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The Effectiveness of Monetary Policy since the Onset of the Financial Crisis

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ABSTRACT/RÉSUMÉ

The effectiveness of monetary policy since the onset of the financial crisis

In the wake of the Great Recession, a massive monetary policy stimulus was provided in the main OECD economies. It helped to stabilise financial markets and avoid deflation. Nonetheless, GDP growth has been sluggish and in some countries lower than expected given the measures taken, and estimated economic slack remains large. In this context, this paper assesses the effectiveness of monetary policy in recent years. It finds that notwithstanding an almost full transmission of policy interest rate cuts and unconventional policy measures to higher asset prices and lower cost of credit in and outside the banking sector in most countries, with the exception of vulnerable euro area economies, monetary policy stimulus did not show up in stronger growth due to a combination of three factors. First, lower policy interest rates may not have provided as much stimulus as expected given the evidence of a decrease in natural interest rates, resulting from the estimated decline in potential GDP growth in the wake of the crisis. Second, balance sheet adjustments of non-financial companies and households, large uncertainty as well as simultaneous and considerable fiscal consolidation in many OECD countries constituted important headwinds. Third, the bank lending channel of monetary policy transmission appears to have been impaired, mainly due to considerable balance sheet adjustments and prevailing uncertainty, which together limited banks' capacity and willingness to supply credit. The paper also stresses that the monetary accommodation risks having unintended negative consequences which are likely to increase with its duration.

JEL classification codes: E32; E43; E44; E5; G01; H12; G28
Keywords: Monetary policy, natural interest rates, credit, financial markets, financial crisis
****

L'efficacité de la politique monétaire depuis le début de la crise financière

Dans le sillage de la Grande Récession, un important stimulus monétaire a été fourni dans les principales économies de l'OCDE. Il a permis de stabiliser les marchés financiers et d'éviter la déflation. Toutefois, la croissance du PIB a été lente et dans certains pays plus faible qu'attendue compte tenu des mesures prises, et le ralentissement économique estimé demeure important. Dans ce contexte, ce papier évalue l'efficacité de la politique monétaire au cours des années récentes. Il trouve qu'en dépit d'une transmission presque complète des baisses de taux d'intérêt et des mesures non conventionnelles de politique monétaire à des prix d'actifs plus élevés et un coût du crédit plus faible à l'intérieur et à l'extérieur du secteur bancaire dans la plupart des pays, à l'exception des économies vulnérables de la zone euro, le stimulus de la politique monétaire ne s'est pas traduit par une croissance plus forte en raison de la combinaison de trois facteurs. Premièrement, des taux plus faibles de politique monétaire pourraient ne pas avoir fourni autant de stimulus qu'attendu étant donné la baisse des taux d'intérêt naturels résultant d'une diminution estimée de la croissance potentielle du PIB dans le sillage de la crise. Deuxièmement, les ajustements des bilans des entreprises non financières et des ménages, une grande incertitude ainsi qu'une consolidation budgétaire simultanée et considérable dans de nombreux pays de l'OCDE ont constitué d'importants vents contraires. Troisièmement, le canal du crédit bancaire de transmission de la politique monétaire semble avoir été réduit, principalement en raison des ajustements considérables des bilans et de l'incertitude qui règne, limitant à la fois la capacité et la volonté des banques à proposer des crédits. Le papier souligne également que l'assouplissement monétaire risque d'avoir des conséquences négatives non souhaitées susceptibles d'augmenter avec la durée.
Codes JEL : E32 ; E43 ; E44 ; E5 ; G01 ; H12 ; G28.
Mots clé : Politique monétaire, taux d'intérêt naturels, crédit, marchés financiers, crise financière.

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THE EFFECTIVENESS OF MONETARY POLICY SINCE THE ONSET OF THE FINANCIAL CRISIS

By

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Introduction

Since the onset of the financial turmoil in the middle of 2007, unprecedented monetary policy stimulus has been implemented in major advanced OECD economies. Interest rates were cut to almost zero, and some central banks made conditional commitments to keep them at this level for an extended period and have expanded massively their balance sheets. The monetary policy response prevented a total meltdown of financial markets and ultimately helped stabilise them. Moreover, deflation has been avoided (except in Japan) and inflation and inflation expectations have hovered around explicit or implicit inflation targets. In contrast, notwithstanding the strong monetary accommodation, real activity has been weak. GDP levels in the euro area, Japan and United Kingdom in 2012 were still below their pre-crisis levels, and only 3% higher in the United States, and estimated economic slack remains large (Figure 1). This has raised questions about the effectiveness and limits of monetary stimulus in terms of boosting activity.

This paper assesses the effectiveness of monetary policy in recent years, focusing on seven selected OECD economic areas (Canada, the euro area, Japan, Sweden, Switzerland, the United Kingdom and the United States). It starts with a brief overview of monetary policy responses and an evaluation of their demand effects. It then reviews four potential explanations of weak demand despite apparent strong monetary policy accommodation: a potential decline in the natural interest rate and ensuing smaller stimulus from policy interest rates; a reduced transmission of conventional and unconventional policy measures to asset prices and the cost of credit; restraints on credit supply and weaker loan demand due to balance sheet adjustments; and headwinds related to balance sheet adjustments and uncertainty, beyond their impact on credit growth, and to fiscal consolidation, which may have partly offset the impact of monetary policy stimulus. This is followed by a discussion of potential unintended negative effects of protracted policy accommodation.

Monetary policy stimulus has been unprecedented

In the wake of the Great Recession, a massive monetary policy stimulus was provided in the main advanced OECD economies. It aimed both at restoring financial market stability, especially in the immediate aftermath of the Lehman Brothers collapse in September 2008, and at boosting aggregate demand and meeting inflation targets in the medium term. With the exception of Japan where interest rates were already low, key policy rates were cut aggressively to nearly zero (by around 500 basis points in the

1. The authors are members of the Macroeconomic Policy Division of the Economics Department except Jean-Paul Renne who is an economist at Banque de France. They are indebted to Sebastian Barnes, Sveinbjörn Blöndal, Boris Cournède, Wendy Dunn, Jørgen Elmeskov and Jean-Luc Schneider for their useful comments. The authors are also grateful to Isabelle Fakih and Maartje Michelson for help in the final document preparation. The opinions expressed in this paper are those of the authors and are not necessarily shared by the OECD, its member countries or Banque de France.

United Kingdom and the United States) and in several countries they have been maintained at this level for almost four years – a development not seen over the past century (Figures 2 and 3; Table 3).[2]

On top of this, a number of non-conventional measures have been implemented. They involved in particular the expansion of monetary authorities' balance sheets, which by end-2012 had at least doubled in the euro area, Switzerland, the United Kingdom and the United States (Figure 4 and Table 3) due to outright purchases of private and public sector securities (the United Kingdom and the United States), secured lending to financial institutions (the euro area), and foreign exchange interventions (Switzerland). In contrast, balance sheets of the central banks in Japan, Canada and Sweden had expanded more modestly, though new measures announced in April 2013 call for the doubling of the asset holdings of the Bank of Japan in the coming two years. Other unconventional measures included the Operation Twist programme in the United States and enhanced forward guidance in Canada and the United States in the form of conditional commitment to maintain low interest rates for an extended period.[3]

These conventional and non-conventional measures should have given a significant boost to aggregate demand:

- Changes in policy interest rates should have had a sizeable impact on GDP and prices according to historical evidence (Table 1). For instance, estimates for the United States suggest that a 100-basis point reduction in the policy rate should usually translate at a peak into a 0.5-0.7% increase in real GDP and a 0.1-0.4% increase in the price level.[4] Estimates obtained for other countries and areas, in particular for the euro area, also point to similar effects (Peersman and Smets, 2001). Simulated impacts from models developed by the Federal Reserve, the OECD and the ECB suggest that the effects of policy rate shocks could be even larger, ranging from 0.4 to 1.4% for GDP and from 0.2 to 1% for prices, with higher impacts in the United States than in the euro area and Japan (Table 1).
- Empirical estimates of the effects of quantitative and credit easing measures are more complex and uncertain and thus sparser. There are more studies measuring quantitative easing (QE) effects on interest rates and asset prices than on output and inflation.[5] Among the few studies trying to assess the macroeconomic impact of QE, Gambacorta *et al.* (2012) cover the current crisis and hence consider the effectiveness of measures at the zero lower bound, while also providing

2. In Canada, the euro area and Sweden some of the initial stimulus was withdrawn in 2010-11, but in the euro area and Sweden policy rates were subsequently cut again.

3. The Bank of Canada announced in April 2009 that it would keep its policy interest rate unchanged until the end of the second quarter of 2010, conditional on the outlook for inflation. Likewise, in December 2008, the Federal Reserve announced that the funds rate target would be maintained at its historical low for some time. This forward guidance was subsequently extended on several occasions, with interest rates expected in September 2012 to be kept at near zero at least through mid-2015. In December 2012, the forward guidance framework was modified by replacing calendar dates with conditions related to thresholds for unemployment and inflation expectations.

4. Using an alternative approach to the VAR, Romer and Romer (2004) find still larger effects – with a decline of output by 4.3% and of prices by 4.2% following a policy rate hike of 100 basis points. These results were, however, criticised as being driven by the inclusion of extreme episodes, the identification procedure of shocks and the choice of the lag structure. Estimations controlling for these three factors yield lower elasticities than Romer and Romer (2004) but higher than in the VAR literature, with declines in industrial production and prices of 2% after five years (Coibion, 2012).

5. See Appendix 1 for a survey of studies investigating the impact on interest rates. Estimates across studies suggest that asset purchases matching 1% of 2009 GDP have an impact on long-term rates ranging from 0 to 28 basis points, with an average impact of 7 basis points.

elasticities for individual countries and areas in addition to panel estimates (Table 2). The estimated elasticities imply that a 10% increase in balance sheets raises GDP at the peak by about 0.2-0.3% and prices by 0.07-0.1% (Gambacorta *et al.*, 2012). These estimates are of the same order of magnitude as the ones reported in other studies (Table 2). Although the design of unconventional monetary policies adopted during the crisis varied across countries, the magnitude of the estimated effects on output appears to be fairly similar when considering individual country estimations. The only exception is Japan where the output effect is negligible, probably because of the relatively small change in the Bank of Japan's total assets during the period of analysis. In contrast, the effects on prices are more dispersed and not always significant.

- The assessment of forward guidance is challenging due to the difficulties of identifying all the different factors that affect market interest rates and the difficulty of designing appropriate counterfactual simulations. The empirical assessment of forward guidance is inconclusive.[6]

Based on the studies reviewed above, policy interest rate cuts and expansions of central banks' balance sheets implemented since the onset of the crisis up to the end of 2012 could have boosted GDP, on their own, by around 11% in Switzerland, the United Kingdom and the United States and nearly 5% in the euro area (Table 3). Yet, over 2009-12, real GDP only increased by about 6% in the United States and Switzerland and around 3% in the euro area and the United Kingdom. In contrast, in Canada, Japan and Sweden, GDP increases over 2009-12 were higher than implied by the monetary policy accommodation. Regarding prices, core inflation rates were lower than predicted in Japan, Switzerland and the United States, but above expectations in Canada, the euro area, Sweden and the United Kingdom. The differences between expected and actual growth does not necessarily imply an ineffectiveness of monetary stimulus, as the calculations do not take into account potential headwinds that could have offset the stimulus from monetary policy. Moreover, these calculations can only be treated as indicative since they are based on estimates that are subject to a large degree of uncertainty, and in the case of unconventional measures, they do not account for the initial size of balance sheets nor the type of measures undertaken.[7] In addition, differences in the timing of various measures and in the lags after which their full impact materialises complicate the assessment.

Reasons behind low growth despite strong monetary stimulus

This section examines four factors that may explain why the apparent strong monetary stimulus has not resulted in strong growth: a potential decline in the natural interest rate and ensuing smaller stimulus from policy interest rates; a reduced pass-through of conventional and unconventional policy measures to asset prices and the cost of credit; restraints on credit supply and weaker loan demand due to balance sheet adjustments; and headwinds related to balance sheet adjustments and uncertainty, beyond their impact on credit, and to fiscal consolidation. A distinction between these aspects is not always clear-cut in practice, particularly when it comes to discerning between demand and supply drivers of credit and between the interest rate and asset prices pass-through and credit supply factors, as they involve a number of endogenous feedbacks which complicates the assessment of their relative importance.

6. Some event studies find support for the role of forward guidance in lowering short and long-term interest rates in the United States (Bernanke *et al.*, 2004; Williams, 2011; and Woodford, 2012). Market interest rates in Canada were also found to be lower following the Bank of Canada's announcement in April 2009 than implied by econometric models estimated over the pre-announcement period (He, 2010). However, other studies provide little or weak evidence that forward guidance improves central banks' control over long-term interest rates (Moessner and Nelson, 2008; and Anderson and Hoffman, 2010).

7. For instance, foreign reserve accumulation accounted for most of the balance sheet increase of the Swiss National Bank and may be expected to have different effects on GDP (in particular by limiting the appreciation of the Swiss franc and ensuing negative effect on exports) than the accumulation of securities by other central banks.

Weaker stimulus from policy interest rates due to the decline in the natural interest rate

A decline in the natural interest rate, *i.e.* the interest rate that maintains demand at the productive potential in the economy, implies that the current monetary stance is less accommodative than conventionally estimated under the assumption that the natural rate had remained unchanged. Indeed, the natural interest rate in recent years is likely to have fallen, at least temporarily (see below), in response to the estimated drop in potential growth (Johansson *et al.*, 2012) as predicted by some theoretical models. To assess the impact of the reduction in potential growth on the natural interest rate, time-varying natural interest rates have been estimated for a group of OECD countries[8] and the euro area *via* the Kalman filter based on a small macroeconomic model and the equilibrium real interest rate concept (Box 1 and Annex 1).

The results suggest that the natural interest rates may have declined to historically low levels in many of the analysed economies in the wake of the crisis (Figure 5). In Canada, Japan, the United Kingdom and the United States, real natural interest rates may even have turned negative, implying that close to zero nominal interest rates provide only modest stimulus in these countries – see below. In contrast, the natural interest rates in Sweden and Switzerland seem to have been stable and relatively high (Figure 5), with a correspondingly stronger impact of the reduction in actual rates. The changes in natural interest rates during the crisis have amplified a general downward trend observed prior to the crisis and identified by other studies. For instance, the real natural interest rate in the euro area is found to have fallen during the 1995-2004 period (ECB, 2004). Likewise, Laubach and Williams (2003) document a gradual fall of the real natural interest rate in the United States between the early 1960s and 2002 and their updated estimates show a further fall towards zero around the end of 2010.[9]

The implications of the decline in the natural interest rate can be illustrated by comparing interest rates implied by the Taylor rule – a conventional tool for assessing the monetary policy stance – based on constant and on time-varying natural interest rates. The former indicates that since 2009 the level of policy rates has been too accommodative or broadly appropriate in the economies reviewed except for Japan (Figure 6). However, when using estimated time-varying natural interest rates, Taylor rules imply that since 2009 interest-rate policy has been too restrictive in Canada, the euro area, Japan and the United States and also more recently in the United Kingdom, though in Canada and the United States the differences between Taylor implied interest rates and policy rates significantly narrowed in 2012 (Figure 6).[10] The gap between Taylor rates based on constant and estimated time-varying natural interest rates has been substantial over recent years, on average around 2-4 percentage points in Canada, the euro area, Japan, the United Kingdom and the United States. Negative policy rates implied by the Taylor rule in several countries would, in principle, justify unconventional monetary policy measures to substitute for interest rate cuts. These results should however be treated with caution as the estimates of natural interest rate are uncertain, reflecting large confidence intervals, weak statistical significance of some parameters, and uncertainties regarding model calibration and estimates of potential growth (Annex 1). There is also uncertainty related to the estimation method as other approaches could render different results (Box 1).

The estimated decline in potential GDP growth over recent years, which is the main driver behind the fall of natural interest rates (Annex 1), stems from a mixture of underlying trends, including demographics,

8. Canada, Japan, Sweden, Switzerland, the United Kingdom and the United States.

9. The updated estimates are available at: http://www.frbsf.org/economic-research/economists/john-williams/Laubach_Williams_updated_estimates.xlsx.

10. In line with other analyses (Ahrend *et al.*, 2008; and Hanoun, 2012), the positive gap between the Taylor-rule and the actual policy interest rates between the early 2000s and 2007 indicate an accommodative monetary bias in most economies in the years preceding the crisis (considered as responsible for the housing boom and the build-up of financial imbalances).

and cyclical factors related to the unwinding of the imbalances built up prior to the crisis. In the wake of the crisis, the estimated increase in structural unemployment rates together with lower labour productivity and capital stock growth weighed on potential growth (Figure 7, Table 4).[11] As the OECD measure of potential output is based on actual rather than trend capital, part of the potential growth decline can be cyclical and thus temporary – due to demand factors affecting investment (like uncertainty, see below).[12] However, a structural adjustment has likely taken place as well. Before the Great Recession, the capital stock of the business sector had been boosted by exceptionally low risk premia in interest rates, and an adjustment to the prospects of a more normal pricing of risk is expected. OECD estimates suggest that the adjustment in risk premia could involve an increase in the cost of capital by 1½ percentage points, which in turn could reduce the desired capital-output ratio by 6.5% and potential output by about 2% on average in the long term (OECD, 2010). At least part of the reduction in business investment in recent years is therefore likely to reflect an adjustment to a lower desired capital stock, but capital spending should recover when the adjustment runs its course.

Longer-term OECD projections indeed assume higher potential growth over the period 2013-17 compared with the previous five years (Figure 7 and Table 4) and this should be reflected in higher natural rates. Although these projections and the link between potential growth and the natural interest rate are uncertain, this will likely imply that with unchanged policy rates, the effective policy stance will become increasingly accommodative. However, it should be noted that in Canada, the euro area, the United Kingdom and the United States the potential growth rate is likely to be lower than prior to the Great Recession (between 0.5 and 1 percentage point). According to OECD projections, this is expected to be a result of slower capital stock growth and the demographic drag (Table 4). The natural interest rate will thus tend to remain lower than prior to the crisis.

Box 1. The natural interest rate: Theoretical concepts and empirical estimation

This box briefly reviews definitions and estimates of the natural interest rate and describes the estimation approach used in this paper.

Theoretical concepts of the natural interest rate

There are various concepts of defining and estimating the natural interest rate. Conventionally, it is referred to as a theoretical – and thus unobservable – real interest rate that equilibrates supply and demand in the economy and which in the medium term is consistent with a closed output gap and stable inflation (Bernhardsen and Gerdrup, 2007).

According to some approaches, the natural interest rate is associated with the long-term equilibrium real interest rate of economic growth models, where it is determined by productivity and population growth and the household rate of time preference. For instance, in the Solow model, the real interest rate is positively related to the rate of growth and negatively to the saving rate (which depends on the rate of time preference):

11. The analysis reported in Annex 1 used estimates of potential GDP from the *OECD Economic Outlook* No. 92 database from November 2012. They were subsequently revised in May 2013 but potential GDP growth rates were not substantially affected for the economies covered.

12. The OECD estimates of potential output *GDPVTR* are based on a constant return to scale Cobb-Douglas production function with Harrod-neutral labour augmenting technical progress: $GDPVTR = (LABEFFS * POPS1500 * LFPRS1500 * (1 - NAIRU) * HCAP)^{\alpha}(KTPV)^{1-\alpha}$, where *LABEFFS, POPS1500*, and *LFPRS1500* are the HP-filter trended labour efficiency (calculated as a residual), population aged 15 and older, and the participation rate for those aged 15 and older. *NAIRU* is the structural rate of unemployment estimated via the Kalman filter. *HCAP* represents an estimate of human capital derived from empirical panel estimates of the return to education. Since the revision of the methodology after the start of the crisis in 2008, *KTPV* denotes the actual measure of productive capital in the whole economy and not the trend capital stock as before, so as to allow for an adjustment to a lower capital stock due to higher post-crisis capital costs. Such concept of potential output seems more suitable for monetary policy guidance.

Box 1. The natural interest rate: Theoretical concepts and empirical estimation (cont.)

$$r = \alpha \frac{\delta + n + q}{s} - \delta,$$

where q is the rate of labour-augmenting technological change, n is the rate of population growth, s is the saving rate, δ is the rate of depreciation, and α is the marginal productivity of capital. Likewise, the equilibrium real interest rate in the Ramsey model is defined by the sum of productivity growth (g) and the household rate of time preference (θ):

$$r = g + \theta.$$

As a result, the natural interest rate should fluctuate over time with changes in its underlying fundamentals.

A slightly different definition is proposed by the general class of New Keynesian dynamic stochastic general equilibrium (DSGE) models, where the real natural interest rate is interpreted as the real interest rate that would apply if all prices were flexible. In this framework, wages or prices are sticky in the short term but flexible in the long term and the natural real interest rates is affected not only by long-term fundamentals (the household discount factor (ρ) and productivity growth (Δa) but also by short-term demand shocks (g)) (Gali, 2002):

$$r_t^* = \rho + \gamma \Delta a_t + (1-\beta)(1-\delta) g_t.$$

Estimation methods

Empirically, the natural real interest rate can be estimated by a number of methods (ECB, 2004; Giammarioli and Valla, 2004). One possibility is to compute the average of actual real interest rates over an entire business cycle. The problem of this method is that it rules out any change in the natural interest rate over a business cycle.

Another method uses market expectations of real yields derived from inflation-linked bonds or market surveys. Yields of inflation-linked bonds can, however, be distorted by liquidity premia, while market expectations may deviate from fundamentals.

An alternative approach consists in estimating the natural rate from the aforementioned DSGE models. One major drawback of these models is, however, that estimates of the real natural rate are sensitive to the model structure as well as to the estimation and calibration of the model parameters. Besides, these models abstract from any lower-frequency drift in the natural rate of interest by using de-trended data and can yield relatively volatile estimates by focusing on the short-term movements in the real interest rate to achieve stable inflation. This latter shortcoming can be addressed by estimating the natural rate *via* the Kalman filter based on a small macroeconomic model (see below).

Estimation approach used in the paper

The approach used in this paper is based on the time-series Kalman filter technique to estimate an unobservable time-varying natural interest rate in a small-scale macroeconomic model (Laubach and Williams, 2003; Mésonnier and Renne, 2007). This macroeconomic model comprises three principal equations: a Philips curve, linking the current inflation rate with its lags,[1] the lagged output gap and oil and import prices; an IS curve, linking the output gap with its lags and an interest rate gap, defined as a difference between the *ex-ante* real interest rate and the natural interest rate; and an equation defining the natural interest rate as a function of potential output growth and a constant coefficient of relative risk aversion (Annex 1). These three equations are augmented by identities defining the output gap and linking the GDP level and growth rates. Potential growth is based on OECD estimates and not estimated as an unobservable variable as in Mésonnier and Renne (2007). Thus, changes in the natural interest rate reflect a slow-moving evolution of potential growth, driven both by longer-term supply-side factors and short-term demand shocks (see the main text). In this framework, when the interest rate gap is nil, and in the absence of new shocks, the output gap closes and inflation stabilises.

These estimated natural rates are however surrounded by a large degree of uncertainty, accounting for the uncertainty associated with the Kalman filter and weak statistical significance of some parameters, but also due to the uncertainty about OECD's estimates of potential output growth. Estimates are also sensitive to the assumptions about the model's parameters, in particular the risk aversion coefficient, and the time-series properties of the estimated equations.

1. Inflation is measured by the headline Consumer Price Index (CPI) with the exception of Sweden, where CPI at constant mortgage interest rates (CPIF) is used to make it more comparable to other countries.

Interest rate pass-through seems to be broadly effective

Low policy interest rates and unconventional monetary policy measures have passed through to a broad set of interest rates. Government bond yields at all maturities had declined to historically low levels in OECD economies until the sell-off in global bond markets in May and June 2013 (Figure 8), with the exception of vulnerable countries in the euro area where yields, although having come down from their peaks, still remained elevated. The identification of the exact drivers behind low long-term government bond yields is difficult, but they likely included near zero current and expected policy rates, potentially linked to forward guidance measures in some countries, low economic growth, outright purchases of bonds and safe-haven effects (Box 2). Similarly, until mid-May yields on corporate bonds had declined to record low levels following the strong increase in the midst of the financial crisis at the turn of 2008. Spreads between corporate and government benchmark bonds had narrowed as well, likely reflecting higher risk-taking in response to the low-interest rate environment and unconventional measures taken by main central banks (Figure 9). Despite large monetary policy easing, exchange rates depreciated relatively little in advanced economies after the initial phase of the crisis until late 2012. This seems to be related to the fact that major central banks eased the monetary policy stance at the same time.

