

Department of Economics and Centre for Macroeconomics public lecture

Debt, Demographics and the Distribution of Income: new challenges for monetary policy

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1. Introduction

In the pre-crisis years, most macro-economists and policymakers used to think of the economy as typically being on a stable growth path with output near its potential level, and with temporary shocks creating short-lived deviations from this path. Monetary policy was largely about responding to these temporary shocks to bring the economy back to its stable equilibrium path swiftly. Monetary policy was therefore mainly driven by cyclical factors: factors that were temporary in nature and that only explained deviations from the economy's potential, which in turn would make the inflation rate deviate from the target rate. I am simplifying here, of course, but I think many central bankers and macroeconomists would recognise this basic description.

In contrast, I believe the setting of monetary policy is currently driven at least as much by structural developments in the UK and globally that may have persistently changed the relationship between growth and interest rates.¹

My particular focus today will be on “3 Ds”: debt, demographics and distribution of income. Some economists have been paying attention to these issues for a long time. But monetary policy makers have not focused on them much, until quite recently. I want to argue that we should.

I will argue that changes in the 3 Ds are interacting powerfully to create an environment where a given level of growth might be consistent with substantially lower interest rates than in the past. This environment might persist for years, even decades. Despite substantial uncertainty about the magnitude and duration of these effects, I draw out some policy implications.

First, the economy may not revert to its pre-crisis average levels of growth and interest rates. But many of the models we use in policy analysis do revert to pre-crisis averages, because persistent effects from the 3 Ds are ruled out by design, to keep the models simple. Although models are useful simplifications of a complex world, we should heed Einstein's recommendation that: “Everything should be made as simple as possible, but not simpler”. We should be careful not to place too much weight on models that have strong mean reversion built in by assumption. The longer our forecasting horizon, the more forcefully this argument applies. Second, for a given level of growth, real interest rates may remain significantly lower than in the past. The possibility of this scenario makes me more patient, other things equal, before raising rates, because we may not have to raise rates very much once we start. Moreover, the fact that, at very low interest rates, policy cannot respond as effectively to bad news as it can to good news also makes me more patient before raising rates.

Finally, I will discuss recent developments in UK growth and inflation, and argue that, in order to be confident enough of the medium-term inflation outlook to justify raising Bank Rate, I would like to see more evidence that growth is stabilising after its recent slowdown, and that a broad range of indicators related to inflation are generally on an upward trajectory from their current low levels.

2. Debt

Debt matters. That was a controversial statement a decade ago. It is far less controversial now.

Post-crisis, we now have ample evidence that households and firms with higher debt levels reduce spending more sharply than those with lower debt levels in response in a downturn.² After a drop in income, debt relative to income goes up even further, to a level that is higher than where the borrower (or the lender³) wants it – a debt overhang. The borrower wants or needs to reduce debt, and in order to achieve that, they cut back spending very sharply.

These micro effects can have macro consequences. Recessions that follow a substantial build-up in debt are more severe and longer-lasting than recessions without a substantial build-up in debt, as can be seen in Figure 1.⁴

The objective of policymakers is to keep inflation close to its target by minimising the shortfall in spending, keeping the economy operating as closely as possible to its full potential. In response to any reduction in spending relative to potential, the central bank cuts interest rates. In response to a sharp and persistent reduction in spending following a debt overhang, the central bank cuts interest rates sharply and keeps them low persistently. I would like to elaborate on the forces at work here.

To reduce an aggregate debt overhang, there are broadly two mechanisms available. The first, fast but painful in the short-term, would be for the borrowers to restructure the debt, imposing a loss on the lenders. That mechanism is typically only available in a small number of cases, and there are no economy-wide tools available for large-scale debt restructuring across many borrower categories.⁵ The question is, in any case, entirely outside the remit of the Monetary Policy Committee.

