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The rebuilding macroeconomic theory project: an analytical assessment

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Abstract: In this paper we review the Rebuilding Macroeconomic Theory Project, in which we asked a number of leading macroeconomists to describe how the benchmark New Keynesian model might be rebuilt, in the wake of the 2008 crisis. The need to change macroeconomic theory is similar to the situation in the 1930s, at the time of the Great Depression, and in the 1970s, when inflationary pressures were unsustainable. Four main changes to the core model are recommended: to emphasize financial frictions, to place a limit on the operation of rational expectations, to include heterogeneous agents, and to devise more appropriate microfoundations. Achieving these objectives requires changes to all of the behavioural equations in the model governing consumption, investment, and price setting, and also the insertion of a wedge between the interest rate set by policy-makers and that facing consumers and investors. In our view, the result will not be a paradigm shift, but an evolution towards a more pluralist discipline.

Keywords: benchmark model, New Keynesian, financial frictions, rational expectations, heterogeneous agents, microfoundations

JEL classification: A23, A31, B22, B41, E00

> The study of economics does not seem to require any specialized gifts of an unusually high order. Is it not, intellectually regarded, a very easy subject compared with the higher branches of philosophy and pure science? Yet good, or even competent, economists are the rarest of birds. An easy subject, at which very few excel! The paradox finds its explanation, perhaps, in that the master-economist must possess a rare combination of gifts. He must reach a high standard in several different directions and must combine talents not often found together. He must be mathematician, historian, statesman, philosopher—in some degree. He must understand symbols and speak in words. He must contemplate the

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> particular in terms of the general, and touch abstract and concrete in the same flight of thought. He must study the present in the light of the past for the purposes of the future.

Quotation from the obituary of Alfred Marshall by John Maynard Keynes (Keynes, 1924, pp. 322–3)

> [T]he economic problem . . . should be a matter for specialists—like dentistry. If economists could manage to get themselves thought of as humble, competent people on a level with dentists, that would be splendid.

Quotation from an essay called 'The Economic Possibilities for our Grandchildren', published in *Essays in Persuasion* by John Maynard Keynes (Keynes, 1930, p. 373)

I. The Rebuilding Macroeconomic Theory Project

In his obituary for Alfred Marshall, published in 1924, John Maynard Keynes remarked that competent economists are rare. Then, in a few short sentences, he suggested why. Nevertheless, some 6 years later, in 1930, Keynes said that economic management should be delegated to technical experts; he hoped that they might become humble.

Why this change of view? As we discuss below, Keynes was already working on the material which would lead to his *General Theory*. That book was his response to the crisis of the 1930s—the Great Depression—and his realization that Marshallian economics was not enough. It would lead to an interventionist approach to macroeconomic policy, managed by specialists. Friedrich Hayek, by contrast, never believed that it would be necessary, or possible, to achieve the kind of policy competence that Keynes sought (see Hayek, 1931, 1944).[1]

Nearly a century later, the Great Moderation collapsed into another crisis: the global financial crisis, or GFC. When this happened, the macroeconomic experts—who were by now in charge—appeared to lack both competence and humility. As a result of the GFC we are no longer clear what macroeconomic theory should look like, or what to teach the next generation of students. We are still looking for the kind of constructive response to this crisis that Keynes produced in the 1930s.

That is why the *Oxford Review of Economic Policy* set up a 'Rebuilding Macroeconomic Theory Project'. Of course, since the GFC, there have been many discussions about how to fix macro. Why do it all again?

We see a clear reason for another discussion. During the Great Moderation, the New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model had become the 'benchmark model': the one taught to students at the start of the first-year graduate macro course. Many of us—although not all—were proud of what had been achieved.[2] But the benchmark model has let us down; it explained neither why the GFC happened, nor what to do about it. What new ideas are needed? What needs to be thrown away? What might a new benchmark model look like? Will there be a 'paradigm shift'?

[1] As we also discuss below, similar views were later set out by Milton Friedman, and are still maintained by RBC theorists and freshwater economists.

[2] Olivier Blanchard famously said 'the state of macro is good' (Blanchard, 2009). But he went on to criticize DSGE models; his paper was not Panglossian.

And how should the new model to be used in our teaching—let us call it the 'new core model'—relate to the evidence-based professional work that macroeconomists do when giving policy advice? There has not yet been a satisfactory discussion of these questions. So we invited a group of macroeconomists to examine them with us.

To provoke initial discussion, we presented our colleagues with the following six examination questions.

(i) Is the benchmark DSGE model fit for purpose?
(ii) What additions to this model are necessary to help us understand growth from now on?
(iii) What are the important inter-temporal complications?
(iv) What are the important intra-temporal complications?
(v) Should the above questions be discussed with big or small models?
(vi) How should our models relate to data?

Appendix I provides some detail on each of the questions.

In response to these questions, Olivier Blanchard posted a piece called 'Do DSGE Models Have a Future?' on the Peterson Institute website. This blog-post provoked considerable interest; some of those who responded joined our project. The responses also led Blanchard to make further postings; his postings are collected together in the article which follows this one (Blanchard, 2018). To focus discussion among our authors, we organized two conferences in Oxford. The first took place in October 2016, before any papers had been written. The second, at which drafts were presented, was held in February 2017. Discussion concentrated not on particular pieces of analysis but on how a new core model might be constructed, what it might look like, and how it might behave *as a whole*. Very quickly, the discussion also came to focus on the relationship between the existing benchmark model, used in teaching, and the professional practice of macroeconomists, providing policy advice. Should that relationship be altered? And how might a new core model facilitate such a changed relationship?

All of the papers have been greatly re-written after that second meeting, and many of them have been discussed among the authors by email. It will be apparent to any reader of this issue of the *Oxford Review* that we invited people with a broad range of views to join our project. It was important to do this. The conversations have been sympathetic and wide-ranging; there has been much good humour and considerable tolerance. We think that much has been learned.

In this initial article we set out our view of what the project has achieved, framed within an account of what macroeconomists had already learned before we began.

Any understanding of what had been learned necessarily depends on being clear about how we got here. As Margaret Macmillan, the Warden of St Antony's College, Oxford, has said recently: '[learning from history] is like looking in a rear-view mirror: if you only look back, you will land in the ditch, but it helps to know where you have come from and who else is on the road.'

So, in section II of the paper we provide an analytical history of two key times in the past when there was a paradigm shift: the 1930s, when Keynes invented macroeconomics, and the 1970s, when the microfoundations revolution happened. These two periods can help one to understand what a paradigm shift is, and whether we now need another one. The 1970s also shows what happens when a paradigm shift is contested and—ultimately—only partly successful.

Any understanding of what had been learned also requires some agreement on what the benchmark model actually was in 2008. To clarify the starting point we ourselves identified the 2008 benchmark as the model of Smets and Wouters (2007). Our contributors—by and large—agreed with this starting point but—when pressed—did not agree on the implications of such a starting point. We therefore provide a brief description of this model, and how it works, in section III and Appendix II.

Then, in section IV we describe the response by our contributors to the first of our examination questions: is the new-Keynesian DSGE model fit for purpose? Most of authors agree that the answer is no. Nevertheless, the wide range of responses has already led to much comment and discussion among the authors. We think that this will be of interest to our readers.

In section V we provide an account, in four parts, of what our authors think needs to be done. First, we summarize their views of what is required in a new core model. These can be grouped under four headings:

(i) incorporating financial frictions rather than assuming that financial intermediation is costless;
(ii) relaxing the requirement of rational expectations;
(iii) introducing heterogeneous agents; and
(iv) underpinning the model—and each of these three new additions—with more appropriate microfoundations.

Second, we briefly describe what the authors say about how the new core model might actually be built. We also collect these ideas together and present our own idea of what we think needs to be done. This will—we think—involve amending or replacing the main behavioural equations of the model for consumption, investment, and price-setting, and also incorporating a wedge between the interest rate set by monetary policy and the rate which affects the private sector's decisions about consumption and investment. The outcome will be a model that is rather different from the benchmark model that was in place in 2008. Nevertheless, we characterize the likely outcome as progressive evolution; we do not think that there needs to be a paradigm shift.

Third, we outline how the new core model should relate to data. In summary, we think that it might best be estimated using Bayesian techniques, provided that much closer attention is paid to evidence from single-equation estimation informed by microeconomic ideas.

Fourth, we describe how most of our contributors have rallied around a much more general proposal: that the macroeconomics profession should delegitimize what Simon Wren-Lewis has called the microfoundations hegemony. If this happens—as we think it should—we think that the outcome will be a more pluralist approach to the subject.

In section VI we offer a brief conclusion describing what we think has been learned.

II. What we can learn from two previous paradigm shifts in macroeconomics

The purpose of this section is not to give a full run-down of the history of macroeconomic theorizing over the last 100 years. Instead, we wish to describe the way in which the economics profession has been in its current situation—a crisis exposing flaws in its

models—twice before: in the 1930s and in the 1970s. In the first case there was a clear paradigm shift. In the second case something much more confused emerged.

(i) Lessons from the 1930s: changes in content and a change in method

The punchline of the 1930s is that, prior to that time, economists only had Alfred Marshall's partial equilibrium method of analysing macroeconomic problems.[3] Then the Great Depression came along. To explain the Depression Keynes took the Marshallian model and added nominal rigidities. This meant that, in response to a fall in investment, the economy did not rapidly return to full employment. To understand what followed, Keynes needed to invent the consumption function, the multiplier, and liquidity preference. We call these changes in content. However, to understand the implications of these changes one also needed a change in method: the kind of general-equilibrium analysis provided by the IS–LM system. This change in both content and method was a clear paradigm shift.

Keynes came to his new position only gradually. We can see what he needed to learn by examining what he said at the Macmillan Committee in 1930, which was convened by a new Labour government at the onset of the Great Depression.[4] Keynes's task was a difficult one. Montagu Norman, the Governor of the Bank of England, said to the Committee, 'I have never been able to see myself why for the last few years it should have been impossible for industry, starting from within, to have readjusted its own position.' It has to be said that Keynes failed in his task: he did not know how to deal with Montagu Norman's objection; he did not yet have the necessary tools.

Here is why. Keynes was, at that stage, still a prisoner of his training in Cambridge as an expositor of Marshallian economics. The Marshallian model analysed three markets—the labour market, the goods market, and the money market—and did so separately, one market at a time.

To someone trained in the Marshallian tradition the problem of unemployment seems simple: it is caused by trade unions and other institutions keeping the wage above the market clearing level. At that wage the supply of labour exceeds the demand for labour. If wages are cut the supply of labour will fall, as some workers will no longer want a job at the lower wage. If wages are cut the demand for labour will also rise, because firms will find it profitable to hire more workers. (The demand for labour is, we now know, also influenced by the level of income and output, but this general-equilibrium idea is not present in the analysis. Income and output are both assumed to be exogenous, for reasons explained below.) A wage cut can therefore restore full employment. Such reasoning explains how Montagu Norman saw the situation: employment is determined by the wages set within each industry, which has nothing to do with the Bank of England's monetary policy. Wage adjustment, he believed, was a matter for industry and its workers. Only after writing *The General Theory* could Keynes see how to object to such an analysis. According to *The General Theory*, if wages are cut but there is no increase in aggregate demand at the same time, then firms find themselves

[3] As Kevin Hoover has emphasized to us, Walras's analysis of general equilibrium predates Marshall. But the interactions between markets, of the kind studied in the Keynesian multiplier process and described below, were not analysed by Walras.

[4] For further details about the pages which follow, see Temin and Vines (2014, 2016).

unable to sell any increase in output, and so do not increase their demand for labour. A cut in wages simply leads firms to cut their prices.

The problem of an imbalance between savings and investment was analysed in a similar way in the Marshallian tradition. The price for savings and investment was taken to be the interest rate. At a high interest rate, firms have to pay more to borrow, so the demand curve for investment slopes down. At a high interest rate, people are eager to save, so the savings supply curve slopes up. (Savings, as we now know, are also influenced by the level of income and output, but—as already noted—this general-equilibrium idea is not present in the analysis.) An interest rate above the equilibrium level will produce a supply of savings above the demand for investment. A decrease in the interest rate will lead to an equilibrium where the supply of savings equals the demand for investment. In this Marshallian framework, there is no reason ever to think that an excess supply of savings could lead to a fall in production, as Keynes wanted to argue.

It was also only after Keynes had written the *General Theory* that he saw how to object to such analysis. According to the *General Theory* the interest rate is determined in the money market by liquidity preference. It will adjust to make the demand for money equal to the supply of money, rather than adjusting to make savings equal to investment. If people decide to save more, then the interest rate need not fall by much and there might emerge a 'paradox of thrift': where savings are not brought into line with investment by a fall in the interest rate, but by a fall in output. This was the kind of analysis that Keynes tried to deploy at the Macmillan Committee. But such a line of argument was not yet available to him. That is because he still believed that the interest rate adjusts to ensure that investment and savings are brought into line with each other, and that resources remain fully employed.