The policy interest rate pass-through to banks' lending rates has been effective in general. In the initial phase of the crisis, money market spreads increased considerably (Figure 10) and likely exerted pressure on lending rates as a large share of bank loans was indexed to unsecured money market rates. However, the massive policy rates cuts, the fading of money market stress and liquidity injections have resulted in lower lending rates, with the exception of vulnerable euro area countries (Figure 11). For instance, in the United Kingdom and the United States average interest rates on new loans declined by around 500 basis points in 2009 and hovered between 2 and 3% since then, whereas in the euro area on average they fell by around 300 basis points at the turn of 2009 and then increased towards the end of 2011 and then declined again, reflecting changes in the policy rate and growing intra-euro area divergences. For the euro area as whole, the strength and time profile of the interest rate pass-through over 2008-09 do not seem to differ from the past experience (ECB, 2010).

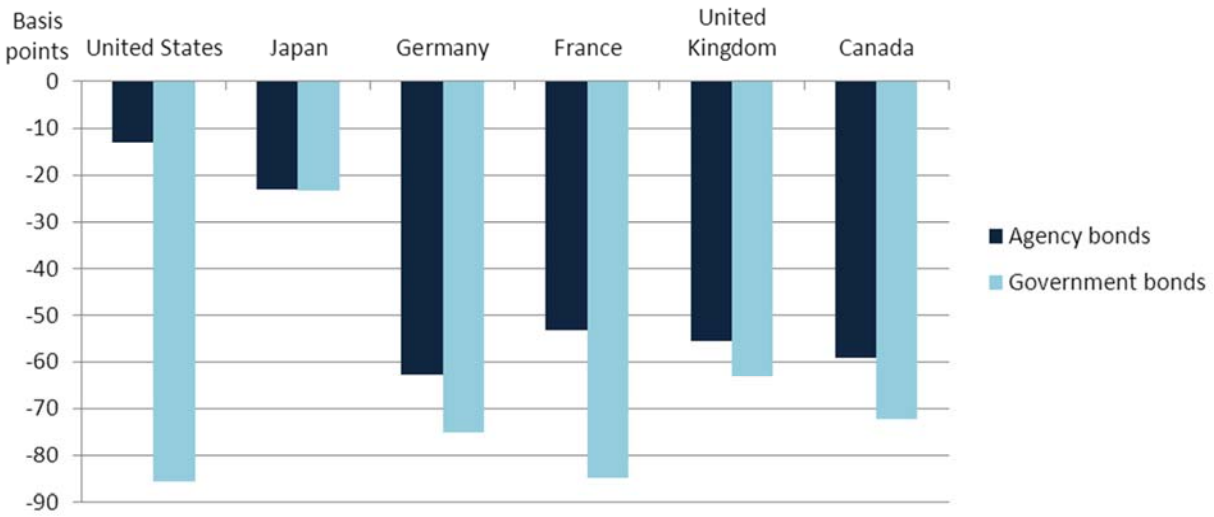
The interest rate pass-through was limited, however, in certain mortgage markets. For instance, in the United States, the Federal Reserve's purchases lowered yields on agency mortgage-backed securities (MBS) and significantly narrowed the spread with Treasury bond yields, but the spread between the primary mortgage rate (the rate paid by borrowers) and the agency MBS yield (the rate received by investors) widened, limiting the drop in primary mortgage rates (Figure 12). This seems to reflect reduced competition resulting from concentration of mortgage origination within a few financial institutions following failures and industry consolidation in the wake of the financial crisis as well as tougher regulation that led many banks to pull back from mortgage business. In addition, higher guarantee fees charged by Fannie Mae and Freddie Mac increased the fixed cost of loan origination (Bauer, 2012; Dudley, 2012). Similar competition issues among mortgage originators may also have been at work in the United Kingdom, with mortgage approvals remaining weak by historical standards despite their increase from the crisis low, while spreads (over the Bank of England bank rate or swap rates) on fixed-rate, tracker or standard variable-rate mortgages were around record highs since2009 (Figure 12). Frictions in the mortgage market coupled with declining house prices until mid-2012 also limited the ability of borrowers to refinance their mortgages in the United States, reducing the benefits of low interest rates for household spending, a channel at work in normal times. In particular, over the first years of the crisis, underwater homeowners were not permitted to refinance despite historically low interest rates, leaving them with weak balance sheets and mortgage payments often above the cost of renting. This problem was alleviated with the easing of the eligibility requirements of the Home Affordable Refinance Program in December 2011.[13]

13. The programme was introduced in March 2009.

Box 2. Safe-haven vs liquidity effects in government bond markets during recent episodes of financial stress[1]

Sovereigns perceived as comparatively safe have enjoyed historically low yields on their long-term bonds in recent years. Many factors lie behind these low levels, including in particular the expectation that monetary policy-controlled short-term interest rates will remain very low for a long period and investors' flight to safety and/or liquidity at times of intensifying stress. One way of gauging whether liquidity or safety matters more quantitatively is to track the performance of bonds issued by government agencies that benefit from the sovereign signature but not from the liquidity of plain government bonds during periods of mounting financial stress. Recent episodes of intensifying financial stress can be identified as the trough-to-peak periods of the Cleveland Fed indicator of financial stress since 2007 (Oet *et al.*, 2011).[2] Plain government bonds have been compared against securities issued by the US Small Business Administration, the Japanese International Cooperation Agency, the German Kreditanstalt für Wiederaufbau, the French Development Agency, UK's London & Continental Railways and the Business Development Bank of Canada.[3]

When stress builds up, yields typically fall more for governments than for their agencies[1]



1. Yield change between the beginning and the end of an episode of intensifying financial stress, average over episodes observed since 2007.

Source: Datastream and OECD calculations.

Across episodes of mounting financial stress, the yields of both plain and agency bonds have fallen significantly (Figure above). Outside Japan, government bonds have recorded noticeably larger average falls than their agency counterparts, suggesting that liquidity effects are at play. In the United States, if taken at face value, the stark difference between the two measures would indicate that the liquidity of the most easily traded fixed-income asset globally has been an important driver of the falls in its yields in periods of mounting stress, whereas the perceived safety has contributed only very little, possibly reflecting the challenging fiscal situation. In contrast, in Germany, government and agency bonds have recorded similar falls during periods of intensifying stress, suggesting that solvency has been the main driving force.

1. This box was written by Boris Cournède.
2. This method leads to identifying four episodes: February 2007 to October 2008, April to July 2010, February to December 2011, and April to mid-June 2012.
3. In contrast with other G7 countries, Italy was not included in the sample because it has not benefitted from recent episodes of flight to quality and no sufficiently long-dated agency bond could be retrieved from Datastream.

Impaired credit supply conditions and weak loan demand

Despite the lowering of bank interest rates, bank credit contracted in most countries reviewed in 2009-10 and its growth has been sluggish since then, though with important cross-country differences (Figure 13). This development can be explained by considerable restraints on credit supply and weaker loan demand, which are analysed below.

On the supply side, the impact of low interest rates on credit growth was weakened by a significant tightening of credit standards in the euro area, in particular in vulnerable countries, the United Kingdom and the United States, though in the latter two countries they have eased more recently (Figures 14 and 15). A number of reasons, related to banks' ability and willingness to extend credit, can explain this tightening:

- Limited availability of funding and uncertainty about future availability of funding initially diminished banks' willingness and capacity to expand credit. The initial seizing up of inter-bank lending and the collapse of securitisation markets resulted in no access to market funding or access only at very high costs.[14] The situation has, however, improved thanks to central banks' liquidity provisions at increasingly longer maturities, the 3-year Long-Term Refinancing Operations (LTROs) of the ECB being a notable example. Nevertheless, commercial banks have accumulated most of the liquidity injected by central banks as excess reserves, especially in the United States and Switzerland but also in the euro area and the United Kingdom (Figure 16), which in most cases was not reflected in credit expansion.[15] With high excess reserves in many countries and early repayments of LTROs by banks in some euro area countries, it is doubtful if the lack of funding is now a key constraint on bank lending in the aggregate in the countries considered.
- Excessive leverage and reduced risk tolerance in banks played a role. Banks entered the crisis with extremely high leverage as a result of strong willingness to take risk (or a lack of risk awareness), and the ensuing deleveraging could have reduced credit supply to the non-financial private sector. The significant reduction in banks' leverage since 2008 appears to have been concentrated on reducing exposures to other financial institutions, but increased risk awareness by banks, as reflected in continued tightening of credit standards, has contributed to reducing credit supply.
- Deteriorating bank balance sheets due to crisis-induced credit losses could have made it difficult for some banks to respect minimum capital requirements and expand credit supply, as issuing new equity (given the scarcity of capital and heightened investor risk aversion) or cutting dividends proved difficult and costly (Borio and Zhu, 2012). Weakened bank balance sheets limited the supply of credit during the recent crisis (Foglia *et al.*, 2010; Holton *et al.*, 2012; and Puri *et al.*, 2011).[16] The size of problem assets indeed increased at the beginning of the crisis and did not decline substantially until late-2012 in a number of countries, especially those where house prices dropped substantially (the United Kingdom, the United States and some euro area

14. In this context, it is worth stressing that empirical evidence for a sample of US and EU banks shows that banks with greater dependence on market funding restricted loan supply more strongly during the 2007-10 period (Gambacorta and Marques-Ibanez, 2011).

15 . Switzerland is a notable exception as it sustained credit growth (Figure 13).

16. Similar effects were documented for the 1990-91 recession in the United States, with a stronger contraction of credit observed for less-capitalised banks (Peek and Rosengren, 1995).

countries).[17] Even so, the extent of non-performing loans has risen surprisingly little so far in some euro area countries (OECD, 2012a, 2013).

- Financial regulation may also have reduced credit supply. Capital requirements of Basel I and II (the latter was implemented in Europe in 2008 but not in the United States) can induce credit pro-cyclicality as asset prices tend to decline and securities ratings tend to be downgraded during recessions and *vice versa* during expansions (Panetta *et al.*, 2009). This may have constrained bank lending capacity in the early stage of the financial crisis and more recently in euro area countries under market pressure. Also, stricter capital requirements (a temporary increase in the ratio of capital to risk-weighted assets to 9% by mid-2012 in the European Union and the anticipation of tighter Basel III requirements to be gradually implemented between 2013 and 2018)[18] could have limited credit expansion temporarily. Even though evidence from Europe suggests the capital requirements were met primarily by equity injections rather than contracting assets and modifying weights, credit did not grow during this period (EBA, 2012). Still, a number of large euro area banks are not well capitalised if compared with a benchmark of a 5% leverage ratio, which has been suggested as a prudent minimum requirement (OECD, 2012b).

On the demand side, the willingness, incentives and capacity of households and businesses to take credit were diminished by several factors, including:

- Weakened balance sheets of households and companies prompted deleveraging and hence could have reduced demand for credit during the adjustment to lower leverage (see below). The extent of deleveraging differs significantly across countries and areas (Figures 17 and 18). For households, considerable deleveraging has already taken place in the United States and the United Kingdom, but it has not started in the euro area as a whole (though a significant reduction in debt-to-income ratios has taken place in a few member countries) nor in Canada. For non-financial corporations, since 2009 the ratio of debt to gross operating surplus has fallen in most countries but has increased in several euro area countries. Thus, it would appear that deleveraging may have played a role in reducing credit demand in the United States in recent years but a lack of deleveraging in other countries casts doubt about its role. Moreover, it is not clear to what extent observed deleveraging is a result of deliberate decisions of households and companies not to take new credit and pay back faster outstanding debt, and to what extent it reflects a fall in credit supply.

- Prevailing uncertainty about future streams of income for households and businesses, related to activity and the situation in labour markets, returns on financial assets, uncertainty about taxes and the risk of the euro area break-up, have likely damped credit demand as well (see below for a discussion on the impact of uncertainty on GDP growth).

17. For instance, in the United States, in 2012, 772 banks remained identified as problem banks with assets of $292 billion; since 2008 non-performing loans have averaged at 4.3% of all loans (prior to 2008 the average was 1.1%); and banks' abilities to absorb future losses had not improved significantly by end-2011 as the coverage ratio, which is the ratio of non-performing loans to loan-loss reserves and equity capital, plummeted from a decade high of 23% in 2006 to 4.2% in 2009 and 5.7% at the end of 2011 (Koepke, 2012).

18. Slovik and Cournède (2011) find that banks would have to increase their lending spreads on average by about 15 basis points to meet the capital requirements effective in 2015 (4.5% for the common equity ratio, 6% for the Tier 1 capital ratio) and by about 50 basis points to meet the capital requirements effective as of 2019 (7% for the common equity ratio, 8.5% for the Tier 1 capital ratio).

- Weakened balance sheets of firms and households reduced their capacity to obtain credit. In the initial phase of the crisis, companies' financial positions affected their chances to get credit even at unchanged credit supply criteria, though the contribution of this effect to the GDP decline in the euro area and the United States has not been clearly identified (Ciccarelli *et al.*, 2010). This is consistent with a general finding that well-capitalised firms are more likely to obtain credit than poorly-capitalised peers (Jimenez *et al.*, 2012). For the household sector, declining house prices reduced access to credit *via* mortgage equity withdrawal and reduced spending. Such effects were more important in the Netherlands, the United Kingdom and the United States where mortgage equity extraction is more widespread than in most other OECD economies (Calza *et al.*, 2007).[19] The loss of the ability to borrow against the home value appears as a major factor behind the consumption collapse between 2006 and 2009 in the United States (Mian *et al.*, 2012). Moreover, households who defaulted on mortgages lost access to credit with possible long-lasting effects. In the United States, the residential mortgage default rate hovered around 10% between mid-2009 and early 2013, while historically it has ranged between 0 and 2% over the business cycle. Empirical evidence suggests that only about 10% of borrowers with a prior serious delinquency regain access to the mortgage market within 10 years of their default (Hedberg and Krainer, 2012).

Distinguishing between supply and demand factors behind credit developments is fraught with difficulties. For the euro area, empirical evidence from the initial phase of the crisis suggests that credit contraction was largely driven by supply factors, especially regarding loans for companies, though negative demand effects also played a role (Ciccarelli *et al.*, 2010). The rebound in credit growth in 2011-12 differed across countries – with stronger growth in the United States and much weaker in the euro area, likely reflecting better US bank capitalisation and easier credit standards than in the euro area, but also lingering effects of the euro area crisis (Figures 13-15).

Other strong headwinds, including fiscal headwinds

Deleveraging and uncertainty likely weakened economic growth more broadly, beyond their direct impact on credit growth, and these headwinds were magnified by fiscal consolidation as explained below.

Apart from reflecting deleveraging where that took place, the sharp increase in saving rates during the recession may have been driven by increased uncertainty. However, the contribution of both factors is debated. For instance, Dynan (2012) and Mian *et al.* (2011) indicate significant effects of households' debt reduction on consumption and saving in the United States during the Great Recession, while Carroll *et al.* (2012) and Cooper (2012) find that deleveraging explained very little of business-cycle variations in consumption and saving. Moreover, there is some evidence that higher saving rates during the Great Recession were driven primarily by precautionary motives (Mody *et al.*, 2012). Notwithstanding problems with identifying drivers of saving rates, the net saving ratio increased between 2007 and 2012 by around 6½ percentage points in the United Kingdom, around 4 percentage points in Sweden and 3 percentage points in the United States, with varying duration of the increase (Table 5). Though only modest increases in saving rates took place in the euro area as a whole, large increases were observed in vulnerable euro area countries (especially Ireland and Spain, but also in Portugal). Rising saving rates created massive headwinds for the economy, even though they declined somewhat over recent years in some countries, particularly in the euro area and the United States. Back-of-the-envelope calculations based on cumulative effects of annual changes in consumption stemming from changes in the saving rates indicate that in several countries this could have reduced GDP between 2008 and 2012 by between around 3% and 4%, and by significantly more – between 6% and 9% – in selected euro area countries (Table 5).

19 . Mortgage equity withdrawals are also possible in Australia, Canada, Denmark, Finland, Ireland, Norway, Spain and Sweden.

The recent crisis was also characterised by a particularly high degree of uncertainty and sharp falls in confidence. Heightened uncertainty increases the opportunity cost of hard and costly to reverse decisions, such as fixed investment, new hiring and purchase of durable goods, weighing on economic activity (Bernanke, 1983; Dixit and Pyndick, 1994; Bloom, 2009 and 2011). Uncertainty as conventionally measured by stock market volatility increased during the crisis though it came down markedly in 2012 and early 2013 before increasing more recently (Figure 19). Cross-country empirical evidence suggests that a one-standard deviation increase in various measures of uncertainty is associated with a decline in annual output growth of between 0.4 and 1.25 percentage points (IMF, 2012b).[20] On this basis, the increase in the level of global uncertainty in 2008-11 would have on average reduced the GDP level in selected OECD countries over this period by around 7% compared with a scenario of uncertainty remaining at its 2003-07 average level. The measure of economic policy uncertainty also increased at the beginning of the crisis but it did not come down as the equity-based measure until late 2012 (IMF, 2012b). The substantial increase in policy uncertainty from 2006 to 2011 is estimated to have reduced the GDP level in advanced economies by 2.5% over this period (IMF, 2012b), and in the United States by 3% (Baker *et al*., 2013). These effects are likely to account also for some uncertainty as measured by global market-based indicators and thus should not be cumulated with the effects discussed above. For the United States the role of uncertainty is consistent with business surveys and anecdotal evidence indicating that regulatory and fiscal uncertainty was a major concern for companies (Fisher, 2012).[21] Equally, survey-based indicators of consumer confidence were depressed in many countries until late 2012 (Figure 20) and they have a direct significant association with current and future private consumption growth (Nahuis and Jansen, 2004). Even if other factors, such as income and wealth, are taken into account, confidence by itself might have some additional explanatory power (Carroll *et al*., 1994; Ludvigson, 2004; Wilcox, 2007), especially if the movements are large (Dees and Brinca, 2011).

Following the recovery from the 2008/09 recession, many OECD countries, especially in Europe, have undertaken large fiscal adjustments and further fiscal policy tightening is expected over coming years (Figure 21). Based on short-term fiscal multipliers and reflecting country-specific composition of consolidation, the adjustment between 2010 and 2012 should have cumulatively reduced GDP levels by at least 1-2½ per cent in Canada, the euro area, the United Kingdom and the United States (Table 6). These calculations may underestimate GDP effects as they are based on multipliers in normal times (ranging from 0.7 to 0.9 after two years). In the current environment of constrained monetary policy at the zero lower bound, concerted consolidation in many OECD countries and sizeable economic slack, the elasticities are likely to be higher – possibly by around two-thirds, implying a GDP reduction of around 2 to 4%.[22]

Summary

The evidence presented above suggests that the extent of stimulus from policy rates might have been halved compared with what might have been expected on the basis of historical evidence in some countries

20. At the end of 2008, the global uncertainty measure increased by 6 standard deviations.

21. In the United States, 90% of small businesses surveyed by the National Federation of Independent Business in September declared not to be interested in borrowing or to have no problem accessing cheap financing (Fisher, 2012). Likewise, the September survey of chief financial offers (CFOs) from Duke University indicated that only 14.5% of CFOs listed credit markets/interest rates among the top three concerns facing their corporations versus 43% and 41% listing consumer demand and federal government policies respectively (Global Business Outlook Survey of chief financial officers by the Fuqua School of Business at Duke University).

22. OECD (2010) finds that with no monetary policy accommodation multipliers are higher by around ⅓ and the same increase is likely when consolidation is implemented simultaneously across countries. See also discussions in Gali *et al*. (2007), Christiano *et al*. (2009), Woodford (2011), Auerbach and Gorodnichenko (2012) and IMF (2012b).

due to the fall in natural interest rates, but this does not account for the effects of unconventional policy measures which could have to some extent substituted for policy rate cuts. Policy interest rate cuts and unconventional policy measures were largely transmitted to asset prices and the cost of credit in and outside the banking sector (with the exception of some euro area countries). Nonetheless, credit growth remained subdued. This mainly owes to considerable balance sheet adjustments of financial companies and prevailing uncertainty, which together limited banks' capacity and willingness to supply credit. On top of this, balance sheet adjustments of non-financial companies and households, large uncertainty as well as simultaneous and considerable fiscal consolidation in many OECD countries provided important headwinds.

By and large, this analysis is consistent with the view that subdued growth – even despite apparent strong monetary stimulus – can be attributed to the correction of imbalances, manifested in high leverage of households and financial institutions, asset price bubbles and excessive risk-taking, that built up in the run-up to the Great Recession (Borio, 2012). The weakened transmission of monetary policy and subdued growth after financial crises or following bursting of housing bubbles conform to a historical pattern (Reinhart and Rogoff, 2010; Bech *et al.*, 2012; and IMF, 2012a).

Unintended consequences of ultra-stimulative monetary policies

Conventional and non-conventional stimuli can bring benefits in terms of stronger growth in the short term (as discussed above), but over time they can have unintended negative consequences. Benefits tend to decline and costs to increase with the duration of monetary stimulus and its repetitive use over subsequent business cycles as argued below.

Strong and prolonged monetary stimulus may delay the needed rebalancing of an economy by masking balance sheet weaknesses and undermining incentives to deal with impaired assets. This is of a particular concern in the banking sector, given its importance for financial stability, support to the real economy and role in credit allocation. Massive liquidity provisions and low interest rates reduce the opportunity cost of rolling over doubtful loans compared with an alternative option of recognising them as impaired and using scarce equity capital to undertake capital-depleting provisions and write-offs. Ever-greening of loans was observed in Japan in the 1990s (Peek and Rosengren, 2005; Caballero *et al.*, 2008) and may now be taking place in some OECD economies (Rawdanowicz *et al.*, 2013), especially in commercial real estate.[23] The shares of recognised non-performing loans in total loans in some of the largest euro area countries are similar to their levels in the early 2000s despite the current much weaker economic situation (OECD, 2012a, 2013). Similarly, depressed market-to-book ratios and low loan loss provisions in many banks are indicative of ever-greening practices (BIS, 2012b).

Ever-greening of non-performing loans in the banking system can show up in the survival of existing inefficient firms in the non-financial sector and lead to credit misallocation. This was the case in the 1990s in Japan where banks provided credit at advantageous terms to troubled clients at the cost of new borrowers (Peek and Rosengren, 2005; Caballero *et al.*, 2008; and BIS, 2012a). In such circumstances, the reallocation of scarce capital can be delayed, possibly having a negative impact on the pace of recovery and potential growth. Repeated cycles of aggressive monetary policy accommodations in subsequent

23. The EBA (2012) argues that average arrears in commercial real estate did not markedly increase, in spite of their sensitivity to the economic cycle, indicating that they might have been subject to forbearance. There are also indications that around a third of British commercial real estate loans have been subject to forbearance (Bank of England, 2012b). Albertazzi and Marchetti (2010) provide some evidence of ever-greening practices by small and less-capitalised banks in Italy during the initial phase of the financial crisis (September 2008-March 2009). According to Bank of England (2012), forbearance by banks on existing loans coupled with low policy rates may have contributed to the recent rise in the number of zombie companies in the United Kingdom

downturns prevents the needed purging of past *malinvestments*, resulting in a growing stock of unproductive investment and expanding debt accumulation, which reduce potential growth over time and the effectiveness of monetary policy when a balance-sheet recession hits the economy (White, 2012). Capital misallocation can also arise from the possibility to finance investment projects with a marginal return equal to the prevailing near-zero interest rate. These negative effects are more likely to arise when low interest rates are maintained over a long period. Set against this argument, one area where such misallocation could take place is property investment, but there has been little buoyancy in this market in most countries, with a few exceptions more recently.

Strong and protracted monetary policy accommodation, in particular related to a massive expansion of central banks' balance sheets (Figure 4), risks raising inflation expectations and inflation. So far, immediate higher inflation does not seem to be likely as inflation has been moderate and spare capacities are estimated, though with large uncertainty, to remain sizeable in many OECD countries (Figure 22) and inflation expectations have been broadly stable, with the exception of Japan where they have been catching up with the new 2% inflation target (Figure 22). Moreover, in several countries money multipliers declined as the large increase in base money in some countries did not spur growth in broad aggregates of money supply (Figure 23), and monetary authorities have the means to withdraw liquidity quickly if signs of excessive credit growth were to emerge. However, in the longer term, such risks can become more pronounced as inflation expectations could increase due to perceptions that central banks will ultimately not use available instruments to reduce ample liquidity given conflicting objectives related to concerns about financial market stability and price stability or even concerns about the independence of a central bank.

Past purchases of government and corporate bonds and relaxation of collateral standards have exposed central banks to interest and credit risks, which may materialise upon the exit from QE policies and normalisation of policy rates. The extent to which resulting losses will be damaging is, however, debatable. As argued by Buiter (2008), central bank solvency can be ensured by monetary issuance to the extent that the monetary authorities do not have significant foreign exchange denominated liabilities and that such issuance does not threaten price stability. Thus, a central bank could in principle operate with negative equity. However, capital losses and no remittances to the government may be perceived as politically unwelcome and potentially undermine central bank independence (Rawdanowicz *et al.*, 2013).