The second method for reducing a debt overhang is slow: if the rate of income growth of the borrower exceeds the rate of interest on the loan, then simply keeping the debt stock fixed – i.e. not borrowing more – will reduce the ratio of debt to income over time, without sharp additional reductions in spending. Why is it important for interest rates to be as low as possible? Because with high interest rates the debt burden would keep rising, as interest gets added to the stock of debt, keeping pace with, or outstripping, income growth. Why is it the process slow? Annual aggregate income growth in most economies tends to be a few per cent per year.⁶ And interest rates on loans are typically above zero, even with policy rates that are nearly zero. So the debt burden erodes only by a few percentage points per year at most.

Monetary policy is set to keep spending in line with the economy's potential, so that inflation is close to target, as I just said. Monetary policy is therefore indifferent between who does the spending. However, if the behaviour of highly indebted borrowers is such that they cut spending more than interest rate reductions are able to stimulate the spending of other borrowers, and savers, then monetary policy must take into account the deleveraging process. Not because it matters per se, but because the debt deleveraging affects aggregate spending, and in turn inflation.

In 2008-09, the MPC cut interest rates all the way to 0.5% – what it perceived to be the effective lower bound at the time – and judged that this was still not enough. Asset purchases were a tool to try to keep stimulating spending when policy rates could not be cut any further. However, asset purchases are an imperfect substitute for lower interest rates, as they transmit a spending impulse to the economy via different channels (wealth effects, reduced risk premia) and the impact of asset purchases – a relatively new tool – is far more uncertain. The fact that policy rates are constrained near zero⁷ may have contributed to the persistent disappointment of growth in the recovery. If we had been able to cut interest rate by several percentage points more, the deleveraging progress might have been faster, and spending might have recovered sooner.

So it is the presence of the lower bound on policy rates together with a debt overhang that has the potential to create persistently weak recoveries.

This argument also highlights a separate reason for why it is particularly crucial during a deleveraging period to keep inflation expectations anchored. As I have argued, the speed of deleveraging is influenced by the

extent to which nominal income growth exceeds nominal interest rates. If, during the weak recovery, inflation drifts persistently below target when interest rates are at their effective lower bound, this reduces the maximum pace of deleveraging that can be achieved, and delays the moment at which normal spending patterns can resume. In this particular argument, inflation has an asymmetric effect on medium-term growth prospects, which in turn feed back onto inflation prospects. Low inflation has a greater risk of becoming entrenched.⁸

Has the low interest rate environment been effective in facilitating an unwind of the debt overhang? Yes. The UK is a good example. The private (non-financial) sector debt to GDP, which rose from 120% to 190% during the pre-recession decade, has fallen back to less than 160% (see Figure 2).

However, looking at the world more broadly, we see that advanced economies as a whole have not yet managed to reduce their debt burden (Figure 3). So the process of reducing the debt overhang probably has further to run. Moreover, emerging markets experienced a more recent run-up in indebtedness, which started around the time of the crisis, and is still continuing. In other words, their deleveraging has not even begun. This has the potential to create persistent spending disappointments, if monetary policy is unable to stimulate other spending sufficiently.

3. Demographics

My second “D” is for demographics. Like debt, it can have long-lasting effects on the relationship between growth and interest rates⁹. The mechanisms are more complex and work along many dimensions. But the impact is potentially large, and even longer-lasting than the effect of debt, because demographic transitions persist for decades.

There are two demographic changes at work across a wide range of countries, which interact in complex ways. First, longevity has risen and is expected to continue rising for the foreseeable future (Figure 4). We are living longer. Second, fertility has declined (Figure 5). We are making fewer babies.

This leads to persistent changes in key demographic variables. First, population growth is slowing. Second, and more importantly, because fertility was high many decades ago (the “baby-boom”) and has been low thereafter, the growth in the number of people of working age is slowing more sharply than the population as a whole (Figure 6). If you make fewer babies, eventually that means you are making fewer workers.

The economic impacts of these effects do not all go in the same direction. A rise in longevity, without a commensurate rise in the retirement age, makes us want to save more, as our savings will have to sustain us for longer. A rise in desired savings pushes the real interest rate down.

