UNIVERSITY OF LEEDS

This is a repository copy of *Unconventional Monetary Policies from Conventional Theories: Modern Lessons for Central Bankers*.

White Rose Research Online URL for this paper:
https://eprints.whiterose.ac.uk/156054/

Version: Accepted Version

Article:

Fontana, G orcid.org/0000-0002-8055-5326 and Veronese Passarella, M orcid.org/0000-0001-7652-5952 (2020) Unconventional Monetary Policies from Conventional Theories: Modern Lessons for Central Bankers. Journal of Policy Modeling, 42 (3). pp. 503-519. ISSN 0161-8938

https://doi.org/10.1016/j.jpolmod.2020.01.001

© 2020 The Society for Policy Modeling. Published by Elsevier Inc. All rights reserved. Licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Reuse

This article is distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs (CC BY-NC-ND) licence. This licence only allows you to download this work and share it with others as long as you credit the authors, but you can’t change the article in any way or use it commercially. More information and the full terms of the licence here: https://creativecommons.org/licenses/

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.

White Rose
university consortium
Universities of Leeds, Sheffield & York

eprints@whiterose.ac.uk
https://eprints.whiterose.ac.uk/

Unconventional Monetary Policies from Conventional Theories: Modern Lessons for Central Bankers

by
Giuseppe Fontana
(University of Leeds, UK and University of Sannio, Italy)
and
Marco Veronese Passarella
(University of Leeds, UK)

Abstract: The aim of this paper is to provide a critical review of some recent developments in macroeconomics. We discuss the introduction of financial frictions in New Keynesian models, which is said to account for the increasing influence of financial markets, institutions and products in real-world economies. For this purpose, we compare the macro dynamics of a benchmark NCM-DSGE model with the behaviour of the same model augmented with a financial accelerator mechanism. Our simulation exercises show that the financial accelerator mechanism can be regarded as an effective, though indirect, way to account for hysteresis in potential output. A fundamental policy corollary follows that central banks should pursue financial stability, rather than price stability, and target current output growth, rather than output gap. Such an unconventional result is obtained by a simple macroeconomic amendment to an otherwise conventional NCM-DSGE model.

Key Words: Monetary policy, Financial Accelerator Mechanism, DSGE, NCM, Hysteresis

JEL Classification Codes: E12, E17, E47, E58

Acknowledgements: The paper is a development of some work done for the EU FP7 research project FESSUD (Financialisation, Economy, Society and SUstainable Development; Grant agreement no: 266800) on how finance can better serve economic, social and environmental needs (Further details here: http://fessud.eu/). The funding source did not have any role in the study design, the collection, analysis and interpretation of data, in the writing of the paper, and in the decision to submit the article for publication.

Contact Details: Giuseppe Fontana, Economics Division, University of Leeds, Leeds, LS2 9JT, UK; E-mail: G.Fontana@leeds.ac.uk.

Marco Veronese Passarella (Corresponding Author), Economics Division, University of Leeds, Leeds, LS2 9JT, UK; E-mail: M.Passarella@leeds.ac.uk; Telephone: +44 (0)113 3434515.

Unconventional Monetary Policies from Conventional Theories: Modern Lessons for Central Bankers

> I can now, with reasonable confidence, proclaim that, having laboured in the field of money-macro for the last 50 years or more, I shall shortly leave it, with the subject probably being in a worse state than when I initially found it. … In practice, in my view, the real advances in economics at the macro level in recent decades have occurred in the field of finance … By abstracting from default, banking and money, macroeconomics has gone down a blind alley (Goodhart, 2014, pp. 78-79)

1. Introduction

The debate in macroeconomics and central banking in the 1990s was dominated by a synthesis between the major schools of thoughts of previous decades, namely New Keynesian Economics (NKE) and Real Business Cycle (RBC) (e.g. Goodfriend and King 1997, Clarida et al. 1999, Romer 2000, Taylor 2000, Dixon 2008, Woodford 2009; Arestis and Mihailov 2011). On the methodological side, the use of dynamic stochastic general equilibrium (DSGE) models originally developed by RBC authors became the privileged analytical tool for macroeconomists. On the theoretical side, the need to focus on the maximising behaviour of an omniscient individual agent was maintained as fundamental theoretical pillar, while it was recognised that deviations from the long-run norm are possible in the short run. Institutional frictions, information asymmetries, price rigidities and other market imperfections may well slow down the pace of adjustment to the long run equilibrium, as stressed by the NKE economists. As a result, monetary policy is effective in the short run, and changes in the interest rate should be regarded as the key policy tool to target inflation, with monetary aggregates being determined residually. In the long run, monetary policies would only have nominal effects. Discretional fiscal policies are also considered very unfavourable. They would end up destabilising inflation expectations, thereby interfering with monetary policy decisions, while they would have no long-lasting effect on real variables. To sum up, the new consensus in macroeconomics (NCM) established between the early 1990s and the outbreak of the US financial crisis in 2007 was based on a hybrid model marked by Classical features in the long run, and weak Keynesian characteristics in the short run.

Today, NCM models are commonly adopted by most of central banks and international financial institutions around the world (e.g. Adolfson *et al*. 2007). And yet, as argued by Goodhart (2009, p. 829), the standard version of these models 'largely eliminates any rationale for banks, financial intermediaries, or even money'. This major flaw, along with recurring forecast errors, gave rise to an intense debate in academic journals and on social media, which has led a number of leading economists to question standard macroeconomic models or suggest some radical amendments to them (we refer, among others, to Blanchard 2016a,b; Blanchard 2017a,b; Galí 2017; Gürkaynak and Tille 2017; Haldane 2017; Keen 2016; Korinek 2015; Krugman 2016; Lavoie 2016; Lindé et al. 2016; Münchau 2016; Romer 2016; Wren-Lewis 2016). Interestingly, some pioneering attempts to account for financial frictions, asymmetries and imperfections were made far before the Global Financial Crisis (GFC), that is, between in the early 1980s and late 1990s. Financial institutions were regarded as possible amplifiers or triggers of the business cycle. The so-called 'financial accelerator mechanism' (FAM) literature was pioneered by Ben Bernanke and other NKE scholars (see, mainly, Bernanke 1981, 1983; Bernanke and Gertler 1989; Bernanke *et al.* 1996, 1999). No wonder if, after the collapse of Lehman Brothers and the subsequent worldwide crisis, the seminal work of Bernanke and his co-authors has been rediscovered and developed (see, among others, Tovar 2009, Christiano *et al.* 2013, and Del Negro *et al*. 2014). However, the new works still rely on the benchmark NCM model, though additional frictions have been included.[1] In fact, these frictions are what is seen to enable households to set both the desired supply of labour and wages, and firms to set both the supply of goods and prices. Since price-resetting is not instantaneous, socially sub-optimal results are likely

---

[1] The standard version of the RBC-DSGE model has been provided by Prescott (1986).

to occur in the short run.

The aim of this paper is to provide a critical review of some recent developments in macroeconomics, while suggesting a few possible amendments to the benchmark model. This allows to shed light on some unexpected, but rather significant policy implications arising from it. The point is that the introduction of financial frictions in the benchmark NCM model through the so-called FAM is said to explain the increasing influence of financial markets in real-world economies. However, on closer inspection, the FAM is not as much a financial mechanism as an indirect way to account for hysteresis of the so-called 'natural' level of output (and employment). We discuss these original implications by estimating a reduced-form NCM-DSGE model. We then use computer simulations to compare the macro dynamics of a benchmark NCM-DSGE model with the behaviour of alternative specifications of the model, which are augmented with financial frictions. Our simulations reveal that central banks should favour financial stability to price stability, and target current output growth rather than the output gap. In the spirit of Lavoie (2006), we show that this conclusion can (in principle) be derived within a rather conventional NCM-DSGE model.

Accordingly, the rest of the paper is organised as follows. In section 2 we provide an outline of the benchmark NCM model. We describe the mechanics of the model through empirical estimation and computer simulation exercises. In section 3 we examine the key features of the FAM literature, as an autonomous branch of NKE. To this purpose, we add a financial accelerator mechanism to the standard NCM model, and explore the long-lasting effects of aggregate demand shocks, via their impact on the balance-sheets of lenders (e.g. commercial and investment banks) and borrowers (e.g. non-financial firms). In section 4 we discuss the role of the central bank in a financial frictions-augmented NCM model. We argue that any intervention that stabilises the collateral net wealth of the borrowers may help neutralise the destabilising effects of financial frictions. By contrast, focusing on output gap and price stability can be highly misleading, because the same output gap is consistent with infinite combinations of current growth and natural growth (once output hysteresis is accounted for). Section 5 offers some additional remarks.