QE policies could also impair the functioning of securities markets. With large purchases of certain securities (like government and covered bonds or mortgage-backed securities), central banks may become too dominant a buyer (and possibly the only active buyer) and consequently limit liquidity and price discovery as few trades take place among private agents. Central banks in Japan, the United Kingdom and the United States already hold a sizeable share of outstanding government bonds, ranging from 15 to 30% (Table 7). During the exit from QE, selling large amounts of government and commercial papers could unsettle markets and crowd out private sector debt. Central banks' dominant role could also lead to an atrophy of certain segments of financial markets, risking a delayed resurrection once the support is withdrawn.

If sustained for a long time, strong monetary stimulus can lead to excessive risk-taking (Borio and Zhu, 2008; Hahm *et al*., 2012). Although more risk-taking is desirable when risk aversion is very strong, it could become a problem when risk aversion has abated. With increasing signs of stronger willingness to take risk, as reflected for instance in issuance and spreads of high-yields bonds, additional easing risks encouraging excessive risk-taking. Low returns on investment-graded financial assets push asset managers to search for yield which necessitates accepting higher risk (Rajan, 2005, 2006). Higher risk-taking could also result from moral hazard, given market expectations that monetary policy will help financial institutions recover from bad investments (Minegishi and Cournède, 2010; Farhi and Tirole, 2012; and

Hahm *et al*., 2012). Low interest rates can also boost net interest margins and financial firms' value, leading potentially to higher leverage and more risk-taking (Adrian and Shin, 2009, 2010).

Similarly, QE-induced shifts from risk-free to more risky assets could also result in asset price bubbles associated with impaired price signalling. Some signs of bubbles in corporate bond markets, especially in the United States, had become apparent prior to the recent sell-off (Rawdanowicz *et al*., 2013). Massive securities purchases have been accompanied by strong stock market gains in the United States, and to a smaller extent in the euro area and the United Kingdom, and the anticipation and subsequent announcement of new quantitative and qualitative easing in Japan have led to strong stock market gains, notwithstanding the correction in late May and June 2013 (Figure 24). As indicated by recent high volatility of equity prices, stock market rallies raise questions about the sustainability of the ensuing stock valuation in the context of sluggish growth.[24]

The yield-search as discussed above also encouraged investors to invest abroad, especially in emerging markets. This had ramifications for exchange rates and monetary policies in economies receiving capital inflows, in addition to the beneficial effects for these economies of stronger export markets as a result of highly expansionary monetary policy in the advanced countries (Bernanke, 2012).[25] To the extent that exchange rates were kept stable, accommodative monetary policy in advanced countries resulted in lower costs of credit and increased credit availability in the recipient countries, risking credit booms and asset price bubbles. On the other hand, if the exchange rate was allowed to adjust, the appreciation weakened international competitiveness and thus economic growth. Overall, emerging market economies dealt well with large capital inflows in the aftermath of the 2008/09 crisis. However, in May and June 2013 there was an abrupt shift in investor sentiment towards emerging market assets in the context of a general reassessment of the timing of tapering and exit from highly accommodative monetary policy in the United States. The sharp drop in equity prices and currencies of some emerging market economies during this episode demonstrates the risks of capital flow reversals and financial turbulence for emerging markets as advanced countries exit from their current monetary policy stance in the coming years.

Conclusions

A massive monetary policy stimulus in the main OECD economies helped to stabilise financial markets and avoid deflation, but sluggish GDP growth has raised concerns about the effectiveness of monetary policy in stimulating demand. Notwithstanding an almost full transmission of policy measures to higher asset prices and lower cost of credit, the analysis provided in this paper suggests that this was due to a combination of three factors. First, lower policy interest rates may not have provided as much stimulus as expected given the evidence of a decrease in natural interest rates, resulting from the estimated decline in potential GDP growth in the wake of the crisis. Given that part of this decline is likely to have been related to a temporary adjustment to a lower desired capital stock and cyclical factors, the natural interest rate should increase over coming years, boosting stimulus if policy rates remain unchanged. Second, balance sheet adjustments of non-financial companies and households, large uncertainty as well as simultaneous

24. Assessing equilibrium stock valuations is intrinsically difficult. For instance, judging by a gap between the Shiller's cyclically-adjusted P/E ratios and its long-term historic average (from 1926), stocks seem expensive now, but by taking a shorter perspective (from 1980) they seem inexpensive.

25 As these channels are complex, there is little empirical evidence on the extent of international spill-overs of recent monetary stimulus in the advanced OECD countries. For instance, Neely (2012) finds that announcements of Large-Scale Asset Purchase in the United States reduced international long-term bond yields and the spot value of the dollar. Based on event studies, Chen *et al.* (2012) find some evidence that US QE programmes lowered bond yields, boosted equity and commodity prices and appreciated domestic currencies in Asian economies. However, the VAR models by the same authors point to a diversified and not always significant macroeconomic impact on emerging economies.

and considerable fiscal consolidation in many OECD countries created important headwinds. Third, the bank lending channel appears to have been impaired, mainly due to considerable balance sheet adjustments and prevailing uncertainty, which together limited banks' capacity and willingness to supply credit. The paper points to risks of unintended negative consequences associated with strong monetary accommodation. This calls for a forward-looking cost-benefit analysis, which is likely to differ across countries, and policy measures to boost the effectiveness of monetary accommodation and minimise future negative consequences.

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TABLES AND FIGURES

Table 1. Estimated macroeconomic effects of a permanent decrease in the policy rate

	Sample	Approach	Estimated peak effect (per cent) of a 100 bp interest rate cut on	
			GDP	prices
United States				
Leeper *et al.* (1996)	1960-1996	VAR	0.35	1.00
Bernanke *et al.* (1997)	1965-1995	VAR	0.40	0.06
Bernanke and Mihov (1998)	1965-1996	VAR	0.40	0.50
Christiano *et al.*, (1999)	1965-1994	VAR	0.70	0.05
Bernanke *et al.* (2005)	1959-2001	Factor Augmented VAR†	0.60	_
Gorodnichenko (2006)	1965-1996	Factor Structure VAR†	0.80	_
Romer and Romer (1994)	1970-1996	Narrative approach with single equation	4.30	4.20
Angeloni *et al.* (2003)	-	FRB/US Model*	1.40	1.00
Hervé *et al.* (2009)	-	OECD Global Model**	1.10	0.70
Coibion (2012)	1970-1996	VAR with Romer and Romer's (2004) shocks	2.00	2.00
NiGEM	-	Model based on historical data***	0.76	0.40
Euro area				
Peersman and Smets (2001)	1980-1998	VAR†	0.40	0.60
Dieppe and Henry (2004)	-	Euro area AWM***	0.40	0.70
van Els *et al.* (2003)	-	Euro area National Central Banks' Models***	0.40	0.40
Blaes (2009)	1986-2006	Factor Augmented VAR†	0.60	0.20
Hervé *et al.* (2009)	-	OECD Global Model**	0.70	0.20
NiGEM	-	Model based on historical data***	0.74	0.25
Japan				
Hervé *et al.* (2009)	-	OECD Global Model**	0.50	0.20
NiGEM	-	Model based on historical data***	1.01	0.17
United Kingdom				
Bank of England (2004)	-	Bank of England Quarterly Model	0.40	0.35
NiGEM	-	NiGEM***	0.71	0.24
Canada				
NiGEM	-	Model based on historical data***	0.36	0.05
Sweden				
NiGEM	-	Model based on historical data***	0.33	0.04

* Effects reported three years after the shock.
** Effects reported five years after the shock.
*** Effects reported two years after the shock.
†Exchange rate effect explicitly controlled for in the estimate.
Source: OECD compilation.

Table 2. Estimated macroeconomic effects of an increase in central bank total assets

	Sample	Approach	Shock	GDP	Prices
United States					
Baumeister and Benati (2010)	2007-09	SVAR	100 basis point decline of 10-year government bond yield spread	2.0	1.0
Chung *et al.* (2011)	March 2010-mid-2011	Model simulations of portfolio-balance effects	Long-term asset purchases LSAP1 and LSAP2 of $2.3 trillion	3.0	1.0
Gambacorta *et al.* (2012)	January 2008-June 2011	VAR	Increase in the central bank balance sheet of 3% (reported effects for a 100% increase)	3.3	2.0
Euro area					
Baumeister and Benati (2010)	2007-09	SVAR	100 basis point decline of 10-year government bond yield spread	1.0	0.8
Peersman (2011)	1999-2009	SVAR	Size of balance sheet increases by 10% (reported effects for a 100% increase)	2.0	–
Gambacorta *et al.* (2012)	January 2008-June 2011	VAR	Increase in the central bank balance sheet of 2.5% (reported effects for a 100% increase)	4.0	3.2
Giannone *et al.* (2012)	January 1999-April 2011	VAR	Increase in ECB balance sheet (effects reported for the increase since the onset of the crisis)	2.0	–
Japan					
Baumeister and Benati (2010)	2007-09	SVAR	100 basis point decline of 10-year corporate bond yield spread	1.1	0.8
United Kingdom					
Baumeister and Benati (2010)	2007-09	SVAR	100 basis point decline of long-term bond yield spread	2.3	1.8
Joyce *et al.* (2011)	1991-2007	SVAR	Asset purchases (£200 billion) corresponding to a decline of the ten-year gilt yield of 100 basis points	1.5-2.0	0.75-1.5
Gambacorta *et al.* (2012)	January 2008-June 2011	VAR	Increase in the central bank balance sheet of 4.5% (reported effects for a 100% increase)	2.7	0.0
Kapetanios *et al.* (2012)	March 2009-January 2010	VAR	Decrease of gilt spread of 100 basis points	1.5	1.25
Canada					
Gambacorta *et al.* (2012)	January 2008-June 2011	VAR	Increase in the central bank balance sheet of 2.5% (reported effects for a 100% increase)	4.0	1.6
Sweden					
Gambacorta *et al.* (2012)	January 2008-June 2011	VAR	Increase in the central bank balance sheet of 4.5% (reported effects for a 100% increase)	3.3	0.9
Switzerland					
Gambacorta *et al.* (2012)	January 2008-June 2011	VAR	Increase in the central bank balance sheet of 3% (reported effects for a 100% increase)	3.3	0.0

Source: OECD compilation.

Table 3. Expected peak effects on GDP and consumer prices of monetary policy stimulus during the crisis

	Cut in policy rate from peak to trough until end-2012	Cumulative peak effects from cut of interest rates		Balance sheet change over 2008Q2-12Q4	Cumulative peak effects from balance sheet increases		Total predicted cumulative peak effects		Actual changes (per cent)			
	Basis points	Per cent		Per cent	Per cent		Per cent		2008-2012		2009-2012	
		GDP	Prices		GDP	Prices	GDP	Prices	GDP	Prices	GDP	Prices
United States	500	5.8	5.5	215	6.0	2.9	11.8	8.4	3.3	6.7	6.5	7.0
Euro area	350	1.9	1.4	115	2.6	2.3	4.5	3.7	-1.5	7.3	3.0	7.0
Japan	40	0.3	0.1	55	0.6	0.4	0.9	0.5	0.2	-2.4	6.1	-1.0
United Kingdom	525	4.3	1.5	345	7.1	3.6	11.4	5.1	-1.0	13.4	3.1	11.0
Canada	425	1.5	0.2	45	1.8	0.7	3.3	0.9	4.9	6.6	7.8	6.3
Sweden	450	1.5	0.2	75	2.5	0.7	4.0	0.8	5.9	4.6	11.5	5.1
Switzerland	275	1.8	0.9	265	8.8	0.0	10.7	0.9	4.0	-0.3	6.0	0.2

Note: The simulations are based on country-specific elasticities of GDP and prices to monetary policy shocks which were calculated for each monetary area as simple averages of elasticities reported in Tables 1 and 2, except for the policy interest rate simulation for Switzerland, which is based on the average elasticity across other countries. These calculations assume no effect of near-zero interest rates on central banks' total assets. Actual price changes are based on the consumer price index, except for the euro area and the United Kingdom where the harmonised consumer price index is used.

Source: OECD calculations and OECD Economic Outlook 93 database.

Table 4. Decomposition of potential real GDP growth

Percentage points (unless stated otherwise)

	Potential Growth (per cent)	Trend Labour Force Participation Rate	(1-NAIRU)	Working Age Population	Human Capital	Labour Efficiency	Capital Stock
				United States			
1998-2007	2.6	-0.1	0.0	0.8	0.1	1.1	0.9
2008-2012	1.8	-0.2	-0.1	0.6	0.1	0.9	0.5
2013-2017	2.0	-0.2	0.0	0.6	0.1	0.9	0.7
				Euro area			
1998-2007	1.9	0.2	0.1	0.4	0.4	0.1	0.7
2008-2012	1.0	0.1	-0.2	0.3	0.3	-0.1	0.5
2013-2017	1.1	0.0	-0.1	0.2	0.2	0.4	0.3
				Japan			
1998-2007	0.8	-0.3	-0.1	0.2	0.4	0.1	0.4
2008-2012	0.6	-0.2	0.0	0.1	0.3	0.4	0.1
2013-2017	0.9	-0.2	0.0	0.0	0.3	0.6	0.2
				United Kingdom			
1998-2007	2.7	0.1	0.1	0.4	0.3	0.7	1.2
2008-2012	0.9	0.1	-0.1	0.5	0.2	-0.8	1.0
2013-2017	1.8	0.1	0.0	0.4	0.2	0.2	0.9
				Canada			
1998-2007	2.8	0.2	0.1	0.9	0.2	0.2	1.2
2008-2012	1.7	0.0	0.0	0.8	0.1	-0.4	1.2
2013-2017	2.0	-0.1	0.0	0.6	0.1	0.3	1.1
				Sweden			
1998-2007	2.7	0.0	0.1	0.4	0.1	1.6	0.6
2008-2012	2.2	0.1	0.0	0.5	0.2	0.7	0.6
2013-2017	2.8	0.1	0.0	0.4	0.2	1.2	0.9
				Switzerland			
1998-2007	1.8	0.0	0.0	0.6	0.1	0.4	0.6
2008-2012	1.9	0.1	0.0	0.8	0.2	0.2	0.6
2013-2017	2.1	0.0	0.0	0.6	0.1	0.7	0.6

Note: The decomposition of potential growth is based on the year-on-year change of the logarithm of the OECD estimate of potential output:

$$GDPVTR = (LABEFFS * POPS1500 * LFPRS1500 * (1 - NAIRU) * HCAP)^{\alpha}(KTPV)^{1-\alpha},$$

where *LABEFFS, POPS1500*, and *LFPRS1500* are the HP-filter trended labour efficiency (calculated as a residual), population aged 15 and older and the participation rate for those aged 15 and older. *NAIRU* is the structural rate of unemployment estimated *via* the Kalman filter. *HCAP* represents an estimate of human capital derived from empirical panel estimates of the return to education. *KTPV* denotes the actual whole economy measure of productive capital.

Source: OECD Economic Outlook 93 database.

Table 5. Cumulative GDP decline due to higher saving rates

Per cent (unless stated otherwise)

	Net Saving Rates						Initial change	Following change	*Ex-ante* cumulated change in consumption as % of GDP	Cumulated GDP effect of changes in saving rates
							(percentage points)			
	2007	2008	2009	2010	2011	2012				
United States	2.4	5.4	4.7	5.1	4.2	3.9	3.0	-1.4	-1.3	-2.9
Euro area	8.9	9.3	10.0	8.4	7.8	7.2	1.0	-2.7	1.1	0.8
Canada	3.0	4.0	5.6	4.5	3.8	4.0	2.5	-1.5	-0.6	-0.9
Japan	0.9	0.4	2.4	2.0	2.3	0.8	1.8	-1.4	-0.3	-2.4
United Kingdom	-4.3	-2.7	1.8	2.0	1.9	2.2	6.5	0.0	-4.1	-3.7
Switzerland	12.5	11.7	11.4	11.3	12.8	14.1	-1.2	2.8	-1.1	0.6
Sweden	7.2	9.0	11.0	8.4	10.2	11.4	3.8	0.4	-2.1	-3.8
Austria	11.6	11.5	11.2	9.1	7.4	7.7	-4.3	0.3	2.6	4.4
Belgium	11.4	11.5	13.3	10.1	8.8	9.7	2.0	-3.7	0.9	0.4
Finland	-0.9	-0.3	4.2	3.3	1.2	-0.3	5.1	-4.6	-0.2	-6.1
France	12.2	12.1	13.0	12.6	12.9	12.5	0.8	-0.5	-0.2	-0.9
Germany	11.0	11.5	10.9	10.9	10.4	10.3	0.5	-1.2	0.5	0.4
Greece	2.6	-4.3	-3.1	-9.4	-12.8	-16.8	-19.4	0.0	14.1	32.4
Ireland	-2.2	3.7	9.8	7.0	5.4	4.8	12.0	-5.0	-4.0	-8.7
Italy	8.9	8.5	7.1	4.9	4.1	3.4	-5.5	0.0	3.9	8.6
Netherlands	6.9	5.9	5.6	3.4	5.0	3.7	-3.6	0.3	1.5	1.8
Portugal	-0.7	-0.8	3.2	2.4	1.1	3.6	4.0	0.4	-3.2	-7.4
Spain	4.0	7.7	12.3	7.1	4.7	1.9	8.2	-10.4	1.3	-5.5

Note: The initial change of the saving rate is computed from 2007 except for Japan and Portugal for which the initial change is computed from 2008. The *ex-ante* cumulated change in consumption as a percentage of GDP and cumulated GDP effects of annual changes in the saving ratios are computed over 2008 to 2012 (2009 to 2012 for Japan and Portugal). The GDP effects of the changes of saving rates are based on back-of-the-envelope calculations using country-specific government consumption multipliers from Barrel *et al.* (2012). The multiplier for the euro area is computed as the average of multipliers for Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal and Spain. The multiplier for Greece is the average of multipliers for Portugal and Spain. The multiplier applied to Switzerland corresponds to the multiplier estimated for Sweden. Because the GDP effects of the changes in saving rates materialise over several years, effects shown until 2012 in the last column do not indicate full implications of past changes in saving rates. This explains for instance why in Switzerland despite an *ex-ante* cumulated decline in consumption as a percentage of GDP over 2008-12 (-1.1%), the total *ex-post* GDP effect remains positive by 2012 (0.6%).

Source: OECD calculations and OECD Economic Outlook 93 database.

Table 6. Estimated cumulative GDP decline due to realised fiscal consolidation

	Estimated GDP decline in per cent	Realised consolidation size (per cent of potential GDP)	sample
United States	2.4	2.6	2011-12
Euro area	2.1	3.2	2010-12
Canada	1.1	1.5	2011-12
United Kingdom	2.2	2.5	2010-12

Note: Consolidation is measured by the change in the underlying primary balance. Based on average elasticities calculated from instrument-specific elasticities and reflecting actual consolidation composition.

Source: OECD calculations and OECD Economic Outlook 93 database.

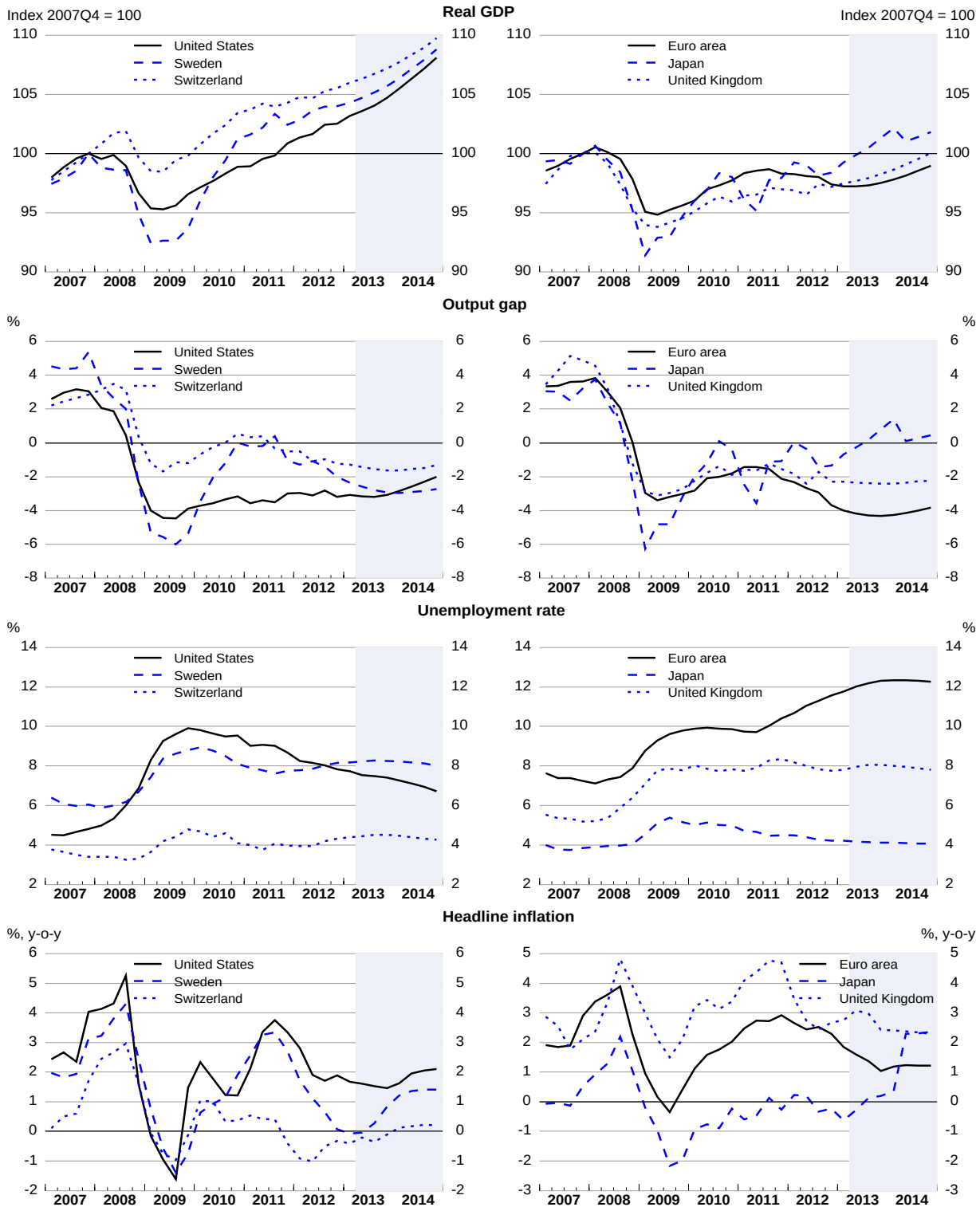
Table 7. Composition of central bank balance sheets

	Assets		Share in total assets	Estimated share of a central bank in relevant market
	bn national currency	% of GDP	%	%
Federal Reserve				
Total	3,317	21.1		
Treasury securities	1,848	11.8	55.7	16.0
Agency and GSE-backed securities	1,194	7.6	36.0	15.9
Other assets	276	1.8	8.3	
European Central Bank				
Total	2,549	26.9		
Government bonds under securities markets programme	197	2.1	7.7	7.0
Covered bonds	62	0.7	2.4	
Securities held for non-monetary policy purposes	347	3.7	13.6	
Other assets	1,943	20.5	76.2	
Bank of England				
Total	403	26.2		
Gilts under asset purchase programme	375	24.3	93.0	29.7
Other assets	28	1.8	7.0	
Bank of Japan				
Total	184,286	38.7		
Government bonds	142,909	30.0	77.5	15.3
Corporate bonds	2,923	0.6	1.6	3.9
REIT	137	0.03	0.1	
ETF	1,722	0.4	0.9	
Other assets	36,596	7.7	19.9	

Note: Data are as of May 2013.

Source: Bank of England, Bank of Japan, Datastream, ECB, Federal Reserve, and OECD.