Indeed, the very possibility that Keynes was trying to understand—low output of goods and generalized unemployment—seemed completely impossible to comprehend for people trained in the Marshallian tradition. The quantity theory of money told them that prices would adjust to make sure that this could not happen. With a fixed quantity of money, prices would adjust to ensure that the demand for money equalled this fixed supply, and that all goods produced would actually be purchased. Of course, prices needed to be flexible to make this happen. Keynes did not yet understand why it did not happen. Only by writing the *General Theory* did he come to understand that, if wages do not adjust in the labour market, the flexible prices in the goods market that Marshall had relied on would not ensure that all production would necessarily be purchased.[5]

The key methodological change in the *General Theory* is that Keynes began to think about the general-equilibrium implications, acknowledging that markets interact with each other. It is now generally understood that once Keynes had assumed sticky nominal wages, he needed to make four more analytical moves to create the model in the *General Theory.* First, if wages do not adjust after a decline in investment, as Montagu Norman believed they would, then there will be a shortage of aggregate demand in the goods market. Second, this fall in aggregate demand will cause consumption and savings to fall, which Keynes analysed using his new piece of equipment: the consumption function. Third, the consumption function can be used to calculate the size of the multiplier, which is needed to show how much output must fall after the decline in investment, to make savings again equal to investment. This is then needed to calculate

[5] Keynes thought that wages did not move fast enough to ensure that the labour market continuously clears; but he also explained why this was so. See Hoover (1995).

the associated fall in employment, which is solely the result of low investment, rather than too high a level of wages. Fourth, and finally, liquidity preference is needed to show that the interest rate will not fall enough to prevent any shortage of aggregate demand from actually emerging. These four moves enabled Keynes to demonstrate that equilibrium unemployment was a genuine possibility.

Meade was the first to set out Keynes's system formally, in a complex system of nine equations (Meade, 1937).[6] But it was not until Hicks exogenized the price level, and so extracted the two-equation IS–LM model from Meade's nine-equation system,[7] that the general-equilibrium properties of the *General Theory* were properly understood (Hicks, 1937). The full workings of the model in the *General Theory*, incorporating exogenous wages but an endogenous price level (because of diminishing return to labour), were not fully explained until much later by Samuelson in his neoclassical synthesis, a much simpler system than Meade's (Samuelson, 1951, 1955).[8]

As we have already noted, the *General Theory* was clearly a paradigm shift from Marshallian economics: there was both a change in content (exogenous nominal wages; consumption function; multiplier; liquidity preference) and a change in method (a move to general equilibrium). There was a period of 25 years, after the Second World War, when this new paradigm was used to guide macroeconomic policy-making. The outcomes were good: it became known as a Golden Age.

Two papers on stabilization policy published by Phillips at the time show what policy-makers were aiming to do (Phillips, 1954, 1957). Phillips showed that, in the face of shocks, a well-designed policy could help to produce good outcomes. In particular, fiscal policies might be designed, making use of PID (proportional, integral, and differential) feedbacks, which would ensure that economic activity converged rapidly to its desired level, without cyclical overshoot, even after allowing for realistic lags in private-sector behaviour. There was a flourishing of empirical macroeconomics at the time, under the influence of Frisch, Goldberger, Haavelmo, Klein, Stone, and Tinbergen. This led to the first economy-wide macroeconomic models being built, models which were used to provide empirical support for the kind of macroeconomic policy-making process described by Phillips.[9]

(ii) Lessons from the 1970s and 1980s: two different responses, many changes in content, and a (contested) change in method

The punchline of the 1970s is that, when the Great Inflation came along, economists were no longer able to use the fixed-price IS–LM system, or the models based on it, to

[6] See Temin and Vines (2013, 2014) and Vines (2008).

[7] Hicks saw that there were four markets in play—goods, money, bonds, and labour—but, because of nominal wage rigidity and thus a non-clearing labour market, it was only necessary to analyse equilibrium in the first three of these markets. He already had much experience, coming from writing his book *Value and Capital*, in showing that equilibrium in three markets could be analysed using a two-dimensional diagram, illustrating the market-clearing outcome in just two markets, as a function of the relative prices of just two goods, because of Walras's Law. The interest rate was clearly a relative price and so belonged on the vertical axis of his diagram. It was the work of genius to realize that, because he had exogenized the price level, he could make the level of output the variable on the horizontal axis, and so obtain the IS–LM diagram.

[8] The resulting model—incorporating all of the goods market, the money market, the bond market, and the labour market—is well set out in Scarth (2014).

[9] See Goodfriend and King (1997, p. 234) for a brief description of the Federal Reserve System's MPS model, perhaps the best representative of the models of that era.

give adequate policy advice. However, compared with what had happened in the 1930s, the response was not a decisive paradigm shift. Instead, there was a much more contested outcome, the consequences of which are still being felt.

The first set of responses to the Great Inflation were put forward by 'saltwater economists' from the US East Coast and those working in the UK, who wanted existing models to evolve. Their approach remained interventionist, but full-employment Keynesianism gave way to a regime of inflation targeting, and active fiscal policy made way for an active monetary policy. These were significant changes, but were an evolution rather than a paradigm shift. They led directly to the New Keynesian approach described in section III below.

The second response was much more of a revolution. 'Freshwater economists' in the US thought that the emergence of inflation had discredited active Keynesianism. Their response involved a striking change in modelling approach. First, they required that models be microfounded, optimizing, and forward- looking, with expectations of the future being model-consistent (at least up to a random error). Second, they required that the economy be treated as if it was in constant equilibrium and therefore did not require policy intervention. The first of these requirements has been largely accepted and the second comprehensively rejected. But both of these outcomes—the acceptance and the rejection—have had significant implications.

The evolutionary approach—adaption

There were four steps to the evolutionary approach: incorporating a Phillips curve, allowing for adaptive inflation expectations, creating an explicit nominal anchor, and endogenizing the supply side of the model.

The first of these four steps involved adding a Phillips curve to the IS–LM model (Phillips, 1958). As Goodfriend and King (1997, pp. 235–6) say:

> In the early years of the neoclassical synthesis, macroeconometric models were constructed and practical policy analysis was undertaken assuming that nominal wages and prices evolved independently from real activity and its determinants. In fact, in the 1950s, there was relatively little variability in inflation. By the mid-1960s this premise could no longer be maintained—inflation became a serious policy concern and it was plain to see that inflation was related to developments in the economy.

Adding a Phillips-curve equation to the IS–LM model greatly changed the way that macroeconomists thought about policy. Phillips (1954) had already noted that aggregate demand would need to be reduced if inflation was positive, and vice versa; 2 years after the publication of the Phillips curve paper, Samuelson and Solow (1960) argued that demand would need to be stabilized around a level of output at which inflation would be stable.[10] This involved recognizing what we now call the 'natural level of output'.

The second step involved modelling what would happen if inflation was not stabilized in this way. Both Friedman (1968) and Phelps (1968) argued that a sustained increase in aggregate demand would cause inflation to rise and that this would gradually be reflected in higher inflation expectations. That would (slowly) shift up the Phillips curve,

[10] See Forder (2010, 2014, 2015).

creating a 'wage–price spiral', something whichwould continue until output returned to its natural level. This argument led to the development of an expectations-augmented Phillips curve, and to a second new equation being added to the IS-LM model: describing how inflation expectations evolve gradually in response to any changes in the rate of inflation. Including this extra equation led to the Phillips curve becoming vertical at the natural level of output.

The inflationary experience of the 1960s led Friedman to argue that Keynesian policymakers had been discredited:[11] they would inevitably cause a wage–price spiral unless there was some institutional constraint that prevented them from doing this. Kydland and Prescott (1977) and Barro and Gordon (1983) carried this argument further, suggesting that policy-makers would promise low inflation, but actually stimulate demand enough to cause inflation, thereby showing themselves to be untrustworthy.[12]

Friedman's response to this problem was to advocate rule-based, non-interventionist monetary policy instead of active Keynesianism. For him no new theory was needed. Simply fixing the money supply was enough; an idea already embedded in the IS–LM system.[13] With a fixed money supply the economy would—he argued—converge to the natural rate. This made short-run, interventionist macroeconomic management unnecessary. Policy-makers should just 'fix the money supply and go home'. Such a strategy was tried in the early 1980s in Britain and (briefly) in the US, but could not be made to work. It quickly become apparent that the demand for money is unstable and that the supply of money cannot be controlled. Furthermore, it also became apparent that such an approach might, of itself, lead to macroeconomic instability.[14] Thus monetarism, as a non-interventionist macroeconomic policy, was a dead horse.

[11] Wright makes this claim in his paper in this issue.

[12] Meade (1978) argued that in the UK a wage-price spiral had arisen for a rather different reason: Keynesian policies made it impossible to resist union militancy, and the resulting wage 'explosions'. Layard *et al.* (1991) developed this argument by showing that union monopoly power would lower the natural level of output—as would producer market power in the product market—thus making it likely that policy-makers would overestimate the natural level of output. Orphanides (2004) provided a related explanation for what had happened in the 1970s in the US. Policy-makers had, he argued, repeatedly overestimated the natural level of output, which had fallen because of oil-price shocks and a slowdown in productivity.

[13] Friedman presented his arguments using the Quantity Theory of Money, but we can encompass what he said within an IS–LM framework, even though Friedman resisted such encompassing. See the discussion by Friedman (1975) and Tobin (1975*b*).

[14] The reason for this is that if the money supply remains unaltered in the face of a positive demand shock, cumulative inflation might emerge, rather than inflation being controlled and the economy returning to the natural level of output. This is because a demand shock will raise inflation, raise the price level, and in turn raise the nominal interest rate. That will reduce aggregate demand, and so bring output back towards its natural level. But the *real* interest rate interest rate will only rise if the nominal interest rate rises by more than the increase in inflation. With a fixed money supply, this might not happen if the elasticity of demand for money is sufficiently high. Of course a higher price level will also reduce the real value of assets fixed in monetary terms, in turn reducing aggregate demand. But higher prices will also redistribute wealth from creditors to debtors whose propensity to spend is high. As a result, the overall outcome might well be cumulative inflation and instability.

Something similar might happen, in reverse, in the case of a negative demand shock, resulting in the kind of debt deflation described by Fisher (1933).

Keynes had set out these arguments (informally) in ch. 19 of the *General Theory*, and they were first set out formally in the second part of Phillips (1954). However, these arguments were more or less completely overlooked; they were not widely recognized until they were set out again by Tobin (1975*a*). Even so, many macroeconomics textbooks have argued—at least until recently—that if only wages (and prices) can be made more flexible but the money supply is held constant, then any shock to aggregate demand would be rapidly corrected. Something like Marshallian economics might even re-emerge!

But if macroeconomic policy was to remain interventionist while resolving the inflation problem, then its objective needed to change. This was achieved by shifting the purpose of macroeconomic policy from ensuring full employment by managing aggregate demand, to actively anchoring nominal prices (rather than passively trying to anchor prices by fixing the money supply). This was the third step in the evolutionary approach to reforming macroeconomic policy from the 1970s onwards. It was only taken gradually.

Initially, Meade (1978, 1981) suggested that a nominal anchor could be achieved by targeting nominal income or nominal GDP; in response to inflation the policy authority would reduce aggregate demand to keep price-times-quantity constant. Weale *et al.* (1989) showed how an interest rate rule could be used to do this.[15] Meade opted for this, rather than an inflation target, because he thought that the latter would be too inflexible.

It was another decade before John Taylor (1992) advocated his eponymous interest rate rule for stabilizing inflation. A Taylor rule can be a nominal anchor if it satisfies the 'Taylor principle': when inflation rises the nominal interest rate must rise by more, so that the real interest rate also rises. Such Taylor-rule macro only brings inflation back on target gradually, and so involves the kind of flexible inflation targeting that would have satisfied Meade.[16] As this view was accepted it replaced the idea of fixed money supply in the IS–LM system: the requirement that the interest rate equate the demand for money to a fixed money supply was replaced by the introduction of a third new equation: the Taylor-rule (or something like it).

Taylor had initially offered his rule as a positive characterization of the way the Fed had actually implemented policy as it moved away from a Keynesian focus on stabilizing employment. But it has since become a normative recommendation for how monetary policy should be pursued in the face of shocks to output and inflation.[17] We have learned that a Taylor rule that targets inflation will ensure that both inflation and the output gap[18] will return to their equilibrium levels.[19] This two-for-one property, described colourfully by Blanchard and Galí (2005) as a 'divine coincidence', depends on the accelerationist nature of the Phillips curve: inflation can only be on target, and unchanging, if output is equal to its natural level.[20] Furthermore, we have learned that

[15] Poole (1970) had already discussed the use of the interest rate, rather than the money supply, as the instrument of monetary policy. But he had done this within a framework in which the objective of policy still remained that of stabilizing real output, rather than controlling inflation. He showed that a good reason for choosing the interest rate, rather than the money supply, as the policy instrument might be that the variance of shocks hitting the LM curve is greater than the variance of shocks hitting the IS curve. But that paper did not address the problem being analysed by Meade, or that would later be analysed by Taylor.