2. Macroeconomics of DSGE benchmark model

Since we are interested in the macroeconomic dynamics of a stylised NCM-DSGE model, rather than in the micro-foundation process and the estimation of deep parameters, we focus on the basic reduced form model.[2] The latter is made up of three aggregate equations, namely an IS-like curve defining the output gap as a function of the real interest rate, a (both backward- and forward-looking) Phillips curve defining the inflation rate as a function of output gap and price expectations, and an interest rate rule aiming at targeting inflation. For the sake of simplicity, we neglect the foreign sector. The mechanics of the model can be presented through simple computer simulations. For this purpose, a two-stage approach is followed. First, the three-equation system is estimated as a $VAR(2)$ model. The lag structure of the model reflects price stickiness and other short-run frictions assumed by NKE scholars.[3] Second, computer simulations are used to compare the behaviour of the benchmark model with that of alternate models, following a shock to the economy. More precisely, the model we estimate and use for simulations is:

(2.1) $y_t^g = a_{10} + a_{11} \cdot y_{t-1}^g + a_{12} \cdot \pi_{t-1} + a_{13} \cdot r_{t-1} + b_{11} \cdot y_{t-2}^g + b_{12} \cdot \pi_{t-2} + b_{13} \cdot r_{t-2} + \varepsilon_{1t}$

(2.2) $\pi_t = a_{20} + a_{21} \cdot y_{t-1}^g + a_{22} \cdot \pi_{t-1} + a_{23} \cdot r_{t-1} + b_{21} \cdot y_{t-2}^g + b_{22} \cdot \pi_{t-2} + b_{23} \cdot r_{t-2} + \varepsilon_{2t}$

(2.3) $r_t = a_{30} + a_{31} \cdot y_{t-1}^g + a_{32} \cdot \pi_{t-1} + a_{33} \cdot r_{t-1} + b_{31} \cdot y_{t-2}^g + b_{32} \cdot \pi_{t-2} + b_{33} \cdot r_{t-2} + \varepsilon_{3t}$

so that the current real interest rate is:

(2.4) $R_t \cong r_t - \pi_t$

where $a_{i,j}$ and $b_{i,j}$ (with $i = 1,2,3, j = 0,1,2,3$) are empirically-estimated parameters, y^g is the output gap (obtained by linear-detrending the real GDP),[4] π is the percentage quarterly change in the GDP

---

[2] We use the formulation proposed by Clarida *et al.* (1999). See also De Grauwe (2010).

[3] The model we estimated is akin to the one used by Cho and Moreno (2006). The choice of 2-period lag is due to the frequency of data, the small sample, and theoretical reasons, as errors are usually assumed to follow jointly a $VAR(1)$ in the literature (e.g. Ouliaris et al. 2016). Estimated coefficient values are shown in Table 3.

[4] We have used the Hodrick-Prescott filter to detrend the logarithm of current output.

deflator, and r is the Fed Funds rate. All data are taken from the Federal Reserve dataset, and run from the first quarter of 1981 to the second quarter of 2017.

The main properties of the model above, call it ‘Benchmark model’, are well known. Therefore, we do not focus on them. Rather, we compare the Benchmark model with alternative specifications of it, through simulations. The continuous line in Figures 1a offers a graphical illustration of the change in real output following a (positive) shock to the autonomous demand – e.g. a fiscal stimulus – in the first quarter of 2018. The inflation rate, the nominal interest rate and real interest rate are shown in Figures 1c to 1d, respectively. The simulated series for current output – as predicted by the Benchmark model – is shown by Figure 2a.[5] Notice that we tested the effect of both a *temporary* (two-year) and a *permanent* increase of government spending (+1% GDP per year). A time horizon of 18 years ahead is considered.

PLEASE INSERT FIGURES 1 AND 2 HERE

As it was mentioned above, inflation and output expectations in the benchmark NCM-DSGE model are always fulfilled in the long run, but can be disappointed in the short run.[6] Due to *price stickiness*, the fiscal stimulus entails an initial positive effect on the growth rate (and hence on output gap), increasing also inflation and interest rates (with the growth of the nominal interest rate outstripping the growth of the inflation rate). However, the positive effect on current output of a temporary shock is completely absorbed after a few years. In addition, since prices are not fully flexible, the adjustment entails a (negative) overshooting of inflation and interest rates before the economy achieves the new equilibrium. Similarly, the current growth rate collapses *vis-à-vis* the natural rate just after the end of the one-off fiscal stimulus, before reverting to its long-run trend (Figure 1g). This negative change in the actual output growth rate is necessary to re-anchor inflation expectations to the desired target rate,

---

[5] In the simulations of the benchmark model displayed by Figure 2 natural output is assumed to grow in line with its average growth rate for the period 2010q1-2017q2.

[6] A critical analysis of rational expectations in DSGE modelling, along with the proposal of replacing fully rationality with «trial and error» learning of agents, is provided by De Grauwe (2010).

and hence to restore the previous equilibrium conditions. Following the Taylor principle, this means that the real interest rate steered by the central banks must grow more than the inflation rate in order to stabilise inflation (e.g. Taylor 1993; Woodford 2003, p. 256). Obviously, analogous considerations apply for a negative shock to output.

The effect of a *permanent* shock to current output is portrayed by Figure 1b. The Benchmark model predicts that the impact of a permanent intervention on the growth rate is just of temporary nature (Figure 1h). By contrast, the effect on inflation is long-lasting (Figure 1c). A permanent change in the fiscal policy stance entails a persistent change in inflation expectations. A fundamental corollary follows that government spending cuts never affect economic growth in the long run. Similarly, expansionary fiscal policies (say a permanent increase in government spending) do not affect the long-run growth rate, but only output *composition*, through a change in relative prices and interest rates. In fact, a 'crowding-out' effect occurs: government spending replaces private expenditure, because of the initial increase in the real interest rate.[7]

All in all, the underlying mechanics of the model is straightforward: a positive (negative) departure of output growth from its 'natural' rate causes inflation to increase (decrease).[8] This, in turn, leads the central bank to raise (reduce) the short-run nominal interest rate. Given the stickiness of wages and prices, a rise (reduction) in the short-run real interest rate follows, which brings current output back to its natural level.[9] The institutional structure of the economy, including prevailing conditions

---

[7] Fiscal policy also affects the effectiveness of monetary policy. However, NKE authors usually stress that this «certainly does not mean that fiscal policy should not be used». This, rather, means that it should be used as «a policy tool in controlling inflation and in the stabilization of the economy» (Allsopp and Vines 2000, p. 19), and that monetary policy needs to take into account fiscal policy's effects.

[8] The natural (or long-run or trend) equilibrium is defined as the state towards which a fully competitive economy would tend in the long run, namely the state in which inflation expectations of agents are fulfilled. In the natural equilibrium state, output volume and employment rate are determined by three fundamentals: i. the quantity of labour-force and capital (i.e. the initial endowments); ii. the system of preferences of individual agents (i.e. the utility function of consumers or households); and iii. the available technology (i.e. the production function of firms).

[9] The rise (reduction) in the interest rate when the inflation rate is above (below) target is called the «nominal-anchor function» of monetary policy; the raise (reduction) in the interest rate in response to a positive (negative) shock affecting the demand is called the «stabilizing function» of monetary policy (e.g. Allsopp and Vines 2000, p. 11).

on the labour market, is sometimes considered,[10] but the natural (or potential) level of output is always assumed to be independent of short-run changes in the aggregate demand, including fiscal and monetary-policy-led changes.

The concept of the 'natural equilibrium' of output and unemployment has been subject to a long-lasting debate in macroeconomics since the mid-1970s. The point is that DSGE models compare the working of a capitalist economy to a pendulum. Whenever the economy is displaced from its equilibrium, it is automatically subject to restoring forces that will bring it back toward the initial position. Many dissenters within the economics profession have stressed that real world economies should be better regarded as complex and *path-dependent* systems (see, for instance, León-Ledesma and Thirlwall 2002, and Fontana and Palacio Vera 2007 for a review of this argument). Autoregressive effects and nonlinearities can be rather strong. As a result, output and employment levels (and growth rates) may well reach different equilibria. Each of them depends, partly at least, on the dynamic process of getting to that position. For instance, if workers are not trained, investments are not undertaken and new technologies are not used for long, this is very likely to affect negatively the future or potential level of output and employment (Setterfield, 2002).