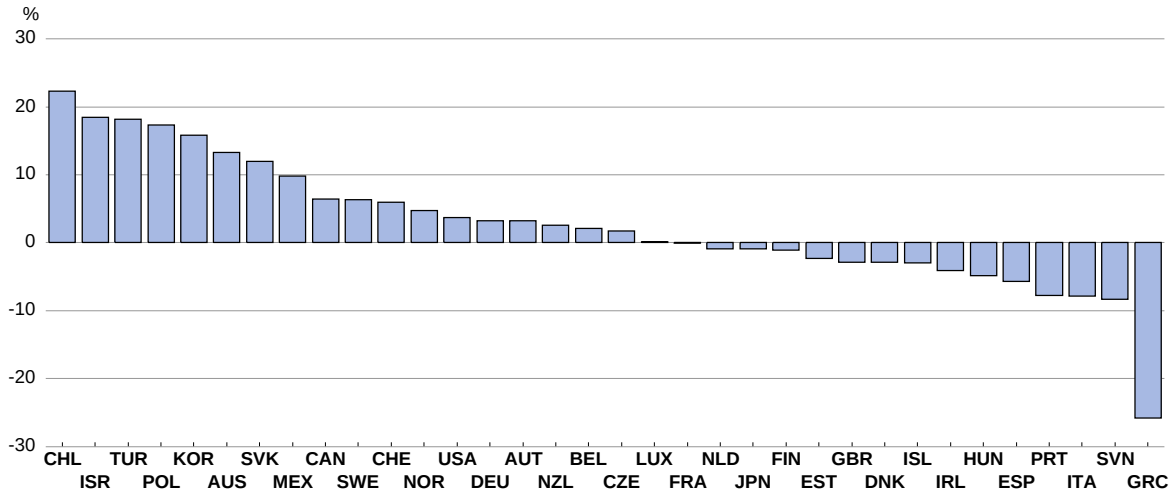
Figure 1. Economic activity has been weak



Source: OECD Economic Outlook 93 database.

Figure 1. Economic activity has been weak (Continued)

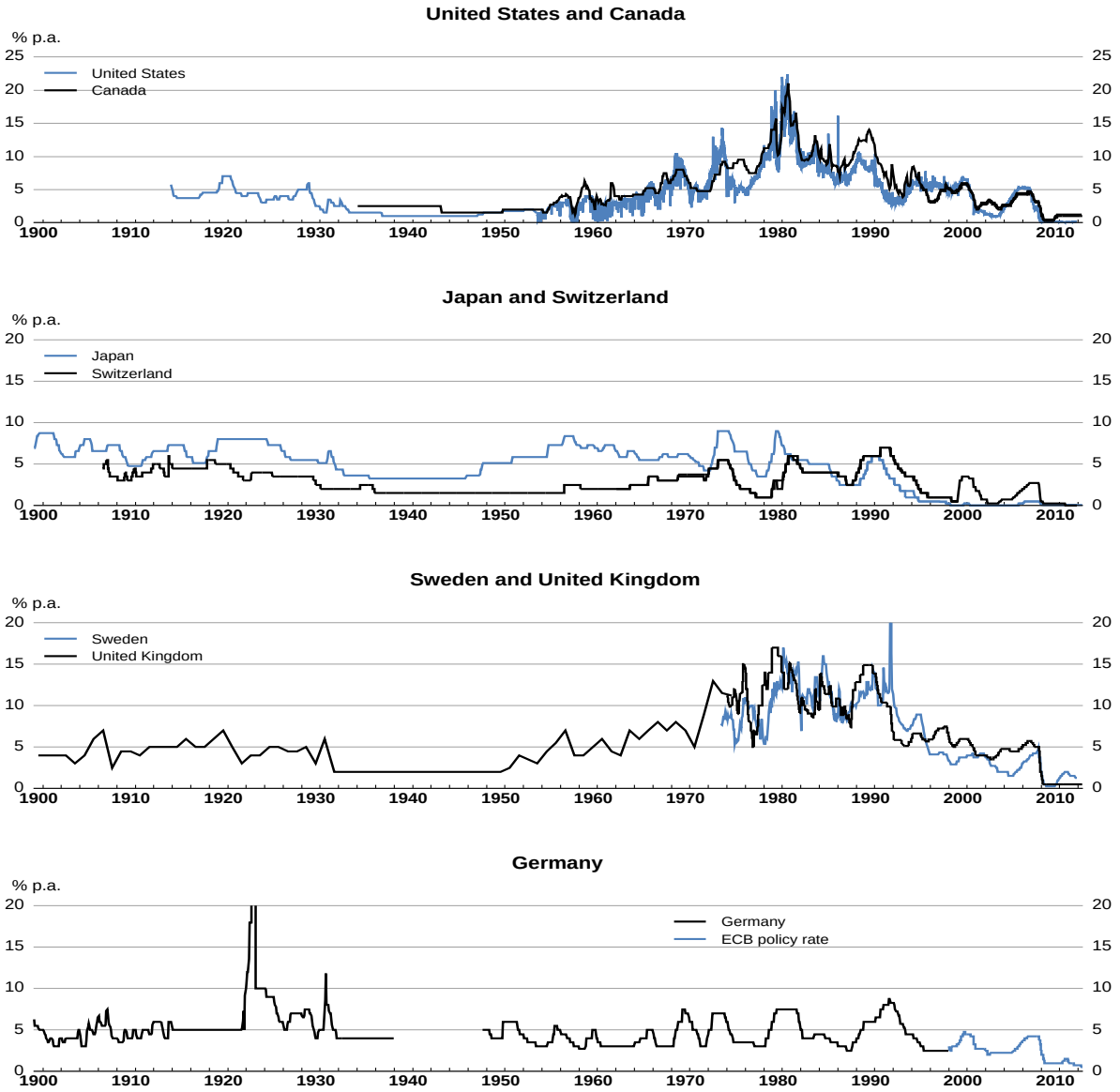
Cumulative real GDP growth from 2007Q4 to 2013Q1



Source: OECD Economic Outlook 93 database.

Figure 2. Policy interest rates have been at historic lows

1900 to 2013Q1



Note: Policy rates are at daily frequency except for Japan where monthly averages are used.

For the United States: from 1914 to June 1954, the Federal Reserve of New York discount rate, then the effective rate of the US Federal Reserve. For Canada: from 1935 to March 1994, the Bank of Canada rate, then the overnight rate.

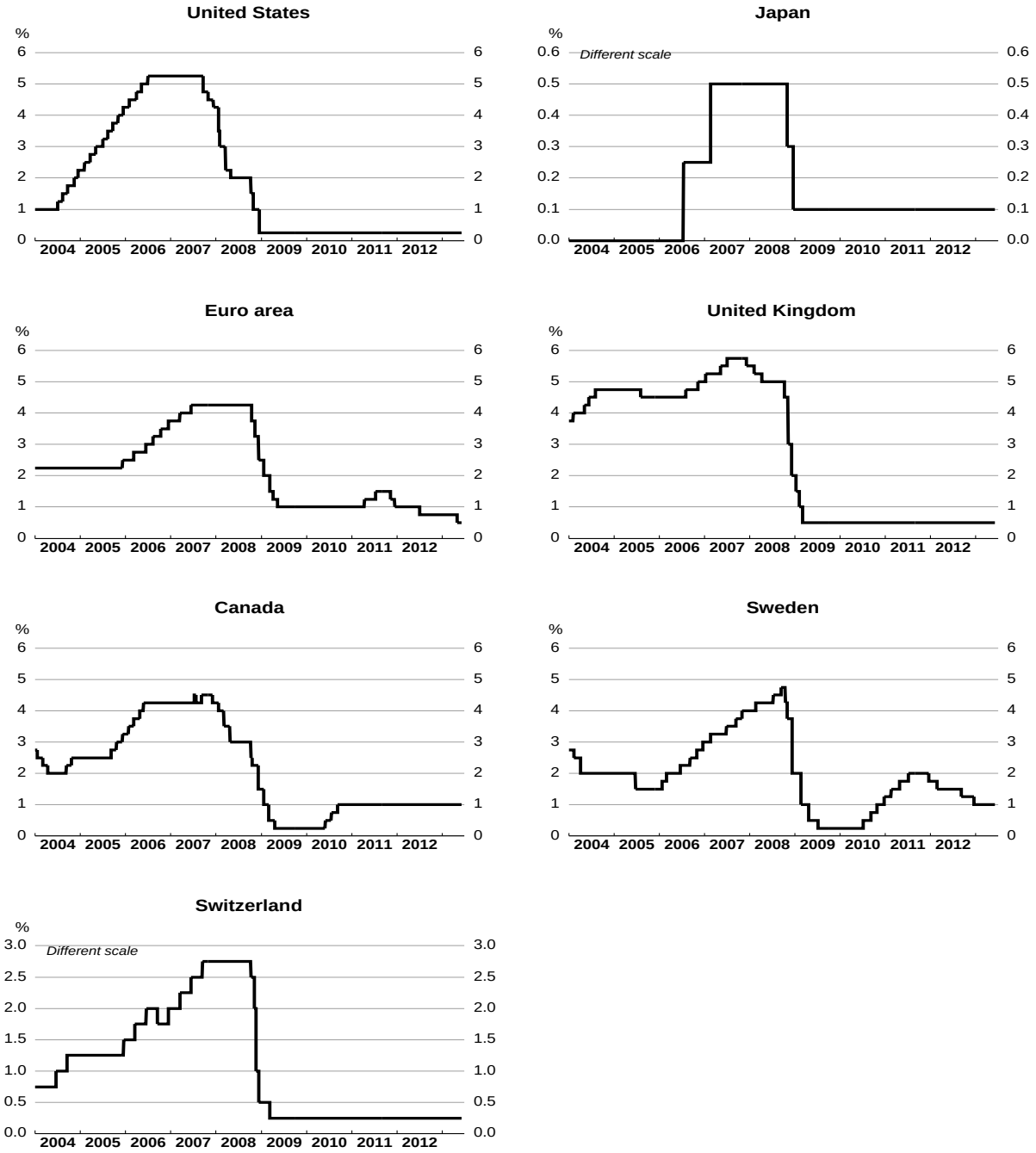
For Switzerland: the Swiss National Bank discount rate until 1993, then the 3-month LIBOR target rate.

For the United Kingdom: the Bank of England rate 1900-1972 (end of year level), the minimum lending rate 1972-81, the London clearing banks' base rate 1981-97 and the repo rate 1997-2006. For Sweden: the Sveriges Riksbank discount rate from 1970 to 1994, then the repo rate.

For Germany: the German official bank discount rate until January 1999. In December 1923 the interest rate was 90%.

Source: Bank of Canada, Bank of England, Bank of Japan, Deutsche Bundesbank, Sveriges Riksbank, Swiss National Bank, US Federal Reserve, and NBER Macrohistory Database.

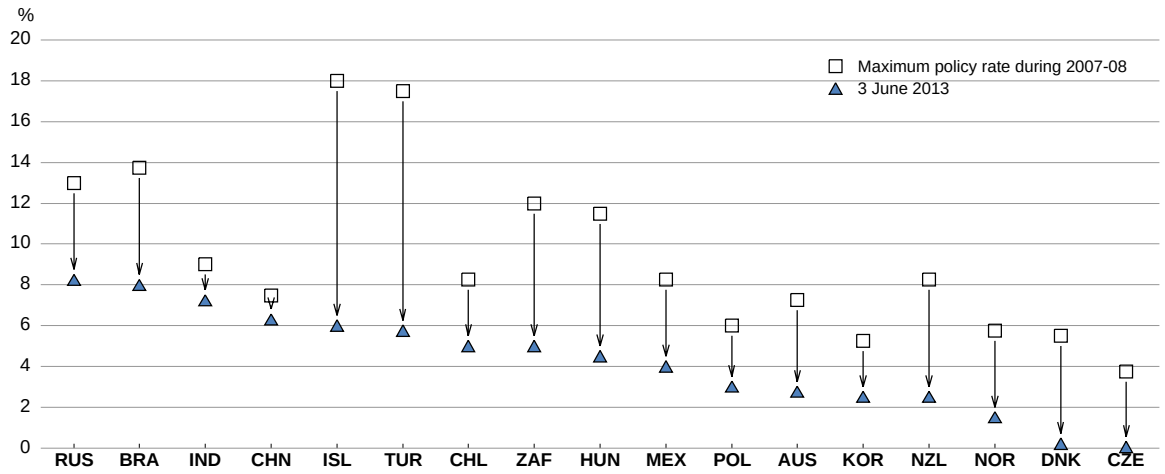
Figure 3. Policy interest rates have been lowered globally since 2009



Note: The policy interest rates are: the Federal Funds target rate for the United States; the uncollateralised overnight call rate for Japan; the ECB main refinancing operations of fixed rate tenders for the euro area; the official Bank of England rate for the United Kingdom; the target for the overnight rate for Canada; the Riksbank repo rate for Sweden and the reference interest rate of the target range, the three-month Swiss franc Libor, for Switzerland.

Source: central banks.

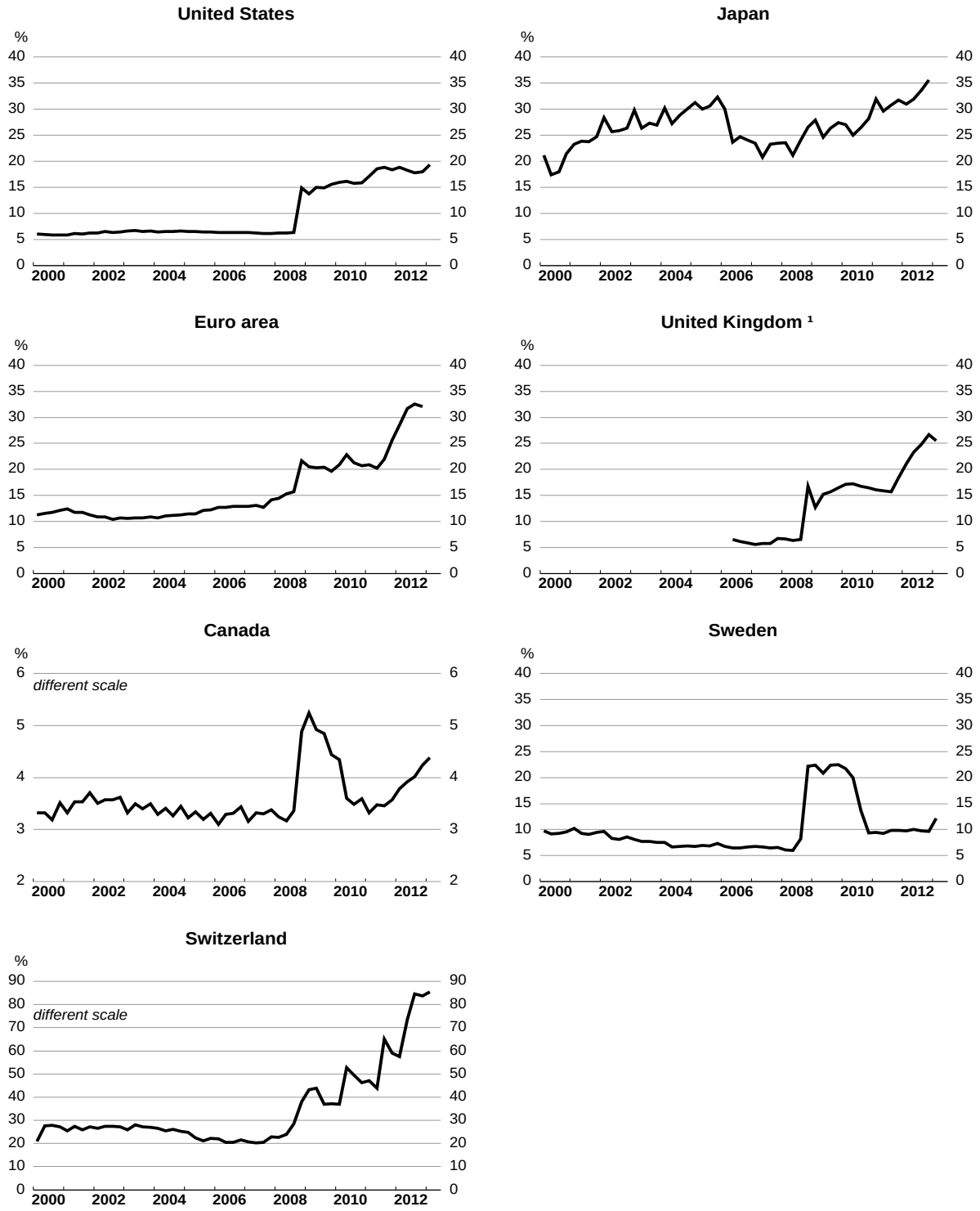
Figure 3. Policy interest rates have been lowered globally since 2009 (Continued)



Source: central banks.

Figure 4. Central bank assets have expanded massively in several countries

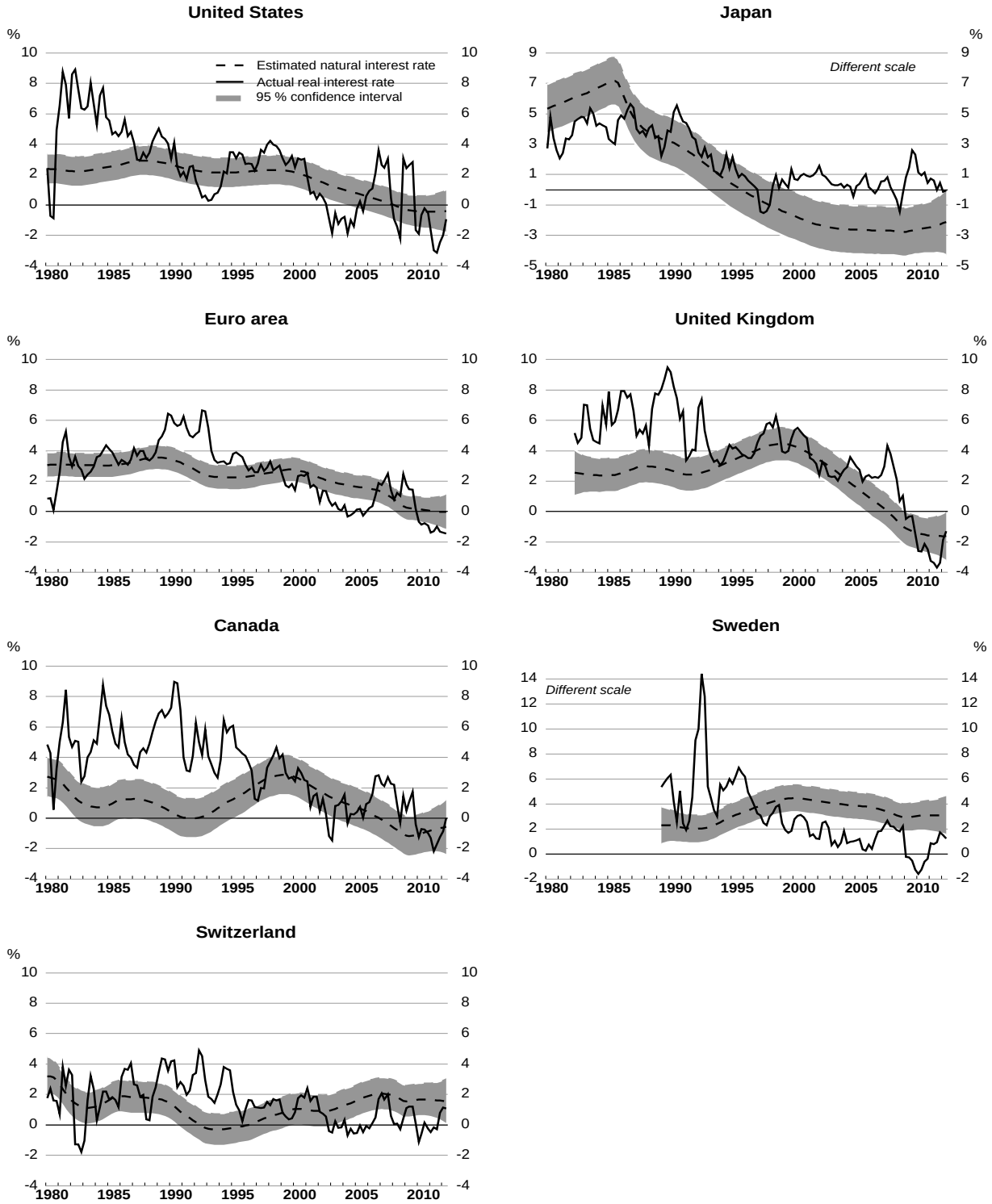
% of GDP



1. The Bank of England does not report consolidated balance sheet before 2006.

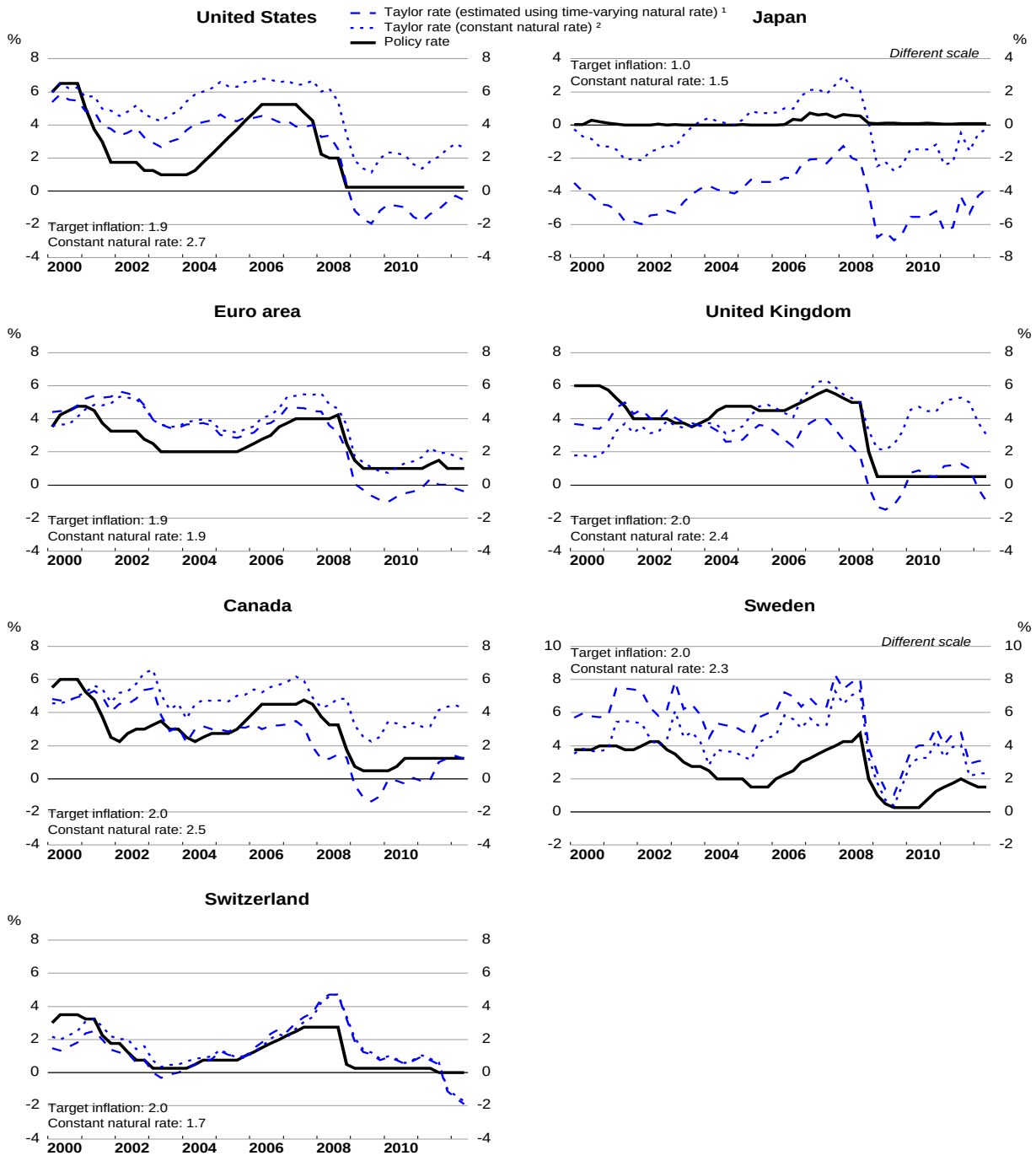
Source: Datastream and central banks.

Figure 5. Estimated natural interest rates have declined



Source: Authors' calculations.

