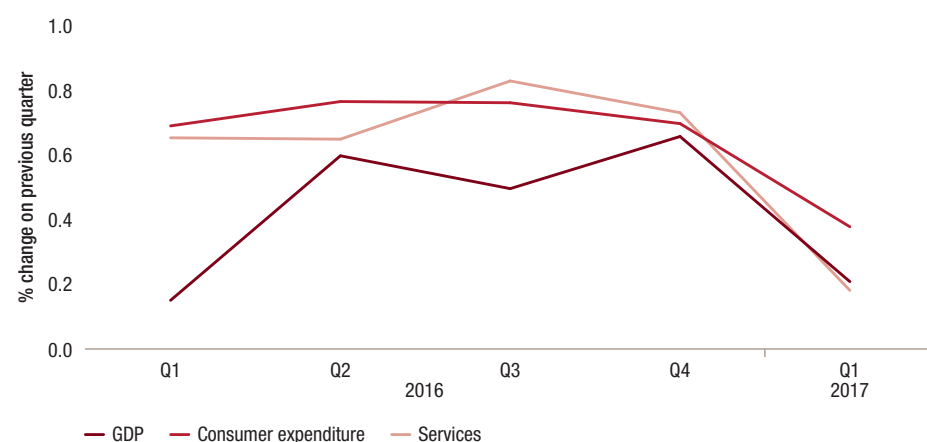
Source: ONS

There was a further hit to disposable incomes from relatively high tax payments in Q1 2017, though consumers seem to have smoothed this out through higher borrowing rather than reducing their spending more markedly in that quarter. But household savings rates were at the lowest for over 50 years in Q1 2017 as a result, which does not look sustainable in the longer term. The Bank of England has also warned recently that consumer credit growth has become uncomfortably high and suggested that some banks may need to tighten up lending standards in this area.

Even as official GDP growth has slowed, the Markit/CIPS purchasing managers' indices (PMIs) for services and manufacturing have remained relatively strong, as shown in Figure 2.3. However, both signalled a slowdown in growth in May and June. The construction PMI saw a strong rebound in business activity during May, but some slowdown in June.

As noted above, a key factor underpinning recent trends has been the sustained weakness of the pound since the Brexit vote, as shown in Figure 2.4. A weak currency makes exports relatively cheaper to overseas customers, promoting the sale of British goods and services while also improving tourist inflows. But the depreciation has also raised the prices of imports, which has pushed up inflation to nearly 3% in the year to May and this could rise further later this year, as we discuss in Section 2.3 below.

Figure 2.3 – Purchasing Managers' Indices of business activity
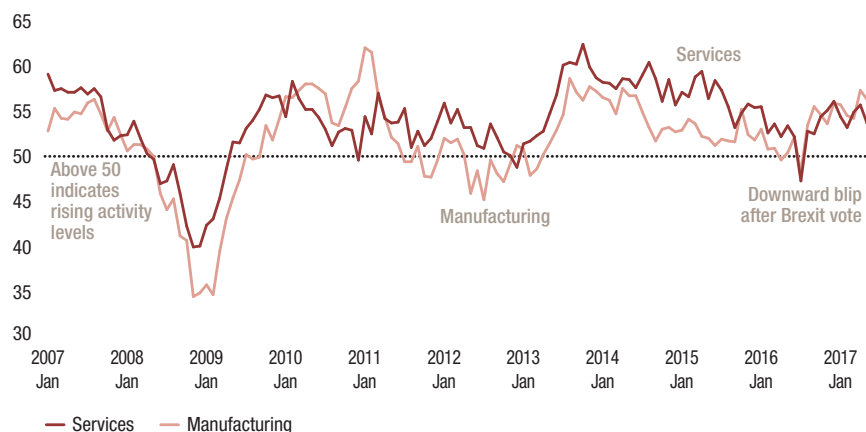
Source: Markit/CIPS

Figure 2.4 – US dollar and euro exchange rates against the pound
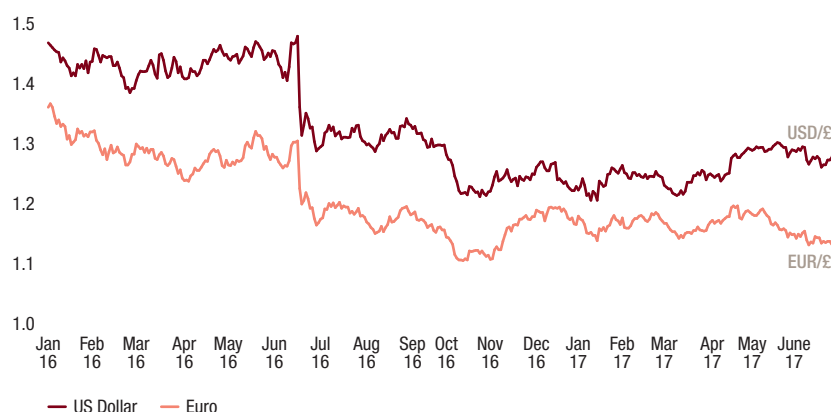
Source: Bank of England

Figure 2.5 – UK Phillips Curve shifts and flattens over time

Source: ONS

Has the Phillips Curve gone flat?

Higher inflation will lead to a real squeeze on consumers so long as wage growth remains subdued by historical standards. Traditional theory would suggest that low wage inflation will correlate with high unemployment (and vice versa), as described in the 'Phillips Curve' (named after the economist who first identified this relationship in the 1960s). However, the unemployment rate in the UK now stands at its lowest level since 1975, and wage growth is comparable to that seen at the time of the recent unemployment peak in 2011, suggesting that this relationship may have broken down.

To explore this further, we have modelled the relationship between wage growth and unemployment using annual data available from 1971. The UK economy during this period can be characterised by three distinct periods:

- **1971-1992:** a period when the UK government struggled to control inflation while unemployment was relatively high and volatile due to three major recessions;

- **1993-2007:** a period of relative economic stability in which the UK government switched to inflation targeting from 1993 onwards; and

- **2008-2016:** the global financial crisis and its aftermath.

As can be seen from Figure 2.5, the relationship between unemployment and wage growth has become much flatter in the 1993-2007 and 2008-2016 periods than in the 1971-1992 period when a downward-sloping Phillips Curve did seem to be in operation, albeit with considerable variation around the 'best fit' line shown in Figure 2.5. As well as flattening, we have also seen the Phillips Curve shift downwards over time as 'normal' levels of nominal wage growth have declined[1].

A number of factors are likely to be at play in these Phillips Curve shifts, but one key factor is the reduction in the bargaining power of workers. Unionisation of the workforce has fallen from 38% in 1990 to 23% in the middle of 2016 (and lower than this in the private sector), while self-employment and part-time and temporary working has increased. These changes reduce wage bargaining power as firms are able to negotiate with individuals rather than groups, while the increased flexibility of modern work may induce people back into the workforce, restricting upward pressure on wages.

The globalisation of organisations and continuing digitalisation is also a likely contributor to this flattening, as a broader range of work can be completed anywhere in the world, thus lifting the constraints of labour supply in any one country. Increased migration to the UK from other EU countries since 2004 may also have played some role here in dampening wage growth in response to increased labour demand as it has made labour supply more elastic. Depending on how UK migration policy evolves, this factor may become somewhat less important after Brexit. This could potentially worsen skills shortages in the UK, but might also offer some support for wage growth at the lower end of the labour market (in addition to the effect of planned future increases in the national minimum wage). Over the next couple of years, however, wage growth seems likely to remain relatively subdued.

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1 Similar shifts in the Phillips Curve were found in a recent analysis by Andrew Haldane, chief economist at the Bank of England:
http://www.bankofengland.co.uk/publications/Pages/speeches/2017/984.aspx

2.2 – Economic growth prospects after Brexit: national, sectoral and regional

Since the last UK Economic Outlook report in March, we have revised estimated real GDP growth in 2017 down marginally from 1.6% to 1.5%. This primarily reflects softening economic indicators, particularly consumer spending and services output in early 2017 as described above. Below trend growth is expected to persist into 2018, when our main scenario is for GDP growth of around 1.4%, as shown in Table 2.1.

As in our March report, we expect UK growth to slow in 2017-18 but we do not expect the economy to fall into recession. We assume here that the Brexit negotiations will proceed reasonably smoothly, and therefore that the UK will avoid an extreme 'hard Brexit' where it falls out of the EU in 2019 without any trade deal or transitional arrangement, so reverting to WTO rules.

The projected slowdown in growth is driven in large part by slower consumer spending growth due to the squeeze on real household incomes from higher inflation. Employment growth could also slow from recent high levels as the economy as a whole slows. So far consumers have increased borrowing to keep spending growth going, but the household savings ratio fell to a record low in the first quarter of 2017 so there are limits to how much further this can go.

Table 2.1 - Main scenario projections for UK growth and inflation

% real annual growth unless otherwise stated	2016	2017	2018
GDP	1.8	1.5	1.4
Consumer spending	2.8	1.9	1.5
Government consumption	0.8	1.0	0.7
Fixed investment	0.5	1.6	1.6
Domestic demand	1.5	1.5	1.4
Net exports (% of GDP)	-0.4	-0.2	-0.1
CPI inflation (%: annual average)	0.7	2.8	2.9

Sources: ONS for 2016, PwC main scenario for 2017-18

Investment growth is expected to continue but only at a moderate rate of around 1.6% in both 2017 and 2018. While public investment and housing investment has held up relatively well recently, business investment growth is likely to be dampened by uncertainty over the outcome of the Brexit negotiations.

Net exports as a percentage of GDP were negative in 2016 and this is expected to continue in 2017-18 but with a declining negative contribution over time. This reflects a boost to exports from the competitive value of sterling and the recovery in growth in the Eurozone in particular. The current account deficit has fallen back as a share of GDP in the past two quarters and this declining trend in the deficit looks set to continue (although we would still expect considerable volatility from quarter to quarter in these figures, in line with what we have seen in the past).

Overall, our growth projections are broadly similar to the latest average of independent forecasters, but somewhat more cautious than those of the Bank of England and the OBR for both 2017 and 2018. Almost all forecasters are, however, projecting some moderation of UK growth over this period.

Alternative growth scenarios – businesses need to make contingency plans

To reflect the uncertainties associated with any such projections, particularly in light of Brexit, we have also considered two alternative UK growth scenarios, as shown in Figure 2.6.

- Our **'strong growth'** scenario projects that the economy will expand by 1.9% this year and 2.6% in 2018. This is a relatively optimistic scenario which assumes that good early progress is made in UK-EU negotiations and that there are strong favourable trends in US and Eurozone growth in 2017-18.

- Our **'mild recession scenario'** sees UK GDP growth become negative in the first half of 2018 as the global outlook worsens and there is little progress in early negotiations with the EU, suggesting that the UK may have to fall back on WTO rules with consequent imposition of tariffs on trade with the EU. This would deepen and prolong the period of uncertainty around the outcome of Brexit, reducing investment, jobs and growth. Even in this downside case, however, we are only projecting a mild technical recession, with negative growth lasting the first two quarters of 2018, as opposed to the deep downturn seen after the global financial crisis, when UK GDP fell by around 6% from peak to trough.

Figure 2.6 – Alternative UK GDP growth scenarios
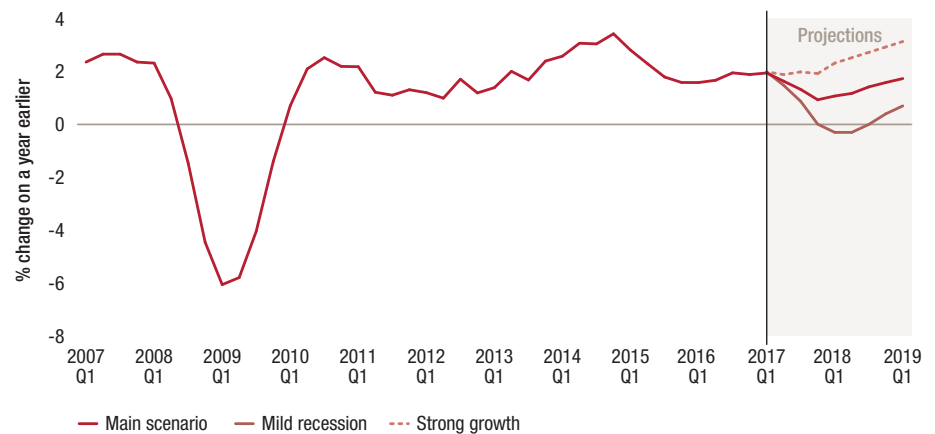
Sources: ONS, PwC scenarios

We do not believe that either of these two alternative scenarios is the most likely outcome, but they are certainly possible. At present, risks to growth still appear to be weighted somewhat to the downside given the political and economic uncertainties related to Brexit. Businesses would therefore be well advised to make appropriate contingency plans for such less favourable outcomes, but without losing sight of the more positive possibilities for the UK economy should these downside risks not materialise.

More generally, companies should be making detailed contingency plans for the immediate impact of Brexit[2] on all aspects of their businesses, covering the kind of questions listed in Table 2.2.

Table 2.2: Key issues and questions for businesses preparing for Brexit

Issues	Implications	Questions
Trade	The EU is the UK's largest export partner, accounting for around 44% of total UK exports – leaving the EU is likely to make trade with EU more difficult.	• How much do you rely on EU countries for revenue growth? • Have you reviewed your supply chain to identify the potential impact of tariffs and additional customs procedures on your procurement? • Have you identified which third party contracts would require a renegotiation in the event of a Brexit?
Tax Contributions	The UK would gain more control over VAT and some other taxes. Brexit could also open the door to new tax initiatives within the EU that the UK might currently have sought to block.	• Have you thought about the impact of potential changes to the UK and EU tax regimes after Brexit? • Have you upgraded your systems to deal with a significant volume of tax changes?
Regulation	The UK is subject to EU regulation. Brexit may mean less red tape. It could also mean that UK businesses need to adapt to a different set of regulations, which could be costly.	• Have you quantified the potential regulatory impact of Brexit to keep your stakeholders up-to-date? • How flexible is your IT infrastructure to deal with potential changes to Data Protection laws? • How ready is your compliance function to deal with potential new reporting requirements arising from Brexit?
Sectoral effects	The UK is the leading European financial services hub, which is a sector that could be significantly affected by Brexit. Other sectors which rely on the EU single market could also feel a strong impact.	• Have you briefed potential investors on the impact of Brexit for your sector and organisation? • How up-to-date are your contingency plans in place to deal with Brexit? • Are you aware of the impact of potential volatility in financial markets on your capital raising plans?
Foreign direct investment (FDI)	FDI from the EU makes up around 45% of the total stock of FDI in the UK. Brexit could put this inbound investment at risk.	• How much do your rely on FDI for growth? • How does Brexit affect your location decisions? • How are your competitors responding to the risk of Brexit?
Labour market	The UK may change its migration policies. Currently EU citizens can live and work in the UK without restrictions. Businesses will need to adjust to any change in this regime.	• How reliant is your value chain on EU labour? • Have you communicated with your UK-based employees who are nationals of other EU countries? What advice should you give them on registering for UK residency? • Has your compliance function considered the additional cost of hiring EU labour after Brexit? • Could changes in access to EU labour increase the case for automation?
Uncertainty	Uncertainty has increased since the referendum and this seems likely to continue through the Brexit negotiation period.	• How well prepared are you to manage future volatility in the Sterling exchange rate as Brexit negotiations proceed? • Have you communicated your approach to Brexit to your key stakeholders, customers and suppliers? • Is your organisation ready for a worst-case scenario where there is a prolonged period of uncertainty and/or a 'hard Brexit'?