From an econometric viewpoint, macroeconomic time series are affected by strong persistency or hysteresis. Consequently, such variables would be better thought as realisations of difference-stationary (or even non-stationary) stochastic processes rather than trend-stationary ones. Small shocks may well have long lasting, if not permanent, effects. The importance of hysteresis of output and unemployment has been remarked, among others, by Hargreaves-Heap (1980), Cottrell (1984-85), Blanchard and Summers (1987), and more recently by Ball (2009), although focusing on different causes. Notice that the implications of hysteresis effects for policy-making are potentially remarkable (e.g. Lavoie 2006). If the long-run level (or growth rate) of output is not exogenously given, there is

---

[10] More precisely, institutions are introduced as *constraints* ruling economic interactions among agents (such as budget constraints, price-setting rules and policy rules).

no necessary crowding-out of government spending on private investment.[11] Unfortunately, the above criticisms of standard macroeconomic models had been mostly neglected in the decade before the GFC. However, recent amendments to the benchmark NCM-DSGE model look like an indirect way of accounting for the path-dependency of macroeconomic variables.

3. Financial frictions in NCM-DSGE models

The failure in forecasting the GFC that hit the US and European economies in 2007-2008 represented a serious blow for the reputation of DSGE models (e.g. Buiter 2009, Foley and Farmer 2009, Krugman 2009). Unsurprisingly, attempts to amend the benchmark model have multiplied since the crisis. For instance, several NCM-DSGE models now include a volatile 'risk premium', whose fluctuations are regarded as the most important shock driving the business cycle (e.g. Christiano *et al*. 2013). In fact, the explicit analysis of the possible interaction between the real economy and the prevailing conditions in finance and credit markets was the core subject of the 'financial accelerator mechanism' (FAM) models developed by Bernanke, Gertler and Gilchrist during the 1980s-1990s (e.g. Bernanke 1981, 1983; Bernanke and Gertler 1989; Bernanke *et al.* 1996, 1999). The main tenet of FAM literature can be summarised as follows (see Fontana and Veronese Passarella 2018, for a detailed review): cash-flows and asset prices move pro-cyclically, and so does the collateral net worth of borrowers, say firms. As a result, the risk premium on loans obtained by the firms rises in recessions and decreases during booms. This accentuates investment fluctuations and enforce cyclical persistence. Consequently, shocks to the net worth of borrowers may accentuate or even trigger real fluctuations in the economy (e.g. Bernanke and Gertler 1989).

Coherently with the standard DSGE methodology, FAM-like models are usually obtained through a process of microeconomics foundation of aggregate equations. A formal presentation of it was initially proposed by Bernanke and Gertler (1989), and has been later developed by other authors,

---

[11] According to Eggertsson and Krugman (2012, p. 1506), «a temporary rise in government spending will not crowd out private spending, it will lead to increased spending on the part of liquidity-constrained debtors».

such as Christiano *et al.* (2013). At the macroeconomic level, the accelerator mechanism looks relatively simple. On close inspection, it is a way to account for the hysteresis of output components. The point is that, other things being equal, the natural growth rate of the economy is a function of the institutionally-determined risk premium (ρ) over the risk-free interest rate on loans. The higher (lower) the risk premium, the lower (higher) the pace of consumption, investment, net export, and hence the lower (higher) the natural output growth. Accordingly, the change in natural output can be defined as a linear function of the risk premium:

(3.1) $\Delta y_t^N = \varphi_1 \cdot \rho_t, \quad -1 \leq \varphi_1 < 0$

The risk premium decreases as creditworthiness requirements are relaxed and/or the market value of collaterals held by the borrowers goes up. This typically happens when the economy grows at a sustained rate. As a result, the change in the risk premium can be expressed as a decreasing function of the output gap:

(3.2) $\Delta\rho = \varphi_2 \cdot (y_{t-1} - y_{t-1}^N)\ , \quad -1 \leq \varphi_2 < 0$

From the two equations above, it follows that:

(3.3) $\Delta y_t^N = \varphi \cdot (y_{t-1} - y_{t-1}^N), \quad \varphi = \varphi_1 \cdot \varphi_2$ and $0 < \varphi < 1$

Equation (3.3) holds that the natural level of output depends positively on current output. The former adjusts to the latter over time. The pace of adjustment is defined by the parameter φ. The higher φ, the quicker the adjustment (see for a similar hysteresis mechanism, Lavoie 2006). If φ is unity, then the natural output equals current output with a lag. If φ is null, then the model collapses to the benchmark one. The hysteresis or risk premium-augmented model is therefore:

(3.4) $y_t = y_t^N + a_{10} + a_{11} \cdot y_{t-1}^g + a_{12} \cdot \pi_{t-1} + a_{13} \cdot r_{t-1} + b_{11} \cdot y_{t-2}^g + b_{12} \cdot \pi_{t-2} +$

$+ b_{13} \cdot r_{t-2} + \varepsilon_{1t}$

(2.2) $\pi_t = a_{20} + a_{21} \cdot y_{t-1}^g + a_{22} \cdot \pi_{t-1} + a_{23} \cdot r_{t-1} + b_{21} \cdot y_{t-2}^g + b_{22} \cdot \pi_{t-2} + b_{23} \cdot r_{t-2} + \varepsilon_{2t}$

(2.3) $r_t = a_{30} + a_{31} \cdot y_{t-1}^g + a_{32} \cdot \pi_{t-1} + a_{33} \cdot r_{t-1} + b_{31} \cdot y_{t-2}^g + b_{32} \cdot \pi_{t-2} + b_{33} \cdot r_{t-2} + \varepsilon_{3t}$

(3.5) $y_t^g = y_t - y_t^N$

(3.6) $y_t^N = y_{t-1}^N + \varphi \cdot (y_{t-1} - y_{t-1}^N), \quad 0 < \varphi < 1$

where (the logarithm of) natural output, y_t^N, is modelled as a function of (the logarithm of) current output, y_t, instead of being obtained through linear detrending of (the logarithm of) real GDP.

Following Fontana and Veronese Passarella (2018), we name the system above the 'H model', where 'H' stands for 'hysteresis'. The basic idea is that investment and current output are crucially affected by the financial soundness of firms' consolidated balance-sheet, with the latter moving pro-cyclically. Therefore, the lower (higher) the market value of financial assets (or other collaterals) held by firms, the higher (lower) the risk premium charged by banks (and/or other non-bank financial intermediaries), ceteris paribus. Consequently, the lower (higher) will be consumption, current investment and output.

The specific response of the 'H model' to a temporary shock is captured by the long-dashed lines in Figures 1a to 1b and 1g to 1h. We set $\varphi = 0.14$.[12] As a result, it takes roughly six years for the shock to be reabsorbed in terms of output gap (relative to the baseline, see Figure 1f). A positive, although temporary, shock to autonomous demand inflates the net wealth of borrowers, while reducing the risk premium, thereby leading to an increase in borrowing/lending. This further stimulates investment and output. On one hand, the increasing effect on current output is magnified by the accelerator mechanism. The change in the current growth rate is now much stronger and lasts longer – see Figures 1g and 1h. On the other hand, the end of the fiscal stimulus now entails a lower rebound effect, because the natural equilibrium of the economy has changed. Similarly, a self-feeding downturn occurs when a negative shock hits aggregate demand. By contrast, due to the structure of the model tested, the impact on inflation and interest rates does not differ from the impact on the benchmark model (Figures 1c to 1f). The fact is that inflation and interest rates still depend on the output gap, and *the same output gap is now consistent with infinite combinations of current output*

---

[12] See Table 3 for a detailed description of model coefficients. In the baseline scenario, current output is assumed to keep growing in line with its average growth rate for the period 2010q1-2017q2.

*and natural outpu*t. As we will argue in the next section, this has noteworthy implications for central banking.

The case of a permanent intervention is even more interesting. Once hysteresis is accounted for, the change in current growth rate due to a permanent change in fiscal policy stance becomes of permanent nature. This, in turn, entails a long-lasting change in the natural growth rate (see Figure 1h).