Slower growth in the working age population means that we need less capital (or need to grow the capital stock more slowly). Fewer workers require fewer buildings and machines; each unit of capital becomes less productive. There is therefore a reduction in desired investment, again pushing the real interest rate down. The fact that we are facing a rise in the number of retirees relative to the number of workers, the dependency ratio (Figure 7), means that we will have more people with lower savings rates (retirees generally do not save) and fewer people with higher savings rates (workers do save). That compositional effect lowers the total desired savings and pushes the real interest rate up.

Which effect dominates? Much further research needs to be done to be confident of the answer, but let me offer two indications that the net effect might be to push real interest rates down significantly.

First, in a recent paper, Carvalho, Ferrero and Necchio (2015) propose an economic model to analyse the interaction between the three effects. They calibrate the model to match the demographic changes that have taken place in G7 countries since 1990, and find that the net effect is to push real interest rates down by 1.5 percentage points so far, with a potential further reduction of 0.5pp still to come.

Second, let us look at the example of Japan. Japan has undergone the demographic changes that other advanced economies are going through, but experienced its reduction in the growth of the workforce, and its increase in the dependency ratio, much earlier on. Japan is about two decades ahead, in demographic terms (Figure 8).¹⁰ Long-term interest rates in Japan fell in the 1990s, showing a very similar pattern then to long-term interest rates in other advanced economies in recent years.

Indeed, in earlier work Carvalho and Ferrero suggest that failing to identify the negative effect of demographics on real rates, and hence on the appropriate stance of monetary policy, could explain the persistent deflation in Japan since 1990s.

Where does this leave us? The economic effects of demographics are clearly complex, but there are some persuasive arguments that suggest that the combined effect might be to push down on real interest rates, and there is at least the possibility that the effect is quite large. Moreover, demographic effects are even more slow-moving than debt effects, so the impact on real rates might be even longer-lasting¹¹.

4. Distribution of income

My third D is for “distribution of income”. This is the most speculative one of my three arguments, and the one that needs further research the most.

Our understanding of the full macroeconomic effects of different income and wealth distributions is still in its infancy, but the work so far suggests it matters greatly. For example, although it has long been recognised that monetary policy might have distributional effects, the textbook model has it working exclusively through inter-temporal substitution of a representative agent (the consumption-saving decisions described earlier). Using a far richer framework, Auclert (2015) finds that a redistribution channel could be as important in explaining why aggregate consumer spending reacts to transitory changes in the real interest rate. If distributional considerations are of first-order importance for understanding the monetary policy transmission, then large shifts in the distribution of income and wealth should be expected to have material consequences for monetary policy. To put it simply: if we know that monetary policy works through distributional effects, it is natural to expect that distribution has monetary policy effects.

As T. Picketty, A. Atkinson and E. Saez and co-authors have pointed out, the distribution of wealth and income within many countries has become less equal over the past several decades. In particular, the wealth and income of the richest segment of the population has risen much faster than that of the rest of the population (Figures 9 and 10).

There is ample micro-economic evidence that the rich have a low marginal propensity to spend. That is highly intuitive: if you give a rich person ten pounds, he is likely to spend less of it, i.e. save more, than if you give a poor person ten pounds. By shifting economic resources towards those more likely to save them, rising income inequality might also be pushing up on desired savings. Rachel and Smith (2015) perform a simple calculation: if you increase the share of national income that has gone to the richest fifth by 7pp (change in the US since 1980), then the net effect on desired savings is an increase of around 2pp. This change alone could push real interest rates down by 0.5 percentage point (see Rachel and Smith (2015), pg 39).