[16] Early proposals for the use of interest rate to control inflation were also put forward in 1992 by Henderson and McKibbin. See Henderson and McKibbin (1993).

[17] See Bean (1998) and Clarida *et al.* (1999).

[18] The output gap is the gap between the level of output and the level output would need to take for inflation to remain constant.

[19] This is the case even if—as in the model set out in Appendix 2—the output gap does not explicitly feature in the monetary authority's reaction function, as it does in a fully specified Taylor Rule.

[20] This new monetary-policy regime made use of, and indeed came to require, the floating exchange rate regime that emerged after the collapse of the Bretton Woods system. A floating exchange rate enables a country to separately use its interest rate as a policy instrument even in the presence of open international capital markets. In such a system it is possible, at least in principle, for policy-makers to use movements in the interest rate to insulate a country from shocks, both domestic and foreign. See the paper by McKibbin and Stoeckel in this issue of the *Oxford Review of Economic Policy*.

if inflation is stable, monetary policy can ensure that the resources of the economy remain fully employed in the face of long-lasting shifts to aggregate demand, effectively by shifting the constant term in the Taylor rule (see Allsopp and Vines, 2015).

The fourth and final step of the post-1970s evolution of macroeconomic theory involved incorporating an endogenous supply-side. The supply side had been studied in detail since the 1950s by the growth theory literature, coming from the models of Solow–Swan and Ramsey.[21] Incorporating an endogenous supply side into the mainstream macroeconomic model was given an impetus by the oil shocks of the 1970s, effectively beginning with the book by Bruno and Sachs (1985) on worldwide stagflation. The work which followed involved recognizing that output depends not just on labour inputs but also on the stock of capital, the level of technology, and the cost of raw-material inputs. The supply side is therefore endogenous, not least because the capital stock depends on the level of investment and the short-run developments that influence investment, including the interest rate. The equation for the evolution of capital added a fourth new equation to the IS–LM model.

The evolution in the structure of macroeconomic theory brought about by the four steps which we have just described was significant. It implied that any long-run reduction in unemployment could only be brought about by supply-side reforms that increased investment, raised technical progress, or improved labour-market practices, rather than by stimulating aggregate demand.[22] The new macroeconomic model which emerged is the benchmark model which we describe in the next section of the paper. Such a model represented a major change in the way macroeconomic theory was understood. But the innovations that caused the change—our four steps—were evolutionary not revolutionary.

The revolutionary approach—a partial change in paradigm

The second response to the inflation problem of the 1960s and 1970s was much more radical. Our discussion of it will be rather brief since Simon Wren-Lewis examines this response, and its consequences, in detail in his paper in this issue (Wren-Lewis, 2018).

Supporters of this approach—freshwater economists in the US— proposed a fundamental change in the way in which macroeconomic models are constructed. Like Friedman, they argued that Keynesian economics had been discredited by the inflation of the 1960s and 1970s. But, unlike him, they thought that a whole new approach was needed. Their new approach had two components.

First came the 'Lucas critique' (Lucas, 1976). This involved criticizing the use of existing models for evaluating the effects of economic policy changes. Such models would not—said Lucas—have a stable structure. They would be estimated on data taken from a period before the policies were implemented, but used to predict the behaviour of a private sector which would adapt its behaviour after the policies had been put in place; such adaption would render the predictions invalid. But—said Lucas—if the models allowed the private sector to form expectations about the future, and to change these expectations in response to new policies, then the models being

[21] The Klein–Goldberger model contained such a feature (Klein and Goldberger, 1955).

[22] This view was first elaborated for the UK by Rowthorn (1977), by Meade (1982), and in subsequent papers by Meade. It was taken up and developed by Layard *et al.* (1991) and has become an accepted part of conventional wisdom.

used (and their evaluation of policy) could become acceptable; providing that the private sector's expectations were consistent with the outcomes predicted by the model ('rational expectations').

Second, Lucas and Sargent (1979) built on this criticism to outline how models should be built to make this rational expectations analysis internally coherent. The new models should—it was said—not only incorporate rational expectations, but should also describe behaviour that was explicitly derived from optimization by economic agents in the light of such expectations. Only then could one be confident that the model would appropriately capture how the private sector would respond to any changes in external circumstances, including changes in economic policy.

Putting these two components together appeared to have a revolutionary effect: rendering macroeconomic policy both ineffective and unnecessary (Sargent and Wallace, 1976). We have already described how the evolutionary approach responded to the inflation of the 1970s by introducing an expectations augmented Phillips curve that was vertical in the long run. In that Phillips curve, inflation at time t depends on expected inflation at time t, on the deviation of output from its natural level, and on the effects of any shocks. This formulation was widely used, not just in large-scale econometric models but also in the smaller analytical models used by macroeconomic theorists. Before the Lucas critique, expected inflation was modelled as some combination of past inflation rates. If, however, that assumption was replaced with rational expectations, then any deviations from the natural level of output must only be due to random shocks. This follows from the fact that, if expected inflation equals actual inflation, then a vertical long-run Phillips curve will imply that any deviation of output from its natural rate must be only driven by shocks. It is no surprise that many Keynesian macroeconomists at the time saw rational expectations as an existential threat. For a while, it appeared that this attack by the freshwater revolutionaries on the traditional Keynesian ideas had been fatal.

While basking in their supposed glory, freshwater economists developed real business cycle (RBC) theory, a set of ideas which attributed economic cycles to technology shocks, rather than to the aggregate demand fluctuations that had been analysed by (discredited) Keynesian theorists. In doing this they used the same insights from the Solow–Swan and Ramsey models that the more traditional economists had used to incorporate an endogenous supply side into their models (in the way which we discussed above). They showed that in a set-up with these features, productivity shocks could give rise to business cycles, in a way which now seems rather obvious.[23]

We now know that the freshwater attack on Keynesian economics failed because it depended not only on rational expectations and optimizing agents, but also on an inadequate formulation of the expectations-augmented Phillips curve. This was

[23] This capital accumulation equation creates a single first-order difference equation for the level of aggregate supply. If productivity shocks are assumed to be autoregressive, which is what RBC analysts assume, this adds another first-order difference equation. The result is a second-order difference equation system for aggregate supply which can produce cycles.

In fact, RBC analysts turned out to engage rather little with the Solow–Swan–Ramsey growth literature. That is because, in most empirical work on RBC models, underlying growth is filtered out of the data using an HP filter. So what is of interest here is simply that RBC models made use of the growth-theory ideas which had already been used by the more traditional economists, rather than doing something completely different. (This point is made by Goodfriend and King, 1997.)

demonstrated in an important set of papers by Fischer (1977), Taylor (1980), and Calvo (1983). All of these papers showed that if wages or prices are not all set simultaneously, then the optimal response to a demand shock of those who set prices in the current period will depend on what inflation is expected to be in the next period, when others can adjust their prices. The same will be true next period, and so on. This kind of 'friction' means that changes in aggregate demand will cause changes in output as well as changes in prices. As a result, monetary and fiscal policy are able to influence output.

As Wren-Lewis describes in his article, this freshwater attempt at revolution thus had two strands. The first, which attempted to show that Keynesian policy was unnecessary and ineffective, failed. The second, which aimed to change the way academic macroeconomics is done, was successful. This success can be seen from the fact that it came to be required that all theoretical models be based on an optimizing framework with model-consistent expectations. Even those who followed the evolutionary Keynesian approach described in the previous section were now required to employ optimizing agents with model-consistent expectations. To proceed in this way, macroeconomists needed to do two things.

First, they needed to microfound the IS curve by splitting it into two components: one for consumption and one for investment. The benchmark model therefore now has an Euler equation for consumption which is based on intertemporal optimization by a representative consumer. This equation gives rise to consumption-smoothing unless interest rates vary over time. The benchmark model also now has an equation for investment which is based on profit maximization by a representative firm. Such a firm chooses investment based on the production function in the supply side of the model, considering its anticipated need for capital in the future, and the costs of adjusting the capital stock.

Second, macroeconomists also needed to microfound their model of inflation. This meant replacing the expectations-augmented Phillips curve (described above) with an equation describing the behaviour of optimizing price-setters, who adjust their prices in the knowledge that not all prices will be adjusted at the same time. This equation follows the work of Fischer (1977), Taylor (1980), and Calvo (1983), and also of Rotemberg (1982).

As a result of these changes, the New Keynesian benchmark model that evolved out of the old IS–LM system, in the way which we have described above, also came to incorporate the kind of microfounded features that had been advocated by the freshwater revolutionaries. One of the earliest models of this kind was constructed in the UK by the Meade group (Weale *et al.*, 1989). That group, to which David Vines belonged, thought that the task of policy design had become the application of ideas from control theory, including ideas about PID control coming from Phillips (1954), to a model with a forward-looking, optimizing private sector. The central new idea was that explicit policy rules are necessary for the control of such an economy, since what people do now will depend on what they expect policy to do in the future.[24] The recent, best-practice versions of models with these features include those constructed by Smets

[24] Another early model of this kind was that produced by Warwick McKibbin, working initially with Jeffrey Sachs (see McKibbin and Sachs, 1991, and McKibbin and Vines, 2000). John Taylor produced a similar sort of model (Taylor, 1993), although his model did not include a study of the capital accumulation process, which—we argue in this paper—it is essential to include.

and Wouters (2007), and Christiano *et al.* (2005). These last two models form the basis of the benchmark model presented in the next section.

This change of approach happened partly because those building policy models came to realize that taking a microfounded approach would greatly assist them in their work. Microfounded models, in which the representative agents have rational expectations, make it possible to show how a policy regime can become more effective when the private sector understands the nature of the policy, and can be relied on to react optimally, in the light of this understanding. Much work in the 1990s and early 2000s showed that this effect is all the stronger if the private sector also comes to believe that the policy-maker is acting with commitment.[25]

Nevertheless, this dominance of microfounded methods in macroeconomics may well have been all too pervasive. Wren-Lewis (2016) describes the very large effect that the microfoundations requirement has had on those building macroeconomic models to be used for policy purposes. As he says, before the attempted revolution, policy models were empirical, using the developments in theory and in econometrics which had followed the publication of Keynes's *General Theory*. But after the attempted revolution, with its emphasis on microfoundations, even those doing policy-related work became much more deductive in their approach. Even those building policy models now see the foundations of their work as coming from basic microeconomic theory, rather than from empirical knowledge about the functioning of the macroeconomic system.

Whether this pervasiveness has been too great is one of the key questions to which we will turn. But first, we set out the New Keynesian benchmark model which emerged from all of the changes to macroeconomic theory which we have discussed in this section of the paper.

III. The New Keynesian benchmark DSGE model

If the task is to improve on the benchmark model that was in place at the time of the 2008 crisis, we must first agree on what that benchmark was. In the interests of clarity we now provide a verbal account of the model: a New Keynesian DSGE model with investment and an endogenous capital stock, one following Christiano *et al.* (2005) and Smets and Wouters (2007).[26] In Appendix II we also provide an algebraic account of the model; we do this because it is in fact hard to find a simple straightforward exposition of this model.

The benchmark model is a microfounded representative-agent model. It is clearly a general equilibrium model since there is an analysis of demand and supply in the goods market and the labour market, and also in the money market and the equity market. It includes equations for consumption, investment, and price-setting that are derived from inter-temporal optimization. Inter-temporal budget constraints are critical in determining asset prices. There is short-term stickiness in wages, and adjustment costs influence investment.

[25] See Woodford (2003). Policies were, in fact, so successful during the Great Moderation that freshwater economists came to believe that they were not necessary. Lucas (2003) argued that 'the central problem of depression-prevention has been solved, for all practical purposes, and has in fact been solved for many decades'. Lucas believed that this outcome meant that active countercyclical policies were not necessary. Krugman argues, in his paper below, that Lucas came to believe this precisely because the policies had been so successful.

[26] See Woodford (2003, ch. 5, § 3) and Schmitt-Grohé and Uribe (2006). Galí's text (Galí, 2015) is important, but does not include investment.

At the core of the model is a real analysis of capital accumulation and growth taken from the Solow–Swan–Ramsey growth model. A representative firm decides on investment and so brings about capital accumulation. But unlike in the growth models, output that is saved is not automatically invested. Instead, there is an explicit forward-looking investment function, depending on the expected future need for capital. The extent of investment at any point in time is governed by capital adjustment costs. The equilibrium Ramsey growth path sees investment and capital accumulation exactly keep pace with population growth and technical progress. The representative consumer follows a forward-looking Euler equation. Along the equilibrium growth path consumers hold the equity created by investment. Financial intermediation ensures that this happens, and it does so at a real interest rate that in the long term must be equal to the rate of time preference (since otherwise consumption would not be smoothed). In the short run the growth path is disturbed by shocks to the level and expected rate of change of technology, to the desire to save, and to the financial intermediation process. There is an endogenous 'neutral' real rate of interest which can ensure that—despite such shocks—resources remain fully employed. The model can be used to study the effects of technology shocks of the kind studied by growth theorists and real business-cycle (RBC) theorists; we display the effects of such a shock in Appendix II.