2   For more material on the potential impact of Brexit on your business, please see our EU Referendum hub here: http://www.pwc.co.uk/the-eu-referendum.html

Growth is expected to slow in most sectors, but manufacturing exports could be stronger in 2017

The sector dashboard in Table 2.3 shows latest ONS estimates of growth rates for 2016 along with our projected growth rates for 2017 and 2018 for five of the largest sectors within the UK economy. The table also includes a summary of the key trends and issues affecting each sector.

Manufacturing is the only major sector expected to experience higher growth in 2017 than 2016, as exporters gain from the weaker pound and stronger global growth.

All other sectors are predicted to experience lower growth in 2017-2018 as they are impacted, to some degree, by leaving the EU.

Of these, the distribution, hotels and restaurants sector will face the largest decline of any sector in growth between 2016 and 2017 as consumer spending growth slows, but should still outperform most other sectors this year and next.

Business services and finance growth will remain relatively strong and will face a smaller decline in growth between 2017 and 2018 than other sectors.

However, financial services companies could be particularly affected by any loss of access to EU markets, notably through the possible loss of 'passporting' rights for UK-based firms[3], which introduces additional uncertainty and may impact performance in the medium term. Construction growth is expected to remain relatively strong in 2017 after a good performance in the first quarter of the year, but could slow in 2018. This reflects the impact of Brexit-related uncertainty on business investment growth, offset by a planned increase in public sector investment.

Table 2.3: UK sector dashboard

Sector and GVA share	Growth			Key issues/trends
	2016	2017	2018	
Manufacturing (10%)	0.7%	1.4%	1.0%	Manufacturing PMI has remained resilient despite Brexit, and peaked at a three-year high in April, before falling slightly in May and June
				Exporters should gain from a weaker pound, limiting the fall in total output during Brexit negotiations
Construction (6%)	2.4%	2.3%	1.2%	Construction PMI rebounded strongly in May, but lost some momentum in June
				The construction sector saw relatively strong growth in the first quarter of 2017, but is expected to weaken during the remainder of 2018
				The government has extended the UK Guarantees scheme to construction to stimulate private infrastructure investment
Distribution, hotels & restaurants (14%)	5.1%	2.2%	1.6%	A weaker pound may drive tourism, both from overseas and domestically, leading to increased expenditure in the hospitality sector
				ONS figures show the retail sector experienced its lowest annual growth rate in May since April 2013, constrained by higher inflation from a weakened pound
Business services and finance (31%)	2.4%	1.8%	1.7%	The financial sector remains particularly concerned about the possible implications of Brexit, especially if a "hard Brexit" occurs with the loss of EU passporting rights
				Some banks are preparing to relocate some functions and thousands of staff overseas, though we have not seen large moves yet
				The Bank of England has increased the counter-cyclical capital buffer to constrain consumer debt levels, which may impact lending by retail banks
Government and other services (23%)	1.5%	1.3%	1.2%	Public services may continue to face real-term cuts for the next few years as confirmed in the Budget
				Since the general election, the government has recommitted to its target of balancing the budget
Total GDP	1.8%	1.5%	1.4%	

Sources: ONS for 2016 estimates, PwC for 2017 and 2018 main scenario projections and key issues.
These are five of the largest sectors but they do not cover the whole economy - their GVA shares only sum to around 85% rather than 100%

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3   The potential impact of Brexit on financial services was considered in detail in our April 2016 report for TheCityUK, which can be accessed here: http://www.pwc.co.uk/industries/financial-services/insights/leaving-the-EU-implications-for-the-UK-financial-services-sector.html

Figure 2.7 – PwC main scenario for output growth by region in 2017 and 2018

Source: PwC analysis

Regional prospects: all parts of the UK likely to see some moderation in growth in 2017-18, but none should fall into recession

London is expected to continue to lead the regional growth rankings in 2017, expanding by around 1.8% as shown in Figure 2.7, although this is down from around 2.4% in 2016. Most other regions are projected to expand at a rate at or below the UK average of 1.5% in 2017, while Northern Ireland is predicted to lag behind somewhat with growth of around 1%.

Growth is expected to decelerate slightly further in most regions during 2018, as the UK continues to feel the effects of Brexit-related uncertainty. But we do not project negative growth in any region in our main scenario.

It is important to note that regional output data are published on a much less timely basis than national data. As a result, the margins of error around these regional output projections are even larger than for the national growth projections, so they can only be taken as illustrative of broad directional trends.

2.3 – Outlook for inflation and real earnings growth

Consumer price inflation (CPI[4]) rose to 2.9% in May 2017, up from 2.7% in April and significantly above the 2016 average rate of 0.7%. The large fall in the value of the pound since the Brexit vote has put upward pressure on prices as did earlier rises in global commodity prices (although these have been reversed in part in recent months, particularly for oil).

Over the course of 2017 we expect CPI inflation to rise further, peaking at over 3% around the turn of this year in our main scenario (see Figure 2.8). We then expect the inflation rate to ease back to around 2.6% by the end of next year as the effects of import price rises due to the weaker pound are no longer included in the 12-month inflation calculation. Annual average rates of inflation in our main scenario would be around 2.8% this year and around 2.9% next year, but this disguises significant movements within these years.

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4 The ONS switched to CPIH as its main inflation indicator in March 2017, despite some continuing methodological concerns about the reliability of the way that CPIH captures owner occupied housing costs through estimates of equivalent market rents rather than actual outlays on mortgage payments. For the moment, we have stuck to CPI as our key inflation indicator, but we may consider switching to CPIH in future if this becomes more widely used. In the long run, however, we would not expect significant differences between average inflation on these two measures (based on long-term historical averages).
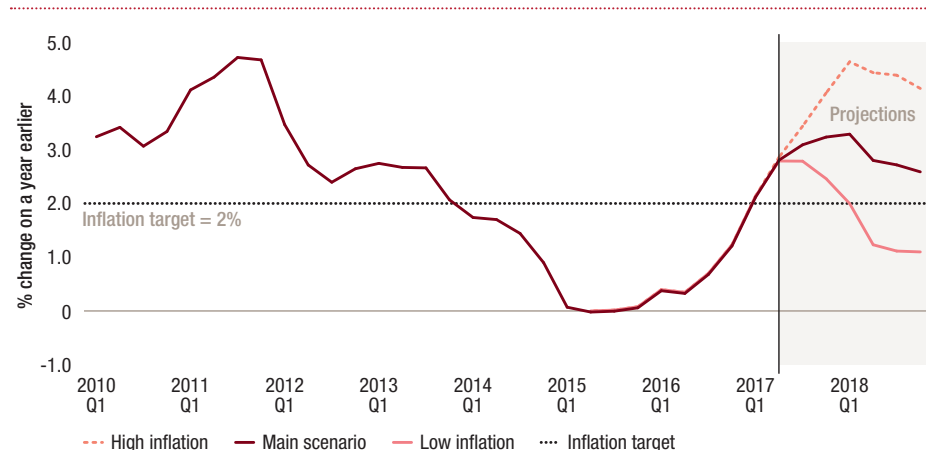
Alternative inflation scenarios

There is considerable uncertainty over how far and fast inflation will rise and will depend on how Brexit negotiations proceed and the strength the global economy over the coming year. As such, we also present two alternative scenarios for UK inflation in Figure 2.8:

- In our 'high inflation' scenario we project inflation to rise to over 4% in 2018 as a result of further falls in the pound and a possible pick-up in global commodity prices if other economies grow more strongly and/or oil supply is constrained by producers.

- In our 'low inflation' scenario, by contrast, the UK and global economies weaken by more than expected in our main scenario in the aftermath of Brexit, while global commodity prices fall back sharply over the next year. In this case, UK inflation could fall back to below the Bank of England's 2% target in 2018.

As with our GDP growth scenarios, neither of these two alternative variants is as likely as our main scenario. But given recent volatility and uncertainty, businesses should plan for a broad range of outcomes. Risks to UK inflation do seem to be weighted to the upside at present (in contrast to risks to real GDP growth, which we think are still weighted somewhat to the downside).

Real earnings squeeze to persist through 2017 and 2018

Consumer price inflation exceeded earnings growth for six consecutive years following the onset of the 2008-9 recession, which was in marked contrast to pre-crisis norms. Positive real earnings growth resumed in 2015 and 2016 as consumer price inflation fell to close to zero, but nominal earnings growth in cash terms was still only just over 2%, which remains weak by historical standards.

Inflation has since picked up and we expect this trend to continue in 2017-18 while growth in nominal earnings growth remains relatively subdued (see Figure 2.9). This implies persistent negative real earnings growth over the period, which in turn will have a negative impact on real consumer expenditure growth. But there are considerable uncertainties around any such projections at present, given the apparent structural shifts in the behaviour of wages in response to variations in unemployment illustrated by our Phillips Curve estimates in Figure 2.5 earlier in this section.

Figure 2.8 – Alternative UK inflation (CPI) scenarios

Sources: ONS, PwC scenarios

Figure 2.9 – CPI inflation vs average earnings growth
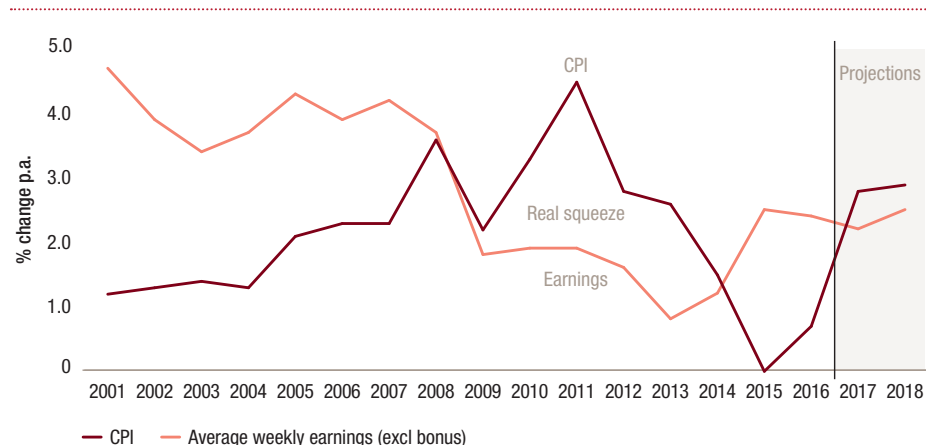
Sources: ONS, PwC analysis

2.4 – Monetary and fiscal policy options

The Monetary Policy Committee (MPC) voted at its meeting in June to maintain the monetary policy stance introduced last August after the Brexit result, holding interest rates at 0.25%. But three members voted to raise rates and subsequent speeches by MPC members point to an active debate on the MPC in coming meetings as to when it is appropriate to start to normalise policy as the US Fed has been doing for some time.

At present, we would expect the majority of the MPC to want to wait for longer to see how the Brexit negotiations go and how this affects UK growth. But with inflation set to rise above 3% later this year, the case for a rate rise has clearly become stronger and we are assuming a modest increase during the course of 2018 in our main scenario.

While monetary policy may gradually tighten over the next 18 months, the Chancellor has come under significant political pressure to further ease austerity. A range of areas including health and social care, schools, police, social housing and public pay have emerged as priorities for additional spending following the election result. But we would expect the Chancellor to defer major decisions on recalibrating tax and spending policy until his Autumn Budget, when he can look at these issues in the round with the benefit of an updated OBR economic and fiscal forecast.

2.5 – Summary and conclusions

The UK economy grew by 2% in the 12 months to the first quarter of 2017, but the quarterly rate slowed to 0.2%, weighed down by slowing consumer expenditure and a weaker services sector.

In our main scenario, we project UK growth to slow gradually from around from 1.8% in 2016 to around 1.5% in 2017 and 1.4% in 2018. The slowdown will be felt across most major industry sectors, although manufacturing exports may receive a short-term boost from the depreciation of the pound and stronger Eurozone growth. London will see growth slow, but could remain the fastest growing UK region as other areas of the country will also see some easing of growth in 2017-18 compared to recent years.

The slowdown in UK growth is projected to be primarily a result of a slowdown in consumer expenditure, with real spending power squeezed as consumer price inflation increases faster than earnings growth. This continued stagnant wage growth, combined with low unemployment, suggests a breakdown of the traditional negative relationship described by the Phillips Curve.

Business investment growth is also expected to remain relatively subdued in 2017-18, driven by continued uncertainty surrounding the negotiations to leave the EU, although this will be partly offset by stronger public investment.

There are considerable uncertainties around any such projections at present, however, so businesses should stress test their business and investment plans against alternative economic scenarios and also review the potential wider implications of Brexit for all aspects of their operations.

3 – UK Housing market outlook

Key points

- House prices in the UK were not impacted by the UK's decision to leave the EU as quickly as expected, though price growth stalled in the second half of 2016 and is now showing signs of a slowdown. Transaction volumes appear to have suffered more, but these effects are compounded by other factors such as stamp duty reform.

- We anticipate that the rest of 2017 will see the slowdown in the housing market continue, yielding annual house price growth of around 3.7%, down from 7% in 2016. In our main scenario, house price inflation will pick up slightly again in later years averaging around 4% until 2025. We find that housebuilding at the level proposed by the government, although welcome, may only have a small effect in constraining house price rises in the short term.

- The London housing market has been most severely impacted by economic and policy uncertainty and the recent changes to stamp duty. Price inflation in London in the first four months of 2017 was around 4% compared with around 13% for the same period in 2016. We project that London's housing market will continue to slow with only 2.8% and 3.8% house price growth on average in 2017 and 2018 respectively.