Figure 6. Taylor rule and policy interest rates

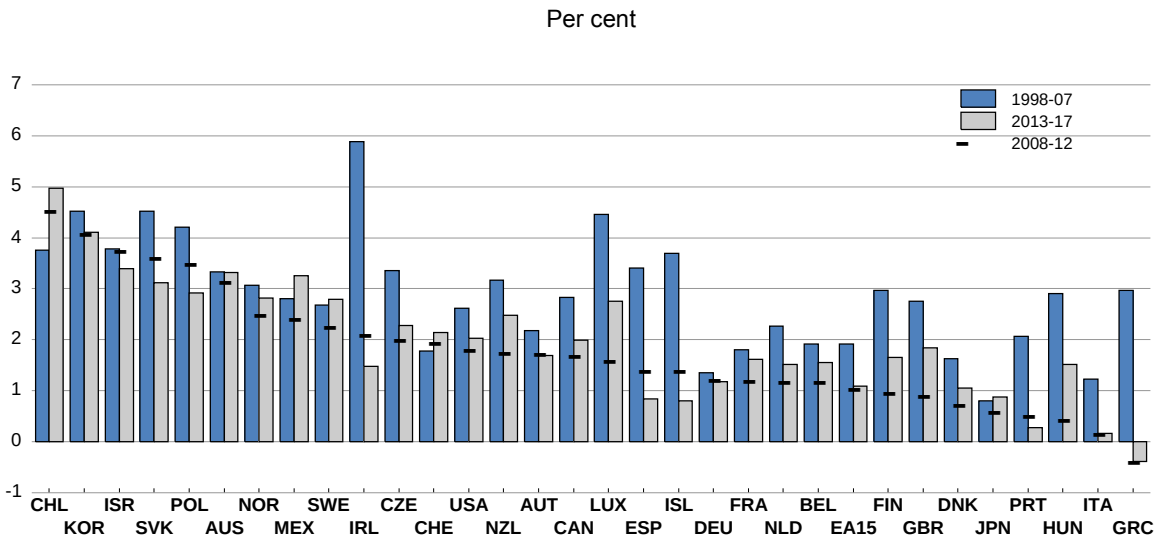


Note: The Taylor rule is given by i=r*+p+0.5(p-p*)+0.5gap, where *r** is the natural real interest rate (see notes 1 and 2 below), *p* is core inflation, *p** is the inflation target (as indicated in the figure), and *gap* is the output gap. Core inflation is measured using harmonised core CPI for the euro area, and simple core CPI for other countries, except for the United States where core PCE is used.

1. Estimated using time-varying natural interest rate – see Annex 1.
2. Based on the 1980-2012 average of real potential GDP growth.

Source: Datastream, OECD Economic Outlook 92 database and OECD calculations.

Figure 7. Real potential GDP growth declined during the Great Recession

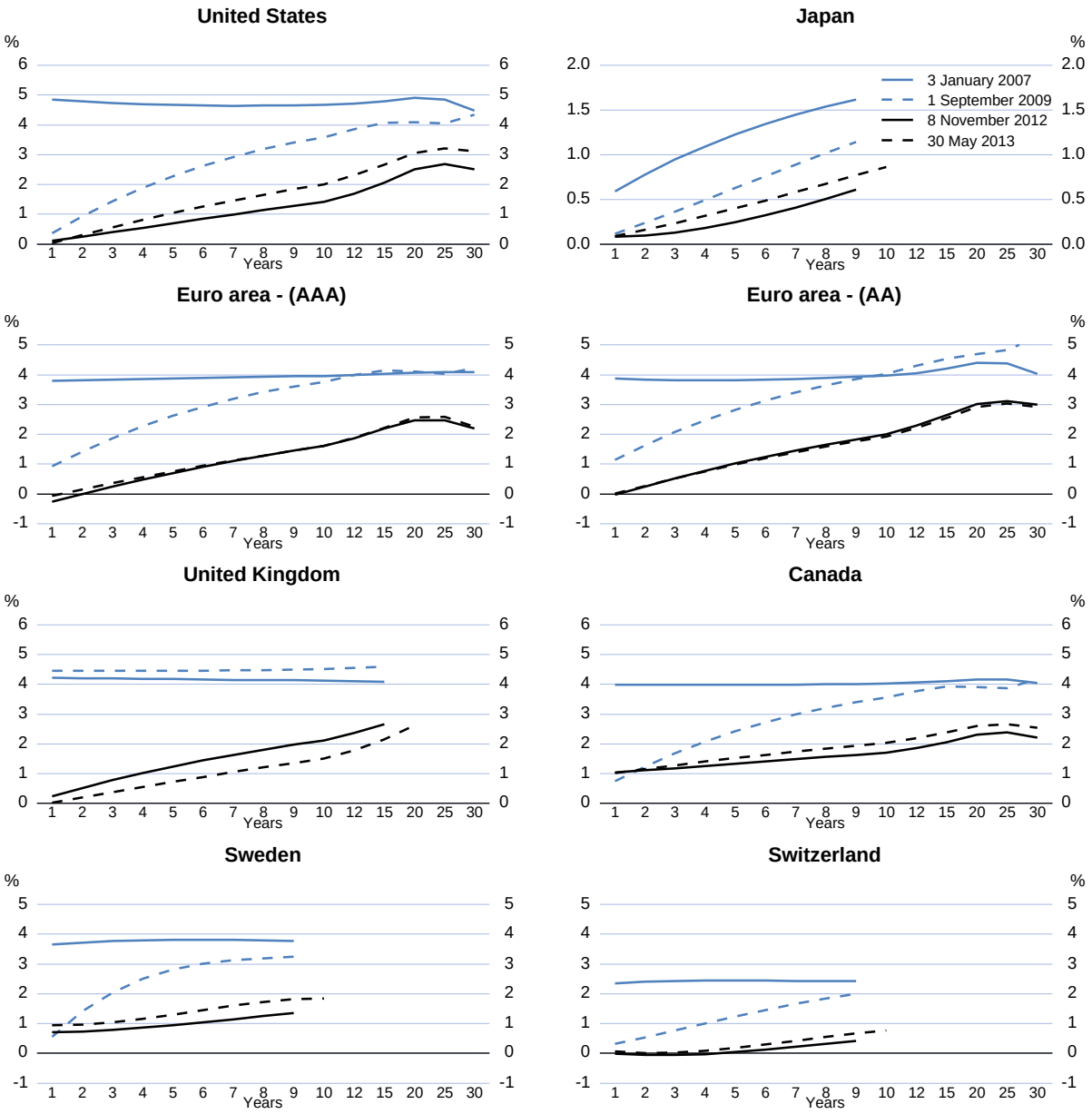


Note: Countries are sorted according to 2008-12 real potential GDP growth.

Source: OECD Economic Outlook 93 database.

Figure 8. Government bond yields have declined markedly

Yields curves

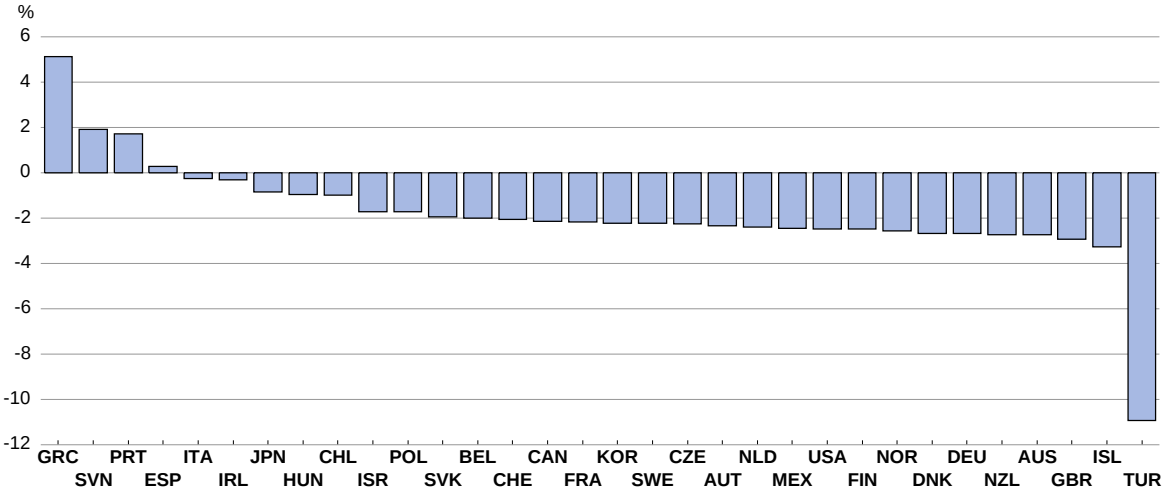


Note: Datastream estimates of the government yield curve based on the 3rd Polynomial constant method.

Source: Datastream.

Figure 8. Government bond yields have declined markedly (Continued)

Change in 10-year government bond yield (in percentage points)

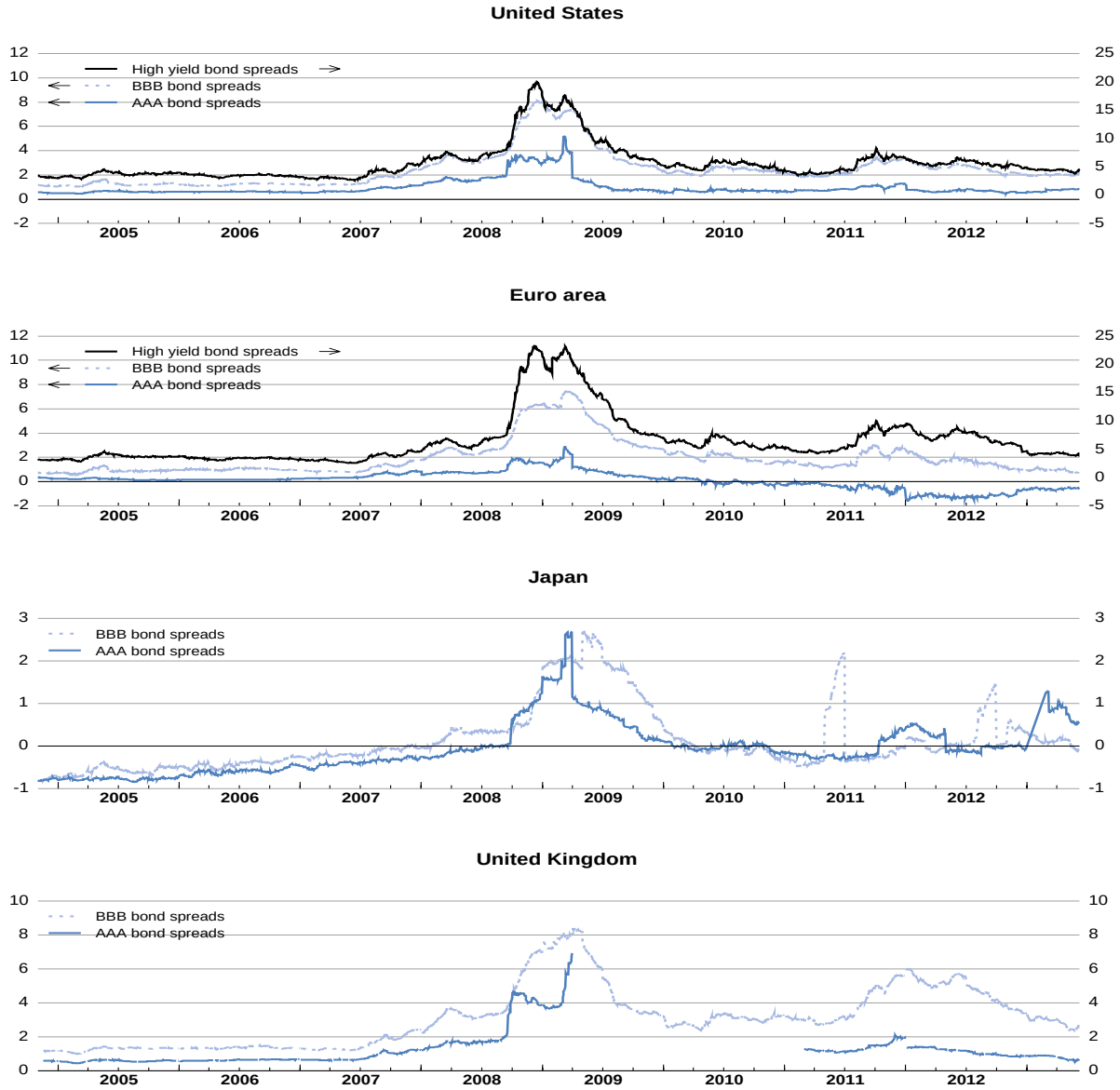


Note: The change is calculated as a difference between the average for 2007 and the average for May 2013.

Source: Datastream and OECD Economic Outlook 93 database.

Figure 9. Corporate bond spreads have declined since 2009

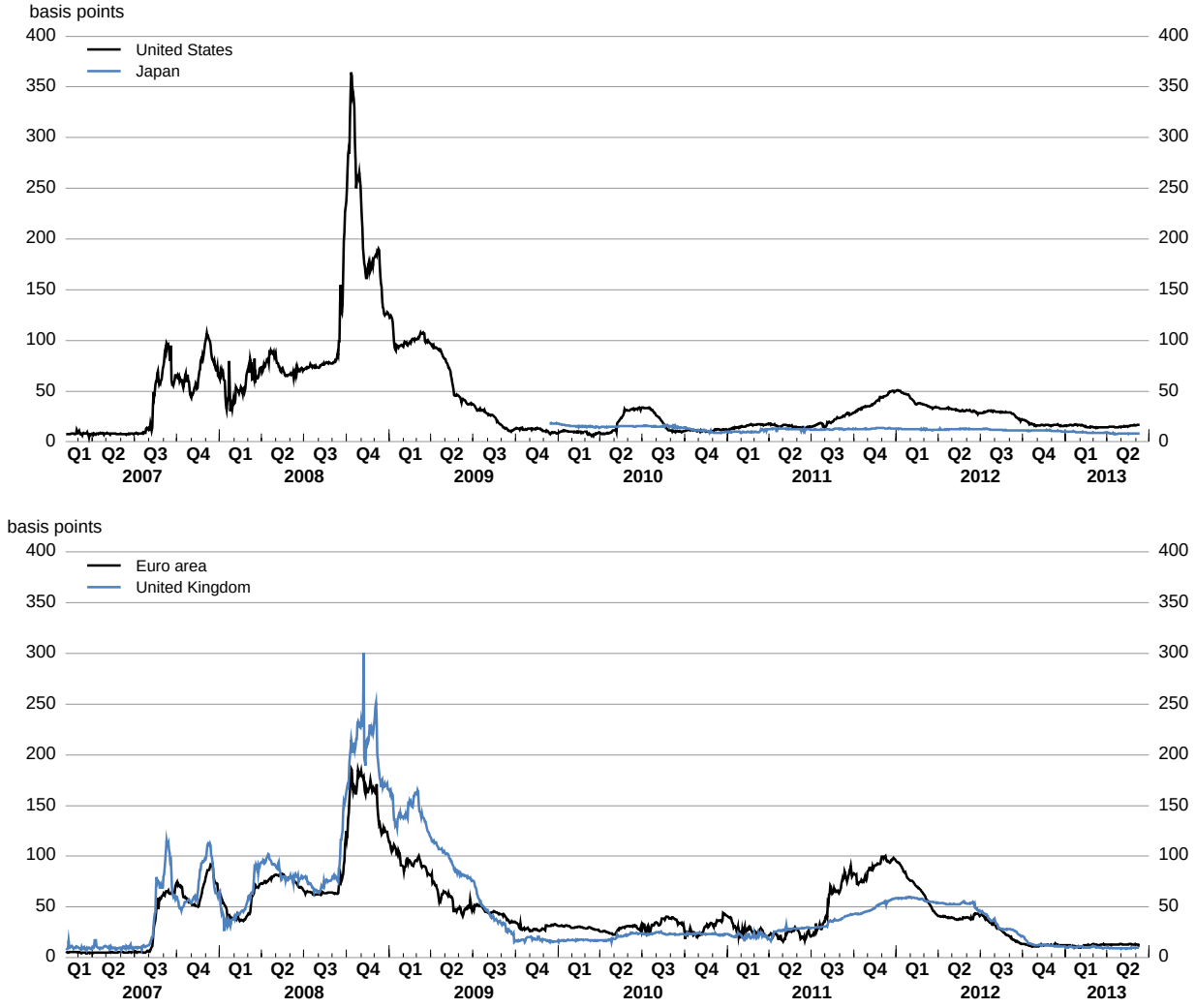
Percentage points (different scales)



Note: Spreads of high-yield bonds (Merrill Lynch indices) less government bond yields (10-year benchmark bonds). Spreads of corporate BBB rated bonds (Merrill Lynch) based on average yields for 5-7 years and for 7-10 years less average government bond yields of same maturities. Spreads of corporate AAA rated bonds (Merrill Lynch for the United States and the United Kingdom; IBOXX for the euro area) based on 7-10 year yields less government bond yields of the same maturity. For Japan the spreads of corporate AAA and BBB are less government bond yields (10-year benchmark bonds). The spike in Japanese BBB bonds yields in early 2011 is related to the earthquake and its aftermath.

Source: Datastream and OECD calculations.

Figure 10. Money market spreads have normalised

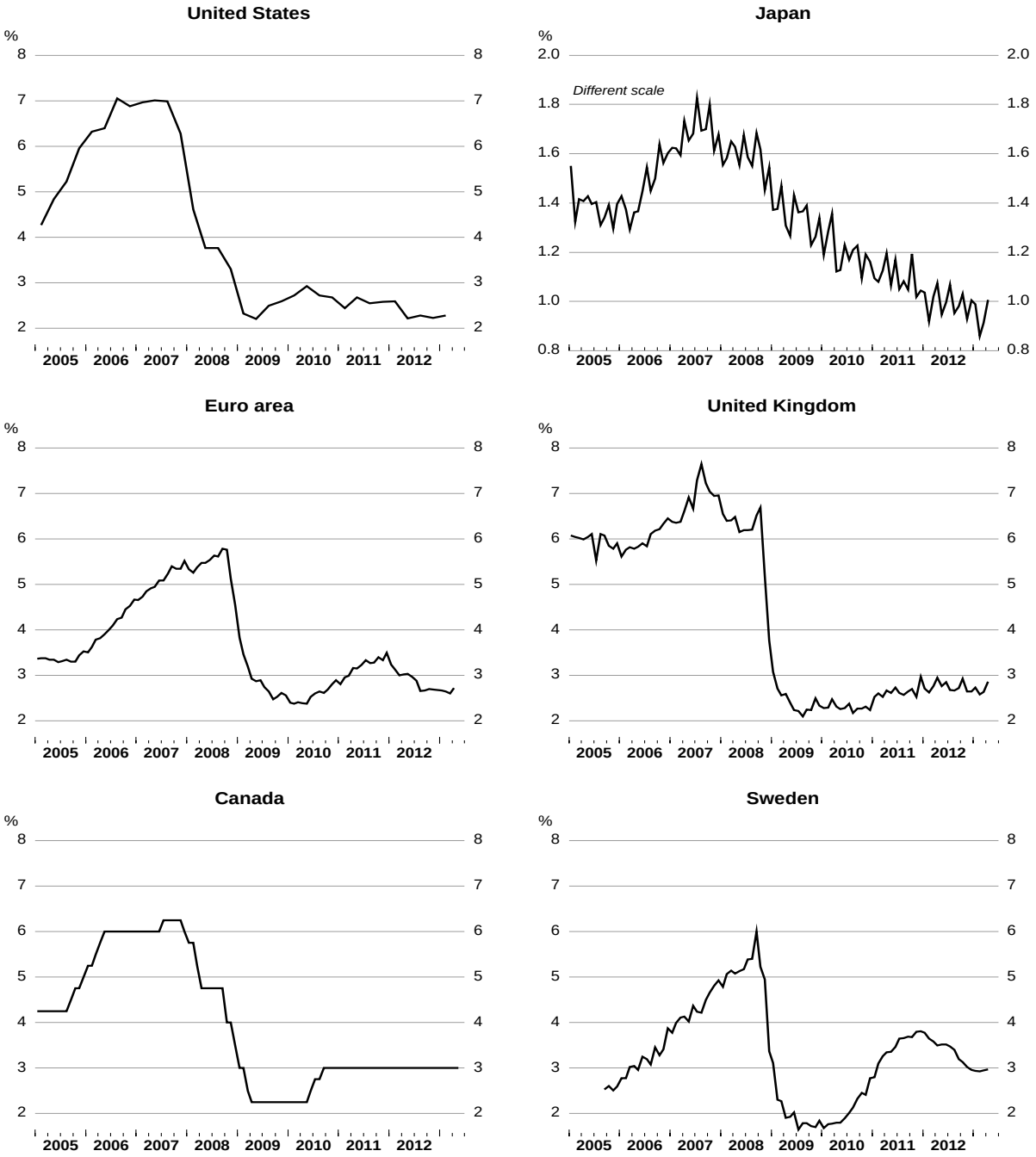


Note: Spread between the three-month EURIBOR and the EONIA swap index for the euro area; spread between the three-month LIBOR and the overnight indexed swap for the United States, Japan and the United Kingdom.

The LIBOR (London Interbank Offered Rate) is the average rate in London interbank market at which a selection of 15 London banks are prepared to lend to another. The Euribor (Euro Interbank Offered rate) is similar, but based on estimates from 44 leading European banks.

Source: Datastream.

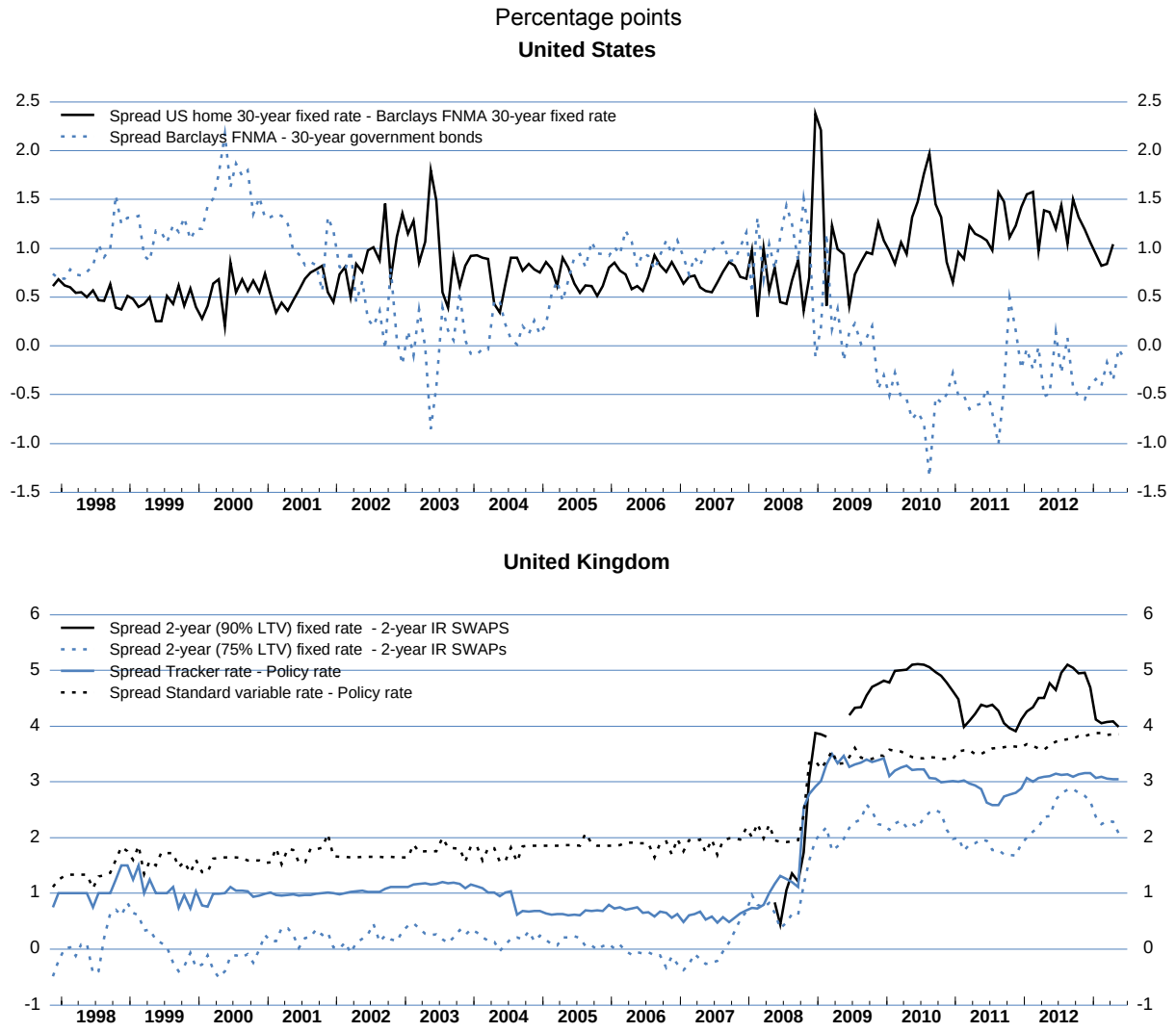
Figure 11. Lending rates have declined



Note: The lending rates (all maturity) for loans to non-financial corporations for the United States, rates for new loans to non-financial corporations and averages across member countries for the euro area, rates for new loans to non-financial corporations and households for Japan, rates for new loans to non-financial corporations for the United Kingdom, rates for new prime loans to non-financial corporations for Canada, rates for new loans to non-financial corporations for Sweden.

Source: Datastream and central banks.