Adding nominal rigidities to this model creates the possibility of an output gap in which output, driven by changes in aggregate demand, differs from aggregate supply, so that inflation can emerge. This leads to a role for monetary policy, in the form of a central bank setting the nominal (and real) interest rate, which pins down the rate of inflation. The Taylor rule is one way of representing such a policy. Subject to inflation being controlled, such a policy can also ensure that demand is just sufficient for resources to be fully utilized—what Blanchard and Galí (2005) call the 'divine coincidence'. Fiscal policy can also stabilize demand, but over time public deficits lead to public debts which, to ensure fiscal solvency, require higher levels of taxes to pay the higher debt interest. Public debt can also crowd out capital, but only if the consumer is treated more subtly, for example in an overlapping generations (OLG) model.[27] The version of the model with nominal rigidities can be used to study the effects of inflation shocks and monetary policy shocks; we display the effects of an inflation shock in Appendix II.[28]

The international version of this benchmark model joins a number of countries together through both trade linkages and asset-market arbitrage. We do not discuss international issues in this paper, but they are covered in this issue by Warwick McKibbin and Andrew Stoeckel (2018).

This is a general equilibrium model of economic growth in which there are also nominal rigidities, and so a need for a nominal anchor. As is well known, this is much more subtle than the partial equilibrium Marshallian model facing Keynes in the 1930s. It is also more subtle than the IS–LM general equilibrium model facing analysts in the 1970s,

[27] In an OLG the real interest rate can take a higher value, in the long run, than the rate of discount of the representative consumer, since consumption smoothing is possible across a lifetime, but not between generations. This means that higher public debt can raise the real interest rate and so crowd out capital.

[28] This version of the model can also be used to study the effects of a demand shock coming—for example—from a change in consumer expenditure or investment expenditure. We do not explicitly display the effects of a shock to consumption in the Appendix, but the results which we show for a negative technology demonstrate the way in which the reduced demand for investment which comes from this shock propagates through the model.

which excluded the microfounded and forward-looking behaviour of consumers and firms, any study of capital and growth, or any of simultaneity in output and inflation.

The simultaneous determination of output and inflation in 'Taylor-rule macro' is now widely understood and has routinely been taught to the last generation of students. But the central role of investment, capital, and growth, which is at the centre of the New Keynesian benchmark model described here, is much less well understood. Many popular treatments contain no investment by firms, only consumers who must always consume everything that is produced (see, for example, Clarida, Galí, and Gertler, 1999 (CGG); Galí, 2015). Such a model (deliberately) prevents one from understanding how the process of growth, which creates a demand for capital and investment, interacts with the short-run analysis of aggregate demand, consumption, and savings which is carried out by CGG. But, investment is central in explaining how economies respond to the kinds of shocks analysed by CGG; *as well as* explaining the process of long-run growth, and the RBC analysis of economic cycles. That is why, in this article, we emphasize the role of capital accumulation and investment in the benchmark model.[29]

The benchmark model can be used to describe, and understand, a number of recent experiences going well beyond the 1960s and 1970s, including the Asian financial crisis. McKibbin and Stoeckel (2018) discuss some of these experiences in this issue, and in our own paper (Vines and Wills, 2018) we discuss the use of this model in thinking about the question of 'secular stagnation'.

Nevertheless, this model failed when faced with the global financial crisis. It was not good enough to give any warning of the emergence of crisis in 2008. And it has been of very little help in understanding what to do next. Notwithstanding these failings, there is not yet a new paradigm in sight, not yet a new *General Theory* for the twenty-first century.

IV. Is the benchmark model fit for purpose?

This is the first of the examination questions that we set our authors. The answer depends on the purpose for which the model is being used.

In his article in this issue, Blanchard (2018) identifies *five* different purposes and so a need for five different types of model.[30] Foundational models should illuminate deep microfoundations. Core models (including our DSGE benchmark model) should provide a generally accepted theoretical framework for the profession, which should be simple enough to teach first-year graduate students.[31] Policy models should closely fit data and facilitate policy analysis. Toy models (including IS–LM) are useful to provide insight for students and can provide a quick first pass at problems. Finally, forecasting models should produce the best forecasts possible. An agreement to differ across this wide range of models provides more freedom, less conflict, and makes our task of rebuilding the core model easier. Perhaps one need not worry if the new core model is not foundational, or does not fit the data, or forecast—or even look like a toy.

[29] Notice also that, because this is *not* a model in which capital accumulation is simply determined by savings behaviour, it differs fundamentally from the kind of analysis put forward by Piketty (see Soskice, 2014).

[30] For a discussion of the Blanchard taxonomy, see Ghironi (2017).

[31] The second half of this sentence comes from Blanchard (2017).

In this issue we find that nearly all of our authors agree that the benchmark New Keynesian DSGE model is flawed. Most also agree with our own view, that it can and should be rebuilt rather than abandoned, though views differ greatly on what exactly will be required. However, some of our authors think that the existing benchmark DSGE model should be discarded, and that we should start again. We think that there is much to learn from their constructive opposition to the rebuilding project, and we discuss those views in this section.

The benchmark model and foundational models

Randall Wright (2018) puts forward a strong defence of foundational models. In his paper he states that RBC models have been good for understanding fluctuations during normal times, endogenous growth models have helped us understand growth and development, search models have been useful for understanding labour market behaviour and unemployment, and microfounded models of exchange have been helpful for understanding monetary issues. His paper is a thoughtful plea for the need to do more foundational work of this kind; the second part of his paper gives an idea of the insight into what can be learned about exchange by modelling the search process.

Randall Wright argues that DSGE models were never suited to the task of studying large crises.[32] Joseph Stiglitz (2018) argues that these models have been good at what they are designed to do: explaining the behaviour of the macroeconomy during 'normal times' like the Great Moderation, and that the crisis hasn't disproved this. Wright—no fan of DSGE models—thinks that in good times it is RBC models which have helped us to understand fluctuations. However, they both argue that a benchmark macroeconomic model should be able to explain crises because, as Stiglitz points out, it is crises that have the largest effects on individual well-being. Doctors can't just treat colds. The answer, they argue, is to blur the boundary between foundational models and DSGE models, dragging the former into the latter.

In the views put forward by Stiglitz and Wright, the reason for the existing benchmark model's inability to explain the crisis is its theoretical underpinnings—its microfoundations—which are the concern of foundational models. Stiglitz argues that we need microfounded institutions, noting how enforcement costs make selfish individuals and honoured contracts incompatible. He goes on to argue that DSGE makes the wrong modelling choices (as do David Hendry and John Muellbauer (2018, this issue)): complicating simple areas and simplifying complex ones; and identifies eight areas where current microfoundations are flawed. These include: the theories of consumption and expectations; investment and finance; heterogeneous agents and aggregation; and the source of and response to shocks, many of which are related. While these are important topics, it is unclear whether they can all be incorporated into a model that is parsimonious enough to teach to graduate students. There is an important—and valuable—sense in which the paper by Stiglitz declares the whole of our Rebuilding Macroeconomic Theory Project to be an impossible exercise.

Wright goes even further. Like Stiglitz, Wright proposes important suggestions for rebuilding the benchmark model. In particular, he argues that we should allow for frictions in trade from search and matching, incomplete information, and imperfect commitment, which can fundamentally change how the model works. However, the major

[32] But see Eggertson and Krugman (2012).

and extraordinary challenge to the profession in his paper is expressed in a key sentence in which he complains that in many economic models, 'there are gains from trade sitting right there on the table—the outcomes [in the models] are not even in the bilateral core'; Wright thinks that this can lead to ridiculous implications. For Wright, none of the frictions which we discuss in the next section can be allowed into a paper on macroeconomics unless they are properly microfounded as interactions between self-interested and selfish individuals. Institutions such as the use of money (or other assets) in exchange, as well as credit and banking arrangements, should emerge as outputs from, rather than inputs to the model. In the words of Wallace (1988), 'money should not be a primitive in monetary theory'.

Some correspondence on this issue may be enlightening. David Vines suggested to Randall Wright that he cannot call on the Bursar of Balliol College every morning to renegotiate his salary, expecting Wright's reply to be 'Why not? And if you haven't modelled why not then your model isn't good enough'. Wright's much more interesting reply was as follows:

> Clearly you could call the Bursar any time you want, but I agree you do not do so very often. I interpret this as meaning it is not too important to call the Bursar all that often. In Keynesian models with Calvo pricing, people really do want to call the bursar or the boss or . . . someone all the time, because it is extremely important in those models. To wit, in such a theory the problem and the only problem with the world is sticky prices (there may be other issues, like monopsonistic competition, e.g., but these are trivial to fix with taxes/subsidies).
>
> Not being able to call the bursar until the Calvo Fairy gives you permission is, in standard Keynesian theory, what causes inefficiencies, too much unemployment, recessions, and—really?—financial crises. [In reality you] . . . do not call the bursar every day because it does not matter; in these models you want to call him but aren't allowed, and that assumption is truly the root of all evil. To say it just slightly differently, if you were going to lose your job because your wage was about 1 per cent off some notion of equilibrium in the sense of Debreu, then I predict you may well call someone.

In fact, this seems like a surprising response. That is because there is no dollar bill left lying on the table in the New Keynesian model. One of the main points of the paper by Blanchard and Kiyotaki (1987) was to show that not adjusting prices (or wages) is a second-order loss for firms/unions, but a first-order loss for the economy as a whole. Of course, we can agree that the Calvo story does not provide a very deep understanding of the *causes* of nominal rigidities. But Wright's response to these inadequacies is to get rid of the Calvo fairy, rather than allowing the Calvo story about the *effects* of nominal rigidities to operate until we can do better. Wren-Lewis argues in his paper that this kind of approach has caused serious damage to policy modellers' ability to construct useful models.

Other frictions in current DSGE models do appear to leave arbitrage opportunities on the table; Stiglitz describes this in the latter part of his paper. Wright rules out imposing such frictions unless they can be properly microfounded. Many other authors in this issue, including Stiglitz, think that it is important to include these frictions in models because they describe reality, which is crucial for policy modelling (see Wren-Lewis,

2018). Wright's ambition of building deep microfoundations into the benchmark model is serious and worthy. But, until that is feasible, there is a risk that removing frictions from the benchmark model will prevent it from saying important things.[33]

Andrew Haldane and Arthur Turrell (2018) also advocate deeper microfoundations in the form of agent-based models (ABMs). They would like to abandon the reliance on a single representative agent with rational expectations, and move away from the rigid 'monoculture' in macroeconomics in which this has become the norm. Their approach shares similarities with Wright's, in that every behaviour in the model emerges from the interactions of individual agents facing explicit rigidities. In this approach frictions like nominal rigidities would be emergent, rather than assumed. However, they differ in that Wright believes that 'while there is naught wrong with numerical work, in general, it is good to have a benchmark that delivers general results by hand', while the Haldane and Turrell approach would—in addition to using current modelling approaches—aim to explore hypotheses within numerical models, and then seek more parsimonious analytical results *ex post*.

The benchmark model and policy models

Jesper Lindé (2018) acknowledges the Blanchard taxonomy, but wishes to blur the boundary between DSGE models and policy models because—he argues—DSGE models were simple and flexible enough to have successfully informed policy during the crisis. In particular, he claims that such models illustrated the benefits of fiscal stimulus at the zero lower bound, and the risks of fiscal consolidation in a monetary union. In his view the flexibility of DSGE models, coupled with the ability to accommodate various extensions, means there are few contenders to take over from them—even in the policy process. Lindé also adds that while DSGE models might not have forecast the crisis (Blanchard's fifth purpose), neither did more specialized forecasting models like Bayesian VARs (vector autoregressions).

Hendry and Muellbauer do not agree with Lindé, arguing that DSGE models are ill-suited to policy purposes. They put the poor forecast performance of DSGEs and VARs down to the lack of asset prices, credit, and financial frictions and the use of linear functional forms in both approaches. They take particular aim at the treatment of consumption. In their view, proper modelling of this variable requires two things. First, abandoning the analytical straitjacket that the Euler equation places on consumption. This does not just mean fitting a 'looser' form of the same equation, with different coefficients than those imposed by theory. Instead, it must link liquid, illiquid, and housing assets to consumption, even if the theory behind the linkages might not be fully understood. Fundamentally, they argue for evidence-based research: driving theory with data.