- Elsewhere in the UK, the East and Southern regions of England will continue to grow above the UK average, but Northern Ireland and the North East will continue to lag behind.

- There is a huge disparity in how sub-regional housing markets have performed since the recession. Whilst the average house price across the UK has grown by 17% since mid-2007, over a quarter of all local authorities are still 'under water'. The region that has seen the greatest decline is Northern Ireland, where on average house prices are 44% below their pre-recession peak.

- There has also been a structural shift in London's housing market recently, as house price growth has moved outward from the capital. Growing unaffordability within London, coupled with policy reform, has seen house price rises in prime central boroughs slow whilst price rises in the outer boroughs and the commuter belt have accelerated. Over the last two years, house prices in the outer boroughs have risen 9 percentage points faster than inner boroughs, whilst house price growth in the fastest growing cities within the commuter belt exceeded that in London by 4 percentage points in 2016.

Introduction

In this section, we explore how the UK housing market has been performing recently and present our projections for house price inflation until 2025. We also present new analysis of regional and sub-regional trends in the market showing the shifting patterns of growth since the recession.

The discussion below begins by briefly reviewing recent housing market developments (Section 3.1) and then goes on to assess future UK and regional house price prospects in Section 3.2. Section 3.3 presents our new research into the development of sub-regional markets.

3.1 – Recent housing market developments

Brexit appears to be a drag on price growth, but the effects have come through more slowly than expected

Shortly after the UK's decision to leave the EU last summer we predicted that house price growth would fall to around 3% in 2016 and slow further in 2017. The market did not respond as quickly as we and most other forecasters expected, but we are now seeing a pronounced slowdown in house price growth.

As shown in Figure 3.1, house price inflation slowed in 2016, falling from 8.2% year-on-year in June to 5.2% in December. But it still averaged 7% for the year as a whole, equating to an average UK house price of £198,000 in 2016.

Soft end to 2016 suggests loss of momentum in the market

The latest available ONS house price inflation figures registered growth of 5.6% in April. Whilst this headline figure appears robust, it masks the fact that the market was broadly flat in the second half of 2016 (see Figure 3.2 below). 2017 also started softly but a strong April has brought it in-line with the 2016 profile. A rapid acceleration in prices over the spring will be required to avoid a sharp drop in the annual house price inflation rate.

This may be unlikely given that alternative data providers on the housing market such as Nationwide and Halifax have reported price growth slowing more sharply than the ONS so far this year.

Figure 3.1 – Annual rate of house price inflation
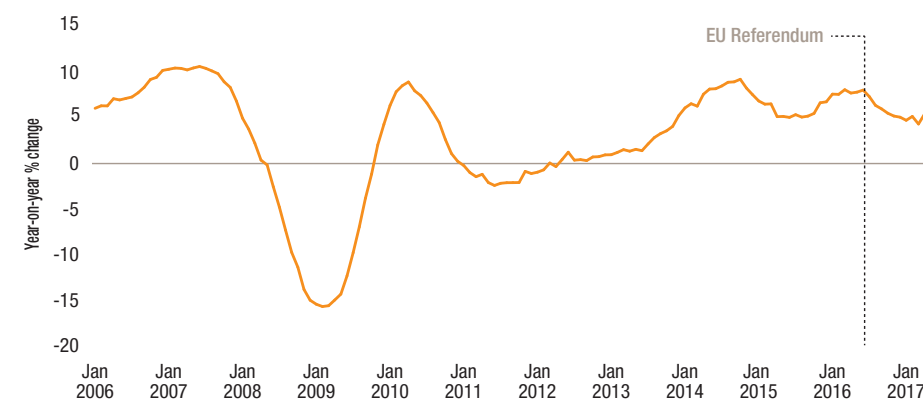
Source: ONS

Figure 3.2 – Cumulative house price inflation by year

Source: ONS

Figure 3.3 – Annual growth in UK housing transactions

Source:

3.2 – House price prospects

In this section, we present our projections for house price inflation in the UK and regional markets. We use econometric time-series models to make our predictions. These link house prices to underlying drivers in the housing market and the economy more generally, such as earning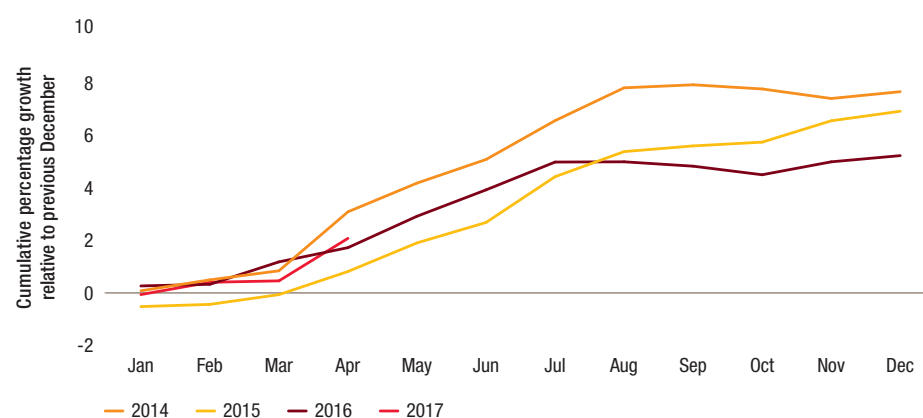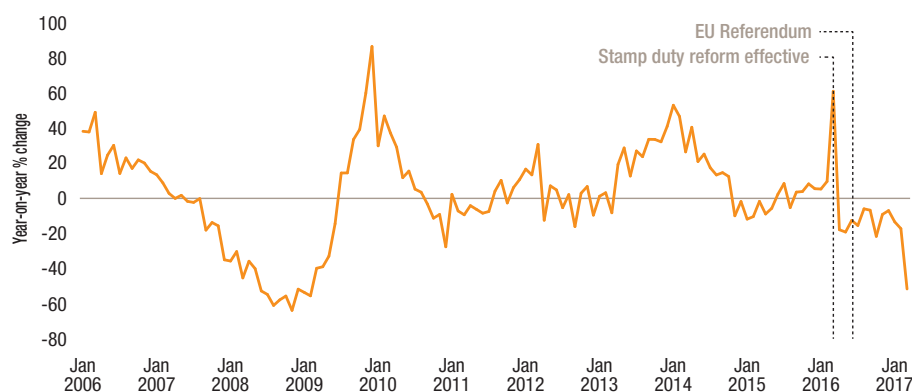s growth, housing supply and credit conditions, and use these relationships to project how prices may evolve going forward[1].

In our main scenario we assume that real earnings growth will remain close to zero in 2017 and 2018, down slightly on the 2016 figure as inflation continues to rise. We project that real earnings growth will recover slightly after 2019 and reach about 1.5% per annum by 2021. Informed by the Council of Mortgage Lenders' forecast we also expect credit conditions to remain fairly neutral and mortgage lending to grow modestly over the next four years.

We assume that the housing supply growth increases slightly over the projection period, equating to growth in the UK housing stock of around 0.9% a year.

Housing transactions are declining

Housing transactions, which tend to be more volatile than prices, are where the uncertainty caused by Brexit has manifested itself most strongly, in combination with effects of recent reforms to stamp duty. As shown in Figure 3.3, the latest data show year-on-year transaction growth has been negative for twelve consecutive months. Only 132,000 transactions were completed in the first two months of 2017 compared with 155,000 for the same period in 2016. The gap widens further if March is included, but this comparison is distorted by the temporary surge in transactions in March 2016 to beat the introduction of the 3% extra stamp duty charge for additional homes in April 2016.

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1   Further details are provided in the technical annex at the end of this article

House price growth slows in 2017 but price-to-earnings ratio still growing

In our main scenario, we project that house prices in the UK will grow at an average of around 3.7% this year. This is slightly less pessimistic than our projection of around 1% for 2017 made this time last year, in light of the less severe impacts of Brexit manifested thus far.

In the medium term, house prices are expected to grow at a slightly higher average rate of around 4% a year as earnings growth is assumed to strengthen. This would imply that house prices continue to outstrip earnings growth as a result of continued structural weakness in supply.

Our analysis suggests that the average residential property in the UK could be worth approximately £220,000 in 2017, £8,000 higher than in 2016, and could rise to over £300,000 by 2025.

Turning to the regional picture, we expect to see some significant changes with London in particular experiencing substantial headwinds. The capital city has seen the highest house price inflation of any UK region in eight out of the last ten years. But we expect this trend to reverse in 2017 and 2018 due to challenging affordability and London's status as the UK's most outward-facing region with the greatest exposure to the risks of Brexit.

Figure 3.4 – UK house price inflation main scenario projection
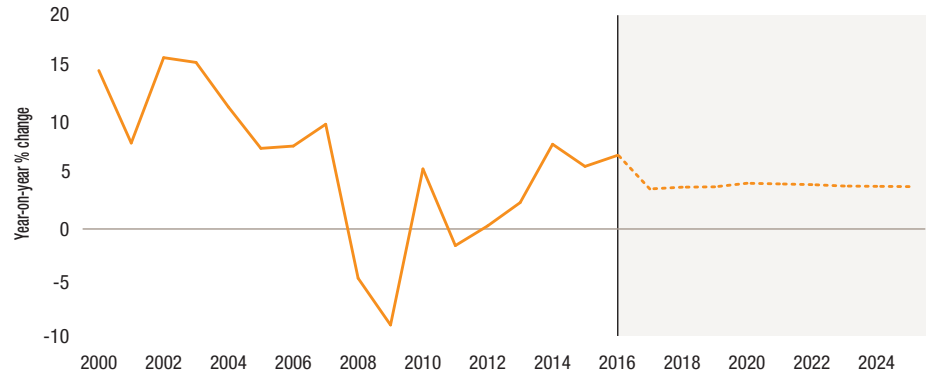
Source: ONS house price index historical data, PwC projections

Table 3.1: UK main scenario house price inflation and average house prices

Year	Main scenario (% growth)	Main scenario (£)
2016 (Actual)	7.0%	£212,000
2017	3.7%	£220,000
2018	3.9%	£228,000
2019	3.9%	£237,000
2020-2025	4.1% average growth	£302,000 in 2025

Source: PwC analysis based on ONS house price index

Box 3.1 – Will building a million homes solve the affordability crisis?

The Government's recent White Paper on housing[2] opens with the statement that "the housing market in this country is broken, and the cause is very simple: for too long, we haven't built enough homes." This view is widely held and has been the subject of significant commentary and analysis – notably the Barker Review of Housing Supply, published as long ago as 2004.

The White Paper concluded that the UK needs 250,000 new homes a year and the current Government has committed to this target by promising to build a million homes by 2020 and another half a million by 2022.

Achieving this target would undoubtedly be welcome, but to what extent will it help affordability? We have used our house price model to simulate what the impact could be.

Over the past three years, approximately 190,000 new homes have been built annually in the UK, 26% more than in the preceding three year period. In our main scenario we project that this upward trend will continue with new build completions reaching around 216,000 by 2020. This equates to growth in the UK housing stock of around 0.9% per year. We compare the price projections from our main scenario to a scenario where 250,000 houses are built each year (which would raise growth in the housing stock to around 1.1% per annum). The results are shown in Table 3.3 below.

Table 3.3: UK house prices– the potential impact of increased supply

Year	House prices, PwC main scenario	House prices, additional building scenario	Difference
2016 (Actual)	£212,000	£212,000	N/A
2017	£220,000	£220,000	No change*
2018	£228,000	£228,000	No change*
2019	£237,000	£237,000	No change*
2020	£247,000	£246,000	£1,000
2021	£258,000	£256,000	£2,000
2022	£268,000	£266,000	£2,000
2023	£279,000	£276,000	£3,000
2024	£290,000	£287,000	£3,000
2025	£302,000	£297,000	£5,000

Source: PwC analysis using the ONS house price index and DCLG net supply of housing

* No change after rounding to nearest £000

Our results suggest that an increase in building of this magnitude would restrict future house price growth slightly, but not fundamentally change the affordability picture. The cumulative effect of the additional building scenario is estimated to be only around £5,000 by 2025.

The reason is that the UK has been building too few houses for the last 40 years and to undo this would require a similarly prolonged period of above average new building. Our analysis suggests that simply achieving the par level of building for 7-8 years will have only a limited impact on the supply-demand balance and so on prices.

2   DCLG (2017), "Fixing our broken housing market"

Figure 3.5 – Projected house price inflation in UK regions 2017 and 2018
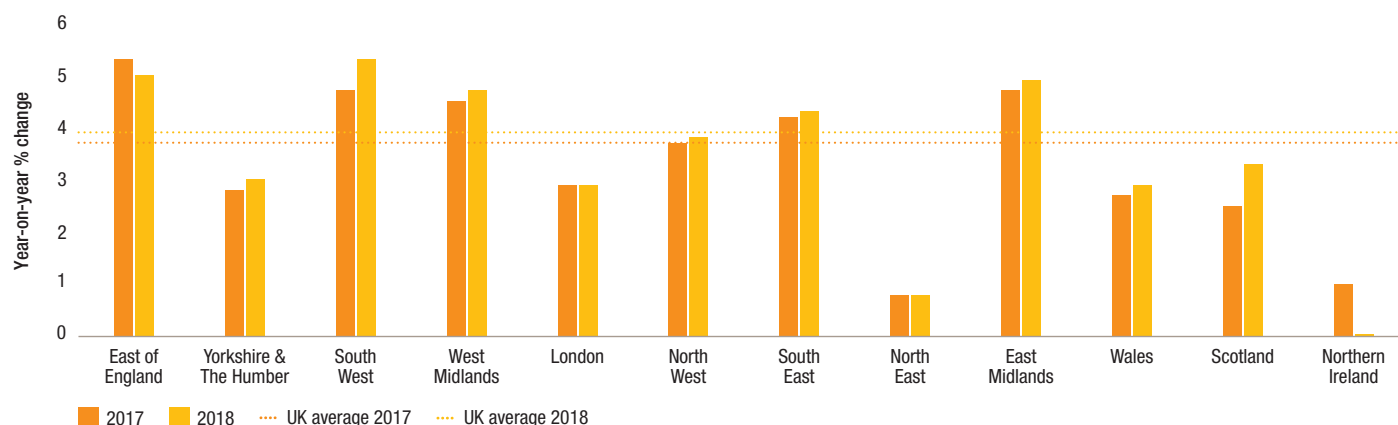
Source: PwC analysis based on ONS house price index

London expected to be amongst the weakest performing regions

House price growth in London in the first four months of this year was less than a third of the equivalent in the first four months of 2016 – averaging around 4% compared with 13% growth in the same period last year. It is important to note, however, that house prices in London still remain significantly higher than in other regions and the average value of a home in London is set to surpass half a million pounds in the next few years.