This is only a partial equilibrium calculation, which leaves the demand for investment unchanged. But recent attempts to address the question of rising inequality in a general equilibrium context suggest an overall negative effect on real interest rates, and even a potential role in explaining persistent slumps when combined with the effective lower bound on interest rates.¹²

The potential impact of changes in the distribution of income goes much further than the direct compositional effect on savings. As Kumhof and Ranciere (2010) point out, a rise in inequality could itself reinforce the rise in debt, as households at the lower end of the income and wealth distribution try to maintain consumption growth despite weaker income growth. Kumhof and Ranciere (2010) show that it has been the lower end of the wealth distribution that has driven the rise in household debt. When there is a realisation that the drop in income growth is more persistent than initially believed, the accumulated debt will be seen as too high, and households will be trying to deleverage, pushing income growth down further for a sustained period, beyond the impact of income inequality alone.

More generally, it is not hard to imagine – though very hard to model – a story where all three Ds interact.¹³ A high debt economy faces headwinds and needs lower interest rates. A high debt economy with adverse demographic trends needs even lower interest rates. And a high debt economy with adverse demographic trends and higher inequality ... well, you get the picture.¹⁴

5. Policy implications

As policy-makers, how are we to incorporate these potentially large but uncertain effects in our thinking?

Standard models for analysing monetary policy are not suited to analysing these effects. The workhorse models for monetary policy are still mostly models with an infinitely-lived representative agent and a deterministic steady state, as well as further simplifying assumptions.¹⁵

Do we use these modelling assumptions because we believe in them? No. We use them because they make the models easier to work with. Recently, there has been much progress in models that abandon these simplifying assumptions. But these mechanisms are still a long way from being usable in a quarterly central bank forecasting model.

In the meantime, we should focus on what we may be missing in our simplified models, and what insights the more complex models provide even if they are not part of our regular toolkit.

Representative agent models imply that, by design, debt does not matter, there are no demographics and there is no distribution of income. That's an important insight. The 3Ds do not matter in standard models, not because rigorous analysis concludes that this is so, but because it has been assumed to be the case. It is not surprising that many economists struggle to make sense of low real interest rates by using a representative agent model.¹⁶

A deterministic steady state means that the model dynamics are driven by temporary shocks, after which the model variables all return to where they were before.¹⁷ Where they return to is typically not really explained by the model. Moreover, it is easy to learn how the economy works, because everything is stable. So assuming that we know the parameters of the model pretty well seems like reasonable assumption. With the 3Ds, these assumptions are obviously wrong. Variables can progress along multi-decade trends without any shocks at all, and the past might be a terrible guide to the future.

Having established that the workhorse models are not suitable for analysing the 3Ds, should we bin the models altogether? Certainly not.

Many features of the workhorse model are still valid. Policy rates still influence short-term growth. Growth still influences slack. Slack still influences inflation. The key steps of the monetary transmission channel are not lost.

But what growth rate will the economy converge to after short-term effect of monetary policy wears off? What level should the policy rate reach when inflation is sustainably back to target? And might where we end up in the medium term also be influenced by policy? These are the questions where the 3Ds play a potentially large role.

Given our still limited understanding of these issues, let me nevertheless offer some policy implications even based on what little we know.

My first policy implication is: do not be confident that the future will look like the past. Representative agent models with a deterministic steady state will always forecast that the future is like the past. They are not useful for answering questions about very long-lasting changes to real interest rates and growth. Relying on these models for analysis of what the economy will look like in a few years is very risky indeed. It results in mean-reverting forecasts like those made by state-of-the-art DSGE models, as shown by the real time estimates of the implied natural interest rate by Curdia (2015)¹⁸ shown in Figure 12. Private sector forecasts of policy rates have also been continuously predicting a reversion to the mean (Figures 13 and 14). Predicting inexorable reversions to the mean can lead to not only big and persistent forecast errors, but can culminate in serious policy mistakes.¹⁹

My second policy implication is: be prepared for the possibility that real interest rates will remain well below their historical average for a very long time, even with economic growth that is close to or only somewhat below its historical average.