Simon Wren-Lewis provides a more extended discussion of the damage done by the DSGE hegemony to the work of building useful policy models. He describes, for the United Kingdom, how this hegemony led to funding for work on policy models being abolished. He also argues that the lack of work on such models explains the inability of

[33] Randall Wright's response to this sentence, when looking at a draft of this article, was 'perhaps—but for a discussion of the future of macroeconomics we might want to be ambitious and suggest that it is best to explain nominal [and other] rigidities, not to assume them'. But should we let the best be the enemy of the good?

the UK's policy community to understand the effects of the financial imbalances which were developing in the run-up to the global financial crisis. His approach, like that of Blanchard, is to argue that policy modellers should be free to work in the way described by Hendry and Muellbauer, rather than being constrained by a theoretical straight-jacket. He explains, with great clarity, how such a constraint can operate.

The benchmark model and toy models

Paul Krugman also (implicitly) accepts Blanchard's taxonomy, but argues that policy-makers actually relied on toy models as their default when the financial crisis came (Krugman, 2018). These were versions of the Hicksian sticky-price IS–LM set-up. Such models were, he says, good enough for what they were required to do. He claims that, while many incremental changes have been suggested to the DSGE model, there has been no single 'big new idea'. This is because the policy responses based on IS–LM were appropriate. In particular, these suggested that that large budget deficits would not drive up interest rates while the economy was at the zero lower bound, that very large increases in the monetary base would not be inflationary, and that the multiplier on government spending was greater than one. Many people were willing to work with DSGE models, and some even considered them superior for many purposes, in agreement with Lindé. But when faced with the question of how to deal with the regime change at the zero lower bound for interest rates, many did not develop new theories, but took Hicksian predictions about policy in a liquidity trap as their starting point. So, Krugman also does not a call for the core DSGE model to be rebuilt.[34] One can recognize the MIT method at work here—'keep it simple, stupid'—which Krugman attributes to Robert Solow (Krugman, 1992).

The benchmark model and forecasting models

Many of our authors—not just Lindé—point out that DSGE models were no good at forecasting the crisis. Some argue that this is a reason why a new framework is needed.[35]

This difficulty is not surprising; it comes from the two critical assumptions underpinning DSGE models: the efficient market hypothesis, and rational expectations. The efficient markets hypothesis gives rise to an expectations-augmented yield curve in which there is no endogenous risk premium. Furthermore, a rational expectations model like our benchmark always converges back to the Ramsey equilibrium growth path. Even if there is a very large reduction in private demand which triggers the zero bound, the economy will not collapse because of the forward-lookingness of consumption, investment, and inflation. In such a model, the efficient markets hypothesis means that things can never go seriously wrong because of a risk premium, and the rational expectations assumption of re-convergence to the Ramsey growth path means that there can never be a really serious crisis.

We have some sympathy with the argument that those who built DSGE models really did persuade themselves that the world was like their model. And if the world really is like such a model, then of course the two factors noted in the previous paragraph mean

[34] The exception to this is his call for further work to be done on pricing behaviour, in order to understand, in particular, why a very large output gap did not lead to disinflation.

[35] The list includes Stiglitz, Wright, Haldane and Turrell, and Hendry and Muellbauer.

that you would never expect things to go badly wrong—the Great Moderation will last forever. The paper by Simon Wren-Lewis implies that something like this happened.

V. Can we build a new core DSGE model that is tractable?

The core DSGE model should provide the simplest possible conceptual understanding of macroeconomic processes, rather than being explicitly designed to have policy relevance, or to be foundational, or to forecast. What should such a core DSGE model involve?

(i) Four requirements for a new core model

As already noted, we think that four key points were made by our contributors: the need for financial frictions in the model, a need to relax the rational expectations assumption, the introduction of heterogeneous agents, and underpinning the model with more appropriate microfoundations. We now summarize the contributions of our authors on each of these four issues. In the next section we outline suggestions about how the new core model might be brought together.

Financial frictions

Given that the 2008 crisis originated in the financial sector, which the benchmark DSGE model assumed works frictionlessly, it is natural that almost all authors in this issue mention financial frictions. The assumption of 'frictionless finance' had the deep implication that finance had no causal role to play and merely provided the financial intermediation which enabled private-sector expectations about the real economy to be realized. There is general agreement that there is a need to focus on the deep mechanisms underlying these frictions.[36]

The empirical case for including financial frictions in the core is outlined by Vines and Wills, and the need to integrate finance with the real economy is central to the paper by Hendry and Muellbauer. Since the crisis we have witnessed changes in spreads, changes in the yield curve and deleveraging, and an introduction of new policies like QE and dynamic macro-prudential regulation. Stiglitz further argues that the financial sector is the source of many shocks in a modern economy, either endogenously through the bursting of bubbles, or exogenously through poor policy. Furthermore, diversification does not always dissipate shocks, but can amplify them through contagion.

[36] Krugman, by contrast, argues that the lack of financial frictions in the benchmark model is not a major problem. The frictions were well understood, using Diamond–Dybvig model, and the experience of the Asian financial crisis. Wright thinks that this view—that the 'financial crisis is easy—it's a bank run like Diamond and Dybvig'—is too simplistic. He notes that in Diamond and Dybvig banks issue simple deposit contracts in an *ad hoc* way where better contracts are feasible; and that endogenizing contracts might remove runs. This is another example of Wright's refusal to include frictions which cannot be microfounded as the outcome of an optimal decision.

This has led to a number of suggestions for how core theory should respond. Liquidity constraints are raised by Blanchard, Vines and Wills, and Wright, among others. Balance sheet effects, like a stock of leverage affecting borrowing capacity, are mentioned in the papers by all of Blanchard, Hendry and Muellbauer, Stiglitz, Wren-Lewis, and Vines and Wills; Blanchard (2017) argues that 'own funds' affect spending decisions. In summary, 'stocks should affect flows': capital for banks and collateral and wealth effects for individuals. Stiglitz argues that risk has first-order effects which are often ignored, seen most clearly in the long time it takes for the collateral of banks to be restored after shocks. Vines and Wills argue that the yield curve should be endogenous—perhaps using a preferred habitat approach—in the hope of reviving the traditions of James Tobin in modern macro. Wendy Carlin and David Soskice (2018, this issue) argue for a need to include a financial accelerator and debt-financed investment in the model, and see a need for including the effects of a leveraged banking system (see also Carlin and Soskice, 2015). Lindé argues for DSGE models with an added financial sector, while Fabio Ghironi (2018, this issue) argues that financial frictions should shed light on the misallocation of resources across heterogeneous firms with market power. Stigiltz warns that it will be difficult to do any of this well.

Wright offers suggestions on how to incorporate these frictions using deep microfoundations. He argues that money, credit, and finance should emerge as outcomes of, rather than inputs to, our theories. By this he means that institutions like monetary exchange and credit should be the results of models, rather than the assumptions underlying them. The types of financial frictions he advocates modelling range across credit, banking, and contracting, set in a dynamic general equilibrium context. The results of doing this can yield new insights. For example, including an explicit role for liquidity can generate self-fulfilling prophecies, like bubbles, booms, crashes, and freezes. This approach shares similarities with Stiglitz and Haldane and Turrell, who all focus on the deep mechanisms underlying the frictions we see in the financial sector.

Relaxing rational expectations

The second change to the benchmark model suggested by our authors is relaxation of the requirement that rational expectations hold in all solutions of the model. Some authors, like Lindé, emphasize that the forward-looking behaviour of DSGE models is crucial in the benchmark model, because it allows us to understand how new unconventional policies, like QE and forward guidance, work. In contrast other authors, like Blanchard, Ghironi, Haldane and Turrell, and Stiglitz, all argue that the agents in our models look too far into the future, and that this leads to unrealistic consumption behaviour (the Euler equation) and price-setting behaviour (in Calvo contracting). This can have important implications for policy, for example such forward-lookingness may lead to low estimates of fiscal multipliers as agents overweight the prospect of future tax increases—as noted by Hendry and Muellbauer, and Stiglitz. Blanchard (2017) suggests incorporating finite horizons, not necessarily coming from finite lives and incomplete bequests, but instead from bounded rationality or from myopia. Haldane and Turrell suggest that a less rigid framework, like ABMs, would allow for many different degrees of rationality, and should make it possible to include the effects of heuristics that make sense in an uncertain world with costly information.

Heterogeneous agents

The third key addition to the benchmark model suggested by our authors is to incorporate heterogeneous agents: both consumers and producers. To do this a number of authors, including Lindé, Carlin and Soskice, Ghironi, Ricardo Reis (2018, this issue), and Vines and Wills, cite recent work by Kaplan *et al.* (2016) and Ravn and Sterk (2016) that parsimoniously includes both heterogeneous agents and search and matching frictions in a DSGE framework. Haldane and Turrell offer ABM as another way to do this. Stiglitz argues that doing this is crucial because the distribution of income matters, both for demand and for welfare outcomes. He discusses the adjustment to a negative shock; a fall in real wages can reduce demand and increase unemployment if workers have a higher marginal propensity to consume than owners of capital.

Furthermore, Ghironi argues that heterogeneous consumers alone are not sufficient, we also need heterogeneous firms. These should vary in product lines, productivity, size, and trade exposure, and should be allowed to dynamically enter and exit the market. They may also interact, strategically or in networks. He notes that this does not require completely new tools, since endogenous producer entry occurs in endogenous growth models (Romer, 1990), and since heterogeneous agents have been part of trade theory since the work of Melitz. Firm entry and exit over the business cycle affects growth through hysteresis; this approach may help us understand the slowdown since the crisis, with zombie (low-productivity) firms not exiting the market, and new firms not entering. Stiglitz adds to this discussion, suggesting that disaggregating into a number of different sectors would help to explain the structural transformation that may, at present, be contributing to slow productivity growth.

It is important to note that a proper recognition of heterogeneity will put paid to the representative agent method that has been so important in all of what we have discussed so far. Heterogeneity in general eliminates any relation between individual and aggregate behaviour. This means that having a 'representative agent' does not, in fact, count as a microfoundation. And attempts to allow for this by ending up, say, with two or three kinds of consumer, as in the work of Ravn and Sterk (2016), do not really get around this aggregation difficulty.

Better microfoundations

The final key—and perhaps most serious—addition suggested by our authors is to use more persuasive microfoundations. In the words of Ghironi, macro needs micro. While there is general agreement that we need better microfoundations, there seem to be three different interpretations of what this might mean.

The first approach, as articulated by Blanchard and Krugman, would involve improving the microfoundations in the existing core model. Krugman argues that the main modelling inadequacy identified by the crisis was on the supply side: stagflation had convinced everyone that there was a natural rate of unemployment, but the fact that sustained high unemployment did not lead to deflation during the crisis calls for a rethink. He notes that there have been surprisingly few calls to rethink ideas about inflation and the natural rate. This is essentially because understanding wages and prices is hard; we cannot always start by assuming rational behaviour and that markets reach equilibrium. Blanchard also identifies the *ad hoc* approach to understanding price stickiness as a problem, arguing that the deep reasons behind this, like the costs of

collecting information, probably have implications which reach beyond wage and price setting, and that we ignore these at our peril.

The second approach would bring into the core the approach used in building foundational models. This requires a deeper approach to microfoundations than is currently used, and is advocated by Wright. As already noted, he argues that the use of money, credit, and other assets in facilitating exchange should emerge as outcomes of, rather than inputs to our theories. He argues that there is no canonical financial-macro model with acceptable microfoundations in the way that versions of Mortensen and Pissarides (1994) or Burdett and Mortensen (1998) models are accepted as benchmarks in labour economics. A necessary requirement for any decent microfoundations—he says—should be to be able to price a dollar bill, which will require establishing a price for liquidity. Rather than models that assume the existence of banks, we need models in which banks arise endogenously. He sets a high bar: in general equilibrium there should not only be no gains from trade sitting on the table—as already mentioned—but no gains from changing institutions as well. Inadequately microfounded institutions should be thrown out of models and replaced by institutions which are modelled as the outcomes of structural frictions of an exogenous kind. He suggests that a fruitful avenue for doing this is search theory, since he thinks of the requirement to search as an exogenous friction. We should have—he says—a theory of how people trade with one another, rather than how they trade with their budget constraints. There should be explicit frictions that make the process non-trivial, and institutions should arise endogenously to facilitate this process. He goes on to propose a simple framework for doing this, noting we should aim to do this analytically, at least for core models. It seems there is an analogy in the natural sciences, chemistry has been 'microfounded' through the use of explanations from quantum physics.[37]

The third approach would bring a radically different approach to microfoundations in the core model, relying on simulation methods rather than analytical models. This is agent-based modelling and is advocated by Haldane and Turrell. Like Wright, they suggest modelling the way in which individual agents trade or interact with each other. However, unlike Wright's proposal, such an approach would be based on many heterogeneous agents, and would need to be solved numerically rather than analytically. Such an approach would—they say—enable one to study complexity, networks, herding, and irrational behaviour. The major advantage of this approach is that it makes it possible to introduce behavioural assumptions for individual agents, and to study systems that are out of equilibrium and in which markets don't clear. This can lead to phase transitions, like the way that opinions form within populations. Blanchard suggests that this approach may have merit, but criticizes the approach for not having yet produced a core model. Haldane and Turrell respond to this challenge by suggesting that a core model is not required, rather they think that the ABM approach should be seen as offering a flexible, modular toolkit. They argue that such an approach might enable one to study all the following features: nominal rigidities, bounded rationality and limited horizons, and incomplete markets and a role for debt. The difference is that in the ABM framework these will be emergent, rather than primitives.