We expect the strongest price growth in the UK to be in the southern regions of England and the Midlands. The East of England is projected to see the fastest house price growth in 2017, at just over 5%, with Northern Ireland and the North East the weakest performing. Table 3.2 and Figure 3.5 indicate the projected house prices and growth rates for all of the UK regions between this year and 2020.

Table 3.2: Regional house price growth and house price values (£000's) in the main scenario

| Region	2016	2017P	2018-2020P Average	2016	2017	2020P
East of England	12.2%	5.3%	4.3%	266	281	319
East Midlands	6.9%	4.7%	4.4%	170	178	202
South West	8.4%	4.7%	4.5%	233	244	279
West Midlands	6.2%	4.5%	4.3%	175	183	208
South East	12.1%	4.2%	4.1%	304	317	358
North West	4.8%	3.7%	4.0%	147	153	172
London	14.0%	2.9%	3.9%	468	481	539
Wales	4.3%	2.7%	3.7%	144	148	165
Scotland	-0.2%	2.5%	4.0%	139	142	160
Yorkshire & The Humber	5.6%	2.8%	3.7%	149	153	171
Northern Ireland	5.9%	1.0%	2.6%	123	124	134
North East	3.4%	0.8%	2.9%	124	125	137
UK average	**7.0%**	**3.7%**	**3.9%**	**211**	**219**	**247**

Source: PwC analysis based on ONS house price index

Alternative UK house price scenarios

Projecting house prices involves many uncertainties, especially in the current period where the UK is likely to undergo major structural changes due to Brexit. To reflect this we always develop two alternative house price inflation scenarios based on different inputs for the model drivers (see Figure 3.6).

Our **high scenario** reflects a stronger macroeconomic environment where earnings growth returns to rates expected prior to the decision to leave the EU and mortgage credit growth is more robust. In this scenario, house price growth could be somewhat stronger in the short term, potentially growing at around 5% instead of 3.7% in 2017, and could be quite significantly stronger in the medium term with average growth of approximately 7% between 2020 and 2025. This scenario would mean that the average UK house price could reach around £370,000 by 2025.

Our low scenario reflects a more severe impact from Brexit on earnings growth, which we assume remains very weak in the medium term. The scenario also supposes tighter credit conditions. In this low scenario, house price inflation could average only around 1% a year in the medium term.

Figure 3.6 – Alternative house price inflation scenarios
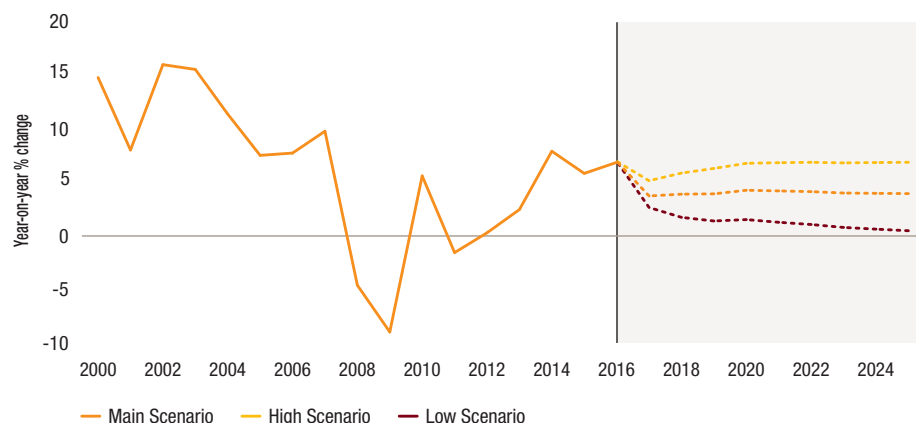
Source: PwC analysis based on ONS house price index

3.3 – Sub-regional housing trends

The creation of the new official house price measure from the ONS and Land Registry last year has generated a new sub-regional set of data on the UK market. In this section, we present three themes that we have identified by analysing these figures:

1. Despite the general perception of a UK affordability crisis, in around one quarter of local authorities house prices are still lower on average than they were 10 years ago.

2. The London market has seen a significant structural shift over the course of the last ten years, with growth radiating out from inner to outer boroughs.

3. More recently the challenging affordability outlook in London has seen demand, and therefore the strongest house price growth, spill over to towns and cities in the London commuter belt.

In the remainder of this section we explore these trends in more depth.

In a quarter of UK local authorities, house prices remain below pre-recession peaks

It is widely accepted that there is an affordability crisis in the UK housing market. Whilst this is true at the aggregate level, given that measures like house price to earnings ratios are at record highs, there have been marked differences in regional market trends since the financial crisis.

The top of the pre-crisis house price cycle came in September 2007, but as Figure 3.7 illustrates, prices in many local authority areas clustered in Northern Ireland, Wales, Scotland, and in the North of England have still not surpassed this peak almost ten years on.

In contrast, no local authorities in the South East, South West, Eastern or London regions have average house prices that are still below their pre-recession peak levels. In the highest growth local authorities, prices have almost doubled over the same period.

Figure 3.7 – Local authority areas where house prices are still below pre-crisis peak levels in 2007

Northern Ireland has seen the sharpest decline in house prices. The average house in the region is 44% cheaper than in 2007.

There is a 78 percentage point gap between the best and worst performing Scottish local authority. House prices in the Shetland Islands rose by 59% since 2007 whilst Inverclyde's fell by 19%.

Liverpool has failed to surpass its pre-recession peak, seeing a decline of 5% since 2007.

London has seen the highest rise in house prices since 2007 averaging a 63% price increase.

■ -46% to -19%	■ -19% to -10%	■ -10% to -5%	■ -5% to 0%	■ 0% to 95%

Sources: ONS/Land Registry, PwC Analysis

*Please note: The map above compares the 3 month average of house prices during their UK peak in 2007 (July-September), and measures them with the 3 month average of current house prices (February – April 2017).

Northern Ireland has experienced the greatest house price declines

The local authorities that have experienced the greatest falls in house prices since 2007 are all based in Northern Ireland. Part of this is due to the Irish property bubble, which spilled north of the border, stoking unsustainable house price gains of 78% between 2005 and 2007 in Northern Ireland. When the crash came it was far more severe there than in any other part of the UK. Prices still remain far below their 2007 peak: the largest gap is found in Armagh Banbridge and Craigavon, where prices remain 47% below peak levels.

The weakest house price performance beyond Northern Ireland has been in the North of England (see Table 3.4). Hartlepool has experienced the greatest price decline of any English authority (-21%), while Inverclyde has seen the largest price decline in Scotland (-19%).

These trends have boosted affordability for first time buyers in these areas in particular. In Blackpool, for example, the average house price to earnings ratio has fallen from 6.2 in 2008 to 4.9 in 2016. County Durham has seen a decline in this ratio from 5.1 in 2008 to 4.4 in 2016. This is in contrast to England as a whole, where the house price to earnings ratio has risen from 6.9 in 2008 to 7.7 in 2016.

By way of contrast, we show the highest growth local authorities in Table 3.5. London dominates with all boroughs experiencing price growth of over 50%. The Shetland Islands[3] and areas of the East and South East that are close to London round out the top ten.

Table 3.4: Areas experiencing the greatest house price declines (2007 – 2017)

Region	Local Authority	Price change relative to pre-recession peak
Northern Ireland	All local authorities in Northern Ireland	Declines vary from -47% in Armagh Banbridge and Craigavon to -39% in Derry and Strabane
North East	Hartlepool	-21%
North East	County Durham	-19%
North West	Burnley	-19%
Scotland	Inverclyde	-19%
North West	Blackpool	-18%
Scotland	East Ayrshire	-17%
Scotland	North Ayrshire	-17%
North West	Hyndburn	-14%
Scotland	West Dunbartonshire	-13%
North East	Sunderland	-13%

Source: ONS/Land Registry, PwC Analysis

Table 3.5: Areas experiencing the greatest price increase (2007 – 2017)

| Region	Local Authority	Price change relative to pre-recession peak
London	All London boroughs	Increases range from 51% in Havering to 95% in Westminster
Scotland	Shetland Islands	59%
East	Cambridge	59%
East	Hertsmere	58%
East	St Albans	57%
East	Three Rivers	56%
South East	South Bucks	55%
South East	Slough	55%
East	Broxbourne	53%
East	Watford	52%
East	Dacorum	51%

Source: ONS/Land Registry, PwC Analysis

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3   Property prices in the Shetland Islands have risen rapidly as a result of strong oil prices in the years after the financial crisis and efforts to diversify considerably in response to softer oil prices since mid-2014, which have supported income levels.

London's outer boroughs begin to outperform its inner boroughs[4]

Over the past two years, there has been a major structural shift in the pattern of price growth within the capital. As shown in Figure 3.8, from 2007 to 2014, central boroughs such as Kensington and Chelsea and Westminster saw the greatest increase in average house prices of 71% and 79% respectively. In contrast, Havering and Barking and Dagenham only achieved price growth of 15% over this seven year period.

Figure 3.8 – Relative cumulative house price rises in London boroughs (2007-14)[5]

15%-30%   30%-40%   40%-55%   55%-65%   65% +
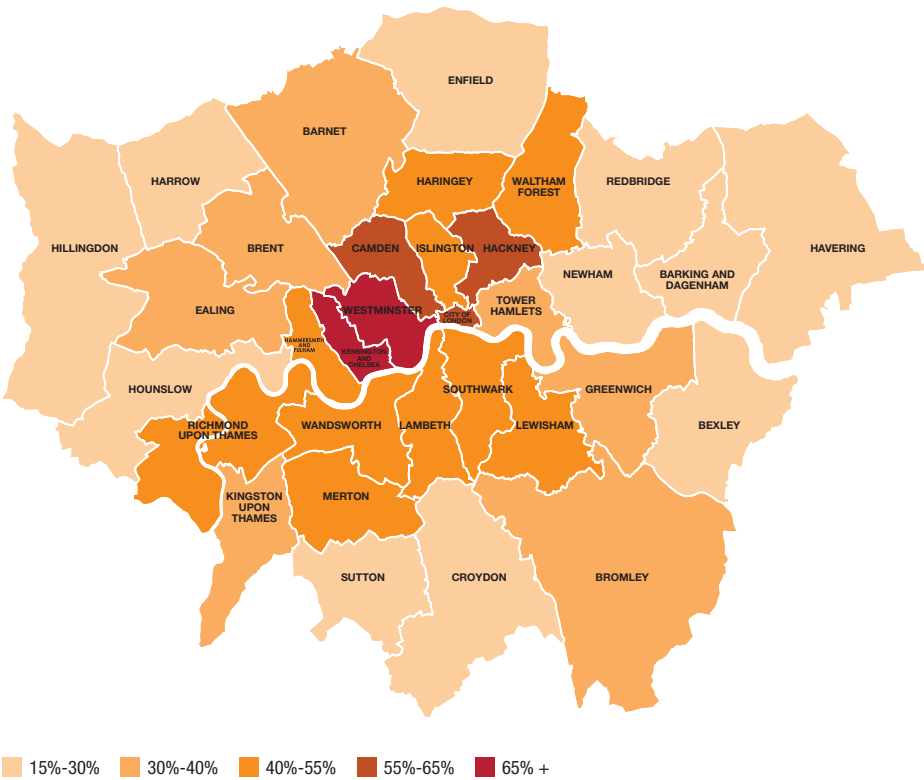
Sources: ONS/Land Registry, PwC Analysis

4   We use the ONS's statistical definition to classify London boroughs to inner boroughs and outer boroughs. Inner boroughs: Camden, City of London, City of Westminster, Hackney, Hammersmith, Haringey, Islington, Kensington, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, Wandsworth. Outer boroughs: Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton, Waltham Forest.
5   The map above compares the percentage difference between the average house price in London boroughs during their 2007 peak (July-September) and the 3 month average of house prices prior to the first major stamp duty reform (October – December 2014).

## Stamp duty reforms and affordability have dampened the inner London market

But this trend has gone into reverse since the end of 2014, with outer boroughs markedly outperforming their central London counterparts (see Figure 3.9). The stamp duty changes introduced in December 2014, which significantly increased transaction taxes on properties worth more that £937,000 (the average price of a property in Westminster is £1,051,000), have undoubtedly had an impact.

This was followed up with another reform in April 2016: applying an additional 3% stamp duty charge for purchases of second homes and additional properties. Taken together, the buyer of a £1.5m property could pay up to £138,750 in tax after the reforms, almost twice the previous bill of £75,000. Demand in these prime central London markets may also have also been impacted by other recent events like Brexit and softer oil prices since mid-2014 limiting demand from Russia and the Middle East.

Prices in outer London boroughs have powered ahead since 2014

From 2014-2017, we see outer boroughs growing at a markedly faster rate than inner boroughs (see Figure 3.9). In particular, boroughs in the North East of London, such as Barking and Dagenham and Havering, have seen the highest rise in house prices over the past two years at 31%. The slowest growing are Kensington and Chelsea and Islington, which have only seen rises of 3% and 4% respectively. On average, we find that house prices in outer boroughs have grown 9 percentage points faster than inner boroughs during this period.