Figure 12. Mortgage interest rate spreads in the United Kingdom and the United States

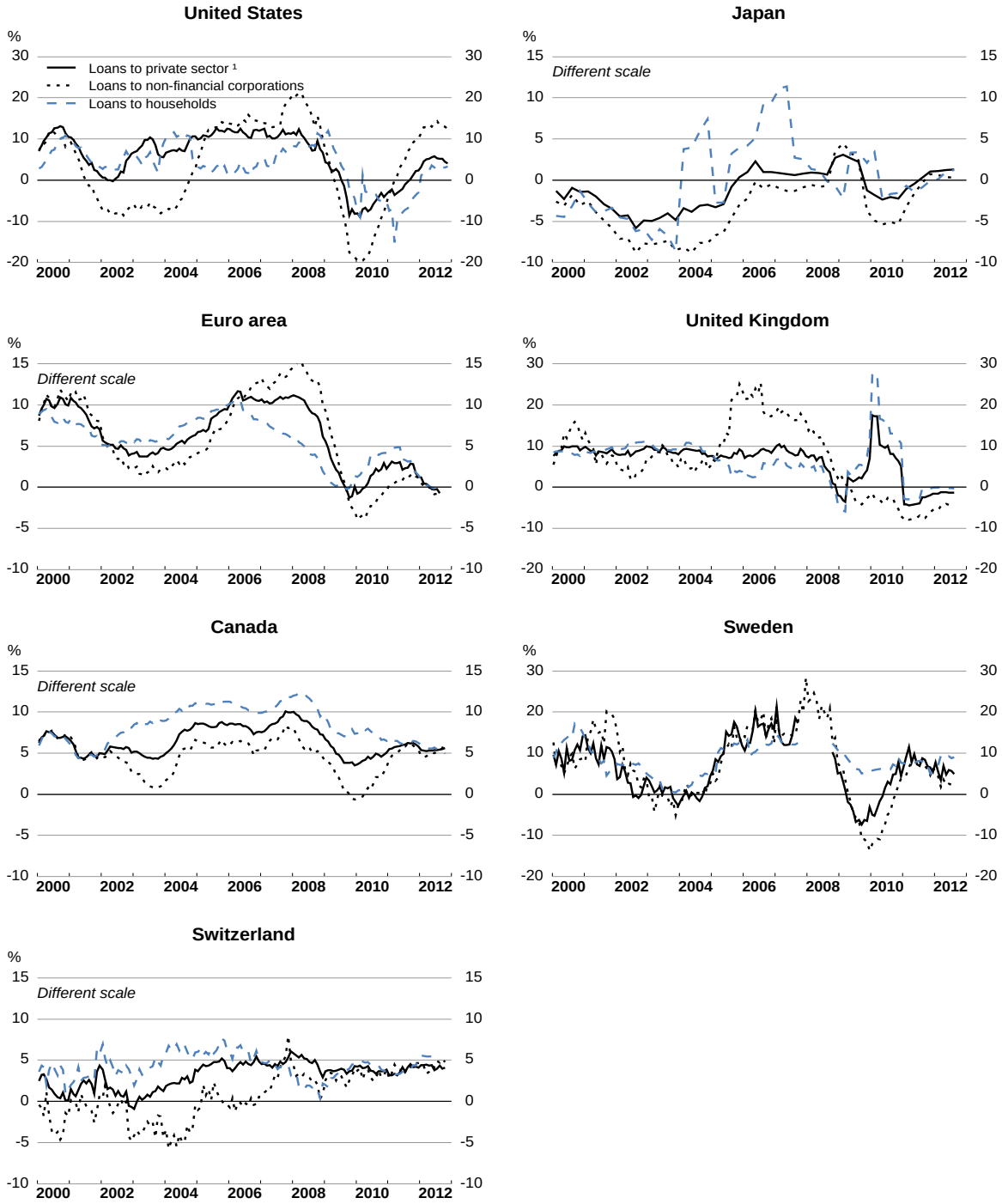


Note: The *Barclays FNMA 30-year fixed rate* is the 30-year fixed rate on a mortgage-backed security of the Federal National Mortgage Association; and Barclays FHFB is the fixed-rate 30-year rate on non-jumbo loans (all homes).

Source: Datastream and Bank of England.

Figure 13. Bank credit growth has been weak in most economies

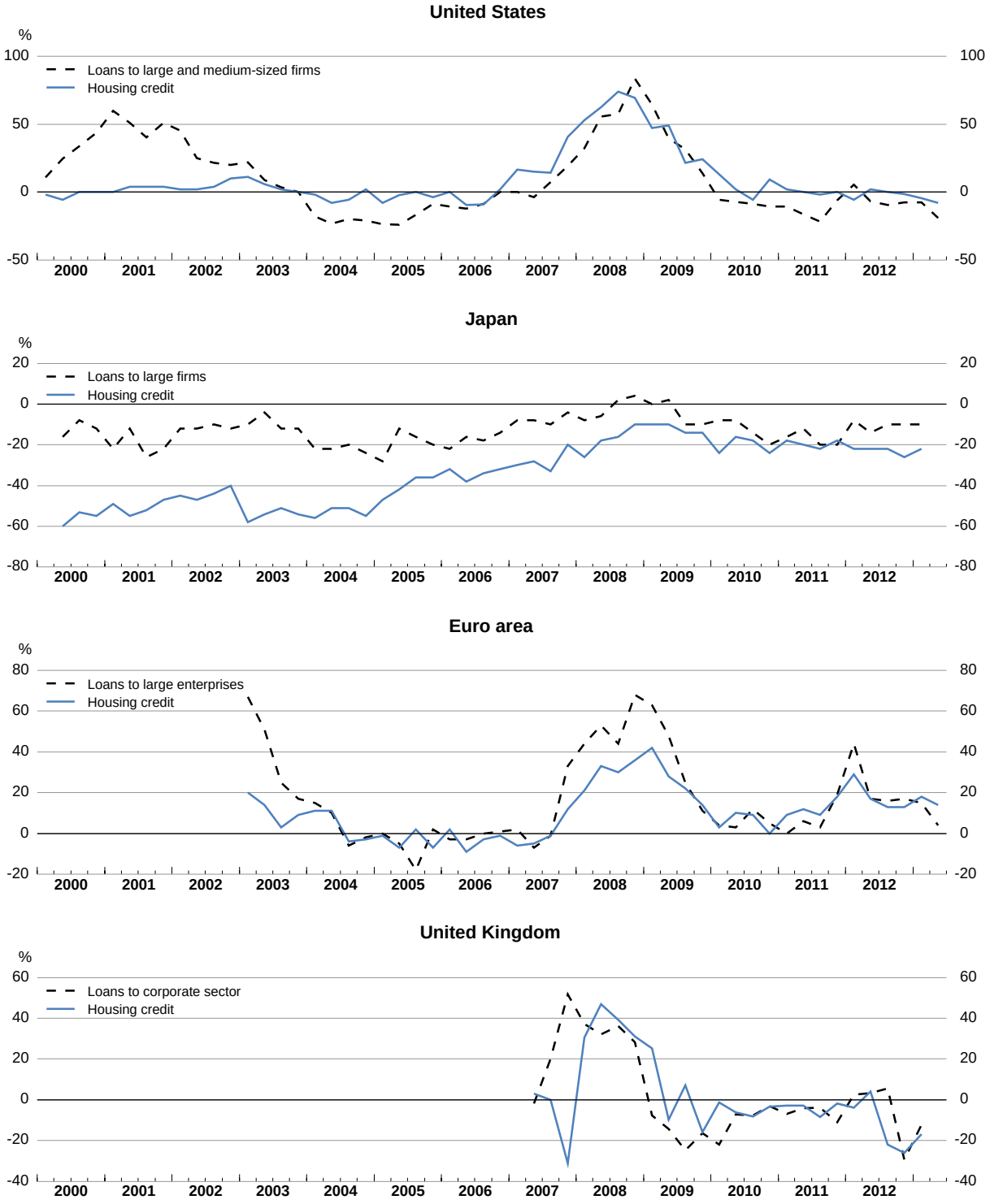
Year-on-year growth rates



Note: For Sweden the break in growth in bank loans to the private sector and households from October 2007 to September 2008 is due to a reclassification of bank/credit institutions within the financial sector.
1. Loans to non-financial private sector *i.e.* private non-financial corporations and households. For the euro area, loans to non-MFIs excluding government. For Canada, loans to business and households. For Sweden, loans to non-MFIs.
2. For Switzerland only non-financial private corporations.
Source: Bank of England, ECB, Statistics Canada, Statistics Sweden and Swiss National Bank.

Figure 14. Credit standards have tightened significantly in 2008-09

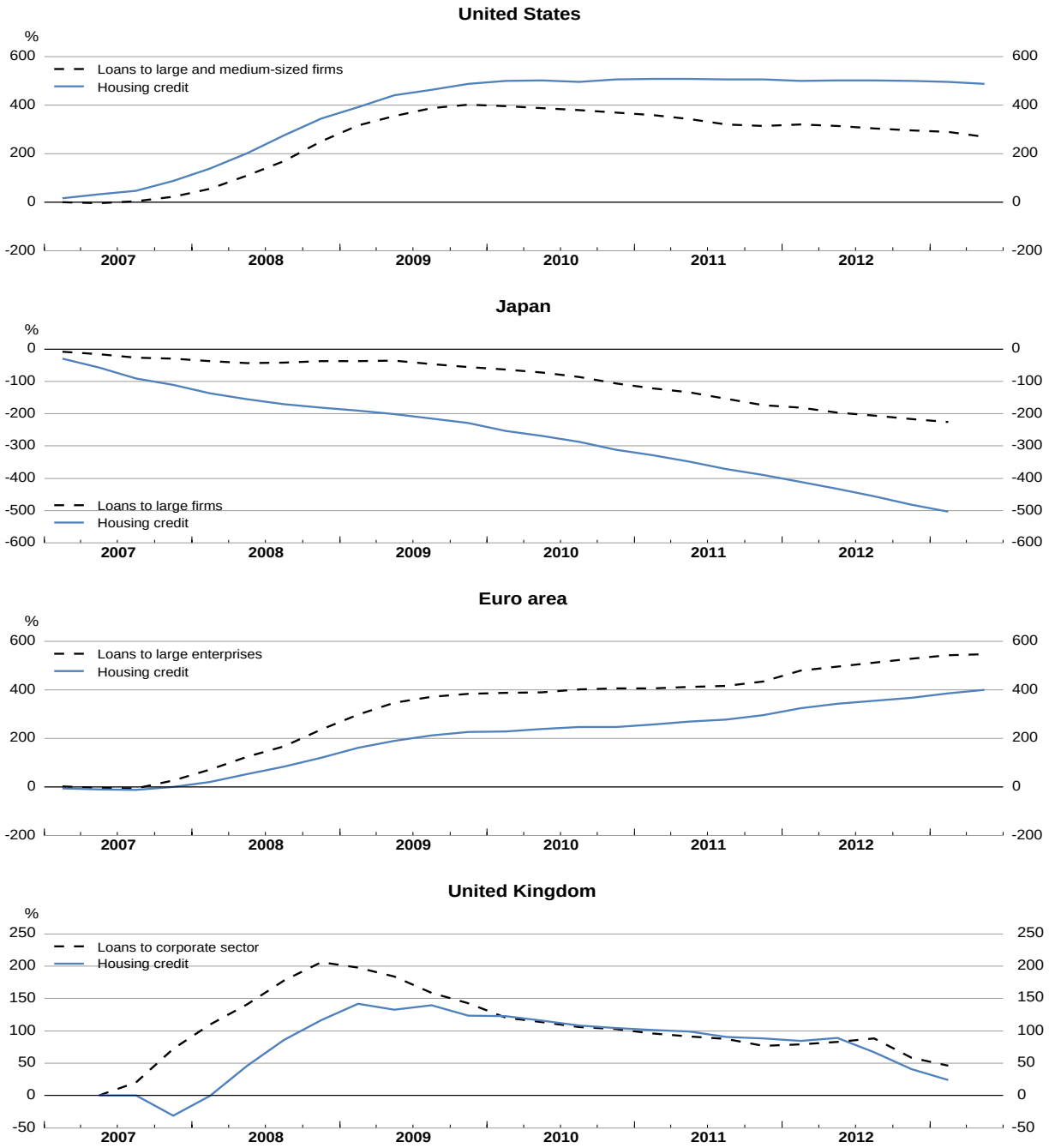
Net percentage of banks tightening



Note: Positive numbers indicate tight credit availability and *vice versa*.

Source: Federal Reserve, Bank of Japan, ECB and Bank of England.

Figure 15. Cumulative sum of net percentage of banks tightening from 2007Q1

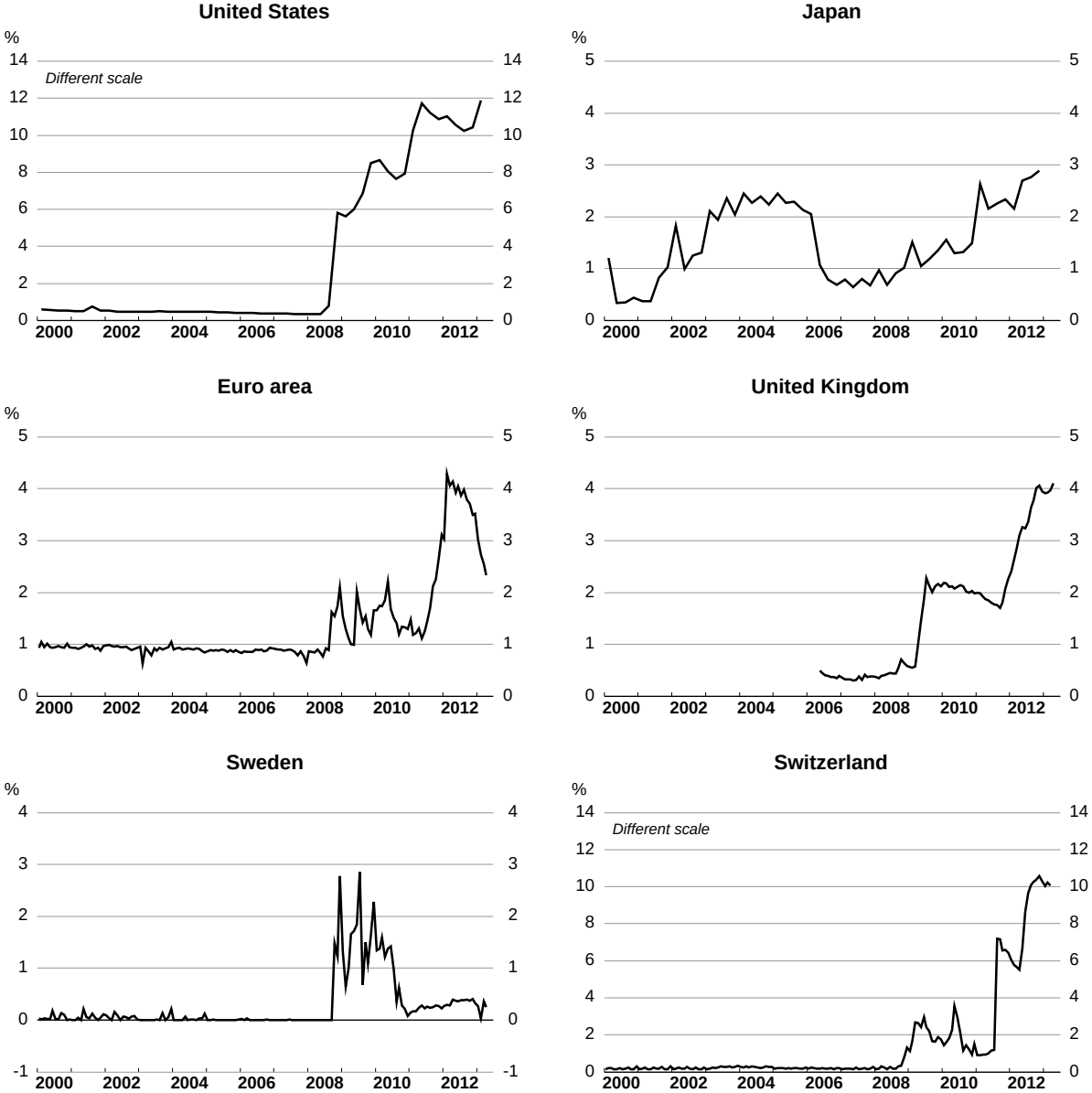


Note: Positive numbers indicate tight credit availability and *vice versa*.

Source: Federal Reserve, Bank of Japan, ECB and Bank of England.

Figure 16. Banks have increased their reserves

Per cent of total assets of banks

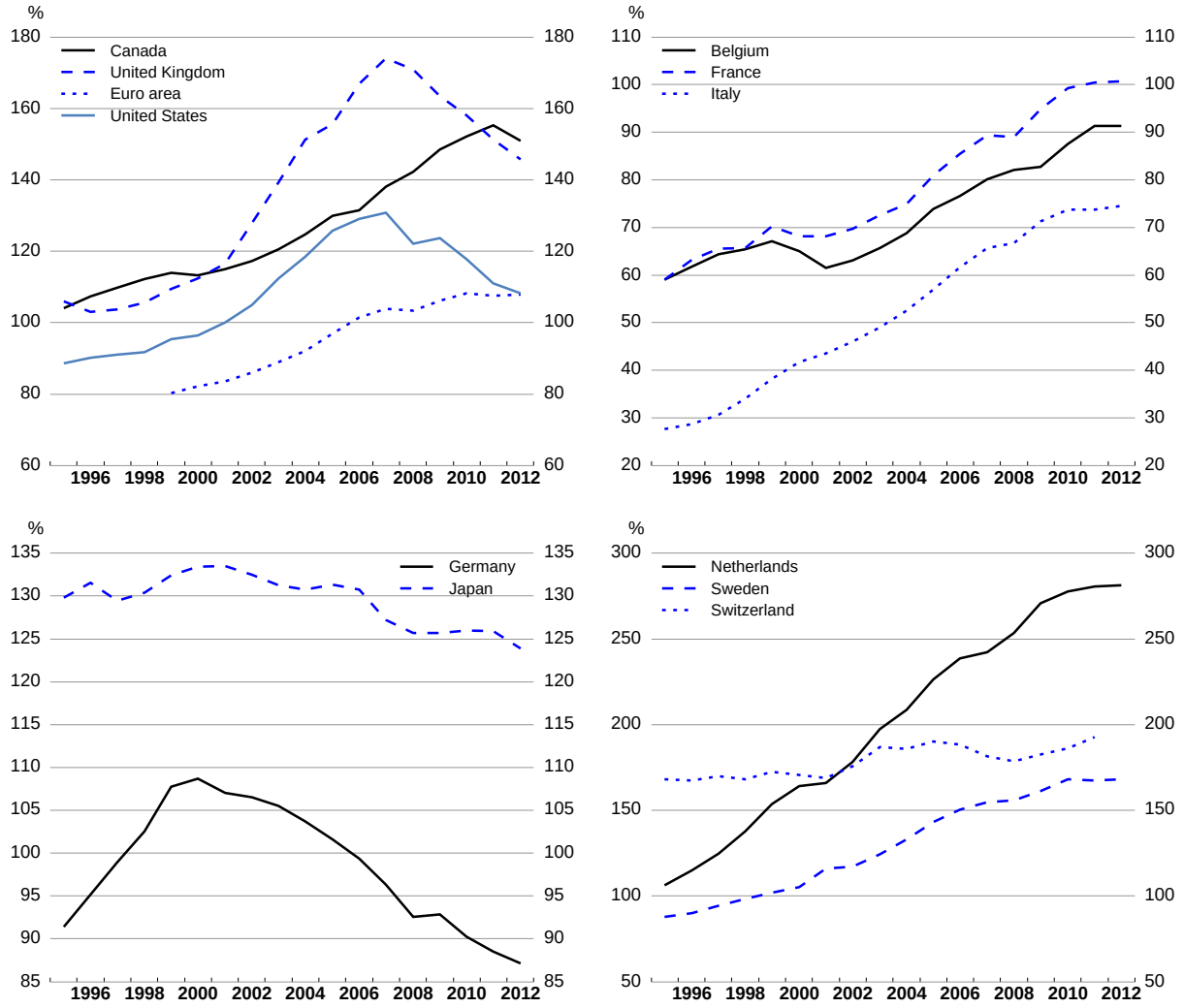


Note: For the United States: Reserves of depository institutions, total (required and excess); seasonally adjusted, break adjusted; for Japan: depository corporations deposits with the Bank of Japan, Flow of funds; for the euro area: the Eurosystems liabilities to euro area credit institutions in euro, total (current accounts, deposit facility, fixed-term deposits, fine-tuning reverse operations, deposits related to margin calls); for the United Kingdom: reserves balances of banks and building societies that are required to hold cash ratio deposits at the Bank were entitled to place further deposits (reserve balances) earning interest at the Bank's Rate; for Sweden: Assets of Swedish credit institutions related to monetary policy operations denominated in Swedish krona at the Riksbank; for Switzerland: Swiss National Bank's liabilities of "sight deposits of domestic bank, foreign banks and institutions.

Source: US Federal Reserve, Bank of Japan, ECB, Bank of England, Sveriges Riksbank and Swiss National Bank.

Figure 17. Ratio of gross debt to gross disposable income for households

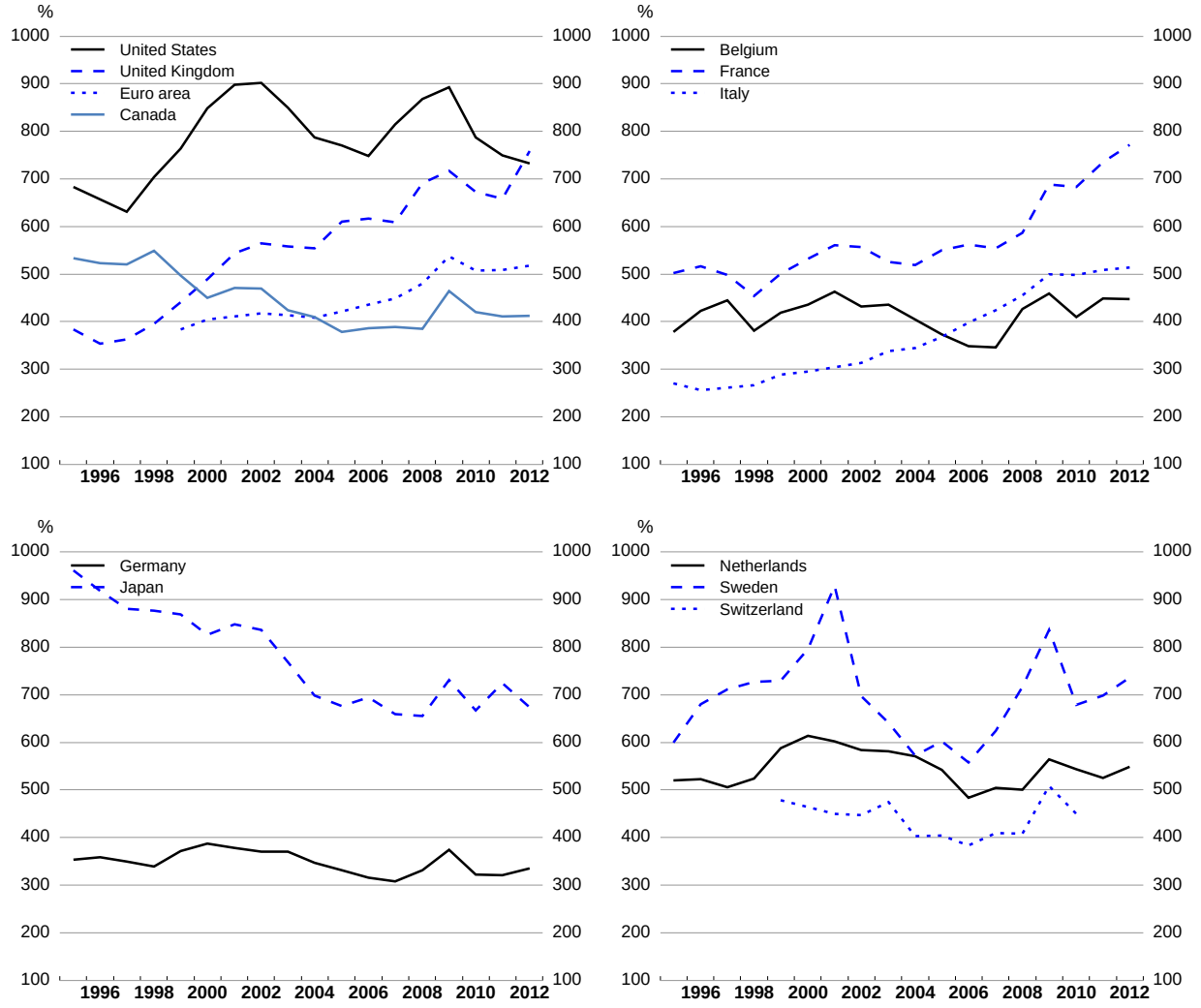
(different scales)



Note: The household sector is the national accounts sectors household and non-profit institutions serving households. Debt is calculated as total liabilities minus share and other equities minus financial derivatives. Financial accounts data are not consolidated for Canada, Japan, Switzerland, the United Kingdom and the United States.