[37] But we would note that this has not led to a demand for all explanations in chemistry to be microfounded in this way.

(ii) How might we incorporate these suggestions into a new core model?

A number of authors have made detailed suggestions as to what the new core model might look like, and many valuable proposals can be found in what they say. Here we make two observations about the overall frameworks which are proposed.

In a way, the least radical proposal is that from McKibbin and Stoeckel. They are clearly engaged in building a policy model. But they also see their model as a core model, arguing that that it contains a valuable framework within which to carry out simulations of actual events, and of hypothetical possibilities. They see such a framework as valuable because it constrains the outcomes of simulations within the framework of a well-understood theoretical structure—that of the existing benchmark model outlined in section III and Appendix II of this paper—and they think that such a structure causes long-run outcomes to be coherent in well-understood ways. Of course they would allow for short-term deviations from the microfounded rationality embodied in this benchmark model, but they nevertheless see having such a structure as something which is important for a policy model as well as for a core model. Nevertheless their proposal is also a radical one in another sense, since they suggest that the core model should have output disaggregated into a number of different commodities and services, and that it should identify the nature of links between different countries.

In a way, the most radical proposal is that of Carlin and Soskice. They aim to provide a model focusing on the short to medium run; one which is capable of providing a clear explanation of why recovery since the global financial crisis has been so slow. They describe the possibility of a Keynesian unemployment equilibrium, whose existence is underpinned by five fundamental assumptions: a zero bound to interest rates, the absence of disinflation in the presence of high unemployment, strategic complementarities among investors capable of giving rise to multiple equilibria, the assumption that technical progress is embodied in investment so that a low-investment outcome will give rise to a low rate of technical progress, and sufficient myopia among investors and consumers that the possibility of a good outcome in the future does not cast a such an optimistic shadow over the present as to rule out the possibility of a Keynesian unemployment equilibrium. Their set-up is one in which there is also a good outcome—what they call a Wicksellian equilibrium—in which resources of the economy are fully employed, the economy grows, and real wages rise, all in the way contemplated by the benchmark New Keynesian model.[38] But their achievement is to show that another different equilibrium is possible, the Keynesian unemployment equilibrium. It is possible to regard their set-up as underpinning the kind of ideas put forward by Krugman in his article. He suggests that, where necessary, we should go on using, with a clear conscience, the kind of IS–LM framework which was the standard model in the 1960s, reassured that this approach proved useful in thinking about the right policy responses at the time of the recent financial crisis.

[38] Wendy Carlin and David Soskice have already provided, in their macroeconomics textbook, a careful comparison of a number of different modelling approaches with the approach embodied in the benchmark New Keynesian model. See Carlin and Soskice (2015, ch. 16). The model presented in their paper in this issue of the *Oxford Review* could be added to the taxonomy discussed in that chapter in a fruitful manner.

We now make our own suggestion about what needs to be done, drawing on the points identified in the previous section of this article. We argue that four changes are needed. We think that the three behavioural equations of the model: describing consumption, investment, and price-setting, must all be amended or replaced. In addition, we argue that a gap should be introduced between the rate of interest set by monetary policy-makers and the rate affecting consumption and investment decisions.

The treatment of consumption needs to recognize finite horizons, liquidity constraints, overlapping generations (a 'death distortion'), a distribution of consumers, and also make allowance for the fact that consumers hold housing as major asset class. An overlapping generations structure would make it possible for the equilibrium real interest rate to stay above the marginal product of capital for extended periods (or even permanently), which may help explain the slow recovery. A distribution of consumers with different levels of wealth would make it possible to study inequality, and also the first-order effects of redistribution on aggregate consumption (due to different marginal propensities to consume). Including housing would make it possible to study consumers' decisions to invest in houses rather than productive capital, which in turn lowers real income in the long term. It appears possible to include this in a simple overlapping generations model (see Barrell and Weale, 2010, and Wang, 2011). However, this will be insufficient if the purpose is to study the house price booms and collapses that Hendry and Muellbauer argue must be examined in a policy model. Such an analysis would require a more complex treatment that also considers the down-payment constraints and varying access to equity withdrawal that characterize home loans.

The Tobin's Q investment equation needs to be replaced by one which allows for liquidity constraints, and for finite horizons which would dampen the responses to changes in Q. These constraints are important in explaining the downturn in investment immediately after the GFC. But these changes would not help in explaining why, even though equity markets are strong and cash flow is weak, corporate investment in advanced countries is still so low. Here the ideas of Carlin and Soskice seem crucial.

The Calvo-contracts equation for inflation needs to be replaced with one which allows for search and unemployment effects, and inertia (like backward-looking expectations).[39] Relative price adjustment between heterogeneous goods is also important. This is something emphasized by Ghironi, in his model with heterogeneous firms, and McKibbin and Stoeckel, in their examination of the effects on the global structure of relative prices of the rise of emerging-market economies.

Finally, we think that a gap should be introduced between the rate of interest set by monetary policy-makers and the rate affecting the consumption and investment decisions of the private sector. Such a gap may be an important reason why investment in advanced countries has not recovered since 2008. The difficulty here comes from two of the critical assumptions underpinning the benchmark model: the efficient market

[39] The importance of the latter can be illustrated by looking at the effects of asymmetric shocks within a monetary union. Kirsanova *et al*. (2007) and Allsopp and Vines (2008) show that asymmetric negative shocks to a country's competitiveness in a monetary union might do little damage if the nominal rigidities are of a Calvo kind, because forward-looking wage-and-price-setters will immediately drop prices in the appropriate manner. But, if wages and prices are persistent, this shock can create deflation and a rising real interest rate in that country—because the union-wide nominal interest rate across the monetary union will be unaffected—causing a further reduction of demand and inflation and so perhaps leading to a cumulative deflation.

hypothesis, and rational expectations. The efficient markets hypothesis means that things can never go seriously wrong because of a risk premium, and the rational expectations assumption (and its implication that an economy will eventually re-converge to the Ramsey growth path) means that there can never be a really serious crisis. Inserting a gap between the policy rate and the rate affecting investment decisions may be a way of fixing this.[40]

What we have listed above is already a bit too much like a shopping list, from which it will be necessary to make choices. Furthermore, it is important to add to our shopping list the proposals made in this issue of *OxREP* by Reis and Stiglitz. In a few short pages, Reis gives a very helpful sketch of what could be included in a new core model. And in a much longer contribution Stiglitz produces a framework in which policy choices can be examined; one which can give rise to both Keynesian-type outcomes in the short run, and to growing equilibria over longer periods of time—if shocks are not too large and if the adjustment process in response to these shocks is satisfactory.

We can begin to see—in outline—how many of these changes might be carried out, one by one. But as Keynes learned in the 1930s, markets interact. So one challenge will be to incorporate each of these things in a way that makes sense in general equilibrium. A second challenge will be to do so parsimoniously.

As and when this is done, we think that there will have been a very significant evolution away from the benchmark model that was in place before the global financial crisis. But we do not think of this as a paradigm shift. There will have been many particular changes in content. But perhaps not a sufficient change in method for the outcome to be described as a real change in paradigm.

(iii) The approach to the data

The authors in this issue say relatively less about our last examination question, on how models should relate to data. Nevertheless, some important things stand out.

Stiglitz draws on a critique by Korinek (2017) of macro-empirical methods to propose a number of ways in which core and policy models can better relate to data. These include: abandoning the HP filter, which ignores important low-frequency phenomena; allowing for the skewness of time series; finding consensus on measuring the goodness of fit; and ensuring that DSGE models do not impose restrictions that contravene the micro evidence.

If one is trying to estimate a DSGE model, then perhaps the Bayesian method remains the most appropriate one. Roughly speaking, this method, as routinely practised, starts with an analytical structure, imposes that structure on the data through priors, and then invents names for the large errors which may appear in the equations to compensate for the violence that the model does to the data, especially if theory tightly constrains some of the parameters. Such a process is more or less what Romer (2016) ridiculed. An important way to escape the Romer ridicule is to inform these priors by means of detailed work estimating the equations one by one, rather than immediately estimating the system as a whole. Sub-system estimation may also help, to take advantage of connections between related equations while avoiding biases from elsewhere in

[40] A different approach to this issue is put forward by Carlin and Soskice in their paper.

the system. But this is difficult to do, partly because the same parameter may appear in more than one equation.[41] Furthermore, as Hendry and Muellbauer argue, if the model excludes highly relevant variables and structural breaks, estimating equations individually is unlikely to help a lot. One must—at the very least—allow for intercept adjustments, and for time-varying parameters.

(iv) A need to change the culture of the macroeconomics profession

A macroeconomics profession which begins to do what we have described in this section of the paper will come to have a rather different culture.

All of the authors in this issue seem to agree with Simon Wren-Lewis that the culture which has emerged in macroeconomics is too hegemonic. Haldane and Turrell use the term 'monoculture' to describe what has happened: namely the view that only models with rational expectations and explicit microfoundations of a particular kind could be accepted into the macroeconomic canon. The emergence of a range of different models will certainly serve to undermine this hegemony. A range of core models is likely to emerge. And the recognition of the way in which a policy model has a different purpose from that of a core model is likely to give rise to a situation in which policy models are very different from core models, and—maybe—to be accompanied by a change in the culture to one in which this difference is both tolerated and respected.

Many argue that the discipline has also become too insular. Ghironi argues that macroeconomics needs to overcome the separation between the study of short-run stabilization policy and longer-run growth, something which we have already discussed in this article. Blanchard argues that DSGE modellers might become less insular by looking at other parts of the economics discipline. Ghironi elaborates on this point: he talks about the need to bridge the gap between closed economy macroeconomics and the study of international macroeconomics and international trade. McKibbin and Stoeckel agree with this. In a different vein, Haldane and Turrell note that those who write macroeconomic articles cite other disciplines much less than happens in other fields.

We think that, in a healthier culture, macroeconomists should be allowed to learn more from data, in the way that microeconomists seem to do. As Wren-Lewis argues, there has been an unhelpful movement in two opposite directions. On the one hand, the Lucas critique and the hijacking of the use of the word 'structural' to mean 'microfounded' has pushed the applied macroeconomists who want to build policy models into a requirement that they deal with data in a very constrained way. On the other hand, there has been a move by those who deal seriously with data into the estimation of VARs, which involve almost no theory. The failure of the twain to meet has—he argues—severely constrained evidence-based progress in macro. We agree with this claim.

How might we move in the required direction? What might pluralist progress involve?

A number of authors argue that models should be modular, like Lego, Meccano (Blanchard), or building blocks (Ghironi). The aim might be a core model that can accommodate 'bolted-on' extensions. Policy models should focus on issues that are

[41] There are a number of other difficulties; some solutions to the problems are offered by Fukac and Pagan (2010).

regularly encountered, while a collection of complementary satellite models might cover less central issues, or ones with less of a general-equilibrium framework. Blanchard argues that we should 'relegalize shortcuts', noting that one person's microfoundations will look like short-cuts to someone else.

Lindé and Stiglitz argue that big and small models should be complementary. Small models might help us to understand new mechanisms, before being incorporated into larger models to test their robustness in general equilibrium. McKibbin and Stoeckel argue that large models—nevertheless ones tightly constrained by theory—can give much real-world insight.

Within each class of model, it may also be that there should be more diversity. Krugman wants a 'looser-jointed' benchmark model, one which can be useful without being microfounded. He also argues—in a way very different from what many others are saying—that financial models can be put on the side, only to be used to examine outcomes at times of crisis, rather than being embedded in any core model.

Haldane and Turrell want a 'rich ecology' of models, to which selective pressure can be applied by controlled experiments, to see which best fit the facts. They argue that such an approach is used in other disciplines, and that it is also used at the Bank of England, their own institution. Stiglitz ends up arguing that we should teach many kinds of models to graduate students. Nevertheless, he describes a parsimonious three-period model which can be used in a productive way to hold the various ideas together.

Such an approach might be like a collection of maps. A London Tube map is extremely reductive, famously overstating the distance between Paddington and Lancaster Gate which can be walked in 10 minutes. However, for the purpose of navigating the Underground this model is elegantly suited. While a tourist on foot might want a map of famous landmarks, a town planner would need something else. The maps we use to navigate the economy should—we think—be similarly varied.

VI. Conclusion

In his after-dinner talk to the annual NBER workshop in 2017, Olivier Blanchard briefly described what frictions should be included in a new core model. But then, in a disarming aside, he said: '[t]his may a hopeless and misguided search. Maybe even the simplest characterization of fluctuations requires many more distortions. Maybe different distortions are important at different times. Maybe there is no simple model . . .'. Nevertheless he then added: 'I keep faith that there is.' That is our hope, too.