This has a direct impact on my own policy views. If I were confident that, over the next few years, policy rates would have to rise significantly to match historical averages of real interest rates, I would be looking for the first possible opportunity to raise rates, to avoid having to raise them very sharply in the next few years.

But I am not confident of that at all. Rather, I think it is plausible that the appropriate real interest rate for the economy might be very low for years to come. So policy rates, when they rise, may not need to rise by much over the coming years. These medium-term considerations make me relatively more patient before raising rates.

The need for patience is further reinforced by the asymmetry that I believe we currently face in monetary policy. While there is some scope for further stimulus should it be required, both via small further reductions in interest rates and via further asset purchases, I believe our ability as a central bank to stimulate spending is nevertheless smaller than our ability to restrain spending, due to the effective lower bound on interest rates, and the fact that asset purchases are an imperfect substitute for rate cuts. Even with symmetric preferences around the inflation target, I must take account of the fact that we cannot respond to bad news as effectively as we can respond to good news. That potentially makes the effects of bad news more persistent even when monetary policy does all it can.²⁰

6. Current outlook

Having discussed highly persistent factors that might influence the outlook for years or decades, let me now shorten my horizon a little and discuss recent developments in the UK economy. The UK recovery gained momentum in 2013, with year over year GDP growth rising from less than 1% to a local peak of around 3% in early 2014. Since then, growth has been slowing modestly to reach a pace of close to 2%.

Over the same period, the composition of global growth has changed, with advanced economy growth relatively stable but growth in emerging economies falling quite sharply, contributing to volatility in global financial markets. Oil prices have fallen sharply due to a combination of rising supply and easing global demand. The risk of a further slowing in emerging economy growth, and risk of spill-overs to advanced economy growth, is one of the key downside risks the MPC highlighted in its November Inflation Report.

Domestically, growth has been supported by resilient private domestic demand in the face of headwinds from abroad as well as from on-going domestic fiscal consolidation. Since 2013, the unemployment rate in the UK has gone from falling rapidly initially, to falling more slowly, to just above 5% in the most recent data available.

Headline CPI inflation has fallen from nearly 3% in 2013 to around zero for most of last year, well below the 2% target. Most of the deviation of inflation from target can be attributed to falls in the prices of food, energy and other imported goods, which in turn was due to the combined effect of sharply lower oil prices and a stronger exchange rate.

Aside from headline CPI, other measures of inflation pressure have also been weak.

Core CPI inflation eased from above 2% in 2013 below 1% last summer, but has recovered somewhat since then.

Household inflation expectations surveys have been slightly below their 15-year averages. And some surveys of companies' inflation expectations, for which we do not have long data histories, have eased recently. As I mentioned earlier, an easing of inflation pressures carries an asymmetric risk, as it can generate its own persistence when monetary policy is close to its lower bound. Market measures of future inflation remain consistent with the target, and it is crucial that this is maintained.

With the unemployment rate approaching the MPC's estimate of long-run equilibrium of around 5%, we might have expected to see some signs of upward wage pressure, but my interpretation of a wide range of indicators related to pay is that upward wage pressures have been surprisingly absent so far.

The official data on average weekly earnings (AWE) showed some signs of acceleration in late 2014 and early 2015, but since then the upward momentum has stalled and even reversed partially. Regular private sector pay growth briefly rose to nearly 4%, but has since eased back to around 2%. Looking at a range of other pay-related indicators,²¹ I do not see convincing evidence yet of upward momentum in pay pressures. With growth still slowing, and inflation pressures either easing outright or disappointing relative to forecasts, I do not believe the conditions are in place to warrant a rise in Bank Rate.

Although I share the MPC's November forecast of stabilising growth and gently rising inflation pressures to bring inflation back to its 2% target in around two years, we have been disappointed on both the growth and inflation front since November. I need to see further evidence that growth is indeed stabilising, and that a broad range of indicators relating to inflation, inflation expectations and pay growth are generally on an upward trajectory from their current low levels before being confident enough in the outlook to justify a rise in Bank Rate.