Figure 3.9 – Relative cumulative house price rises in London boroughs (2014-17)[6]

Legend: 1%-7% | 7%-12% | 12%-18% | 18%-24% | 24% +
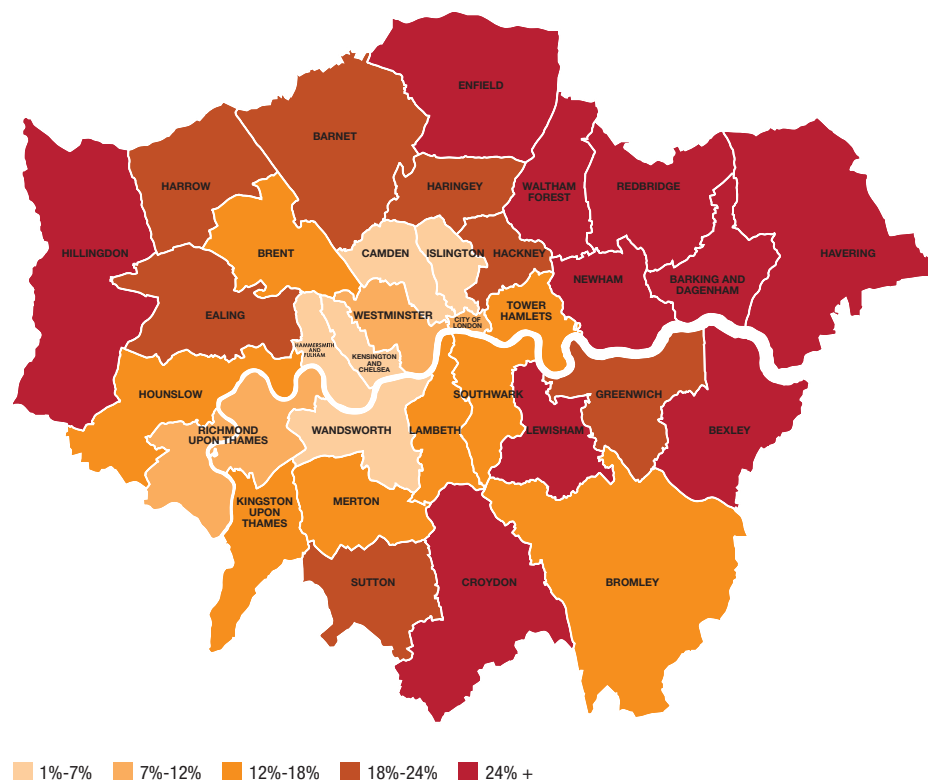
Sources: ONS/Land Registry, PwC Analysis

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6   The map above compares house prices from a 3 month average prior to the first major stamp duty reform (October – December 2014) to a 3 month average of the latest data available (February – April 2017).

Figure 3.10 – Difference between house price inflation in the 15 fastest growing commuter belt cities and London

Source: ONS, PwC analysis

2017 value represents year to date figures up to April

Commuter belt cities begin to outperform London for price growth

The final theme we highlight in this section is that the outward shift in demand within the London boroughs is beginning to be seen beyond the boundaries of the capital. Many towns and cities within the commuter belt have recently experienced stronger price growth than London.

Figure 3.10 shows the difference in house price growth between 15-high performing commuter areas and London. London achieved stronger growth over much of the period, including the late 1990s and 2006 to 2014. However, since 2015, the commuter towns and cities have significantly outperformed London with average growth 4 percentage points faster in 2016 and 6 percentages faster in 2017 so far.

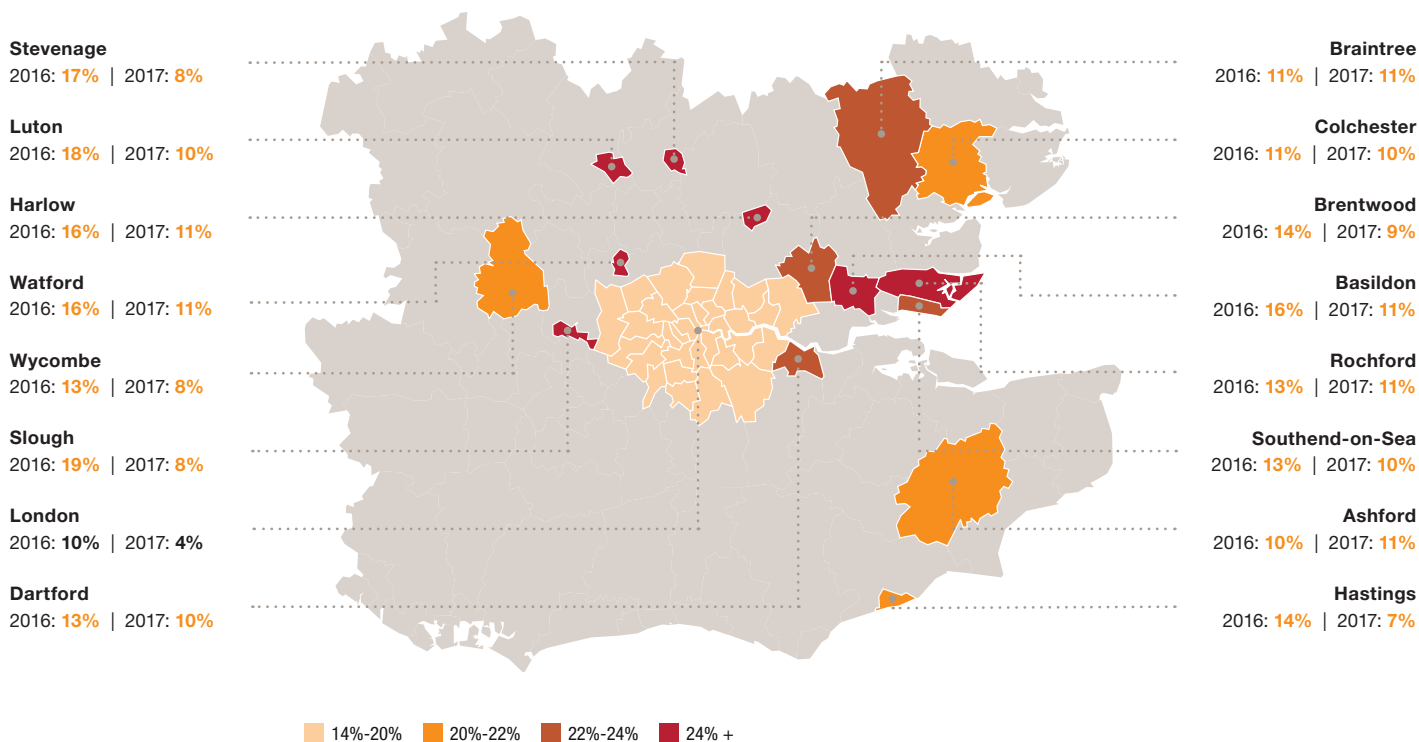### London prices hit by the affordability crisis

One of the primary reasons for this is the affordability crisis within London, which has seen first-time buyers in particular struggling to buy in the capital. In 2016, house prices in London were 13 times median earnings, while the 15 commuter belt towns offer a lower (albeit still high) ratio of 9 times earnings.

The fastest growing commuter towns and cities

In Figure 3.11, we present the top performing commuter towns and cities in 2016 and 2017 so far. The areas with the fastest growth rates are situated to the North and East of London, with Basildon and Rochford recording 11% annual growth in the first four months of 2017. Overall Essex appears to be the key hotspot, probably because house prices there have been lower than those in commuter towns west of London.

Cost may explain the lack of high growth towns and cities in 2016-17 to the South West of London. Areas like Guildford and Woking had average prices of £411,000 and £444,000 respectively in April 2017. This was not far below the London average of £483,000, so people seeking an affordable option may need to look elsewhere.

Figure 3.11 – The fastest growing commuter towns and cities by house price growth (2016 - 2017)[7]

Stevenage
2016: **17%** | 2017: **8%**

Luton
2016: **18%** | 2017: **10%**

Harlow
2016: **16%** | 2017: **11%**

Watford
2016: **16%** | 2017: **11%**

Wycombe
2016: **13%** | 2017: **8%**

Slough
2016: **19%** | 2017: **8%**

London
2016: **10%** | 2017: **4%**

Dartford
2016: **13%** | 2017: **10%**

Braintree
2016: **11%** | 2017: **11%**

Colchester
2016: **11%** | 2017: **10%**

Brentwood
2016: **14%** | 2017: **9%**

Basildon
2016: **16%** | 2017: **11%**

Rochford
2016: **13%** | 2017: **11%**

Southend-on-Sea
2016: **13%** | 2017: **10%**

Ashford
2016: **10%** | 2017: **11%**

Hastings
2016: **14%** | 2017: **7%**

14%-20%   20%-22%   22%-24%   24% +

Sources: ONS/ Land Registry

3.4 – Summary and conclusions

UK house price growth was not affected by the Brexit vote as quickly as expected, but headwinds have been evident towards the end of 2016 and during the first months of this year. We anticipate that house price inflation will be more modest going forward. However, in our main scenario, the house price-to-earnings ratio will continue to grow and even achieving 250,000 new homes per year is unlikely to provide a quick fix for this affordability problem given many decades of undersupply.

London has seen a slowdown in its housing market over the past two years, particularly within the prime central boroughs, linked to severe affordability concerns, stamp duty changes and probably also the greater extent to which economic and political uncertainty impacts the prime central London market.

House prices in the UK have grown fastest in the past 2-3 years in the outer boroughs of London and cities located in London's commuter belt.

Our model indicates that the East and Southern regions of England will continue to outperform house price growth in London and be the prime engine of UK house price growth over the next few years. By contrast, Northern Ireland and some parts of Northern England and Scotland still have average house prices below their pre-crisis 2007 peaks.

7   We use January – April 2017 figures to measure our 2017 price growth, as this is the latest data available

Annex
Supplementary data on local house price trends

Table 3A.1: House price by London borough, % change 2007-2014 and 2014-2017

Rank 2007-14	Borough	% Change	Rank 2014-17	Borough	% Change
1	Westminster	79%	1	Barking and Dagenham	31%
2	Kensington and Chelsea	71%	2	Havering	31%
3	City of London	64%	3	Newham	30%
4	Camden	59%	4	Hillingdon	28%
5	Hackney	57%	5	Bexley	28%
6	Southwark	53%	6	Enfield	27%
7	Hammersmith and Fulham	50%	7	Redbridge	27%
8	Islington	49%	8	Waltham Forest	26%
9	Haringey	46%	9	Croydon	25%
10	Lambeth	46%	10	Lewisham	24%
11	Wandsworth	44%	11	Barnet	22%
12	Richmond upon Thames	43%	12	Greenwich	22%
13	Merton	43%	13	Harrow	22%
14	Lewisham	42%	14	Haringey	22%
15	Waltham Forest	41%	15	Hackney	20%
15	Brent	39%	15	Sutton	19%
17	Ealing	38%	17	Ealing	18%
18	Kingston upon Thames	35%	18	Hounslow	18%
19	Tower Hamlets	35%	19	Bromley	17%
20	Greenwich	34%	20	Brent	17%
21	Barnet	34%	21	Merton	16%
22	Bromley	32%	22	Kingston upon Thames	15%
23	Harrow	29%	23	Tower Hamlets	14%
24	Hounslow	28%	24	Southwark	13%
25	Sutton	27%	25	Lambeth	13%
26	Hillingdon	24%	26	Richmond upon Thames	10%
27	Enfield	24%	27	Westminster	9%
28	Bexley	23%	28	City of London	7%
29	Croydon	23%	29	Camden	7%
30	Newham	20%	30	Wandsworth	7%
31	Redbridge	17%	31	Hammersmith and Fulham	5%
32	Havering	15%	32	Islington	4%
33	Barking and Dagenham	15%	33	Kensington and Chelsea	3%

Source: ONS/ Land Registry, PwC Analysis

Table 3A.2: House price growth by commuter city, % change April 2016 – April 2017

Rank	Commuter City/Town	House Price Growth (April 2016-April 2017)
1	Dartford	13.1%
2	Watford	11.6%
3	Colchester	10.8%
4	Braintree	10.7%
5	Basildon	10.2%
6	Rochford	10.2%
7	Luton	10.1%
8	Harlow	9.5%
9	Ashford	8.8%
10	Slough	8.6%
11	Brentwood	8.5%
12	Wycombe	8.4%
13	Southend-on-Sea	8.1%
14	Canterbury	8.0%
15	Tunbridge Wells	7.7%
16	Brighton and Hove	6.9%
17	Stevenage	6.6%
18	Horsham	6.3%
19	Milton Keynes	5.8%
20	Chelmsford	5.6%
21	Sevenoaks	5.2%
22	St Albans	5.0%
23	Oxford	4.8%
24	London	4.7%
25	Winchester	4.3%
26	Guildford	3.7%
27	Crawley	3.0%
28	Woking	2.2%
29	Maidstone	2.0%
30	Reading	1.1%
31	Hastings	1.0%
32	Cambridge	1.0%

Source: ONS/ Land Registry, PwC Analysis

Technical annex: Modelling methodologies

UK house price projections

Our analysis focuses on ONS and Land Registry house price indices. Data from the ONS vary from those provided by Nationwide and Halifax, though broad trends tend to be similar over time. We focus on the ONS data as they cover a larger sample size, given that Nationwide and Halifax base their indices on only their own mortgage approvals.

The PwC house price model consists of two parts: a long run equilibrium equation and a short run error correction model that indicates how house prices adjust back towards this equilibrium level.

In the long run, real house prices are driven by three key variables: real annual earnings, the ratio of the housing stock to the population ('supply') and a variable which reflects general credit conditions. Monetary values are deflated into real (inflation adjusted) terms using CPI.

In the short run, changes in real house prices are driven by: deviations from the long run equilibrium; changes in real annual earnings; changes in credit conditions; and the previous period's mortgage interest rate (cost of borrowing). The coefficients for these model variables and other summary statistics for both models are shown in the tables below.

The parameters of the model were estimated using the standard ordinary least squares (OLS) econometric technique based on annual data from 1975-2016.

Regional house price projections

The regional house price projections relate to the main scenario only, but it should be borne in mind that uncertainties are even greater at the regional than the national level, so these projections can only be considered illustrative. Our regional projections are based on a regression between house price to earnings ratios and mortgage rates. The results are then adjusted so as to aggregate to the UK average estimates.

Long run model (Cointegrating equation)

R-squared = 0.93

Dependent variable: Real house prices		No. of observations=42
	Coefficient	t-statistics
Earnings	16.40	10.9
Supply	-1666.5	-4.7
Credit	13898.4	2.0
Constant	391948.7	3.6

Short run model

R-squared = 0.63

Dependent variable: Change in Real house prices		No. of observations=41
	Coefficient	t-statistics
L. co-integrating equation residual	-0.11	-1.5
D.Credit	24431.1	4.6
D.Earnings	7.4	3.7
L.Mortgage rate	-594.6	-2.3
Constant	6272.9	2.6

Note: 'D' refers to the first difference of a variable (i.e. change on previous year). 'L' refers to the lagged value of a variable in the previous year.

4 – A machine learning approach to estimating current GDP growth[1]

Key points

- Businesses and policy makers need to keep a constant watch on the UK economy. However, the ONS's preliminary estimate of GDP growth is released with a significant lag and can often be materially different to later final estimates of GDP growth. This creates the need for alternative indicators of current economic activity.

- Nowcasting models can meet this need by utilising frequently released information to assess current economic activity. They are used across the globe, most notably by central banks in advance of the release of official GDP statistics. Over certain periods in the UK such models have been able to outperform preliminary GDP estimates.