As support for this journey-in-hope, we think that we have learned two things from this project. The first lesson is that it is time to do away with the microfoundations hegemony. Long ago the University of Cambridge (UK) established DAMTP—the Department of Applied Mathematics and Theoretical Physics. But this did not impede progress in experimental physics at that university. It is time for our subject to allow more room for, and show more respect for, those engaged in building, and using, policy models. These macroeconomists are now doing our equivalent of experimental physics.

The second—and related—lesson is that there needs to be more pluralism. Just like in the sixteenth century, after the Christian Reformation, there may no longer be a true church. It is time to put the religious wars behind us.

Appendix I: Rebuilding macroeconomic theory: the examination questions

We asked contributors to answer all, or some, of the following six examination questions. There are two questions on each of context, content, and method. These were designed to focus on how everything fits together, as distinct from focusing on particular details. All of the questions related to the benchmark New Keynesian DSGE model which was set out for the authors in the manner which we have set it out in section III of this paper.

1. Is the benchmark DSGE model fit for purpose?

What is the purpose of macroeconomics at present? To describe how economies work? To diagnose policy failures? To guide future policy? Does the benchmark model still do these things?

2. What additions to this model are necessary to help us understand growth from now on?

Are slow population growth and a low rate of technical progress endangering the long-run growth process (as envisaged by Summers and Krugman)? If so, how do we best model this? In what way—if at all—is technical progress currently endangered (as imagined by Gordon)? Or is growth mainly driven by the decision to save (as imagined by some interpretations of Piketty)? What is the role of physical infrastructure, public capital, and human capital in the growth process and how is the necessary investment and education to be provided? What are the implications of this growth process for income inequality? How best to think theoretically about the role of financial intermediation in the growth process? What is the relative importance of equity and loan finance? To what extent are leveraged financial institutions necessary for financial intermediation, or might peer-to-peer lending come to supersede these institutions? When will deleveraging stop constraining the growth process, as it has for the last 6 years? To what extent are public deficits and debt necessary in the stimulus of demand and in the provision of infrastructure, public capital, and human capital? Does answering these questions require an approach different from the benchmark model, or simply a modification of that model?

3. What are the important inter-temporal complications?

The benchmark DSGE model assumes perfect foresight, rational expectations, and well-functioning capital markets; policy is assumed to be made either with full credibility, or under discretion; most models have unique solutions across time. Clearly actual history is not like this. In reality information is limited, balance sheet constraints exist, and there are feedbacks from stocks to flows (including from the stock of money to the flow of expenditure). Agents are subject to habits and norms. As a result, there are likely to be multiple equilibria, both real and nominal. What is the role of policy

in guiding the economy to one particular equilibrium? Most fundamentally, what are causal connections—both ways—between long-run growth and short-run stabilization policy? Does answering these questions require an approach different from the benchmark model, or simply a modification of that model?

4. What are the important intra-temporal complications?

Why does aggregate demand not always adjust to aggregate supply, including after shocks? How do the resulting fluctuations in capacity utilization affect the growth process? The benchmark DSGE model recognizes one reason for this—nominal rigidities. But should we go beyond this to think about coordination failures? What important coordination failures result from interactions between agents that are not captured in such a representative-agent framework (e.g.in the Dixit–Stiglitz model)? In other words, when do multiple equilibria matter? Does answering these questions require an approach different from the benchmark model, or simply a modification of that model?

5. Should the above questions be discussed with big or small models?

Should we, like physicists—or like James Meade and some contemporary DSGE theorists—aim for a general theory of everything? Or should we instead push for a set of simple, tractable models, each of which just tells part of the story (the MIT method)? In other words, should we 'relegalize shortcuts', as suggested by Blanchard? Has a desire for completeness meant that we cannot see the wood for the trees? Conversely, has a desire for elegance caused us to omit important details?

6. How should our models relate to data?

Do our models use data appropriately? In particular, should the structures of estimated models be data-determined (as in VARS) or theory-constrained (as in Bayesian model building). Is there a mid-way between these extremes?

Appendix II: The New Keynesian Benchmark Model

We first set out the components of the real model that underlies the New-Keynesian benchmark model. For brevity and simplicity, we do not set out the utility-maximization problem of the representative consumer or the profit-maximization problem of the representative firm; we simply set out the first-order conditions, and equilibrium conditions, derived from these two sets of optimization decisions.[42] And, also for simplicity, we assume a constant labour force and an unchanging level of technology; the

[42] For relevant details see Schmitt-Grohé and Uribe (2006) and Woodford (2003, ch. 5, § 3).

model can be generalized in a straightforward way to incorporate labour force growth and exogenous technical progress.

Notation is as follows: *C, I, Y, L, K, w, R,* and *Q* represent (respectively) consumption, investment, output, labour supply, the capital stock, the real wage, the (gross) real interest rate, and Tobin's Q. The model consists of the following eight equations.

$$\frac{1}{C_t} = \beta R_t E_t \left(\frac{1}{C_{t+1}} \right) \tag{1}$$

$$w_t = \chi C_t L_t^{\varphi} \tag{2}$$

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{3}$$

$$w_t = (1-\alpha)\frac{Y_t}{L_t} \tag{4}$$

$$R_t = E_t \left[\frac{\alpha \frac{Y_{t+1}}{K_{t+1}} + 1 - \delta + (Q_{t+1} - 1) + \frac{1}{2\xi}(Q_{t+1} - 1)^2}{Q_t} \right] \tag{5}$$

$$I_t = K_{t+1} - (1-\delta) K_t + \frac{\xi}{2} \frac{(K_{t+1} - K_t)^2}{K_t} \tag{6}$$

$$Q_t = 1 - \xi + \xi \frac{K_{t+1}}{K_t} \tag{7}$$

$$Y_t = C_t + I_t \tag{8}$$

Equation (1) is the inter-temporal Euler equation for the representative consumer; equation (2) is the intra-temporal labour-supply equation of the representative consumer, which equates the (real) wage to the marginal disutility of labour.[43] Equation (3) shows aggregate supply[44] and equation (4) shows that the representative firm employs labour up to the point where the marginal product of labour is equal to the wage. Equation (5) shows that the representative firm carries out investment up to the point at which the marginal product of capital is equal to the real interest rate, plus an allowance for the depreciation of the capital stock, minus any anticipated capital gains on the capital stock, plus an allowance for the marginal costs of capital adjustment.[45] Equation (6) shows that capital accumulation is equal to investment, minus depreciation, minus

[43] The consumer's utility function is logarithmic in consumption and decreasing and convex in labour.

[44] The production function of the representative firm is Cobb–Douglas.

[45] Because of the interaction of Equations (5)–(7), this term has an effect which is *increasing* in ξ when the model is simulated, even although ξ appears in the denominator of Equation (5).

the resources wasted whenever the capital stock is adjusted; adjustment costs are convex and quadratic—the bigger is ξ the greater are these costs. Equation (7) determines Tobin's Q; the equation shows that the larger are adjustment costs of capital (i.e. the larger is ξ) the further will Q deviate from unity when the capital stock is away from its equilibrium. Equations (5)–(7), when taken together mean that, when the model is simulated, the larger is ξ, the more gradual will be any adjustment of the capital stock to its desired level. Equation (8) shows that aggregate demand is always equal to aggregate supply; the model solves for the real interest rate R which brings this about—effectively by making saving equal to investment. The model is log-linearized around the non-stochastic steady state and solved using the Blanchard–Kahn method; K is a predetermined variable and C and Q are jump variables.

Notice from Equations (5)–(7) that whenever there is a shock to the system, and providing that $\xi > 0$, the real interest rate must move away from the marginal product of capital plus an allowance for depreciation, in order to re-establish an equilibrium in which saving equals investment. This is precisely because there are costs in adjusting the capital stock.

In this model, although all markets clear, there are general-equilibrium interactions between markets. Keynes found that such interactions happened between markets when he postulated sticky wages—implying that the labour market might not clear—and so effectively turned Marshallian analysis into IS–LM. Here the general-equilibrium story is an additional one: the microfoundations of this model mean that interactions between markets happen, even if all markets clear. In particular, the demand for labour depends on consumption and thus on the interest rate and investment. Any shock, such as a fall in investment as analysed below, will therefore shift the demand for labour inwards at any level of the real wage. It will also lead to a lower interest rate, higher consumption and so shift the supply curve of labour inwards at any level of the real wage. The outcome in the labour market, and in particular the equilibrium real wage, will depend on the shifts in labour demand and supply, which are caused by developments in the product market.

Notice that, in the (implausible) limiting case, in which $\xi \rightarrow 0$, the model converges to an RBC model, in which whatever is saved is costlessly invested. In such a set-up, Tobin's Q always remains equal to unity, and the real interest rate is always just equal to the marginal product of capital plus an allowance for depreciation. There is no need for an endogenous interest rate to make savings equal to investment.[46] This chain of reasoning shows why it is essential to include capital adjustment costs in the model.

The parameters used in the simulation below are standard and are shown in Table 1; these parameters correspond to the idea of a quarterly model.

The effects of a sustained negative shock to the aggregate level of productivity, A, are illustrated in Figure 1. RBC theorists normally study shocks which are autoregressive, for reasons explained in the text, but it is more revealing to study the effects of a sustained technology shock.[47]

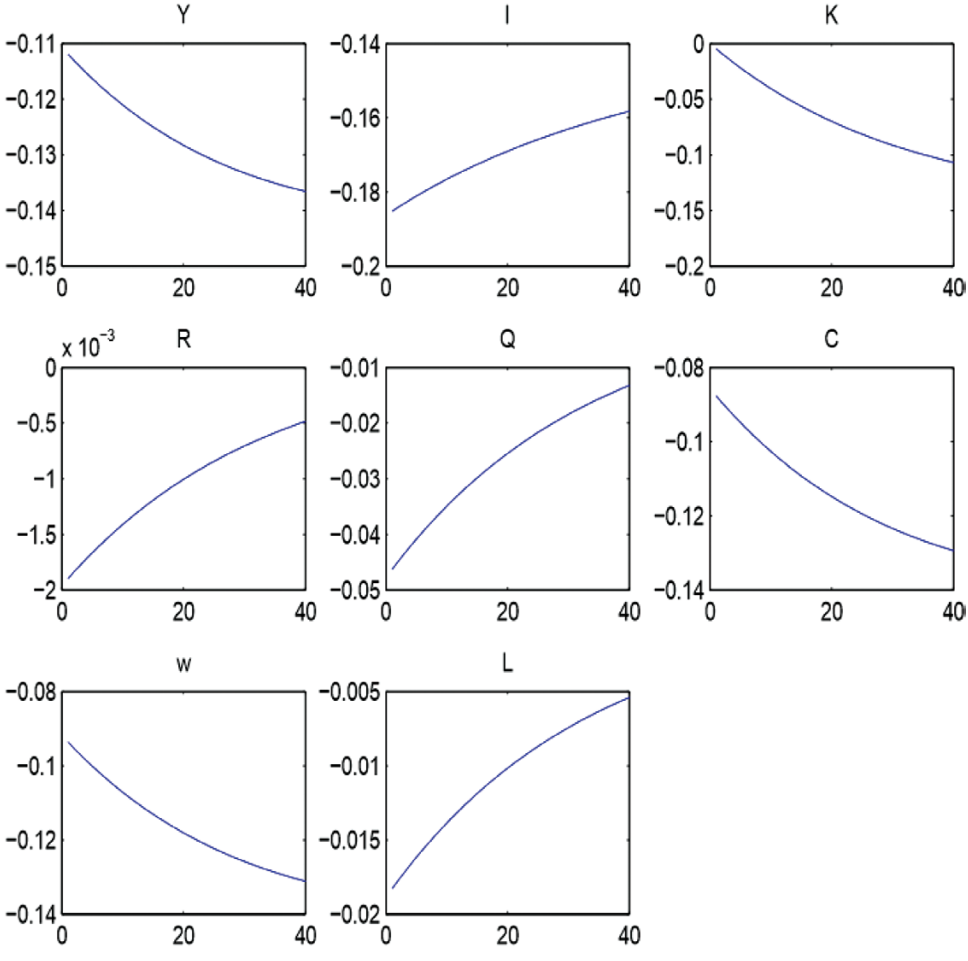
[46] Nevertheless, the shock analysed in the example below would still have general equilibrium effects on the labour market: the reduction in productivity would reduce both labour demand and—by reducing the real interest rate—increase consumption and thereby reduce labour supply.

[47] Control engineers teach their students that subjecting a model to sustained shocks reveals things about the structure of the model which are not revealed by transient shocks.