While the H model accounts for level hysteresis, it does not consider super-hysteresis, concerning the growth rate of output. Therefore, the latter still tends to its pre-shock value. However, φ may well be expected to move pro-cyclically, thus generating a drift in the growth rate of output. This can be shown by amending the model to account for the relationships between the speed of adjustment of output, the risk premium and net wealth. We obtain:

(3.7) $\varphi_t = \varphi_{t-1} - \gamma \cdot \rho_t,$ with $\gamma > 0,$

(3.8) $\rho_t = \eta_0 - \eta_1 \cdot \Delta V,$ with $\eta_1 > 0,$

(3.9) $V_t = V_{t-1} + \omega \cdot y_t,$ with $\omega > 0,$

where V is the stock of net wealth, that is, the value of borrowers' collaterals. It grows during booms, thus allowing for a reduction in the risk premium. More precisely, equation (3.7) holds that the change in the speed of adjustment of natural output to current output depends negatively on the risk premium (for the adjustment in times of distress and distrust takes longer than the adjustment in times of confidence); equation (3.8) holds that the risk premium coefficient reduces as the amount of borrowers' collaterals grows; and equation (3.9) states that the value of collaterals moves pro-cyclically (where net wealth is simply defined as the share of income that is saved every year), in line with FAM assumptions.

Finally, using equations (3.8) and (3.9) into (3.7), we obtain:

(3.7*bis*) $\Delta\varphi = \sigma_0 + \sigma_1 \cdot y_{t-1},$ with $\sigma_0 = -\gamma \cdot \eta_0$ and $\sigma_1 = \gamma \cdot \eta_1 \cdot \omega > 0,$

which holds that output adjustment is pro-cyclical. More precisely, it accelerates as the output level grows.[13] This is the basic assumption of Model SH (for $\sigma_1 > 1$). However, we test also the opposite hypothesis that output adjustment is counter-cyclical (i.e. $\sigma_1 < 1$). We compare the reactions of these two models with the benchmark model and the H Model ($\sigma_1 = 0$) after a positive shock to aggregate demand. The new system shows a super hysteresis effect, which is displayed by the dashed line in Figures 1a to 1h. We named this new model 'Super-H model', because it is marked by a long-lasting acceleration in both current and natural output. It mimics the behavior of output when several hysteresis mechanisms – financial accelerator, unemployment persistence, technological lock-in effects, etc. – interact together. The main features of the three models are summarized by Table 1, while Table 2 displays models' predicted series under alternative scenarios.

PLEASE INSERT TABLES 1, 2, 3 HERE (OR WHERE MOST CONVENIENT)

Notice that, once a simple hysteresis mechanism is introduced in the benchmark NCM-DSGE model, the fit for US cyclical fluctuations since the mid-1970s is shown to improve significantly (e.g. Gilchrist *et al.* 2009; also Merola 2013). Our model validation exercise corroborates this insight. Figure 3 compares the auto- and cross-correlation structures of (selected) simulated data with the observed series. This allows checking whether, and how accurately, each model generates data with reasonable time series properties. All in all, the auto-correlation structure of current output generated by hysteresis-augmented models ('H models' in Figure 3's captions) is similar to the auto-correlation structure of the observed series – see Figures 3b and 3c. Besides, both output and the inflation rate move pro-cyclically, in line with available observations – see Figure 3d. Significantly, Figure 3c shows that hysteresis-augmented models outperform the Benchmark model in terms of output auto-

---

[13] For the sake of simplicity, we assume that $\sigma_0 = -\gamma \cdot \eta_0 = 0$ and $\sigma_1 = \gamma \cdot \eta_1 \cdot \omega = 0.0007$ hereafter. Unlike other model parameters, we did not estimate coefficients σ_0 and σ_1. Rather, we calibrated them in such a way to generate similar baseline scenarios across different models. Notice also that the qualitative behaviour of the model is unaffected by the coefficient values chosen (a sensitivity test can be provided upon request).

correlation likeness, whereas they provide similar results for output-inflation cross-correlation.[14]

PLEASE INSERT FIGURE 3 HERE

4. Inflation targeting and financial asset stabilisation

As mentioned, DSGE models have been increasingly questioned since the outbreak of the GFC. And yet seldom it has been stressed that the introduction of financial frictions potentially leads to a different rule for central banking in NCM-DSGE models. In formal terms, the change in the *IS*-like curve in the NCM model *should entail a change in the monetary policy rule*, meaning in the reaction function of the central bank. The point is that, once it is admitted that bank lending is constrained by the creditworthiness of borrowers, while credit demand is affected by borrowing conditions, it turns out that the market value of financial assets should be one of the priority targets of the central bank. To put it boldly, in the presence of financial frictions and other hysteresis factors, the main task of the central bank is not as much the stabilization of inflation expectations (through the steering of the interest rate) as the *strengthening of the balance-sheets* of banks and borrowers, through the *stabilization of asset prices*. This means also that the key output variable for central banking is not the gap between current and natural output, but the current growth rate. The reason is that the same output gap level becomes consistent with infinite combinations of current and natural growth rates of output, when economic variables are affected by hysteresis (or other types of path-dependency). The same goes for the inflation rate, as the same rate can result from different combinations of current and natural growth rates of output. To get intuitive evidence of this, compare Figures 1a (or 1b) with Figure 1f. While the effect on output gap of a fiscal shock is identical across different models, the related growth rates of current output (and hence the growth rates of natural output) are quite different. The notion of output gap has little relevance when output hysteresis is considered.

---

[14] For a similar validation method, see Caiani et al. (2016). The reason hysteresis-augmented models outperform the Benchmark model is that the former are driven by current output, whereas the latter is anchored in an exogenously-given growth rate.

The structure of NCM-DSGE models usually leads their advocates to be over-confident about the (short-run) impact of monetary policy (via interest rate fine-tuning) on output components. While we remain sceptical about monetary policy effectiveness, our amended models and simulation exercises suggest that a direct support to the market value of financial assets may well reduce the depth of demand shocks. This different monetary policy strategy would also diminish the frequency of the shocks. In other words, we argue that the central bank should not exclusively or even mainly target the output gap. Rather it should aim at stabilising current output (either in a direct way or in an indirect way), by supporting the value of collaterals. In a sense, this is what many leading central banks have done since the outbreak of recent financial crises.

It remains to be understood whether hysteresis-augmented models will be in due time embraced by central banks and other international financial institutions as an essential theoretical tool for policy-making. In principle, the benchmark NCM-DSGE model can be extended to account for output hysteresis and other types of path dependency. However, this amendment should lead to a change in the reaction function of the central bank. The latter should pursue financial stability, and target current growth, with the natural output being an endogenous variable.

5. Conclusions

In the mid-2000s, a convergence of views in mainstream macroeconomics emerged, the so-called the New Consensus in macroeconomics (NCM). On the theoretical side, it was a synthesis between the RBC approach and the NKE. On the modelling side, the new synthesis was built upon the dynamic stochastic general equilibrium (DSGE) models. Despite its mathematical elegance, the NCM was rather short-lived, because the outbreak of the US financial crisis brought about a (slow) process of revision of old mental habits. After the GFC, a new class of models was born with the explicit goal of introducing the financial imperfections of real-world economies into the benchmark NCM-DSGE framework. We have argued that this new class of models represents a return to a somewhat unconventional branch of NKE, based on the financial accelerator mechanism (FAM). The latter was pioneered by Bernanke and other scholars in the early 1980s. Unlike the benchmark DSGE model, FAM models allow for some long-lasting effects of money and credit on real variables. Although seldom explicitly recognised, the introduction of financial frictions into the basic model also account for hysteresis of potential output, thereby addressing one of the main problems with old DSGE models.

There are two main policy implications from this analysis. First, the standard monetary policy rule of targeting price stability should be rejected. Once a financial accelerator mechanism is introduced, conventional models can produce ‘unconventional’ results. The main goal of the central bank should no longer be price stability, but the strengthening of the balance-sheets of banks and borrowers, through the stabilization of financial asset prices. Significantly, this is what the world-leading central banks have been doing since the GFC. Our amendment to the benchmark model allows us to bridge the gap between standard macroeconomic theory, which maintains that central banks should only be preserving price stability by steering the output gap via the policy rate, and central banking practice, where the boundaries of monetary policy have been pushed well beyond price stability. Our paper and simulations show that targeting output gap and pursuing price stability can be highly misleading, since the same output gap and inflation rate are consistent with infinite combinations of current and natural growth rates of output, when the latter tends to adjust to the former.