7. Conclusion

I have argued that changes in debt, demographics and the distribution of income (the 3 Ds) may have persistently altered the relationship between real interest rates and growth, over horizons of years or even decades.

The economy may not revert to its pre-crisis average levels of growth and interest rates. But many of the models we use in policy analysis do revert to pre-crisis averages, because persistent effects from the 3D s are ruled out by design.

For a given level of growth, real interest rates may remain significantly lower than in the past. The possibility of this scenario makes me more patient, other things equal, before raising rates. Moreover, at very low interest rates, policy cannot respond as effectively to bad news as it can to good news. That asymmetry also makes me more patient before raising rates.

The recent evolution of the UK data has been one of growth that is still solid, but has been slowing. Inflation pressures remain muted across a wide range of indicators, despite low levels of unemployment. In order to be confident enough of the medium-term inflation outlook to raise Bank Rate, I would like to see evidence that growth is not slowing further, and that a broad range of indicators related to inflation are generally on an upward trajectory from their current low levels.

¹ Most of the issues in my speech have featured in the debate about “secular stagnation” raised by Summers (2014) (see discussion in Teulings and Baldwin (2014)), or have been analysed with a particular focus on long term real rates (see Bean *et al* (2015) and Rachel & Smith (2015) and references therein for comprehensive discussion).

² See Mian and Sufi (2009, 2010, 2011), IMF (2012), Bunn and Rostom (2015), Cloyne and Surico (2016), and Cloyne *et al* (2015), among many others.

³ My focus on this talk will be on deleveraging effects through borrowers, though there is a large amount of research, evidence and policy discussion (FPC/PRA) focusing on the role of lenders balance sheets in originating, propagating and amplifying the effects of deleveraging.

⁴ See Schularick and Taylor (2012), Mian *et al* (2015), Jorda *et al* (2013), Reinhart and Rogoff (2009), IMF (2012), and Juselius and Drehmann (2015), among many others.

⁵ As Mian, Sufi and Trebbi (2010, 2014) discuss, there are significant institutional and political obstacles to large scale debt restructuring, which is one reason why, for example, there was no large-scale mortgage principal reduction in the US following the crisis. The European debt crisis is another clear example of where politics become a major issue determining the feasibility of what might be economically desirable arrangements.

⁶ That is true for economies that have a low inflation target and have actual inflation close to target.

⁷ Where exactly the lower bound on policy rates is, depends on institutional features of a country’s financial system and preferences of policymakers. But the fact that policy rates are constrained somewhere near zero is a deep feature of any economy that has paper currency. Were a central bank to try to set policy rates too low, people would have an incentive to hold more and more of their wealth in paper currency, whose nominal yield is zero. So policy rates too far below zero become increasingly ineffective, possibly counter-productive.

⁸ The fuller story emphasises the potential for a debt-deflation spiral first proposed by Fisher (1933) to understand the Great Depression, particularly when monetary policy is constrained by the lower bound on nominal interest rates. See Eggertsson and Krugman (2012), Benigno *et al* (2015), Guerrieri and Lorenzoni (2015), Eggertsson and Mehrotra (2014), Korinek and Simsek (2015), Rognlie *et al* (2015) for modern treatments of the dynamic effects of deleveraging when monetary policy is constrained. In these models the crucial policy prescription is to ensure low enough real rates, which involves keeping inflation high enough. Downward nominal wage rigidity is another nominal friction that means we care about keeping inflation rates anchored, as falling inflation would put further downward pressure on the real economy by exacerbating labour market frictions (Benigno and Ricci (2011), Daly and Hobijn (2014), Fallick *et al* (2016)). The evidence of downward nominal wage rigidity is another reason to worry about low inflation.

⁹ An early reference here is Keynes (1937), who analysed the macroeconomic impact of a stagnating or declining population. He argued that the reduction in desired investment would require lower interest rates. He also argued that a more equal income distribution would be beneficial, in order to reduce desired saving.