- To provide an earlier estimate of GDP in the UK we have built our own nowcasting model utilising machine learning techniques. Our analysis shows that output indices used by the ONS when forming their preliminary estimate are strong predictors of final GDP. However, the inclusion of other indicators, such as house prices, materially improves our ability to predict movements in GDP.

- Our nowcasting model suggests that GDP growth in the second quarter of 2017 will continue to be sluggish at around 0.3% relative to the previous quarter. This is up very slightly from the ONS estimate of 0.2% in the first quarter of 2017 due to somewhat stronger growth in the services sector, offset in part by contracting industrial production and construction sector output. This means that the first half of 2017 represents the weakest two consecutive quarters of UK GDP growth since 2012 during the Eurozone crisis.

- Nowcasting models can also be used in a variety of policy and business contexts. For example, in predicting sectoral GVA, industry sales or firm revenues. Such wide applicability allows policy makers and businesses to understand the present better, so that they can plan more effectively for the future.

Introduction

What is the state of the UK economy right now? Is it expanding or shrinking and by how much? These are questions that official GDP statistics try to answer, but they take time to be published – can we obtain a quicker answer using other data sources?

In this article we explain the importance of having a timely view of the state of the UK economy for both businesses and policy makers and review methods available to do this. We then describe the analysis that we have undertaken to understand the relationships between frequently released economic indicators and GDP, building our own model which "nowcasts" UK GDP growth.

We use our nowcasting model to estimate GDP growth for the second quarter of 2017, in advance of the preliminary ONS estimate being published later in July, and discuss what this means for businesses and policy makers.

The discussion is structured as follows:

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1   This article was written by Sam Hinds, Lucy Rimmington, Hugh Dance, Jonathan Gillham, Andrew Sentance and John Hawksworth of PwC's economics practice.

4.1 – What is the need for a timely view on the state of the economy?

Both businesses and policy makers need to keep a constant watch on the UK economy. Businesses need a timely and accurate read out to make effective decisions day-to-day and policy makers need to understand what the economy is doing so that they can make the most informed economic policy decisions. This need for information becomes even more important during a period of heightened economic uncertainty, as we are now experiencing since the UK's decision to leave the EU in June 2016 (see Figure 4.1).

Growth in GDP is often relied upon to gauge the current state of the economy, but calculating GDP involves intensive data gathering and processing, meaning there is a lag between the completion of a quarter and knowing how the economy has performed (see Figure 4.2). In the UK such a lag is comparatively short with the ONS releasing its preliminary estimate of GDP just under a month after a given quarter - quicker than any of the other G7[3]. Nonetheless there is still a significant amount of time where businesses and financial markets do not have a comprehensive official view of the current state of the economy (bearing in mind that, immediately before the preliminary ONS release, the latest available official GDP data relates to a period 4-7 months earlier).

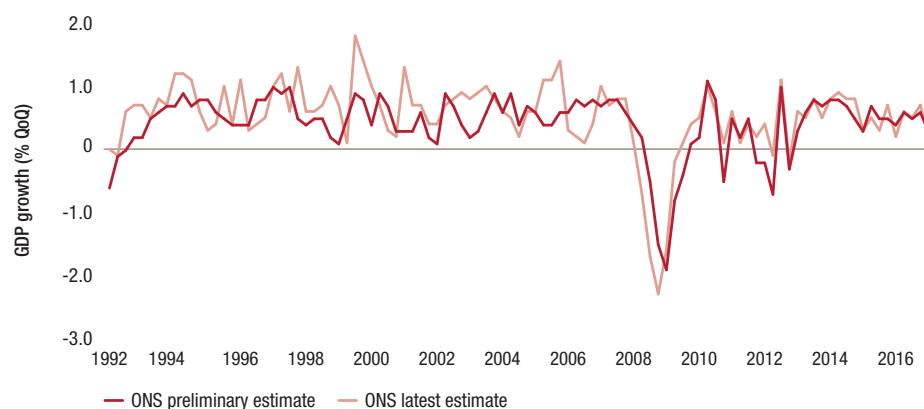**Figure 4.1 – Economic policy uncertainty in the UK[2]**
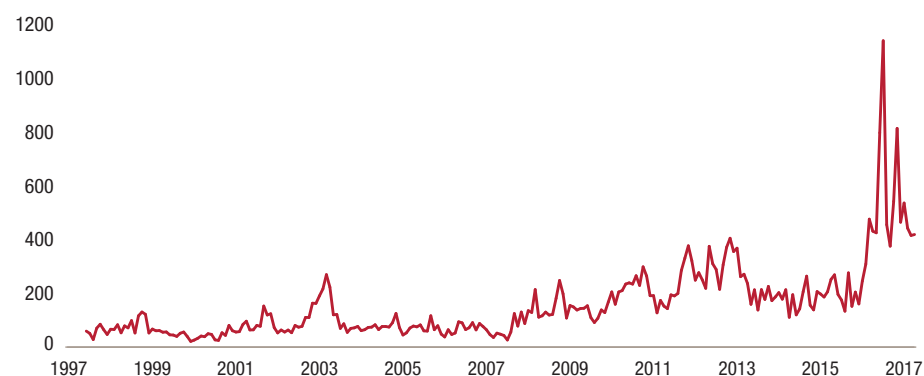
Source: Economic Policy Uncertainty

Figure 4.2 – Timeline of the preliminary ONS GDP data release
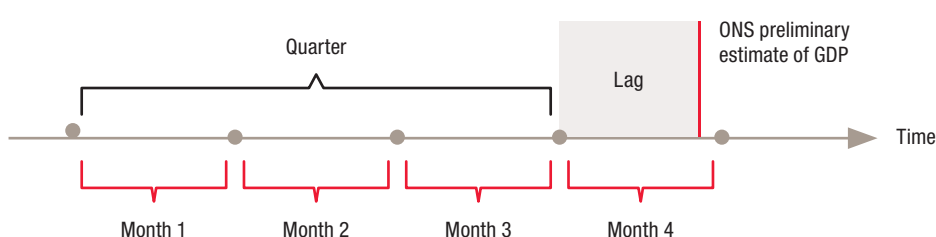
Source: ONS, PwC

Figure 4.3 – Preliminary and latest estimates of UK GDP growth (QoQ)

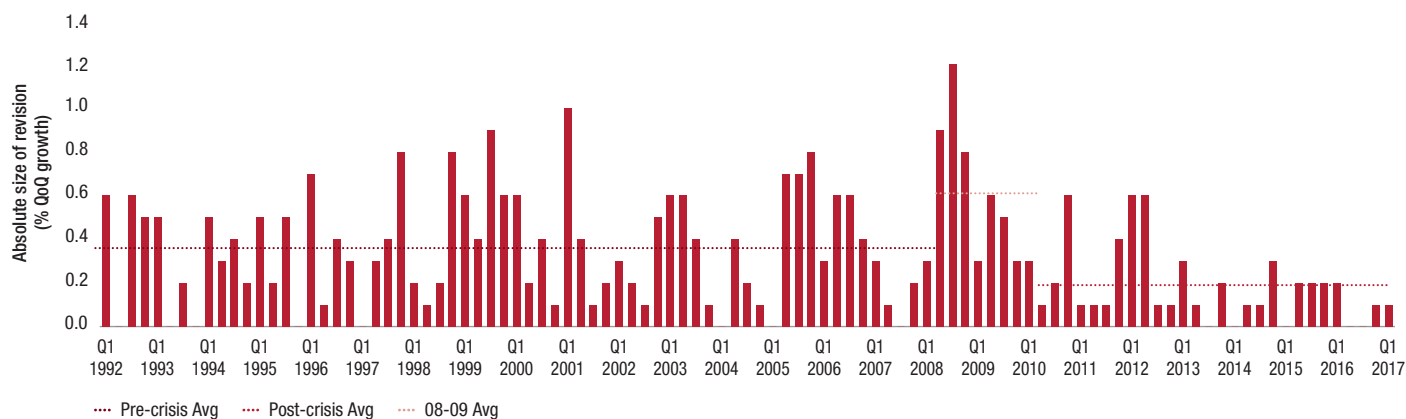ONS preliminary estimate   ONS latest estimate

Source: ONS, PwC

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2   This index is a widely used measure of economic uncertainty (for the UK and other major economies) produced by a team of US academic economists.
      See their website here for more details: http://www.policyuncertainty.com/index.html
3   Bean (2016) "Independent review of UK economic Statistics", P.18
      See here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/507081/2904936_Bean_Review_Web_Accessible.pdf

Figure 4.4 – The absolute size of revisions to UK GDP growth

Sources: ONS, PwC

The ONS produces its preliminary estimate of GDP growth using actual data from the first two months of a quarter and forecasts for the third month. The ONS estimates that, at the time of the preliminary release, it has approximately 45% of actual data available[4]. As more data become available, initial GDP estimates are revised many times and, as a result, final GDP estimates can be materially different to those in preliminary releases (see Figures 4.3 and 4.4).

We can see from Figure 4.4 that revisions to preliminary ONS GDP growth estimates were relatively large before and particularly during the financial crisis. This was one motivation for central banks to develop alternative indicators of current economic activity using nowcasting models as described in Section 4.2 below.

Since the financial crisis, the economic environment has become less volatile and the average revision between the preliminary and latest ONS GDP growth estimate has fallen significantly to an average of just under 0.2 percentage points, as Figure 4.4 shows.

Nonetheless, there is still a case for developing nowcasting models that are more timely than preliminary ONS GDP growth estimates, provided that there is no significant loss of accuracy in the process. This is what we have aimed to do in developing our own nowcasting model as described later in the article. First, however, we review the use and performance of other nowcasting models.

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4   ONS (2016) "Methods and Sources",
     See here: http://webarchive.nationalarchives.gov.uk/20160105160709/
     http://www.ons.gov.uk/ons/guide-method/method-quality/specific/economy/output-measure-of-gdp/methods-and-sources/index.html

4.2 – The use and performance of nowcasting models

Nowcasting models have been developed over the last 15 years in answer to this need for a timelier but still accurate view of the current state of the economy. In addition, the models aim to pick up changes in the economic cycle as they happen and provide an explicit and transparent view of which factors are currently impacting GDP growth. Its ability to provide useful insights in these areas has seen nowcasting become an increasingly popular tool for policy makers globally.

There are a range of different approaches that can be taken to produce nowcasts, from judgement-based techniques to statistical analysis of the relationships between more quickly available higher frequency data for the period and the less frequent GDP publication. The institutions that have developed nowcasting models most intensively are central banks and sub-national monetary authorities (as in the US). Table 4.1 sets out how five notable monetary authorities use nowcasting models.

Table 4.1: Use of nowcasting models by notable monetary authorities

Country	Central Bank	Use of nowcasting
United Kingdom	Bank of England	The Bank of England's Monetary Policy Committee (MPC) uses a compilation of nowcasts from three different models to form its initial view on the current state of the economy. In particular: (i) based on different industries (e.g. retail services, manufacturing, construction etc.) to mimic the production approach to calculating GDP, (ii) a mixed-data sampling model and (iii) a dynamic factor model. These are then taken together to form a judgement-based nowcast which is used by the MPC to inform its monetary policy decisions from month-to-month.
United States	Federal Reserve Bank of Atlanta (FRBA)	FRBA's Centre for Quantitative Economic Research produces frequent publicly available nowcasts of US GDP in advance of and following the US Bureau of Economic Analysis's advance estimate. It nowcasts thirteen separate expenditure components of GDP (e.g. consumer spending, investment, etc.) to mimic the expenditure approach to calculating GDP using dynamic factor modelling.
United States	Federal Reserve Bank of New York (FRBNY)	FRBNY publishes its own publicly available nowcast of US GDP growth to provide "a model-based counterpart to the more routine forecasts produced at the bank, which have traditionally been based on experience knowledge". Similar to FRBA, it also uses a dynamic factor approach, but does not mimic a particular approach to calculating GDP.
Eurozone	European Central Bank (ECB)	The ECB also uses dynamic factor-based nowcasting models to inform its policy decisions. Its staff have released a number of working papers which form cornerstones of the nowcasting literature, such as "Now-casting and the real-time data flow" (2013), by Marta Bańbura, Domenico Giannone, Michele Modugno and Lucrezia Reichlin.
Norway	Norges Bank	Norges Bank uses a variety of statistical nowcasting and short-term forecasting models of GDP and inflation to inform its policy rate decisions. Using several models it compiles a composite nowcast using a technique it calls SAM (System for Averaging Models), which produces a weighted average of the results of different models.

Sources: Bank of England, FRBA, FRBNY, ECB, Norges Bank, PwC

In the UK, in addition to public bodies, research organisations such as the National Institute for Economic and Social Research (NIESR), private consultancies and investment banks also produce nowcasts of UK GDP.

Nowcasting techniques have also been used in several different contexts in addition to predicting movements in GDP, as described in Box 4.1.

Box 4.1 – Other applications of nowcasting

Nowcasting techniques provide a general framework for trying to predict the current level of a data point which is released infrequently or with a significant lag.

In the UK there are a number of sectoral or industry statistics that are usually released with a significant lag by the ONS and nowcasting can be used to estimate such figures before they are released to help "bridge the gap" between the completion of a time period and the release of data. The ONS is currently exploring the potential for this, having consulted on nowcasting methods to approximate public service productivity estimates and having produced its own nowcasts of household income throughout 2016.

The Economic Statistics Centre of Excellence (ESCOE) in association with the ONS has also recently begun work to nowcast regional estimates of Gross Value Added (GVA).

Its aim is to (i) *"produce and disseminate timely model-based quarterly regional estimates of nominal GVA to the same timetable as the UK's first estimates of quarterly GVA for the UK as a whole"* and (ii) *"produce historical quarterly estimates of regional GVA, if feasible, at greater levels of regional and sectoral levels of disaggregation".* Such data would greatly improve the ability to analyse sub-national economic impacts of particular events or policies.

Nowcasting can also be used to exploit so-called "Big Data" to predict sectoral statistics. This is something that has been investigated by Hyunyoung Choi and Hal Varian of Google who have used search trends to predict monthly automobile sales in the US (see Choi and Varian (2009) for more information). Use of such innovative data could be taken potentially further, helping businesses to understand their sales, revenues and other KPI's on a much more frequent basis than ever before.