Second, the strengthening of the balance-sheets of banks and borrowers is a necessary, but not sufficient condition for a successful economy. It is necessary because a functioning credit market is an essential condition for output growth. As explained by Keynes “credit is the pavement along which production travels and the bankers if they knew their duty, would provide the transport facilities to just the extent it is required in order that the productive powers of the community can be employed at full employment” (Keynes CW VI, p. 197). But it is not a sufficient condition. Borrowing and lending needs to be at the service of production, which will only happen if there is an expected buoyant demand for goods and services. If this is not the case, like after the GFC, then government spending (or foreign demand) is the necessary condition to stimulate output and employment (Fontana et al. 2017), which in turn will boost – *ceteris paribus* – borrowing and lending.

References

Adolfson, M., Adersson, M., Lindé, J., Villani, M., and Vredin A. (2007) Modern forecasting models in action: improving macroeconomic analyses at central banks. *International Journal of Central Banking*, 3(4): 111-144.

Allsopp, C. and Vines, D. (2000) The assessment: macroeconomic policy. *Oxford Review of Economic Policy*, 16(4): 1-32.

Arestis, P. and Mihailov, A. (2011) Classifying monetary economics. *Journal of Economic Surveys*, 25(4): 769-800.

Ball, L.M. (2009) Hysteresis in Unemployment: Old and New Evidence. *NBER Working Paper Series*, No. 14818.

Bernanke, B.S. (1981) Bankuptcy, liquidity and recession. *American Economic Review Proceedings*, 71(2): 155-159.

Bernanke, B.S. (1983) Nonmonetary effects of the financial crisis in the propagation of the great depression. *American Economic Review*, 73(3): 257-276.

Bernanke, B.S. and Gertler, M. (1989) Agency costs, net worth and business fluctuations. *American Economic Review*, 79(1): 14-31.

Bernanke, B.S., Gertler, M. and Gilchrist, S. (1996) The financial accelerator and flight to quality. *Review of Economics and Statistics*, 78(1): 1-15.

Bernanke, B.S., Gertler, M. and Gilchrist, S. (1999) The financial accelerator in a quantitative business cycle framework. In: *Handbook of Macroeconomics* (J.B. Taylor and M. Woodford Eds.). Vol. 1, Amsterdam: Elsevier, pp. 1341-1393 [Also available as *NBER Working Paper Series*, No. 6455].

Blanchard, O.J. (2016a) Further Thoughts on DSGE Models. 3 October. Realtime economic issues watch. [Online]. [Accessed 14 August 2017]. Available from: https://piie.com/blogs/realtime-economic-issues-watch/further-thoughts-dsge-models.

Blanchard, O.J. (2016b) Do DSGE models have a future? Peterson Insititute for international economics strategic brief, PB 16-11. Washington (USA): Peterson Insititute for international economics. Available from: https://piie.com/system/files/documents/pb16-11.pdf.

Blanchard, O.J. (2017a) On the need for (at least) five classes of macro models. 10 April. Realtime economic issues watch. [Online]. [Accessed 14 August 2017]. Available from: https://piie.com/blogs/realtime-economic-issues-watch/need-least-five-classes-macro-models#_ftn1

Blanchard, O.J. (2017b) The need for different classes of macroeconomic models. 12 January. Realtime economic issues watch. [Online]. [Accessed 14 August 2017]. Available from: https://piie.com/blogs/realtime-economic-issues-watch/need-different-classes-macroeconomic-models.

Blanchard, O.J. and Summers, L.H. (1987) Hysteresis and the European Unemployment Problem. *NBER Working Paper Series*, No. 1950.

Buiter, W. (2009) The unfortunate uselessness of most ‘state of the art’ academic monetary economics. *Financial Times*, 3rd March.

Caiani, A., Godin, A., Caverzasi, E., Gallegati, M., Kinsella, S. and Stiglitz, J.E. (2016) Agent based-stock flow consistent macroeconomics: Towards a benchmark model. Journal of Economic Dynamics and Control, 69(3): 375-408.

Cho, S., and Moreno, A. (2006) A small-sample study of the New Keynesian Macro Model. *Journal of Money, Credit and Banking*, 38(6): 1461-1481.

Christiano, L., Motto, R. and Rostagno, M. (2013) Risk shocks. *NBER Working Paper Series*, No. 18682.

Clarida, R., Galì, J. and Gertler, M. (1999) The science of monetary policy: a New Keynesian perspective. *Journal of Economic Literature*, 37(4): 1661-1707.

Cottrell, A. (1984–85) Keynesianism and the natural rate of unemployment: a problem of pedagogy. *Journal of Post Keynesian Economics*, 7(2): 263-268.

De Grauwe, P. (2010) The scientific foundation of dynamic stochastic general equilibrium (DSGE) models. *Public Choice*, 144(3-4): 413-443.

Del Negro, M., Giannoni, M.P., and Schorfheide, F. (2014) Inflation in the Great Recession and New Keynesian Models. *Federal Reserve Bank of New York: Staff Reports*, No. 618 (May 2013; revised January 2014).

Dixon, H.D. (2008) New Keynesian macroeconomics. In: *The New Palgrave Dictionary of Economics* (S.N. Durlauf and L.E. Blume Eds.). Second Edition, Basingstoke & New York: Palgrave Macmillan.

Eggertsson, G.B. and Krugman, P. (2012) Debt, deleveraging, and the liquidity trap,' *Quarterly Journal of Economics*, 127(3): 1469–1513.

Foley, D. and Farmer, J.D. (2009) The economy needs agent-based modelling. *Nature*, 460: 685-686.

Fontana, G. and Palacio-Vera, A. (2007) Are long-run stability and short-run output stabilization all that monetary policy can aim for?. *Metroeconomica*, 58(2), 269-298.

Fontana, G. Pacella, A. and Realfonzo, R. (2017) Does fiscal policy affect the monetary transmission mechanism? A monetary theory of production (MTP) response to the new consensus macroeconomics (NCM) perspective, *Metroeconomica*, 68(2), 378-395.

Fontana, G. and Veronese Passarella, A. (2018) The role of commercial banks and financial intermediaries in the new consensus macroeconomics (NCM): a preliminary and critical appraisal of old and new models. P. Arestis (ed), *Alternative Approaches in Macroeconomics: Essays in Honour of John McCombie*, Basingstoke & New York:

Palgrave Macmillan, pp. 77-103.

Galí, J. (2017) Some scattered thoughts on DSGE models. In: *DSGE models in the conduct of policy: use as intended* (Gürkaynak, R.S. and Tille Eds). [Online]. London (UK): CEPR Press. Available from: http://voxeu.org/content/dsge-models-conduct-policy-use-intended

Gilchrist, S., Ortiz, A. and Zakrajšek, E. (2009) Credit risk and the macroeconomy: evidence from an estimated DSGE model. paper prepared for the FRB/JMCB conference 'Financial Markets and Monetary Policy. held at the *Federal Reserve Board*, Washington D.C., 4-5 June.

Goodfriend, M. and King, R. (1997) The New Neoclassical Synthesis and the role of monetary policy. In: *NBER Macroeconomics Annual 1997* (Bernanke B.S. and Rotemberg J. Eds.). Vol. 12, Cambridge (Massachusetts): MIT Press, pp. 231–296.

Goodhart, C.A.E. (2009) The continuing muddles of monetary theory: a steadfast refusal to face facts. *Economica*, 76(304, s1): 821-830.

Goodhart, C.A.E. (2014) The parlous state of macroeconomics and the optimal financial structure. *International Review of Financial Analysis, 36: 78-83.*

Gürkaynak, R.S. and Tille, C. (2017) Introduction: Are DSGE models useful for policymakers? In: *DSGE models in the conduct of policy: use as intended* (Gürkaynak, R.S. and Tille. Eds). [Online]. London (UK): CEPR Press. Available from: http://voxeu.org/content/dsge-models-conduct-policy-use-intended

Haldane, A. (2017) An economy that works for everyone (in discussion with Bronwen Maddox). [Online]. 5 January, The Institute for Government, London. [Accessed 14 August 2017]. Available from: https://livestream.com/accounts/5208398/events/6729795/videos/145963063.

Hargreaves-Heap, S.P. (1980) Choosing the wrong natural rate: accelerating inflation or decelerating employment and growth. *Economic Journal*, 90(1): 611-620.

Keen, S. (2016) The need for pluralism in economics. 13 August. Steve Keen's Debtwatch. [Online]. [Accessed 14 August 2017]. Available from: http://www.debtdeflation.com /blogs/2016/08/13/the-need-for-pluralism-in-economics/

Korinek, A. (2015) Thoughts on DSGE. Matching the Moment, But Missing the Point? 'A Just Society': Honoring Joseph Stiglitz's 50 years of teaching, 16-17 October, Columbia Business School, New York (USA). [Online]. [Accessed 14 August 2017]. Available from: https://www.ineteconomics.org/perspectives/blog/matching-the-moment-but-missing-the-point.