¹⁰ There is also a long-standing economic debate about the direct asset pricing effects of demographic shifts. Significant changes in the relative size of prime age earning cohort can have material impact on the prices of risky assets, including equities and housing (Geanakoplos *et al* (2004), Abel (2001, 2003), Mankiw and Weill (1989)). The relative timing of housing crises coincides with the relative timing of demographic changes in Japan and Western Economies. This suggests the medium term boom-bust cycle in housing and risky assets could itself be related to demographic cycles if agents fail to see the long but transitory effect of demographics on prices, and wealth (which is plausible given our difficulty in agreeing or even identifying them from available data).

¹¹ Long-run forecasts of the key demographic variables we have highlighted depend not only on the future evolution of fertility and longevity, but also policies that affect migration and labour market participation.

¹² See for example Eggertson and Mehrotra (2014) and Auclert and Rognlie (2015).

¹³ Eggertsson and Mehrotra (2014) is a rare example of a framework considering all three as potential factors for generating persistent slumps that need not revert back to old normal.

¹⁴ The last time we had similar demographic prospects, debt deleveraging and income inequality as high as today was in the late 1930s, when Alvin Hansen raised the prospect of "secular stagnation". In Hansen's defence, the baby boom and massive fiscal expansion during and after WWII are exactly what would counteract or reverse the drivers of his secular stagnation hypothesis.

¹⁵ These include local approximations (predominantly linear approximations), perfect foresight, which combined result in the absence of any reasonable role for risk and uncertainty as well as no occasionally binding constraints such as the lower bound on interest rates. See critical reviews by Caballero (2010) and Korinek (2015).

¹⁶ The papers cited in footnotes 8 and 12 feature deviations from representative agents as a crucial element. See also Kaplan *et al* (2016), Cloyne *et al* (2015) and Best *et al* (2015) for further theory and empirical evidence for how relaxing the representative agent model assumption is crucial for understanding the transmission of monetary policy.

¹⁷ Brunnermeier and Sannikov (2014) is a good example of the importance of moving away the deterministic steady state modelling. They model endogenous risk in a dynamic general equilibrium model in the spirit of much of the canonical macro literature with credit frictions pioneered by Ben Bernanke, Nobu Kiyotaki and others, but without linear approximations around a steady state. Solving for the full nonlinear equilibrium they find much richer dynamics for leverage and risk premia, and show that amplification mechanisms are much larger because we do not know for sure we will recover to the steady state (which is the case with deterministic steady state). In fact, the economy can stay away from the ergodic steady state for long periods of time.

¹⁸ The natural rate of interest is the real interest rate that is consistent with an economy at full employment and with stable inflation. Curdia *et al* (2015) suggest this is a useful measure to assess the appropriate stance of monetary policy.

¹⁹ A number of prominent economists (among them Ben Bernanke, Mike Woodford, Paul Krugman and Lars Svensson) argued forcibly in the late 1990s early 2000s that Japan could have done more to avoid the persistent deflation since their experience at near zero interest rates started, including not responding to signs of increasing inflation prematurely. And it is the prevalent view in the economics profession that the magnitude of the real economy contraction during the Great Depression was partly due to monetary policy not being sufficiently accommodative (Ben Bernanke being a leading academic on the subject). The rapid and aggressive monetary policy easing in the recent crisis, including the use of unconventional monetary policy and forward guidance, reflects this view of monetary policy when constrained by the lower bound on nominal interest rates.

²⁰ Orphanides and Wieland (2000), Evans *et al* (2015) and Gust *et al* (2015) have made the case for asymmetric optimal policy response induced by the presence of a lower bound on interest rates, leading to a delayed rate rise relative to an unconstrained counterfactual. This effect has been highlighted in recent speeches by Janet Yellen (2015) and Lael Brainard (2015).

²¹ BCC, CBI, REC, VOCA, Private Sector Settlements, CIPD, and the BoE Agents' Survey.