So, how accurate are nowcasting models at predicting current GDP growth in the UK? Evidence for the UK is somewhat limited, but Figure 4.5 summarises the relative performance of models from a selection of three sources: NIESR, Professor James Mitchell of Warwick Business School (who surveyed alternative nowcasting approaches in 2009) and the Bank of England[5]. Furthermore, the performance of NIESR and Mitchell's nowcasts are compared to the ONS's preliminary estimate (which for this purpose is treated as a forecast of the final GDP estimate). Such a comparison is not made for the Bank of England's figure as its nowcasting models are calibrated to predict preliminary rather than final estimates of GDP.

The performance of each model is based upon information available before the ONS preliminary data release and is summarised by each model's Root Mean Squared Error (RMSE) - a standard measure used to evaluate predictive power. The RMSE is typically larger than the average size of the gap between the model's prediction and actual GDP growth, but is a more reliable measure which helps select models with a lower likelihood of occasional extreme misses. This explains why the RMSE for the ONS is somewhat larger than the average forecast error over the same period.

Perhaps surprisingly, both NIESR and Mitchell's nowcasts outperform the ONS preliminary estimate in predicting final GDP. NIESR's model performs particularly well with a RMSE of 0.29%. However, as we noted above, the ONS preliminary estimates have improved considerably since the financial crisis (as shown in Figure 4.4) and it remains to be seen if these models could outperform the ONS today.

Figure 4.5 – Performance of UK nowcasting models
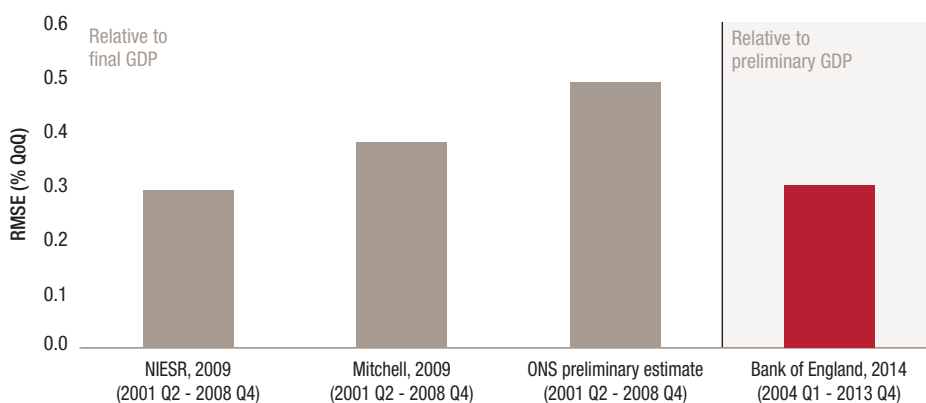
Sources: Mitchell (2009), Bank of England (2017), ONS, PwC

We also note that the Bank of England's ability to nowcast is also impressive with a RMSE of around 0.3%. However, comparison should not be drawn between its RMSE and that of NIESR or Mitchell as RMSEs are only comparable when they consider the same variable (i.e. final or preliminary GDP) over the same time period. The Bank of England's figure differs from the others in both these respects. RMSEs depend upon on how volatile GDP was in a given period. This explains why, during a period of volatile growth such as 2007-2008, estimates of current GDP growth become more inaccurate (for example in 2007-08 the RMSE for the ONS preliminary estimate increased to 0.62%).

RMSEs of around 0.3% may seem fairly large to some, but it is important to note that the factors that drive growth in different periods materially alter as the economy evolves and the shocks affecting it change. So being able to predict GDP growth with an RMSE of 0.3% is relatively impressive (recall the average error is smaller than the RMSE and likely to be around 0.2-0.25%).

Overall, the evidence suggests that nowcasting models can provide a broadly similar degree of accuracy to the ONS preliminary estimates of GDP growth, despite the nowcasting estimates being more timely. Academic research also shows that the nowcasts represent a significant improvement on standard statistical forecasting models that only make use of past data, in some cases at least halving the size of the RMSE[6].

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5 Figures for NIESR are quoted in the same paper as those of Mitchell – Mitchell (2009) "Where are we now? The UK recession and nowcasting GDP growth using statistical models", National Institute Economic Review, No. 209 July 2009
6 Castle, J.L., Hendry, D.F. and Kitov, O.I. (2013) "Forecasting and Nowcasting macroeconomic variables: A methodological Overview", University of Oxford Dept. of Economics Discussion paper Series, No. 674, September 2013

4.3 - Using machine learning to nowcast current GDP growth

In an effort to further improve on the already relatively impressive predictive power of existing models, we have built a nowcasting model using a machine learning technique known as Elastic Net Regularisation and Variable Selection ("Elastic Net")[7]. This is a form of predictive modelling introduced in 2005 that has only recently started to be used to nowcast GDP[8]. See Box 4.2 for details.

We would stress, however, that applying this technique still involves a lot of expert human input to frame the problem, evaluate alternative modelling approaches and interpret results. Machine learning techniques are being used here to augment not replace the expertise and judgement of human economists.

Box 4.2 – Technical summary of the Elastic Net nowcasting approach

The Elastic Net Regularisation and Variable Selection ('Elastic Net') technique is a machine learning algorithm that augments standard statistical techniques (such as Ordinary Least Squares regression) by introducing a 'penalty factor' in the regression model that constricts the size of the impact between different variables and GDP. This helps to prevent the model from 'over-fitting' past data, and improves predictive power when being used in conjunction with new, unseen data. More specifically, the program "learns" the right penalty size to optimise the model's out of sample performance using a well-known method called "K-fold cross-validation".

The technique's name – the elastic net – comes from the fact that using this particular algorithm allows the use of highly similar variables in the same model, which each help to predict GDP, rather than forcing the modeller to have to choose between them. It creates an invisible 'net' around such groups of variables which can stretch to accommodate additional variables (hence the name 'elastic').

The key benefits of using the elastic net method are its ability to:

- account for the co-movement between different variables over time;

- choose the variables (out of those we had initially selected) worth keeping in the model by learning which are useful for predicting GDP over different time periods and excluding those that are not; and

- predict GDP more accurately using unseen data through K-fold cross-validation (which involves fitting the model over different sub-sets of the data) to figure out the optimal penalty factor.

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7   For more details please see Zou and Hastie (2005) "Regularization and Variable Selection via the Elastic Net", Journal of the Royal Statistical Society. Series B (Statistical Methodology), Vol 67, No. 2
8   For example, the IMF has recently applied the Elastic Net methodology to nowcast Lebanese GDP (see: IMF (2016) "Seeing in the dark: A Machine-Learning Approach to nowcasting in Lebanon" for more details) and has shown that this outperforms another prevalent machine-learning technique known as 'Random Forests' in terms of predictive power. The Deutsche Bundesbank also recently published a working paper titled "Macroeconomic now- and forecasting based on the factor error correction model using targeted mixed frequency indicators" which uses Elastic Net and associated methods to nowcast German GDP.

To determine which variables should be considered in our analysis we have looked to mirror the make-up of the UK economy. As the services sector now accounts for almost 80% of UK GDP, we have included a number of services-focused variables. We have then complemented this with other indicators to account for the production side of the economy and "softer" indicators such as consumer and industrial confidence to capture changes in GDP which occur as a result of expectations. A full list of the variables we considered is set out in Table 4.2[9].

We have tested our nowcasting model over the past four years using the data that would have been available at the end of each quarter (i.e. around a month in advance of the ONS preliminary estimates)[10].

As shown in Figure 4.6, our model performs well over this period: it is able to pick up changes in the direction of actual GDP growth correctly 94% of the time with an RMSE of 0.18%. Indeed, 55% of the nowcasts from this model were within 0.1% of the actual GDP growth value over this four year test period.

**Table 4.2: Variables considered in our analysis**

Variable(s)	Source
• Services index • Industrial production index • Manufacturing index • Construction index • Claimant count • Working days lost to industrial action (000's) • Retail sales index • Consumer price index • Value of exports – balance of payments basis • Value of imports – balance of payments basis • Unemployment rate	ONS
• 3 month average LIBOR • Average unsecured lending rate on credit cards (banks and building societies) • UK mortgage standard variable rate • Average unsecured lending rate on £10k loans (banks and building societies) • UK base rate • British Sterling effective exchange rate index • Monthly average gold price against Sterling	Bank of England
• Value of VAT receipts • Value of corporate tax receipts	HMRC
• Below capacity utilisation survey	CBI
• Services PMI survey • Manufacturing PMI survey • Construction PMI survey	CIPS/Markit
• House Price index	Nationwide
• Consumer confidence indicator • Industrial confidence indicator	European Commission
• Brent Crude Oil Price	Thomson Reuters Eikon

Source: PwC

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9   Variables have been adjusted to a constant price base and de-seasonalised where required.
10 To test our model in the most robust and realistic way, for each quarter between 2013 Q2 and 2017 Q1 we re-estimated our model and utilised the most up-to-date information that would have been available at each point in time to predict GDP growth in that quarter (i.e. only making a "one-step ahead" prediction).

Figure 4.6 – Performance of our nowcasting model
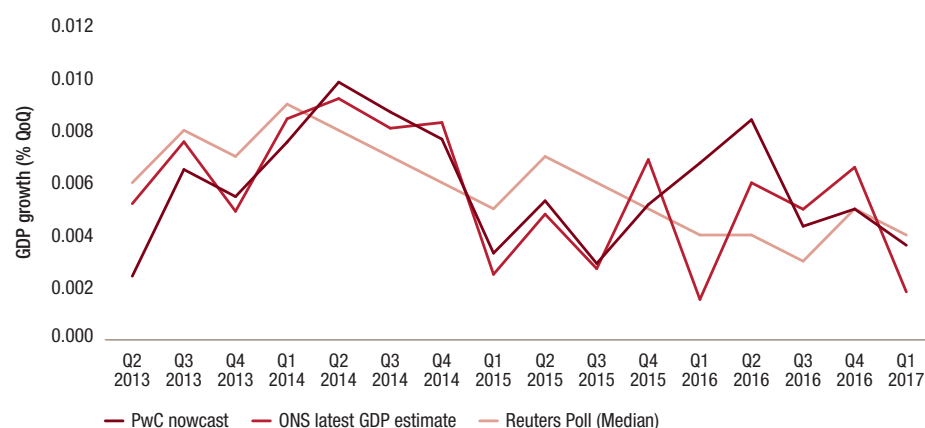
Sources: ONS, Thomson Reuters Eikon, PwC

This improves on the commonly referenced Reuters Poll of Forecasters as our model has both a smaller RMSE and an improved ability to pick up changes in the direction of GDP growth. Furthermore, our model is only marginally worse than the ONS preliminary estimate itself, which has an average RMSE of 0.16% over this period as a predictor of the latest available GDP estimates after later revisions. This is despite the fact that the ONS estimate is based on more available data as it is released around a month later than the effective date at which our nowcasts were made in this test exercise.

However, we recognise that there are two quarters where there were relatively large variances between our nowcast model estimates and the latest available ONS GDP estimates:

- **Q2 2013**. Our model under-estimated GDP growth in this period because in the final month of the quarter there was a larger increase in key variables (notably the ONS services index) than expected when the nowcast would have been made. Unfortunately the impact of a one-off 'surprise' like this is a general limitation of any nowcasting model.

- **Q1 2016**. Our model over-estimated GDP growth in this period because it did not incorporate movements in net trade expenditure and other factors such as inventories that led to a downward revision in estimated growth in this quarter much later in December 2016 and February 2017 (from 0.4% initially to 0.2% in the latest ONS estimates for growth in this quarter).

To arrive at our preferred model specification for each time period we apply the Elastic Net algorithm, which analyses the predictive power of each variable. If a given variable, taken together with the others, does not add to the predictive power of the model, the algorithm 'shrinks' the size of the impact that such a variable has on the nowcast to zero – effectively excluding it from the model.

Performing this procedure over different periods gives us a different mix of important variables over time. This allows us to understand which indicators become more or less important at different times for estimating current GDP growth. Figure 4.7 shows the rank of the top 5 variables included in our model each quarter based on the absolute strength of the estimated relationship they have with GDP.

The ONS services output and industrial production indices are consistently most strongly associated with movements in GDP growth. Construction and manufacturing indices also play a prominent role, being ranked third and fourth over time[11]. Having a lesser, but still important impact, are two indicators that capture other factors: the ONS retail sales index and the Nationwide House Price index[12]. A discussion of these variables and their estimated average relationship with GDP is set out in Table 4.3.

Figure 4.7 – Top 5 variables that impact our nowcasts over the past 4 years
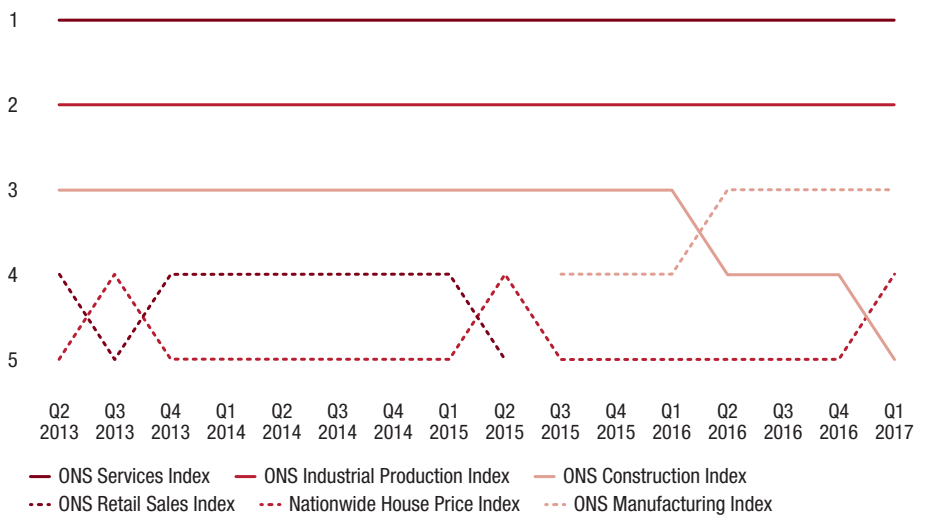
Source: PwC

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11 It is important to note that it is consistent to include multiple similar variables in the model, as the elastic net algorithm is able to make use of the useful, predictive information in each series – if any – without their co-movement being a problem (as explained in Box 4.2).

The estimated relationships represent the average percentage point change in GDP growth that our model associates with a one percent increase in a given indicator[13]. For example, our model estimates that, on average from 2013-2016, a one percent increase in the ONS services index would be associated with a 0.6 percentage point increase in GDP growth.