Source: Eurostat, OECD Economic Outlook 93 database and OECD National Accounts database.

Figure 18. Ratio of gross debt to gross operating surplus for non-financial corporations

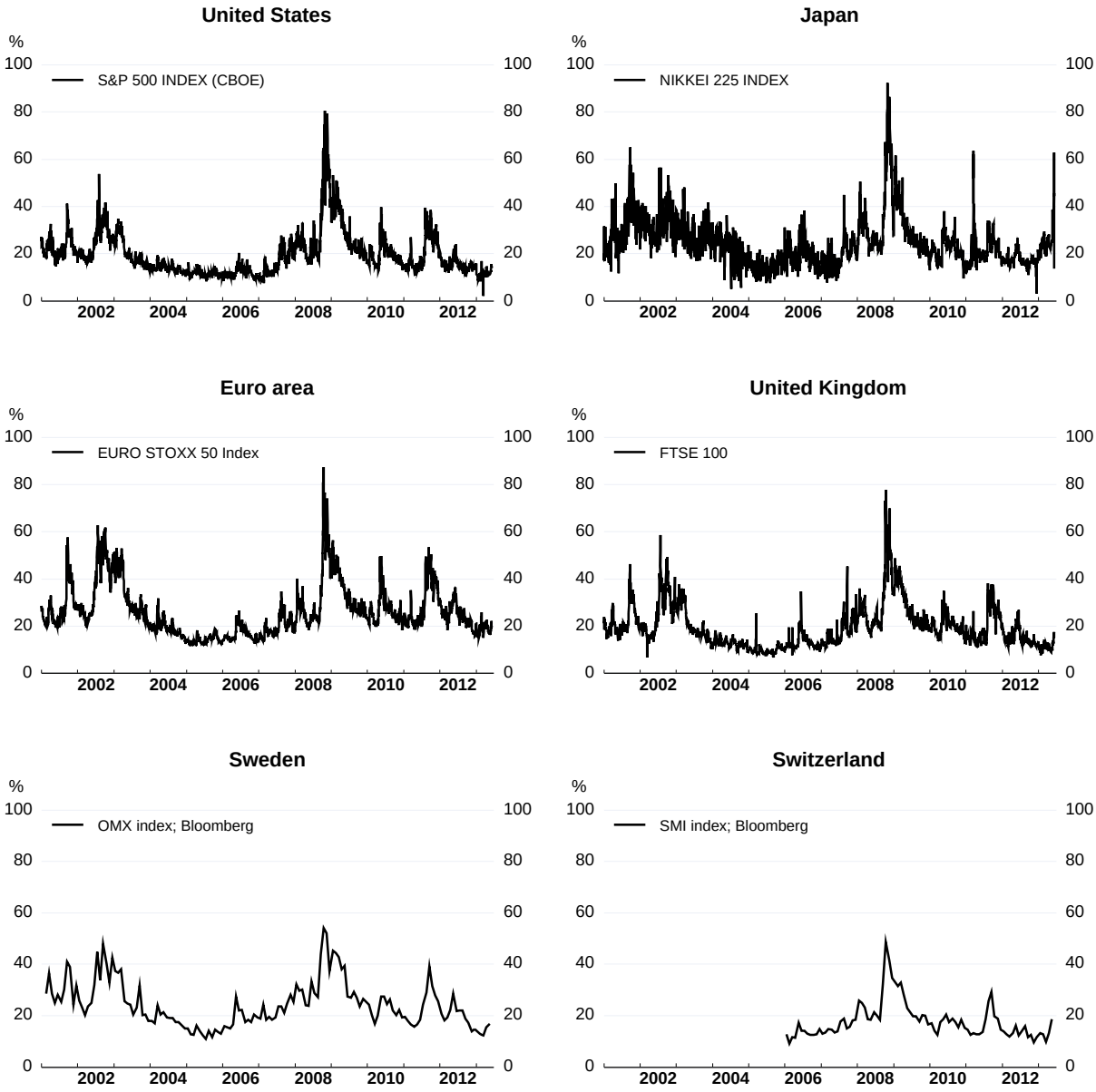


Note: Debt is calculated as total liabilities minus share and other equities minus financial derivatives. Financial accounts data are not consolidated for Canada, Japan, Switzerland, the United Kingdom and the United States. The denominator is the gross operating surplus except for Canada (the net operating surplus) and the United Kingdom (the gross operating surplus and mixed income).

Source: Eurostat, Statistics Canada and OECD National Accounts database.

Figure 19. Stock market volatility

Implied volatility of call option on stock exchange indices



Note: The indices are the leading stocks traded on each representative market.

Source: Datastream and Bloomberg.

Figure 20. Consumer confidence has been depressed

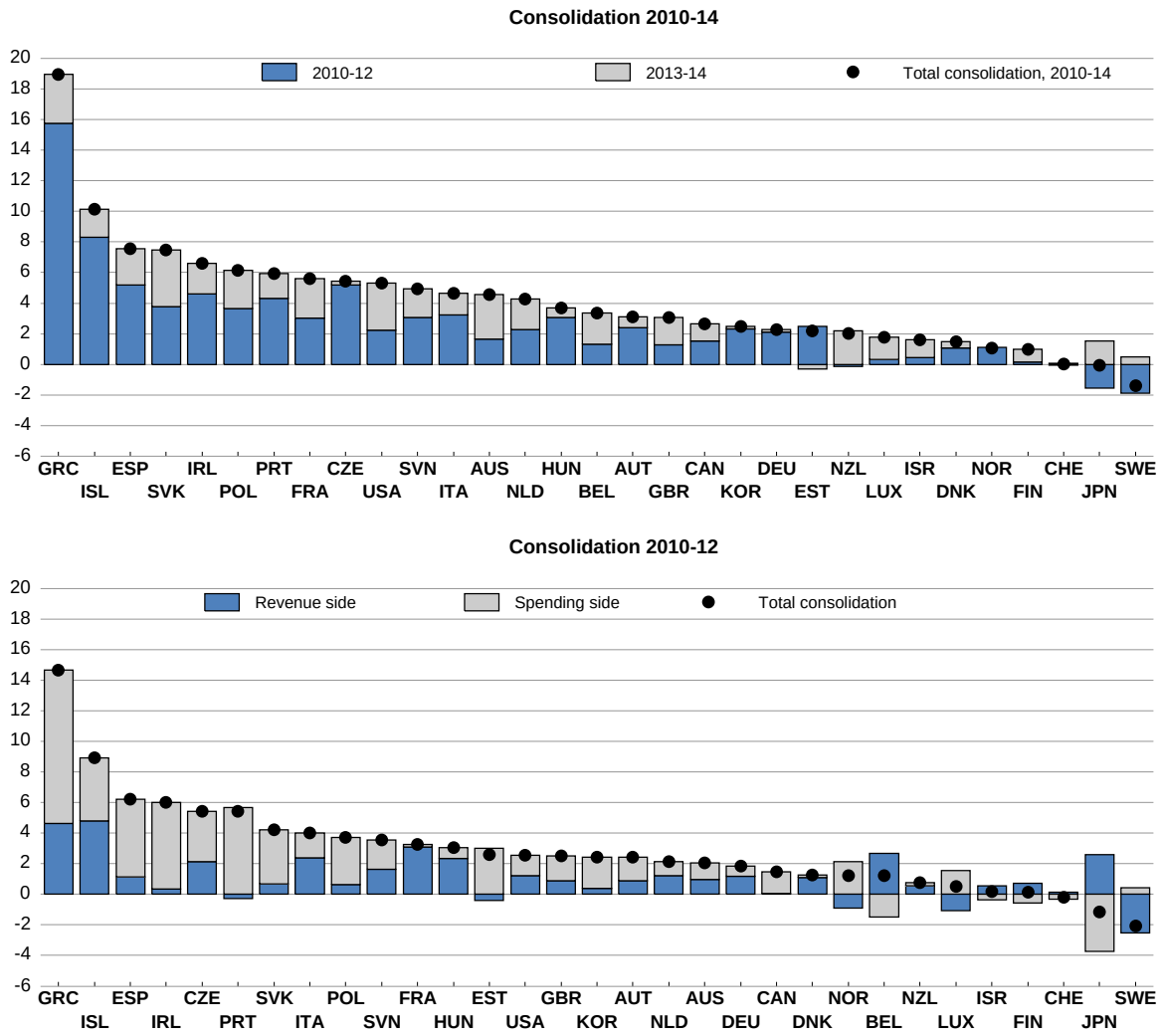
Normalised survey indicators, units of standard deviations

Note: Normalised figures over the period 1999-2013. Values above zero signify levels of consumer confidence above the historical average.

Source: Datastream, European Commission, and OECD calculations.

Figure 21. Massive consolidation in many OECD countries[1]

In per cent of potential GDP



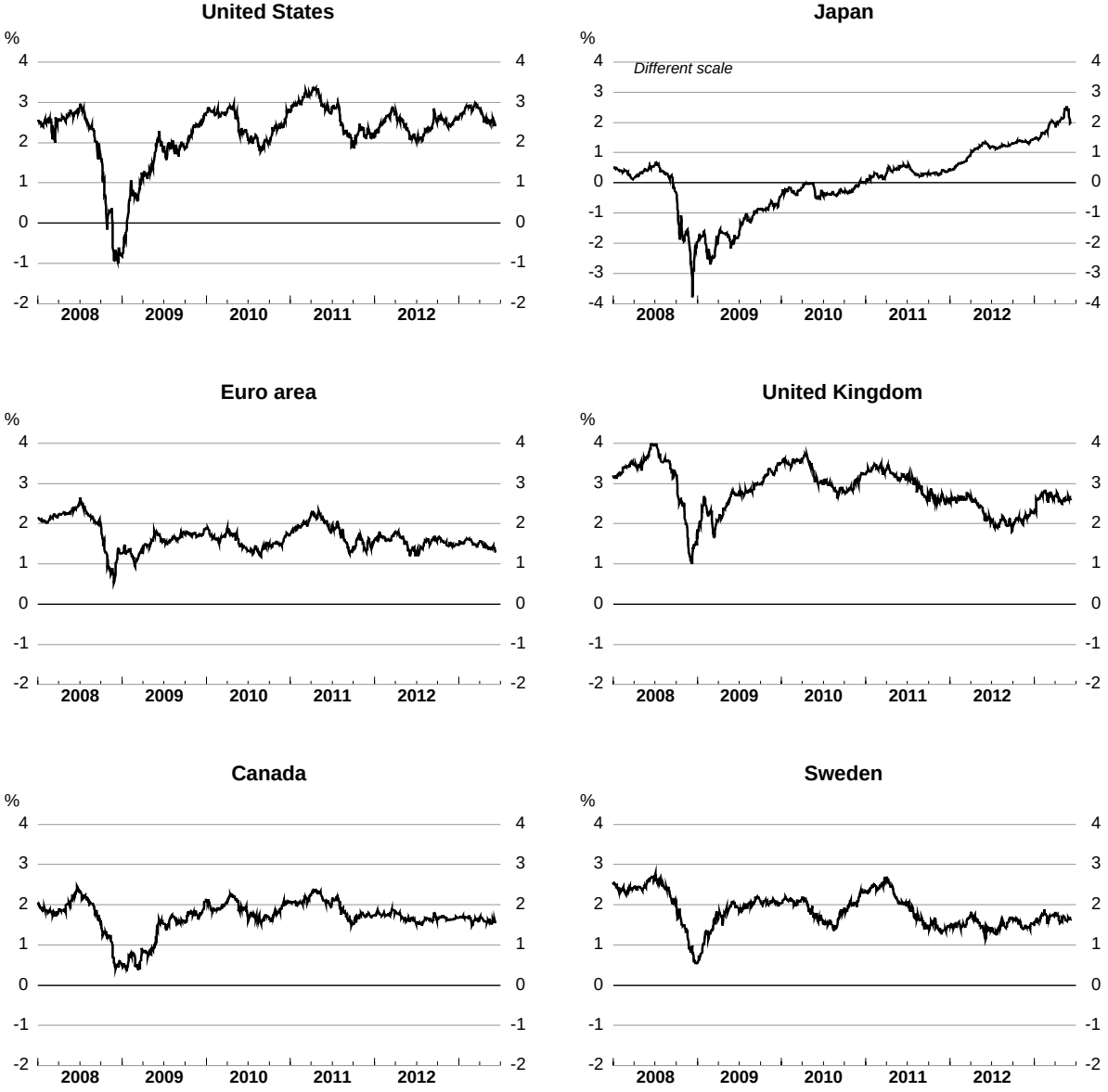
Note: Total consolidation is the projected difference in the underlying primary balance; revenue side is the projected increase in the underlying receipts excluding interest earned on financial assets; and spending side is the projected decline in the underlying primary spending excluding interest payments on debt.

1. Consolidation starts in 2010 for most countries except for Canada, Finland, Germany, Poland, the Slovak Republic and Switzerland (start in 2011), Hungary (start in 2012), and Japan (start in 2013).

Source: OECD Economic Outlook 93 database and OECD calculations.

Figure 22. Inflation expectations have been broadly stable

Based on bond yield differentials (Merrill Lynch)



Note: Expected inflation implied by the yield differential between 10-year government benchmark bonds and inflation-indexed bonds.

Source: Datastream.

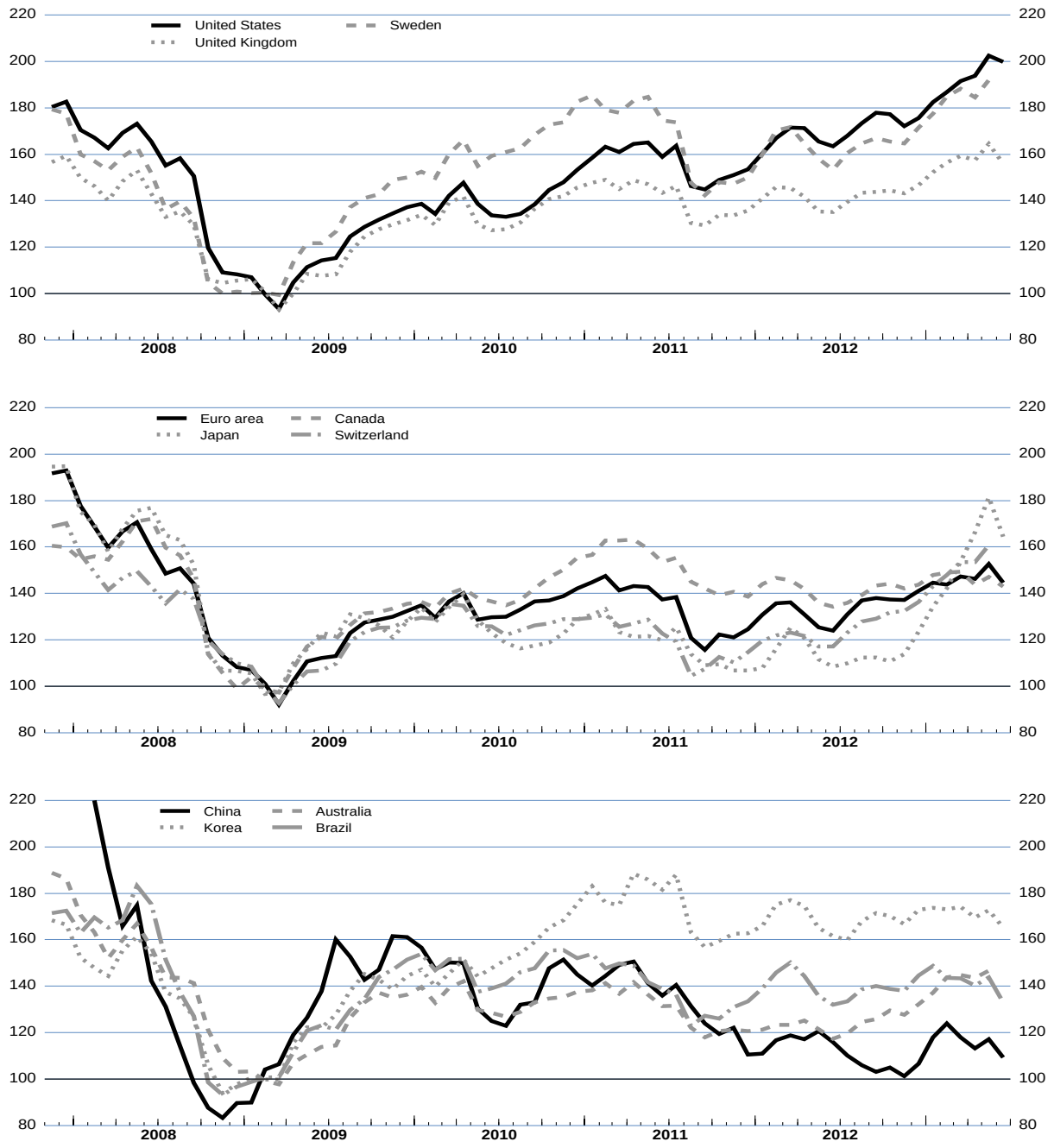
Figure 23. Money multipliers have declined in some countries

(Different scales)

Source: Datastream, European Central Bank and Bank of England.

Figure 24. The degree of stock market rebound differs

2009Q1 = 100



Note: Monthly frequency. Stock indices are based on: US Dow Jones (total) for the United States, FTSE Eurotop 100 for the euro area, Nikkei 225 for Japan, FTSE 100 for the United Kingdom, Toronto Composite for Canada, Swiss Market for Switzerland, OMX Stockholm for Sweden, ASX 300 index for Australia, Datastream market index for Brazil, CSI300 for China and KOSPI index for Korea.

Source: Datastream.

APPENDIX 1. EFFECTS OF QUANTITATIVE EASING

Numerous studies aim at estimating the effects of central banks' quantitative easing (QE) programmes (Table A1). The two approaches employed are: (1) event studies which identify major events closely related to QE, such, as central banks' announcements, and look at how yields changed around those event dates; and (2) regression analyses employing data on the amount of purchased assets or event dummies. Both approaches have advantages and disadvantages. The first approach may hold other factors affecting macroeconomic conditions constant by using a narrow window but may miss the effects of QE appearing outside the window. The second approach may be able to evaluate the overall effects of QE but might not control for other factors sufficiently.

Williams (2011) reviews the estimates of the effects of large-scale asset purchases, covering not only recent QE programmes but also their pre-crisis predecessors, such as the original US Operation Twist in the 1960s. He argues that the re-normalised estimates are around 15-20 basis points for asset purchases corresponding to 600 billion dollars (4% of GDP) and match the typical response of the 10-year Treasury yield to a 75-basis point cut in the federal funds rate. Studies shown in Table A1 find that asset purchases corresponding to 1% of nominal GDP reduce long-term interest rates by estimates that range from not statistically significant to 28 basis points, with an average of 7 basis points across the studies. The effects of QE on interest rates are statistically significant in most studies, though there is a need to take into account that they are accompanied by considerable estimation errors in the case of regressions and are based on few observations in the case of event studies. One study also found that QE in the United States depreciated the dollar significantly (Neely, 2011).[26]

Much less is known about the effects of QE on the overall economy. In particular, the link between QE and the public's anticipation of future inflation is not well understood. Williams (2011) argues that unconventional policy is still relatively unfamiliar to the public. On the other hand, akin to the European Central Bank, which stresses that its Securities Market Programme is not part of the monetary policy stance but it only ensures the transmission of the stance, numerous central bankers see a risk that the public may perceive the purchase of government bonds as monetisation, which could ultimately result in inflation expectations becoming unanchored. Using financial market data, Krishnamurthy and Vissing-Jorgensen (2011) estimate that QE1 and QE2 in the United States raised 10-year inflation expectations by 0.96-1.46 and 0.05-0.16 percentage points, respectively. On the other hand, Lam (2011) finds little change in 5-year breakeven rates in response to the Bank of Japan's monetary easing in October 2010, which involved 5 trillion yen (1% of GDP) asset purchases.

26. Employing the event study approach, Neely (2011) finds that US QE1 depreciated bilateral dollar exchange rates by 3.6-10.8% depending on the currency.

Table A1.1. Estimated effects of asset purchase programmes

	Measure/Sample	Approach	Estimated effect	Estimated effect of purchases matching 1 per cent of 2009 GDP on long-term rates (bp)
D'Amico and King (2011)	300 billion dollars purchase of Treasury securities in US QE1	Cross-section regression	30 basis points in the average maturity Treasury yield	14
Gagnon *et al.* (2011)	Total asset purchases (1.75 trillion dollars) in US QE1	Event study	91 basis points in the 10-year Trasury yield	7
	Changes in the net public-sector supply of longer-term debt securities in 1985-2008	Time-series regression	52 basis points in the 10-year term premium for asset purchases corresponding to QE1	4
Krishnamurthy and Vissing-Jorgensen (2011)	Total asset purchases (1.75 trillion dollars) in US QE1	Event study	180 basis points in the 10-year Treasury yield	14
	Reinvesting policy and total asset purchases (600 billion dollars) in US QE2	Event study	16 basis points in the 10-year Treasury yield	4
Hamilton and Wu (2012)	Maturity composition of publicly held debt since 1990	Affine no-arbitrage model	14 basis points in the 10-year Treasury yield for 400 billion dollars asset purchases	5
Stroebel and Taylor (2012)	1.25 trillion dollars purchases of mortgage-backed securities in US QE1	Time-series regression	30 basis points in mortgage spreads	3
Hancock and Passmore (2011)	500 billion dollars purchases of mortgage-backed securities in US QE1	Time-series regression	100 basis points in mortgage rates	28
Meaning and Zhu (2011)	Total asset purchases (1.75 trillion dollars) in US QE1	Event study	80 basis points in the 10-year Treasury yield	6
	Total asset purchases (600 billion dollars) in US QE2	Event study	No effect	-
	Total asset purchases (600 billion dollars) in US QE2	Cross-section regression	21 basis points in the average-maturity Treasury yield	5
	US Operation Twist in 2011	Event study	8 basis points in the 10-year Treasury yield	3
	US Operation Twist in 2011	Cross-section regression	22 basis points in the average-maturity Treasury yield	8
	Total asset purchases (200 billion pounds) in UK QE1	Event study	50 basis points in the 10-year gilt yield	3
	Total asset purchases (200 billion pounds) in UK QE1	Cross-section regression	27 basis points in the average-maturity gilt yield	2
	Total asset purchases (75 billion pounds) in UK QE2	Event study	No effect	-
Joyce *et al.* (2011)	Total asset purchases (200 billion pounds) in UK QE1	Event study	100 basis points in medium to long-term government bond yields	7
Oda and Ueda (2007)	Purchases of long-term government bonds in 1995-2003 in Japan	Time-series regression	Not statistically significant	-
Lam (2011)	Various asset purchases programmes and liquidity supply operations since December 2008 in Japan	Event study	10 basis points in the 10-year government bond yield for 5 trillion yen asset purchases	9

Source: Authors' compilation.

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ANNEX 1. TIME-VARYING NATURAL RATES OF INTEREST IN SELECTED OECD MONETARY AREAS[27]

Introduction

More than 100 years ago, the natural rate of interest (NRI) was defined by Knut Wicksell in the following way: "There is a certain rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor to lower them."[28] Over the past decade, the concept of NRI has enjoyed a renaissance within academic, practitioner and central-bank circles.[29] Estimating the natural rate of interest and its possible variations over time is important in the conduct of monetary policy since this concept can, if properly approached, provide a yardstick for assessing the expansionary or restrictive tendency of real interest rates at any given time (Amato, 2005; Weber *et al*., 2007; Borio and Disyatat, 2011). Besides, financial market participants are interested in such a variable because it could help produce long-run forecasts of interest rates, the latter being important ingredients in the pricing of long-term public and private securities.[30]

However, the NRI is not directly observable and depends on factors, such as the potential growth of the economy and the inter-temporal elasticity of substitution in consumption, whose measurements are not obvious. If the determinants of the NRI were constant over time, it would suffice to compute the average of the real short-term rate over a long period to estimate it. However, factors affecting supply and demand of credit evolve over time and, as a consequence, the NRI is a time-varying variable. If these movements are sufficiently large, the long-run average can even be a poor predictor of the NRI (Williams, 2003).[31]

This annex presents econometric estimates of time-varying natural interest rates in the spirit of the work of Laubach and Williams (2003) and Mésonnier and Renne (2007) for Canada, the euro area, Japan, Sweden, Switzerland, the United Kingdom and the United States.[32] These monetary areas are chosen because of their importance in the global economy. Also, the stability of their economic policies and the stable behaviour of their main macroeconomic variables make the estimation relatively less prone to potential break problems than for other monetary areas.