Krugman, P. (2009) Lionel Robbins Lecture. lecture made at the *London School of Economics*, 10 June 2009.

Krugman, P. (2016) The state of macro is sad (wonkish). 12 August 2016. The conscience of a liberal. [Online]. [Accessed 14 August 2017]. Available from: https://krugman.blogs. nytimes.com/2016/08/12/the-state-of-macro-is-sad-wonkish/.

Lavoie, M. (2006) A Post-Keynesian amendment to the new consensus on monetary policy. *Metroeconomica*, 57(2): 165-192.

Lavoie, M. (2016) Rethinking Macroeconomic theory before the next crisis. 23 September. Institute for New Economic Thinking: Blog. [Online]. [Accessed 14 August 2017]. Available from: https://www.ineteconomics.org/perspectives/blog/rethinking-macro-theory.

León-Ledesma, M.A. and Thirlwall, A.P. (2002) The endogeneity of the natural rate of growth. *Cambridge Journal of Economics*, 26(4): 441-459.

Lindé, J. Smets, F. and Wouters, R. (2016) Challenges for Central Banks' Macro Models.: Taylor, J.B. and Uhlig, H. Handbook of Macroeconomics. Volume 2. North-Holland Elsevier Science: New York, pp. 2185-2262.

Merola, S. (2013) The role of financial frictions during the crisis: an estimated DSGE model.

National Bank of Belgium: Working Paper Research, No. 249.

Münchau, W. (2016) Reform the economic system now or the populists will do it. Financial Times. [Online]. 18 December. [Accessed 14 August 2017]. Available from: https://www.ft.com/content/72f96588-c38b-11e6-81c2-f57d90f6741a

Ouliaris, S., Pagan A.R. and Restrepo, J. (2016) Quantitative Macroeconomic Modeling with Structural Vector Autoregressions – An EViews Implementation (file downloadable from: http://www.eviews.com/StructVAR/structvar.pdf, 19 September 2016).

Prescott, E.C. (1986) Theory ahead of business cycle measurement. *Federal Reserve Bank of Minneapolis Quarterly Review*, 10(4): 9-33.

Romer, D. (2000) Keynesian macroeconomics without the LM curve. *Journal of Economic Perspectives*, 14(2): 149-169.

Romer, P. (2016) The truble with macroeconomics. [Online]. 5 January, Commons Memorial Lecture of the Omicron Delta Epsilon Society. [Accessed 14 August 2017]. Available from: https://paulromer.net/wp-content/uploads/2016/09/WP-Trouble.pdf.

Setterfield, M. (2002) Introduction: a dissenter's view of the development of growth theory and the importance of demand-led growth. Setterfield M. (Ed.), *The Economics of Demand-led Growth: Challenging the Supply-side Vision of the Long Run*, Cheltenham: Edward Elgar, pp. 1-16.

Taylor, J.B. (1993) Discretion versus Policy Rules in Practice. *Carnegie-Rochester Conference Series on Public Policy*, 39(1): 195-214.

Taylor, J.B. (2000) Teaching modern macroeconomics at the principles level. *American Economic Review*, 90(2): 90–94.

Tovar, C.E. (2009) DSGE models and central banks. *Economics: open access/open assessment e-journal*, 3: 1-30 [http://www.economics-ejournal.org].

Woodford, M. (2003) *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton: Princeton University Press.

Woodford, M. (2009) Convergence in Macroeconomics: Elements of the New Synthesis. *American Journal of Economics: Macroeconomics*, 1(1): 267-79 (PDF file downloadable from: http://www.columbia.edu/~mw2230/Convergence_AEJ.pdf, 30 April 2013).

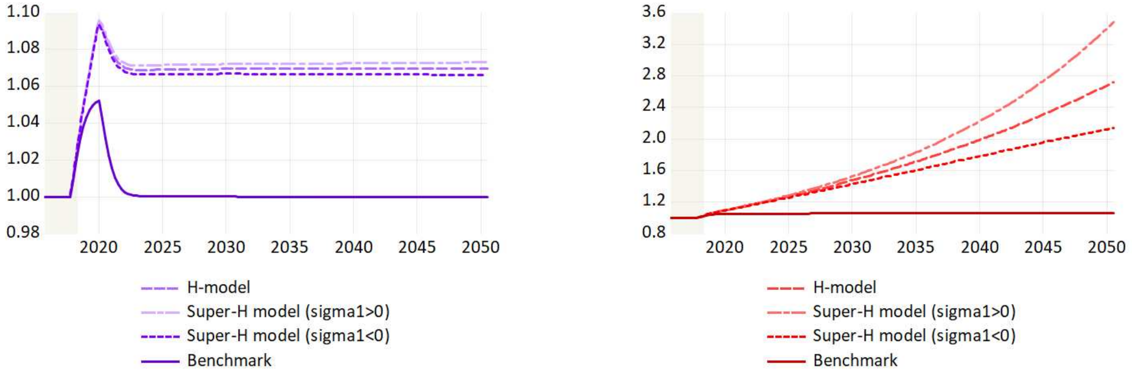
Wren-Lewis, S. (2016) Blanchard on DSGE. 12 August. Mainly macro. [Online]. [Accessed 14 August 2017]. Available from: https://mainlymacro.blogspot.co.uk/2016/08/blanchard-on-dsge.html.

Figures and Tables

Figure 1. Output, inflation rate and interest rate following shock (+1%) to government spending

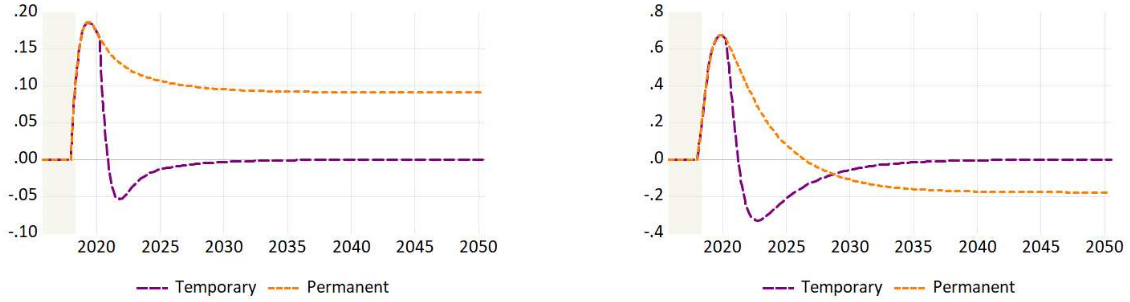
a) Output following temporary shock to government spending (relative to baseline)

b) Output following permanent shock to government spending (relative to baseline)



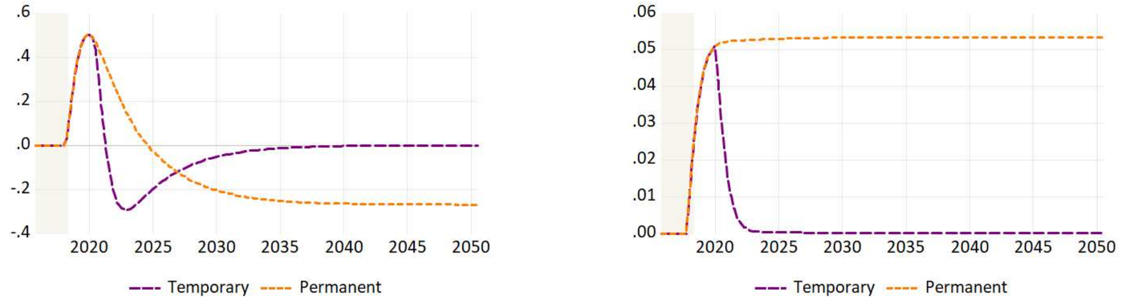
c) Inflation following shock to government spending (all scenarios, difference with baseline)

d) Interest rate following shock to government spending (all scenarios, difference with baseline)



e) Real interest rate following shock to government spending (all scenarios, difference with baseline)

f) Output gap following shock to government spending (all scenarios, difference with baseline)



(cont'd)