Table 1: Parameter values

Parameter	α	β	δ	χ	φ	ξ
Numerical value	0.35	0.99	0.025	0.3	0.33	10

Figure 1: Response to a negative 10% TFP shock



After the shock, profit-maximizing firms will want to hold a lower capital stock, and so the new Ramsey equilibrium must have this feature. That leads to a period of disinvestment; the length and intensity of which depend on the costs of capital adjustment. As a result of this disinvestment, the level of aggregate supply will fall more in the long run than in the short run. The sustainable level of current consumption will fall, and, in the interests of consumption smoothing, consumers will cut their level of consumption immediately. As a result, although aggregate supply is reduced, aggregate demand will also fall even if the real interest rate does not change. If adjustment costs in investment are sufficiently small—as assumed here—then the fall in demand in will

be larger than the fall in supply.[48] This means that the rate of interest will need to fall to ensure that savings remains equal to investment; and that aggregate demand remains exactly equal to the lower level of aggregate supply. In this Ramsey model without financial frictions, the interest rate received by consumers is equal to the cost of capital to investors, after allowing for the costs of adjusting the capital stock.

We can imagine that a perfectly capable central bank sets the interest rate necessary to keep aggregate demand equal to aggregate supply. It does this by manipulating consumption to make savings fall in a way which is consistent with the desired (gradual) decumulation of capital.

We now add nominal rigidities to the model, and a Taylor rule, and so arrive at the full new-Keynesian benchmark model, which we can use to study the behaviour of inflation. We use this model to simulate a cost-push shock.

We proceed by introducing differentiated goods and nominal rigidities in the manner of Calvo (1983). Specifically, we assume a continuum of goods producing firms, i, where i lies in the range [0,1]; these firms operate under monopolistic competition. These goods are aggregated into a single 'final' good by means of a Dixit–Stiglitz aggregator in which the elasticity of substitution between the varieties of goods is equal to ε. Any firm re-optimizes its price in a period with fixed probability $(1 - \kappa)$. (This is the Calvo fairy at work.) With probability κ prices are not re-optimized and are assumed to rise at the average rate of inflation. Finally, we assume—as is standard in the literature—that there is a subsidy to the firms (paid by a lump-sum tax) so that in the steady state firms produce the same quantities as in the flex-price economy, even although each firm faces a downward-sloping demand curve and so can restrict output. This means that the steady state values for C, I, Y, L, K, w, R, and Q are the same in the full new-Keynesian benchmark model as they were in the real model presented above.

The three new variables in this full model are π, the rate of inflation, R^n, the nominal (gross) interest rate, and mc, which represents real marginal cost.[49]

Of course, the model no longer solves for a real interest, R, that would make savings equal to investment in a way which would ensure the absence of inflationary pressure. Instead it allows aggregate demand to move relative to aggregate supply, in a way which creates inflationary pressure. It then allows the central bank to determine the real interest rate by setting the nominal interest rate, in response to developments in the inflation rate, according to a Taylor rule. Equation (9) expresses the real interest rate in terms of the nominal interest rate; equation (10) shows the way in which the central bank sets the nominal interest rate according to a Taylor rule, one in which—for simplicity—there is no output term.

$$R_t = E_t\left(\frac{R_t^n}{\pi_{t+1}}\right) \tag{9}$$

[48] We regard this as a plausible restriction on the parameterization of the model, although opinions on this differ.

[49] For brevity and simplicity, we do not set out the profit-maximization problem underlying the price setting behaviour of the representative firm; we simply set out the first-order conditions, For details see Schmitt-Grohé and Uribe (2006) and Woodford (2003).

$$R_t^n = \beta^{-1}\left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi} \tag{10}$$

The term β^{-1} at the front of the Taylor rule determines the constant term when the rule is written in linear form; it shows that the real interest rate will converge to its equilibrium value β^{-1} when any disturbances to inflation have disappeared. That is necessary in order for consumption to be in equilibrium—see equation (1) above.

The first eight equations of this new system are identical to those in the real system presented above, except for two crucial alterations. We replace equation (4) with the following equation

$$w_t = mc_t\left(1-\alpha\right)\frac{Y_t}{L_t}\,. \tag{4a}$$

This equation solves for levels of real marginal cost, *mc*, different from unity, thereby enabling aggregate demand to move in a way which is not constrained by aggregate supply. We know, from equation (2), that the economy always lies on the labour supply curve. We also know, from equation (8), that output is demand determined. Consider the effects of an increase in demand, caused by, say, a demand shock. This will cause output to rise, which from the production function—equation (3)—will lead to higher employment. The real wage must rise as the economy moves up the labour supply curve (equation 2), *ceteris paribus*. But, as more labour is employed, the marginal product of labour must fall (because of diminishing returns). Thus, because the wage is rising (as the economy moves up the labour supply curve), but the marginal product of labour is falling (because of diminishing returns), real marginal cost (which equals the wage divided by the marginal product of labour) must be rising. That is what equation (4*a*) shows.

We replace equation (5) with the following equation

$$R_t = E_t\left[\frac{\alpha mc_{t+1}\dfrac{Y_{t+1}}{K_{t+1}} + 1 - \delta + \left(Q_{t+1}-1\right) + \dfrac{1}{2\xi}\left(Q_{t+1}-1\right)^2}{Q_t}\right] \tag{5a}$$

The reasoning underlying this equation is similar to that applying to equation (4*a*), but now the direction of causation is different. Consider again the effects of an increase in demand, caused by a demand shock. This will cause output to rise and so lead to higher employment and a higher wage. But higher output will also raise the marginal product of capital and so encourage investment. But the extent to which investment rises will be constrained by the wedge between the wage and the marginal product of labour, which is what is captured by the real marginal cost variable, *mc*. Equation (5*a*) shows the effect of this wedge on *Q* and thus on investment.

Finally, equation (11) shows the new-Keynesian Phillips curve, in which inflation in any period depends on the (discounted) expected future rate of inflation plus a term which depends on the logarithm of the real marginal cost of labour to firms.[50]

[50] The logarithm of the real marginal cost of labour shows the proportional deviation of real marginal cost from the value of unity which it would have at the intersection of the labour supply and labour demand

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\beta)(1-\kappa\beta)}{\kappa} \ln(mc_t) + \mu \,. \tag{11}$$

This equation effectively shows, for example, that whenever aggregate demand rises above aggregate supply, and so *mc* rises above unity, any firm visited by the Calvo fairy will raise its price level. It will do this to an extent which depends on how many other firms are being visited at the same time—i.e. on the size of κ —and also on how high π is expected to be in the next period. The model is solved using the Blanchard–Kahn method; the inflation rate, π, is an additional jump variable.[51]

We use the following calibration for the two new parameters that we introduce: ϕ_π = 1.5, κ = 0.75. The first of these corresponds to the parameter used by Taylor when he first introduced his rule; this value ensures that whenever the inflation rate changes the real interest rate moves in the same direction, satisfying the Taylor principle discussed in the text. A value of κ of 0.75 ensures that the Calvo fairy arrives at each firm, on average, once a year. We do not need to calibrate ε. This is because, although the size of ε influences the size of mark-up of prices over marginal cost, this mark-up is constant and so disappears when the system is log-linearized.

The term μ shows a cost-push shock. For simplicity we specify this as a reduced form shock to the Phillips curve. There are various ways which have been used in the literature to microfound this shock.

We deliberately do not display the results of a technology shock in this model with nominal rigidities, as there are only minor differences to Figure 1. The reason is because the monetary authorities follow the Taylor rule above. When there is a negative productivity shock, inflation will need to fall to induce the central bank to lower the nominal (and thus the real) interest rate. This is needed to prevent demand falling by more than supply. The larger the parameter ϕ_π in the Taylor rule, the less inflation needs to fall to achieve this. In the limit, as ϕ_π tends to infinity, the response to a technology shock of a model with nominal rigidities becomes identical to that of the real model shown above. Even with the parameters chosen here, the differences between the simulation of the model with nominal rigidities and the results shown in Figure 1 are so small that it is not worth repeating the exercise.

This model with nominal rigidities enables us to display the results of a cost-push shock. Figure 2 shows the responses of the model to a 1 per cent shock to the multiplicative cost-push-shock term, μ. We assume the shock follows an AR(1) process with persistence 0.8, as is common in the literature; this prevents the results shown in the pictures having a spike, as the result of a spike in inflation.

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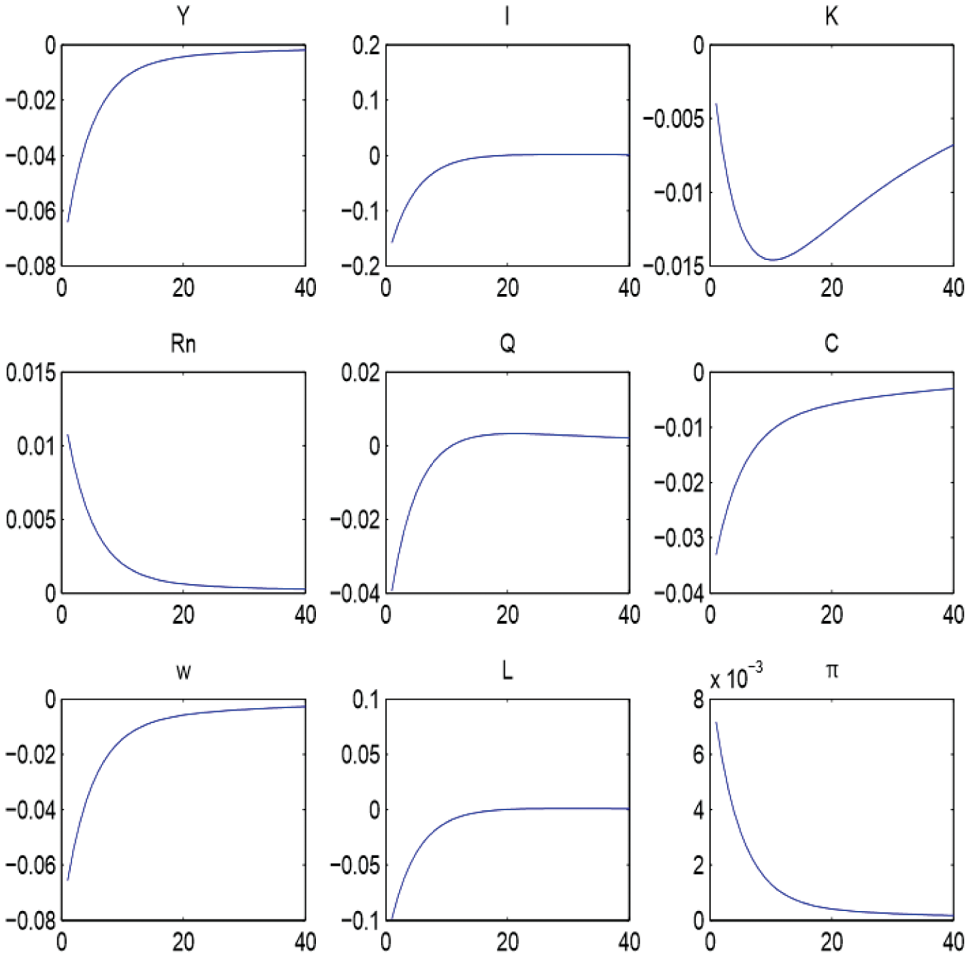
curves, at which point the wage equals the marginal product of labour and there would be no inflationary pressure. This argument is complicated, in an inessential manner, by the term β In front of the term $E_t \pi_{t+1}$ on the right-hand side of this equation. For an explanation, see Galí, (2015).

[51] Note that, as κ tends towards unity, the setting of prices tends towards full flexibility. If—in the case of a value of κ close to unity—demand pressures were to make real marginal cost differ from unity, then that would cause a very large disturbance to inflation. In an economy with a nominal anchor provided by a Taylor rule, such as equation (11), the central bank would raise the real interest rate, and that would, of course, moderate the demand pressures. In such an economy, as κ tended towards unity, the economy would tend towards one in which there was perfect price flexibility, output always equalled its natural level, and inflation moved instantaneously to a level at which the real interest was such as to bring about exactly that level of output.

Figure 2: Response to a 1% positive cost-push shock



After the shock, all firms are assumed to raise their prices as a result of the shock. The shock to inflation induces an immediate rise in the nominal (and real) interest rate. Consumption falls, and so does investment, because Tobin's Q falls. Output, employment, and the real wage fall, because workers are always on their labour supply curve.[52] Inflation comes down only gradually, partly because the cost-push shock is autoregressive, but also because each firm moderates their price cuts because they know that some other firms are not yet reducing their own prices.

This model shows that the capital stock is depressed as a result of the disinvestment which happens during the adjustment process, but is gradually rebuilt to its initial level.

[52] A choice by consumers to lower consumption in response to higher interest rates will be accompanied by a desire for less leisure and so push the labour supply curve to the right, thereby magnifying the fall in the real wage.

This is obviously something which cannot be studied in the Clarida, Galí, and Gertler model, in which all aggregate demand takes the form of consumption. Luk and Vines (2015) show that the method of controlling inflation by monetary policy, which is examined here, rather than partly controlling inflation by fiscal policy, can be costly precisely because it causes disinvestment during the adjustment process, something which needs to be reversed in a way which is costly. But they also find—somewhat surprisingly—that the welfare effects of doing this are small.

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