We think that this analysis is important for two reasons: (i) it allows businesses and policy makers to gain further clarity on which indicators and announcements matter most when trying to understand the current level of GDP growth; and (ii) it allows us to give a more precise estimate of what GDP growth is at any given point in time.

Table 4.3: Discussion of key variables which impact our nowcasts

Variable	Estimated relationship with GDP growth	Discussion
ONS Services index	0.60	This is a monthly indicator of output growth in the services sector, which is the dominant element in total GDP and so, as expected, has the highest weight in our nowcasting model.
ONS Industrial production index	0.13	The ONS Industrial production index is another monthly indicator of output growth but has a smaller weight in our nowcast as it does in total GDP.
ONS Manufacturing index	0.04	Typically a modeller might discard the ONS Manufacturing output index and only use the Industrial production index in compiling a nowcast, since there is a high degree of overlap between the two variables. However, elastic net regularisation allows the model to learn whether there is any residual usefulness to allowing Manufacturing and Industrial production to predict GDP simultaneously and our testing shows that there is.
ONS Construction index	0.03	The ONS Construction index is a quarterly indicator of output growth in the construction sector[14]. As expected, this is positively associated with GDP growth.
Nationwide House Price Index	0.02	House price growth tends to be associated with GDP growth as increases in house prices stimulate confidence and consumer spending by increasing effective wealth. Rises in house prices also stimulate construction output.
ONS Retail sales index	0.02	The ONS Retail sales index measures changes in the volume of retail sales per month and is available on a relatively timely basis compared to other service sector data. This would be expected to be positively associated with GDP growth.
Other variables	<0.01	Other different variables are included in our model over different time periods, but of these the factor that has the most persistent and largest impact is the number of people claiming unemployment benefits. As you would expect, the relationship it has with GDP is negative.

Sources: Bank of England, FRBA, FRBNY, ECB, Norges Bank, PwC

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12 While not featured in Figure 4.9, the number of people claiming unemployment benefits (i.e. the Claimant Count) also had a large impact, but marginally lower than the impact of retail sales or the Nationwide House Price index. This is particularly noteworthy as the Claimant Count represents the variable which tends to have the strongest negative relationship to GDP rather than the positive relationships associated with the other indicators listed in Figure 4.9.
13 Such relationships are presented as an average over 2013Q2-2017Q1
14 The ONS also has a monthly construction index, but this has only been available from 2010 onwards, whereas the quarterly version of the indicator has been available since 1997. We used both when building our model, but found the longer dataset that we could use with the quarterly dataset allowed us to nowcast more accurately.

## 4.4 - Our estimate for UK GDP growth in Q2 2017

Using data available as at 7th July 2017, our nowcast of quarter-on-quarter UK GDP growth for Q2 2017 is around 0.3%. As shown in Figure 4.8, this is very slightly higher than the latest ONS estimate of GDP growth in the first quarter of 2017 (0.2%), but still remains significantly lower than our current estimate of long-term trend quarterly UK growth of around 0.5%

A full decomposition of our nowcast is set out in Figure 4.9. This shows that our prediction of a slight pick-up in GDP growth from the first quarter of 2017 is predominantly driven by somewhat stronger growth in the services sector. Retail sales growth in particular was stronger in April, although it did then fall back in May.

However, manufacturing and construction sector growth will be weaker than in the first quarter based on currently available data, pulling down overall estimated GDP growth in the second quarter. Relatively weak recent house price growth (based on the Nationwide index, which we use here as it is more timely than the official ONS house price data) also contributes to our estimate of continued subdued overall GDP growth in Q2 2017.

As Figure 4.9 shows, our unrounded estimate for Q2 2017 GDP growth is 0.25%, though we have rounded this up to 0.3% in line with the usual ONS practice of expressing GDP growth rates to only one decimal place. But, based on our nowcast, it would not be a big surprise if the preliminary ONS GDP estimate for Q2 came out at 0.2%.

Figure 4.8 – UK GDP growth (% QoQ) Q2 2013 - Q2 2017
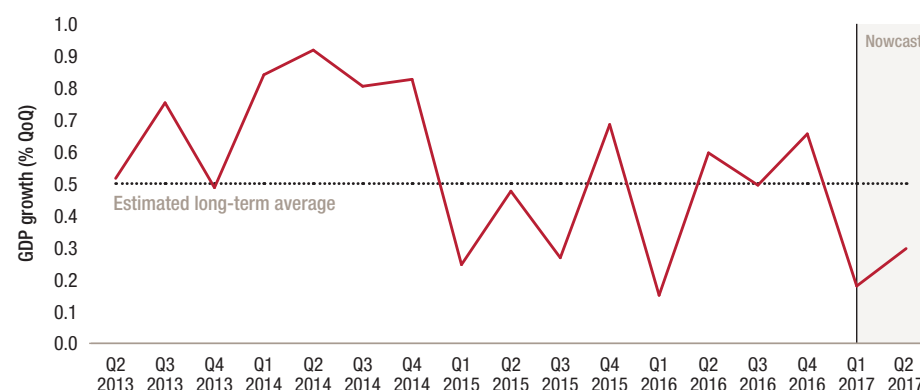
Sources: ONS, PwC

Figure 4.9 – Decomposition of our Q2 2017 GDP growth nowcast[15]
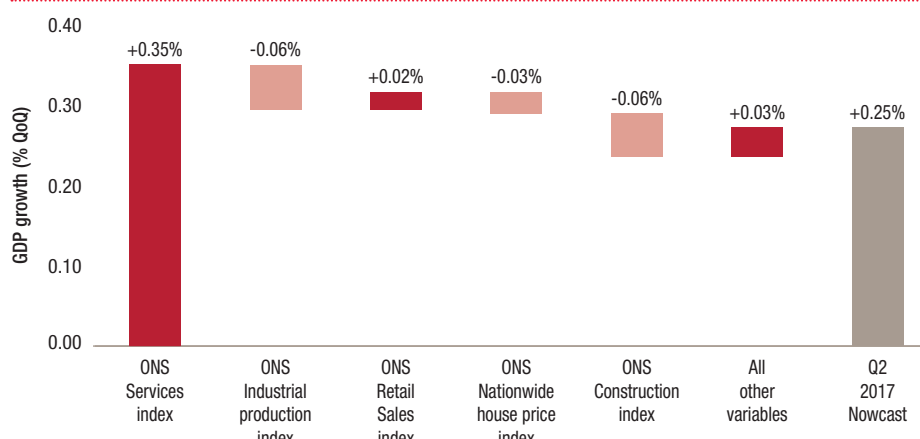
Source: PwC

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15 The main contributor to the positive contribution of other variables is a constant term that is included to approximate other factors that are not included explicitly in our model.

In summary, Q2 2017 growth may be slightly higher than in the first quarter, but still some way below long-term trend. As discussed in Section 2 above, we expect this relatively sluggish growth to continue for some time given ongoing uncertainty relating to the Brexit negotiations and the squeeze on real consumer spending power from higher inflation linked to the weakness of the pound since the EU referendum last year.

4.5 – Summary and conclusions

With a slowing economy and relatively high levels of political uncertainty in the UK, it is important for businesses and policymakers to get an accurate understanding of the state of the economy in a timely way. We have shown that nowcasting presents an effective way to do this, using current data which is published on a more frequent basis than official ONS estimates of GDP.

Using our machine-leaning-based nowcasting model we estimate that GDP growth in the second quarter of 2017 will continue to be relatively sluggish at around 0.3% on the previous quarter. This is up very slightly from 0.2% in the first quarter of 2017 due to somewhat stronger projected growth in the services sector, but still some way below estimated trend GDP growth of around 0.5% per quarter. This means that the first half of 2017 seems likely to see the weakest six months of UK GDP growth since 2012 during the Eurozone crisis.

We have focused on GDP estimates in this article, but there are also a range of other possible applications of nowcasting techniques, for example in estimating sectoral GVA and industry sales. The ability to apply nowcasting techniques to such a wide variety of different contexts makes them potentially powerful tools that can help policy makers and businesses to understand the present state of the economy and their markets better, so that they can plan more effectively for the future.

Appendix A
Outlook for the global economy

Table A.1 presents our latest main scenario projections for a selection of economies across the world.

World economic growth strengthened through 2016 and this is expected to continue, increasing the global weighted average real growth rate to 2.9% in 2017 and 3% in 2018 (using GDP at market exchange rates as weights). This growth is expected to be driven by the large emerging economies with continued strong growth of around 7-7.5% in India and around 6-6.5% in China projected for 2017 and 2018. The outlook for emerging markets has also brightened as a result of improving economic conditions in Russia and Brazil, which are now moving gradually out of recession.

Steady but moderate growth of around 1.5-1.6% is projected for the Eurozone in 2017 and 2018. Relative to the rest of the G7, quite strong growth is projected for the US economy in 2017-18 as fiscal stimulus strengthens an already recovering economy. But this could be offset by gradual rises in US interest rates to keep inflation under control.

These projections are updated monthly in our Global Economy Watch publication, which can be found at www.pwc.com/gew

Table A.1: Global economic growth and inflation prospects

	Share of world GDP	Real GDP growth (%)		Inflation (%)	
	2016 at MERs	2017	2018	2017	2018
US	24.5%	2.2	2.4	2.3	2.5
China	15.2%	6.5	6.1	1.8	2.5
Japan	5.6%	1.0	0.7	1.3	1.5
UK	3.9%	1.5	1.4	2.8	2.9
France	3.3%	1.5	1.4	1.2	1.3
Germany	4.6%	1.5	1.5	1.8	1.9
Greece	0.3%	1.6	2.0	0.8	1.2
Ireland	0.4%	3.6	3.2	1.0	1.2
Italy	2.5%	1.0	0.9	1.1	1.2
Netherlands	1.0%	1.6	1.7	1.5	1.5
Portugal	0.3%	1.4	1.2	1.0	1.0
Spain	1.6%	2.3	2.1	1.3	1.5
Poland	0.6%	3.2	3.4	1.7	1.7
Russia	1.8%	1.1	1.4	4.7	4.5
Turkey	1.0%	2.6	3.1	9.6	8.0
Australia	1.7%	2.7	2.8	2.5	2.2
India	2.8%	7.3	7.4	5.0	4.9
Indonesia	1.2%	5.1	5.3	4.5	4.4
South Korea	1.9%	2.6	2.8	1.6	2.8
Argentina	0.9%	2.3	2.6	25	-
Brazil	2.4%	0.4	1.5	5.0	4.5
Canada	2.1%	2.0	2.1	2.1	2.1
Mexico	1.6%	1.5	2.0	4.0	3.5
South Africa	0.4%	0.9	1.5	6.2	5.8
Nigeria	0.7%	0.8	1.8	15.8	14.1
Saudi Arabia	0.9%	0.8	1.5	3.5	4.4
World (PPP)		3.4	3.5	3.1	3.0
World (Market Exchange Rates)	100%	2.9	3.0	2.7	2.7
G7	46.4%	1.8	1.8	2.0	2.2
Eurozone	15.8%	1.6	1.5	1.4	1.5

Source: PwC main scenario for 2017 and 2018; IMF for GDP shares in 2016 at market exchange rates (MERs).

Appendix B
UK economic trends: 1979 – 2016

Annual averages	GDP growth	Household expenditure growth	Manufacturing output growth*	Inflation (CPI**)	3 month interest rate (% annual average)	Current account balance (% of GDP)	PSNB*** (% of GDP)
1979	3.7	4.8			13.7	-0.6	4.3
1980	-2.0	0.1			16.6	0.5	3.9
1981	-0.8	0.3			13.9	1.5	3.1
1982	2.0	1.2			12.2	0.6	2.3
1983	4.2	4.4			10.1	0.2	3.0
1984	2.3	2.5			10.0	-0.5	3.3
1985	4.2	5.1			12.2	-0.3	2.6
1986	3.2	6.1			10.9	-1	2.0
1987	5.4	5.1			9.7	-1.6	1.3
1988	5.8	7.4			10.4	-3.6	-0.6
1989	2.6	3.9		5.2	13.9	-4.1	-0.6
1990	0.7	1.0		7.0	14.8	-3.1	0.6
1991	-1.1	-0.6		7.5	11.5	-1.3	2.6
1992	0.4	0.9		4.3	9.6	-1.5	5.6
1993	2.5	2.8		2.5	5.9	-1.3	6.8
1994	3.9	3.2		2.0	5.5	-0.5	5.8
1995	2.5	2.1		2.6	6.7	-0.7	4.7
1996	2.5	3.9		2.5	6.0	-0.6	3.3
1997	3.1	4.5		1.8	6.8	-0.2	1.6
1998	3.2	3.9	0.4	1.6	7.3	-0.4	-0.1
1999	3.3	4.9	0.6	1.3	5.4	-2.4	-1.1
2000	3.7	4.9	2.2	0.8	6.1	-2.1	-1.8
2001	2.7	3.5	-1.5	1.2	5.0	-1.9	-0.6
2002	2.4	3.7	-2.2	1.3	4.0	-2	1.6
2003	3.5	3.8	-0.6	1.4	3.7	-1.7	2.6
2004	2.5	3.3	1.8	1.3	4.6	-1.8	2.7
2005	3.0	3.0	0.0	2.1	4.7	-1.2	2.9
2006	2.5	1.8	2.2	2.3	4.8	-2.2	2.6
2007	2.6	3.0	0.6	2.3	6.0	-2.4	2.4
2008	-0.6	-0.8	-2.8	3.6	5.5	-3.5	5.2
2009	-4.3	-3.5	-9.4	2.2	1.2	-3	10.1
2010	1.9	0.7	4.6	3.3	0.7	-2.7	9.1
2011	1.5	-0.7	2.2	4.5	0.9	-1.8	7.1
2012	1.3	1.9	-1.5	2.8	0.8	-3.7	7.7
2013	1.9	1.6	-1.0	2.6	0.5	-4.4	5.9
2014	3.1	2.1	2.9	1.5	0.5	-4.7	5.6
2015	2.2	2.5	-0.2	0.0	0.6	-4.3	4.2
2016	1.8	2.8	0.8	0.7	0.5	-4.4	2.9
Average over economic cycles****							
1979 - 1989	2.8	3.7			12.2	-0.8	2.2
1989 - 2000	2.3	3.0		3.3	8.3	-1.5	2.3
2000 - 2014	1.8	1.9	-0.2	2.2	3.3	-2.6	4.2

* After the revisions to the national accounts data, pre-1998 data is not currently available ** Pre-1997 data estimated *** Public Sector Net Borrowing (calendar years excluding public sector banks)
**** Peak-to-peak for GDP relative to trend
Sources: ONS, Bank of England

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