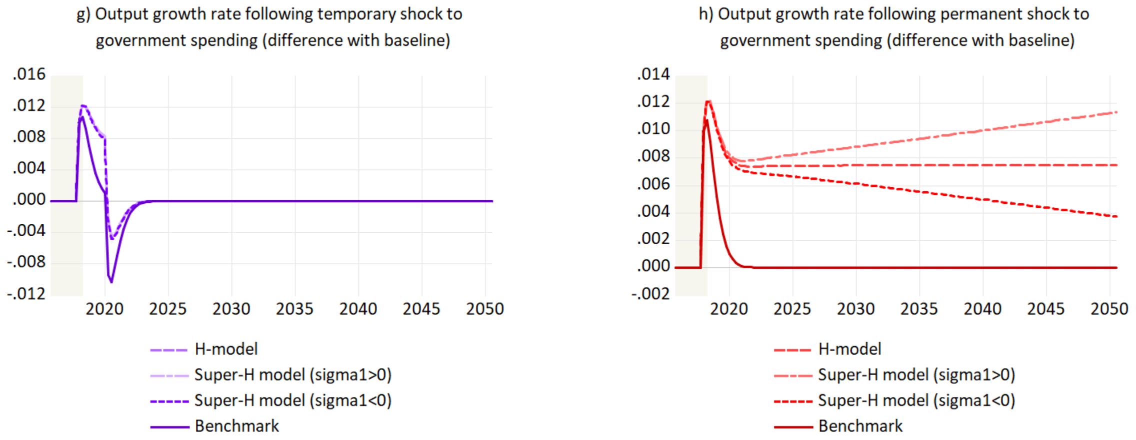

g) Output growth rate following temporary shock to government spending (difference with baseline)
.016
.012
.008
.004
.000
-.004
-.008
-.012
2020
2025
2030
2035
2040
2045
2050
H-model
Super-H model (sigma1>0)
Super-H model (sigma1<0)
Benchmark
h) Output growth rate following permanent shock to government spending (difference with baseline)
.014
.012
.010
.008
.006
.004
.002
.000
-.002
2020
2025
2030
2035
2040
2045
2050
H-model
Super-H model (sigma1>0)
Super-H model (sigma1<0)
Benchmark

Figure 2. Real GDP under three different scenarios and using four different models (adjusted in-sample and out-of-sample predictions)

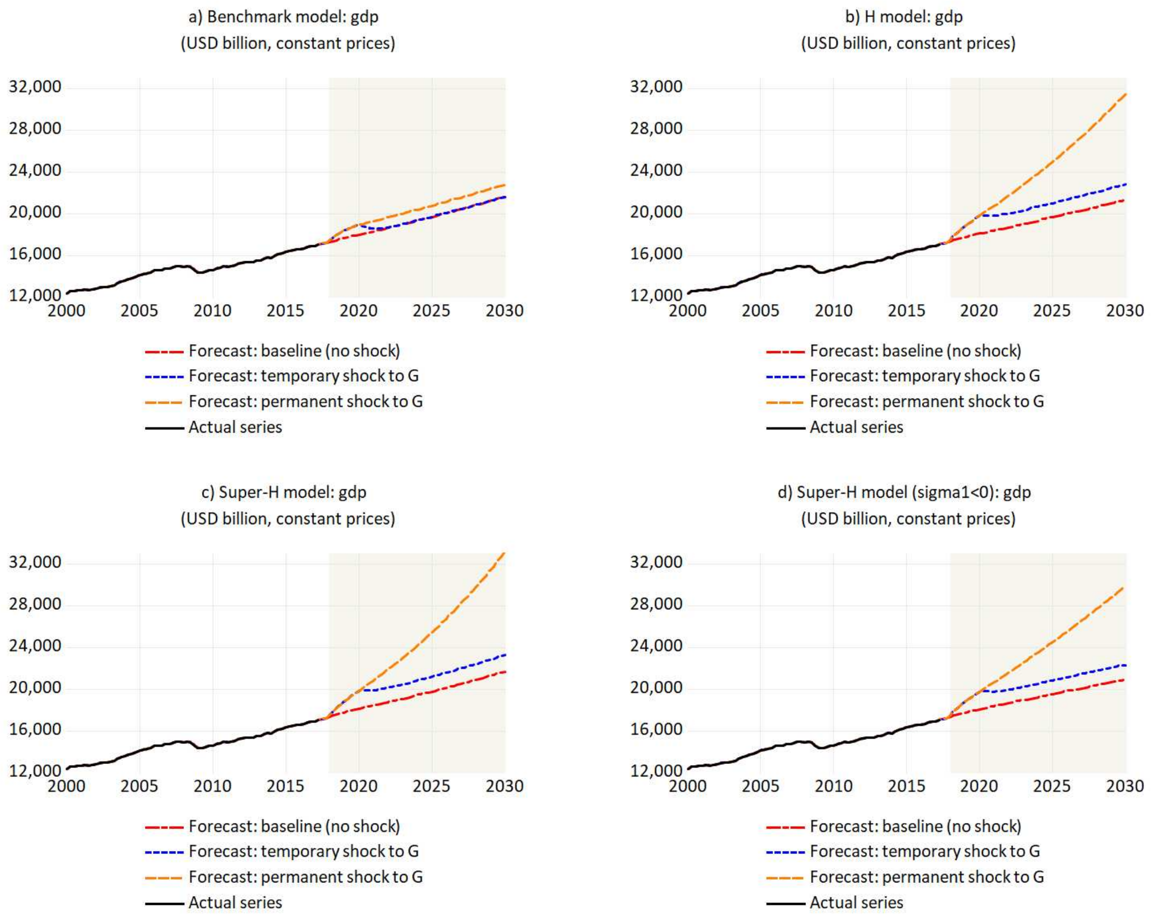
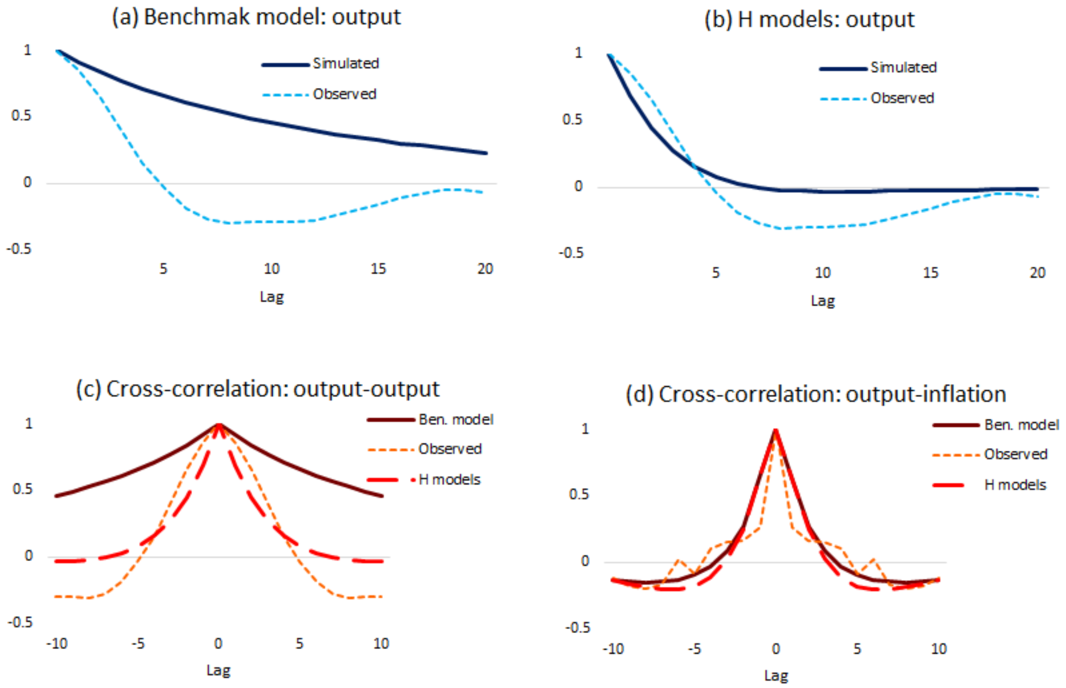


Figure 3. Auto- and cross-correlations: in-sample series vs. out-of-sample (predicted) series



Note: Output is expressed in logarithms. A Hodrick-Prescott filter was used to separate the cyclical component of each series from its trend. Only the cyclical component is considered. Observed data refer to the period 1981Q1-2017Q2. Simulated series refer to the period 2017Q3 onwards (out-of-sample predictions).

Table 1. Responses of the three models to a positive shock to autonomous demand (using value to baseline ratios)

	Temporary shock		*Permanent shock*	
	Inflation rate	*Growth rate*	*Inflation rate*	*Growth rate*
Benchmark model	Back to target	Back to natural	Higher	Back to natural
Model H	Back to target	Back to natural but long-lasting impact	Higher	Higher: new natural rate (hysteresis)
Model Super-H	Back to target	Back to natural but strong impact	Higher	Accelerating rate (strong hysteresis)

Table 2. Shock to aggregate demand. Quarterly growth rates of real output under three different scenarios and using four different models: out-of-sample forecast.

	Baseline				**Permanent shock**				**Temporary shock (2 years)**			
	Benchmark	H model	SH model $\sigma_1 > 0$	SH model $\sigma_1 < 0$	Benchmark	H model	SH model $\sigma_1 > 0$	SH model $\sigma_1 < 0$	Benchmark	H model	SH model $\sigma_1 > 0$	SH model $\sigma_1 < 0$
2018Q1	0.005436	0.007243	0.007254	0.007231	0.015436	0.017243	0.017254	0.017231	0.015436	0.017243	0.017254	0.017231
2018Q2	0.00512	0.006631	0.006656	0.006605	0.015863	0.018774	0.018814	0.018734	0.015863	0.018774	0.018814	0.018734
2018Q3	0.004908	0.006004	0.006047	0.005962	0.014071	0.018071	0.018154	0.017988	0.014071	0.018071	0.018154	0.017988
2018Q4	0.004769	0.005465	0.005525	0.005405	0.011871	0.016754	0.016887	0.016621	0.011871	0.016754	0.016887	0.016621
2019Q1	0.004681	0.005044	0.005122	0.004966	0.009866	0.01541	0.015597	0.015223	0.009866	0.01541	0.015597	0.015223
2019Q2	0.004626	0.004731	0.004826	0.004635	0.008251	0.014263	0.014504	0.014023	0.008251	0.014263	0.014504	0.014023
2019Q3	0.004595	0.004511	0.004623	0.004399	0.007041	0.013371	0.013663	0.013078	0.007041	0.013371	0.013663	0.013078
2019Q4	0.004578	0.004359	0.004489	0.004231	0.006179	0.012718	0.01306	0.012376	0.006179	0.012718	0.01306	0.012376
2020Q1	0.00457	0.00426	0.004404	0.004115	0.00559	0.012261	0.01265	0.011872	0.00559	0.012261	0.01265	0.011872
2020Q2	0.004567	0.004196	0.004355	0.004037	-0.0048	0.001954	0.00239	0.001519	0.005202	0.011954	0.01239	0.011519
2020Q3	0.004569	0.004155	0.00433	0.003981	-0.00579	-0.00039	3.20E-05	-0.00081	0.004956	0.011756	0.012234	0.011277
2020Q4	0.004571	0.004131	0.004319	0.003942	-0.00436	-0.00043	-4.50E-05	-0.00082	0.004807	0.011633	0.012155	0.011111
2021Q1	0.004576	0.004116	0.00432	0.003913	-0.00238	0.000271	0.000629	-8.60E-05	0.004719	0.01156	0.012123	0.010996
2021Q2	0.004579	0.004108	0.004325	0.00389	-0.00051	0.001153	0.001484	0.000821	0.004671	0.011519	0.012125	0.010915
2021Q3	0.004584	0.004103	0.004335	0.003872	0.001022	0.001967	0.002281	0.001655	0.004647	0.0115	0.012146	0.010853
2021Q4	0.004587	0.0041	0.004346	0.003854	0.002191	0.002631	0.002934	0.002328	0.004637	0.011491	0.012178	0.010805
2022Q1	0.004592	0.004099	0.004359	0.003838	0.003033	0.003133	0.003431	0.002833	0.004634	0.01149	0.012219	0.010762
2022Q2	0.004595	0.004097	0.004371	0.003823	0.003616	0.003491	0.003792	0.00319	0.004636	0.011493	0.01226	0.010723
2022Q3	0.004598	0.004097	0.004385	0.003809	0.004003	0.003738	0.004045	0.003431	0.004638	0.011495	0.01231	0.010691
2022Q4	0.004602	0.004096	0.004399	0.003793	0.004253	0.0039	0.004216	0.003585	0.00464	0.0115	0.01235	0.01064
2023Q1	0.004604	0.004094	0.004412	0.003777	0.004408	0.004004	0.004331	0.003676	0.004644	0.01151	0.0124	0.01062
2023Q2	0.004607	0.004095	0.004425	0.003763	0.004502	0.004065	0.004405	0.003727	0.004646	0.01151	0.01244	0.01057
2023Q3	0.00461	0.004093	0.004439	0.003748	0.004556	0.004102	0.004455	0.003749	0.004647	0.01151	0.01249	0.01054
2023Q4	0.004612	0.004092	0.004452	0.003733	0.004585	0.00412	0.004486	0.003753	0.004648	0.01152	0.01254	0.0105
$\sum$	0.112136	0.10992	0.114518*	0.105322	0.112499	0.176573	0.183449*	0.169697	0.16494	0.312306	0.324943*	0.299668

Note: average value for 2010Q1-2017Q4 = 0.005227. The last row displays the cumulative growth rate for the period 2018Q1-2023Q4. $*$ Highest cumulative growth rate per scenario.

Table 3. Key to symbols and coefficient values

Symbol	**Description**	**Baseline value at 2017Q4**	**Remarks / Sources**
y	Current output (real GDP, log)	17010.7	Federal Reserve data on US economy*
y^g	Output gap	-0.00185	Our calculations on Federal Reserve data*
y^N	Natural output (using HP filter on log of curr. output)	17042.22	Our calculations on Federal Reserve data*
π	Inflation (% change in GDP deflator)	0.24923	Federal Reserve data on US economy *
r	Fed funds interest rate	0.95	Federal Reserve data on US economy *
R	Real interest rate	0.70	Our calculations on Federal Reserve data*
ε_1	Additional government spending	0.00	Pre-experiments value
φ	Speed of adjustment of natural output to curr. output	0.14	Calibrated to generate fig. 1 to 6 baseline
ρ	Coefficient accounting for impact of risk premium	0.10	Calibrated to generate fig. 1 to 6 baseline
V	Collateralisable net wealth of borrowers	0.00	Pre-experiments value
σ_0	Parameter in output adjustment function	0.00	Calibrated to generate fig. 1 to 6 baseline
σ_1	Parameter in output adjustment function	0.00005	Calibrated to generate fig. 1 to 6 baseline
a_{10}	Parameter of output gap function	0.000799	Estimated from Federal Reserve data**
a_{11}	Parameter of output gap function	1.074354	Estimated from Federal Reserve data**
a_{12}	Parameter of output gap function	-0.001303	Estimated from Federal Reserve data**
a_{13}	Parameter of output gap function	0.002703	Estimated from Federal Reserve data**
a_{20}	Parameter in inflation rate function	0.129934	Estimated from Federal Reserve data**
a_{21}	Parameter in inflation rate function	8.230165	Estimated from Federal Reserve data**
a_{22}	Parameter in inflation rate function	0.375025	Estimated from Federal Reserve data**
a_{23}	Parameter in inflation rate function	0.012371	Estimated from Federal Reserve data**
a_{30}	Parameter in interest rate function	0.044523	Estimated from Federal Reserve data**
a_{31}	Parameter in interest rate function	11.76684	Estimated from Federal Reserve data**
a_{32}	Parameter in interest rate function	0.181075	Estimated from Federal Reserve data**
a_{33}	Parameter in interest rate function	1.191679	Estimated from Federal Reserve data**
b_{11}	Parameter of output gap function	-0.259102	Estimated from Federal Reserve data**
b_{12}	Parameter of output gap function	-0.000115	Estimated from Federal Reserve data**
b_{13}	Parameter of output gap function	-0.002660	Estimated from Federal Reserve data**
b_{21}	Parameter in inflation rate function	-7.559381	Estimated from Federal Reserve data**
b_{22}	Parameter in inflation rate function	0.265167	Estimated from Federal Reserve data**
b_{23}	Parameter in inflation rate function	0.004159	Estimated from Federal Reserve data**
b_{31}	Parameter in interest rate function	-12.48577	Estimated from Federal Reserve data**
b_{32}	Parameter in interest rate function	0.108251	Estimated from Federal Reserve data**
b_{33}	Parameter in interest rate function	-0.258762	Estimated from Federal Reserve data**

Notes: * accessed on August 9th 2017. ** Vector Autoregression Estimates. Sample (adjusted): 1981Q3 2017Q2. Included observations: 144 after adjustments.