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27. This annex was prepared by Jean-Paul Renne.

28. 1936 translation from 1898 text, p. 102.

29. Andrés *et al.* (2009), Tristiani (2009), De Fiore and Tristani (2011) are examples of recent theoretical works where the NRI concept plays a major role.

30. Also, it has been empirically shown that the interest-rate gap, that is the difference between the effective real rate and the NRI, contains useful information to forecast future inflation (see *e.g.* Neiss and Nelson, 2003; or Mésonnier, 2011).

31. Orphanides and Williams (2002) stress the importance of the measurement issue by showing that underestimating the extent of misperceptions regarding the natural rates may exceeds the costs of overestimating such errors.

32. The main alternative methodology to estimate NRIs relies on dynamic stochastic general equilibrium (DSGE) models (Giammaroli and Valla, 2003). In this class of models, known as New Keynesian models or the Neo-Wicksellian framework, the NRI is defined as the real rate of interest that would prevail absent nominal rigidities (Woodford, 2003). As discussed by Edge *et al.* (2008), such estimates tend to be volatile and these authors reckon that the ones deriving from semi-structural Kalman filter models seem more consistent with policymakers' priors.

The estimates rely on a small-scale macroeconomic model that relates the fluctuations of the NRI with those of output and inflation. In this model, the NRI appears as the short-term interest rate that is consistent with stable inflation absent shocks to demand and supply. More precisely, if the real short-term rate is above the NRI, monetary policy is contractionary, pulling GDP and inflation down (and *vice versa* when the effective rate is below the NRI). Since the gap between the effective real short-term rate and the NRI influences output and inflation, the fluctuations of the latter variables contain information regarding the location of the NRI. This information can be extracted by means of a statistical technique known as the Kalman filter. Williams (2003) provides the intuition behind this filtering technique: at each period, the Kalman algorithm adjusts the estimate of the NRI based on how far off the model's prediction of GDP is from actual GDP. If the prediction is in line with actual outcomes, the estimate of the NRI remains unchanged. If, however, actual GDP is higher (lower) than predicted, this suggests that monetary policy probably is more stimulative (restrictive) than previously thought, implying that the difference between the effective short-term rate and the natural one is more negative (positive) than expected. Hence, the estimate of the natural rate is adjusted/updated by an amount proportional to the GDP prediction error, or "surprise".

The analysis detects substantial variations in the estimated NRIs for the seven monetary areas over the past decades. These fluctuations mainly reflect changes in potential growth. While the estimates are robust to the choice of the price index, they are sensitive to the calibration of the elasticity of inter-temporal substitution in consumption. In addition, the estimation technique results in non-negligible filtering errors (that are evaluated). Consistently with previous studies (Orphanides and Williams, 2002), our estimates are surrounded by a substantial amount of uncertainty. This should be taken into consideration when using the natural rates as indicators of excess demand pressures.

Model

The estimation of natural interest rates is based on the following small-scale macroeconomic model:[33]

(1) $y_t = y_t^* + z_t,$

(2) $\pi_t = \delta(L)\pi_{t-1} + \alpha z_{t-1} + \gamma.\mathrm{oil}_{t-1} + \zeta.\mathrm{imp}_{t-1} + \varepsilon_{\pi,t},$

(3) $z_t = \phi_z z_{t-1} - \beta\{i_{t-1} - E_{t-1}(\pi_t) - r_{t-1}^*\} + \varepsilon_{z,t},$

(4) $y_t^* = y_{t-1}^* + g_t + \varepsilon_t^*,$

(5) $r_t^* = \mu_r + \theta(g_t - \mu_g),$

(6) $g_t = \mu_g(1-\phi_g) + \phi_g g_{t-1} + \varepsilon_{g,t},$

where y_t and y^*_t are respectively the logarithms of GDP and potential GDP, π_t is the inflation rate, z_t is the output gap, r^*_t is the natural interest rate, g_t is the trend growth rate of potential GDP, i_t is the nominal short-term interest rate, oil_t is the (log) annual growth rate of oil prices and imp_t is the (log) annual growth rate of import prices. The latter two variables are expressed in domestic currencies and demeaned.

Equation (1) simply defines the output gap z_t. Equation (2) is a Phillips curve that describes inflation dynamics, with inflation depending on its own lagged values and on real activity (through the output gap). Further, as in Laubach and Williams (2003) the Philips curve relationship includes relative-price shocks as measured by import and oil prices. Equation (3) formalises the relationship between the output gap z_t and the lagged interest rate gap, *i.e.* the difference between the *ex-ante* real interest rate ($i_{t-1} - E_{t-1}(\pi_t)$) and the

33. Several articles emphasise the empirical robustness of such small-scale backward looking models – see for instance Rudebusch and Svensson (1998).

natural interest rate. Potential GDP growth is the sum of a persistent component g_t, and a volatile component ε^*_t (equation 4). The specification of the natural interest rate r^*_t (equation 5) stems from basic optimal growth models (the textbook Ramsey model). In these models, the inter-temporal utility maximisation of representative agents implies that the real interest rate depends on the growth rate in per capita consumption and the inverse of the inter-temporal elasticity of substitution in consumption (*i.e.* the elasticity between consumption growth rate and real interest rate). Hence, θ can be interpreted here as a coefficient of relative risk aversion. The trend growth rate of potential GDP g_t is assumed to follow an auto-regressive process (equation 6).

The four shocks entering these equations ($\varepsilon_{\pi,t}$, $\varepsilon_{z,t}$, $\varepsilon_{g,t}$ and ε_{*t}) are independently and normally distributed, with standard deviations σ_π, σ_z, σ_g and σ^*, respectively.

Estimation

Data

For each monetary area, two inflation series have been used alternatively: the first is based on headline Consumer Price Indices (CPI),[34] and the second is based on the GDP deflator (PGDP). OECD estimates of the output gap and potential growth are included in the estimation procedure (see below). Inflation rates are computed as the (log) annual growth rates in the price indices. Interest rates refer to 3-month interbank interest rates or T-bill yields. For all areas, the last quarter of the estimation sample is 2012Q2.

Estimation procedure

Equations 1-6 form a state-space model where equations 1 and 2 are measurement equations, defining the dynamics of observed variables, and equations 3 to 6 are the transition equations, defining the dynamics of the latent factors. Equations 1-6 constitute the data generating process (DGP) of the different variables. In order to guide the estimation of potential GDP and to ensure the compatibility of the results with available OECD estimates, this system of equations is augmented with an additional measurement equation, stating that the (modelled) potential GDP is equal to the OECD estimated one, up to a small deviation:

$$(7) \qquad y_t^* = y^*_{oecd,t} + \xi_t,$$

where the ξ_t's are Gaussian i.i.d. measurement errors with a standard deviation set to 0.1 percentage point of GDP. It should be noted that even if the potential GDP were considered as perfectly observed (*i.e.* if $\xi_t \equiv 0$), equation 4 would not become superfluous. Indeed, this equation specifies the decomposition of the potential growth rate into two terms (a persistent trend g_t and a volatile component ε_t*).

34. Contrary to the ones of other areas, Swedish inflation includes "housing component" (mortgage payments). Therefore, for Sweden, the CPI is replaced by the CPI at constant interest rates (CPIF) which differs from CPI by keeping the interest rate for household mortgage interest payment constant.

For any set of parameters specifying the dynamics of these variables, the Kalman filter technique can be used to compute the log-likelihood associated with the model (Kim and Nelson, 1999; Hamilton, 1994).[35] Parameter estimates are obtained by maximising this log-likelihood.[36] In order to facilitate the estimation procedure and to make this procedure stable across the different areas and price indices, some parameters are calibrated:

- The parameter μ_r, which is the unconditional average of the natural rate of interest, is set to the historical (sample) average of the real interest rate.
- The parameter μ_g, which is the unconditional average of the (quarterly) growth rate, is set to the sample average of the real potential GDP growth rates.
- σ^* is such that the shocks ε_{*t} account for a limited part of output growth fluctuations (25%).[37]
- σ_g is calibrated in such a way that the unconditional variance of the natural rate of interest is equal to the sample variance of the real interest rate.[38]
- The δ_is sum to one (implying that one of the δ_is is not estimated). This assumption leads to the accelerationist form of the Phillips curve – a standard approach in small-scale macroeconomic backward-looking models.

The risk aversion coefficient θ proved to be difficult to estimate (which is notably reflected by the fact that its estimate strongly depends on the estimation period). To address this problem, Mésonnier and Renne (2007) propose to use calibrated values that are in line with the empirical studies estimating the inter-temporal elasticity of substitution (or equivalently, risk aversion coefficients). Unfortunately, this literature is not consensual about the magnitude of this parameter. Therefore, in this paper, the model has been estimated for different values of θ: 4, 10 and 16 (for the quarterly frequency), *i.e.* for respective annualised values of 1, 2.5 and 4.[39] The value 10 is chosen to be the baseline – see below.

Estimations are carried out in two steps. In the first step, all parameters (except the ones that are constrained – see above) are estimated and their statistical significance is assessed. In the second step, the model is estimated excluding parameters – among γ, ζ and the δ_is – which turned to be insignificant (at the 10% confidence level) in the first step.

35. The Kalman filter produces two kinds of latent-variable estimates: filtered and smoothed estimates. At each date t, the smoothed estimates rely on the full available information (from date 1 to date T, say) while the filtered ones do not exploit the information that correspond to future dates ($[t+1,T]$) (Kim and Nelson, 1999; Hamilton, 1994). The estimated variables in this study are smoothed estimates.

36. The numerical maximisation is carried out on the Scilab software; two algorithms (Nelder-Mead and quasi-Newton) are recursively used until convergence is reached.

37. If this is not imposed, either this variance or the one associated with the innovation entering equation (6) tends to be zero. As remarked by Mésonnier and Renne (2007), this reflects the fact that it is difficult to disentangle idiosyncratic shocks to potential output from transitory shocks on output. The ratio of 25% corresponds to the ratio of the standard deviation of ε^* with respect to the one of (observed) output growth. Estimation results are robust to this calibrated ratio.

38. The unconditional variance of the natural rate of interest is given by $[\theta^2\sigma_g^2/(1-\Phi_g^2)]$.

39. In the model, the output growth rates (Δy, Δy^* and g) are expressed at the quarterly frequency. Therefore, an inter-temporal elasticity of substitution of 1 corresponds to a parameter θ of 4 – see equation (5).

Results

The parameter β – the elasticity of the output gap to the interest-rate gap – is statistically significant for Canada, the euro area, Sweden and the United States (Tables A2.1-7). This finding is robust to inflation definitions and parameter values for θ. To the extent that this β measures the influence of the interest rate gap on the output gap, the fact that it is statistically significant suggests that the interest rate gap is an important driver of real activity. In contrast, for Japan, Switzerland and the United Kingdom the parameter in most cases is not statistically different from zero (Tables A2.1-7).

Figures A2.1 and A2.2 depict the estimated NRIs. As evident, over recent years, in most areas they have declined to very low levels, even turning negative in Canada, Japan, the United Kingdom and the United States. Sweden and Switzerland are exceptions, as natural interest rates have remained stable and relatively high since the beginning of the Great Recession. It should be noted however that there is large uncertainty about the exact levels of natural interest rates as indicated by the 95% confidence intervals, accounting for the filtering uncertainty in the Kalman filter,[40] and the choice of parameter θ (Figures A2.3 and A2.4). The larger the value of θ, the wider the (in-sample) fluctuations of the natural interest rates. These fluctuations appear implausibly wide (small) when θ is equal to 16 (4). Thus, 10 is chosen as the baseline value of θ. It lies between the one used by Laubach and Williams (2003) for the United States (about 4 when converted at the quarterly frequency) and the one used by Mésonnier and Renne (2007) for the euro area (16). On the positive side, the estimated levels of the natural interest rate do not change much for the range of θ between 8 and 12 (Figures A2.3 and A2.4).[41] Moreover, since the estimations are based on OECD's estimates of potential output growth, there is also uncertainty about these estimates, especially as potential growth is frequently subject to revisions (Koske and Pain, 2008; Bouis *et al.*, 2012).

Summary

This paper presents econometric estimates of time-varying NRIs in the spirit of the work of Mésonnier and Renne (2007) and Laubach and Williams (2003) for Canada, the euro area, Japan, Sweden, Switzerland, the United Kingdom and the United States.

The approach relies on a small-scale macroeconomic model that depicts the interactions between inflation, GDP growth, the output gap and an interest rate gap. The latter is defined as a difference between the *ex-ante* real interest rate and the natural interest rate. In this framework, when the interest rate gap is nil, and in the absence of new shocks, the output gap closes and the inflation rate stabilises. From an econometric point of view, the model is a state-space model where the natural interest rate is a latent state variable estimated by the Kalman filter technique.

The results demonstrate that the natural interest rates do vary across time and that the interest-rate gaps are important drivers of output gap dynamics. Further, over the past few years, the natural interest rates have reached unprecedented low levels in several areas, with the exception of Sweden and Switzerland.

40. Kalman-filter techniques are optimal in the present case, where the variables follow Gaussian processes. Heuristically, this means that conditionally on the knowledge of the model parameterisation, these techniques lead to the lowest possible filtering-error variances.

41. In particular, confidence intervals obtained for these values, not displayed in figures for sake of clarity, largely overlap.

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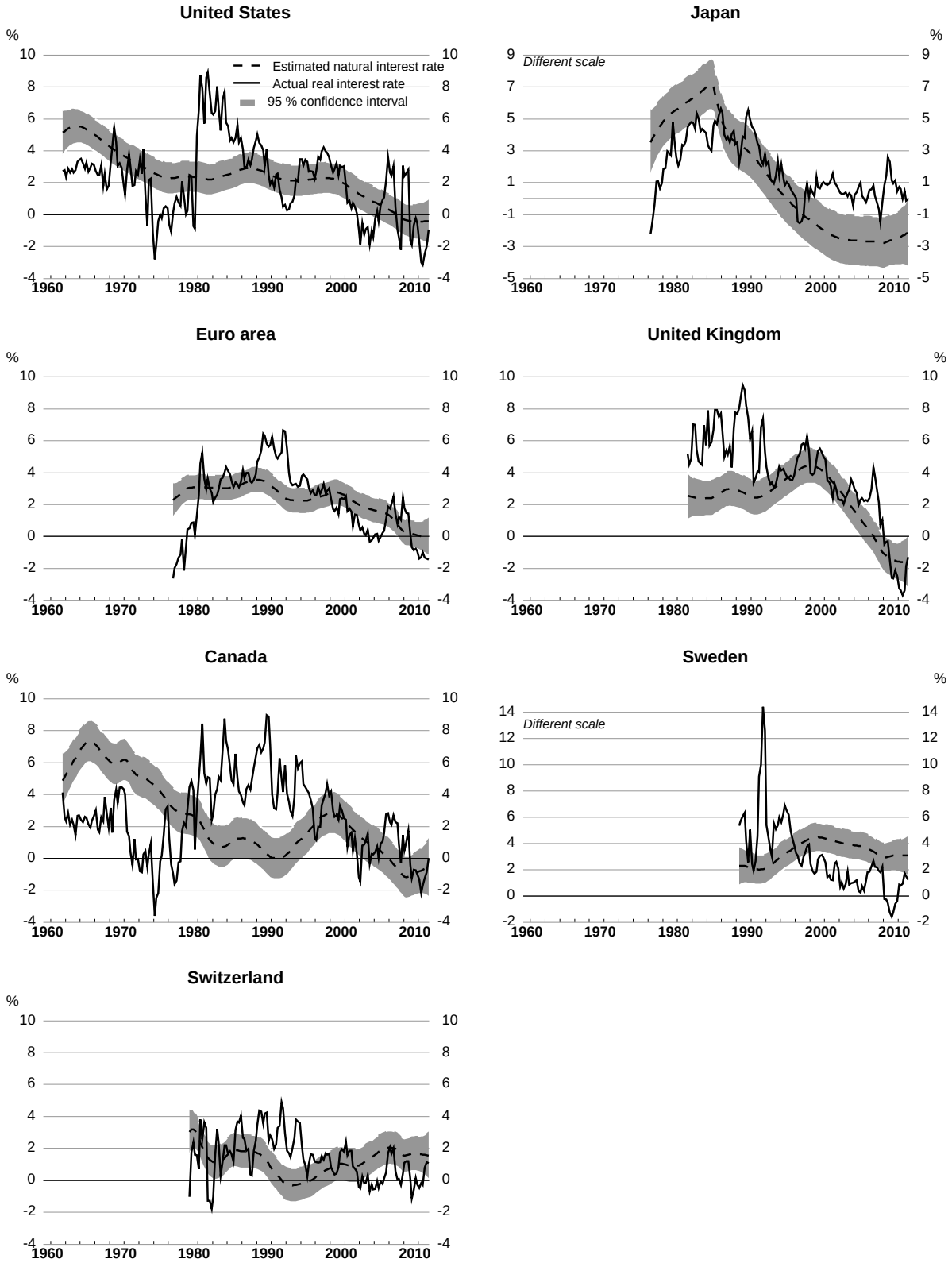
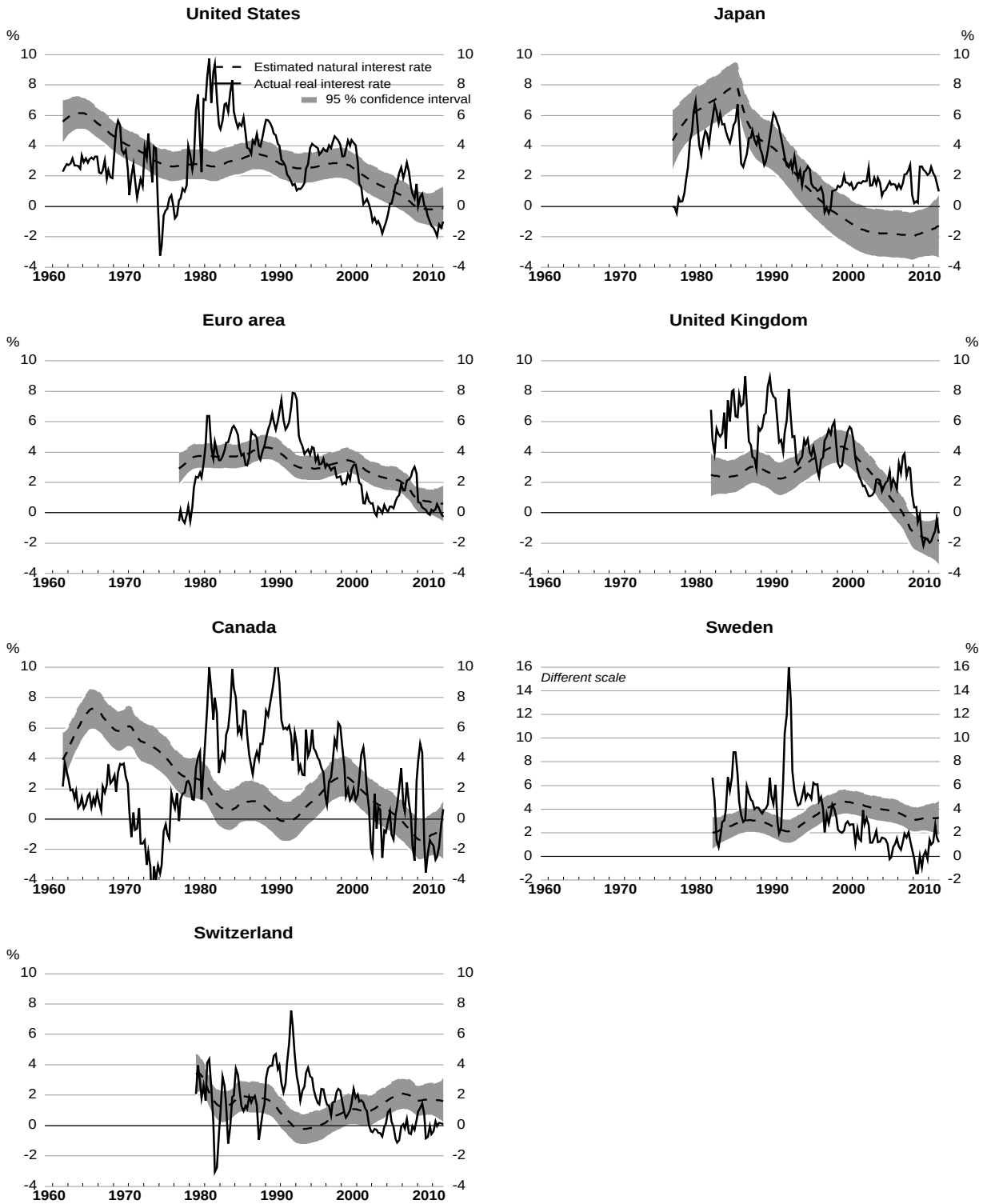
Figure A2.1. Real natural interest rates (based on CPI and theta=10)



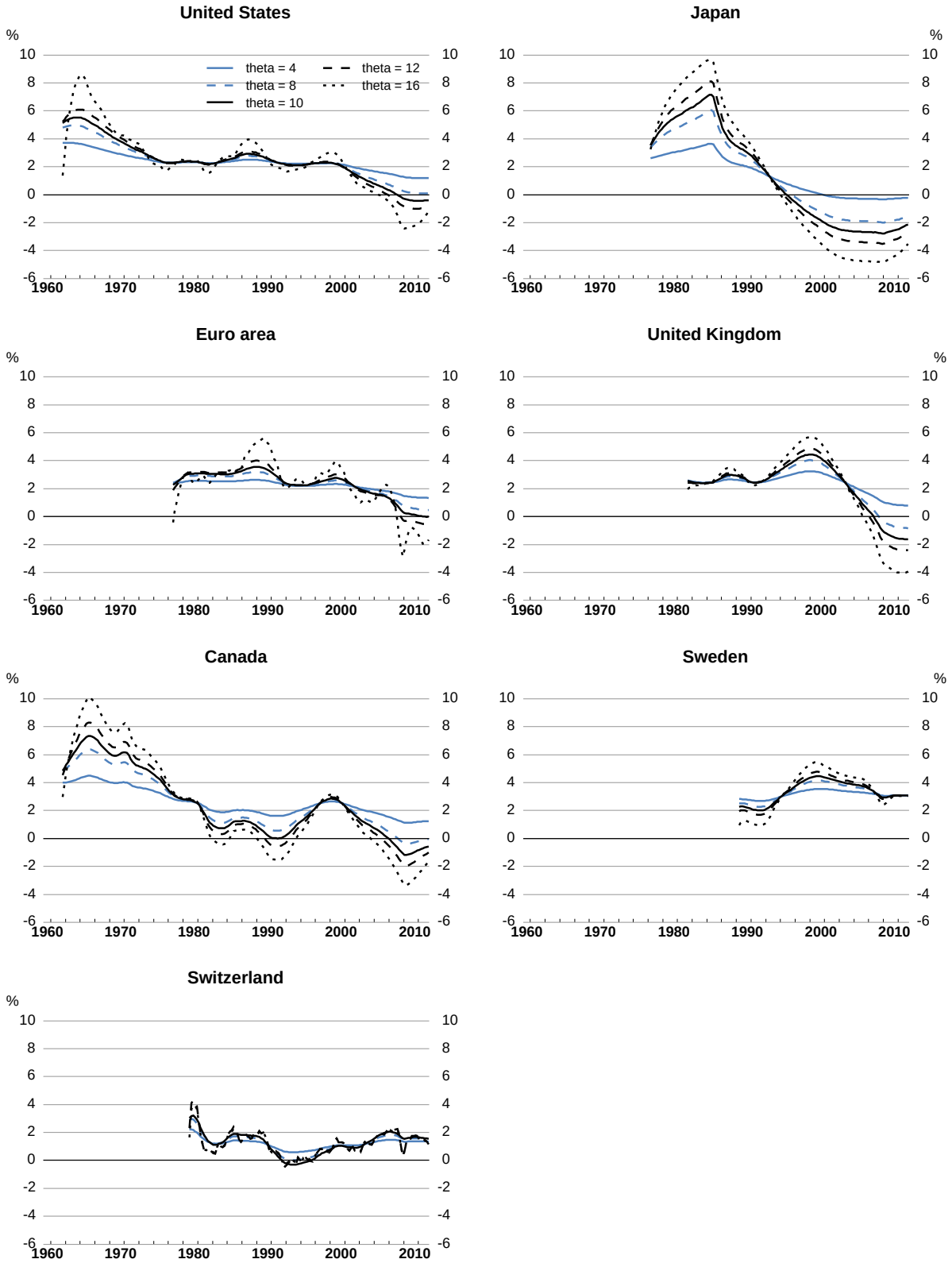
Source: Author's calculations.

Figure A2.2. Real natural interest rates (based on GDP deflator and theta = 10)



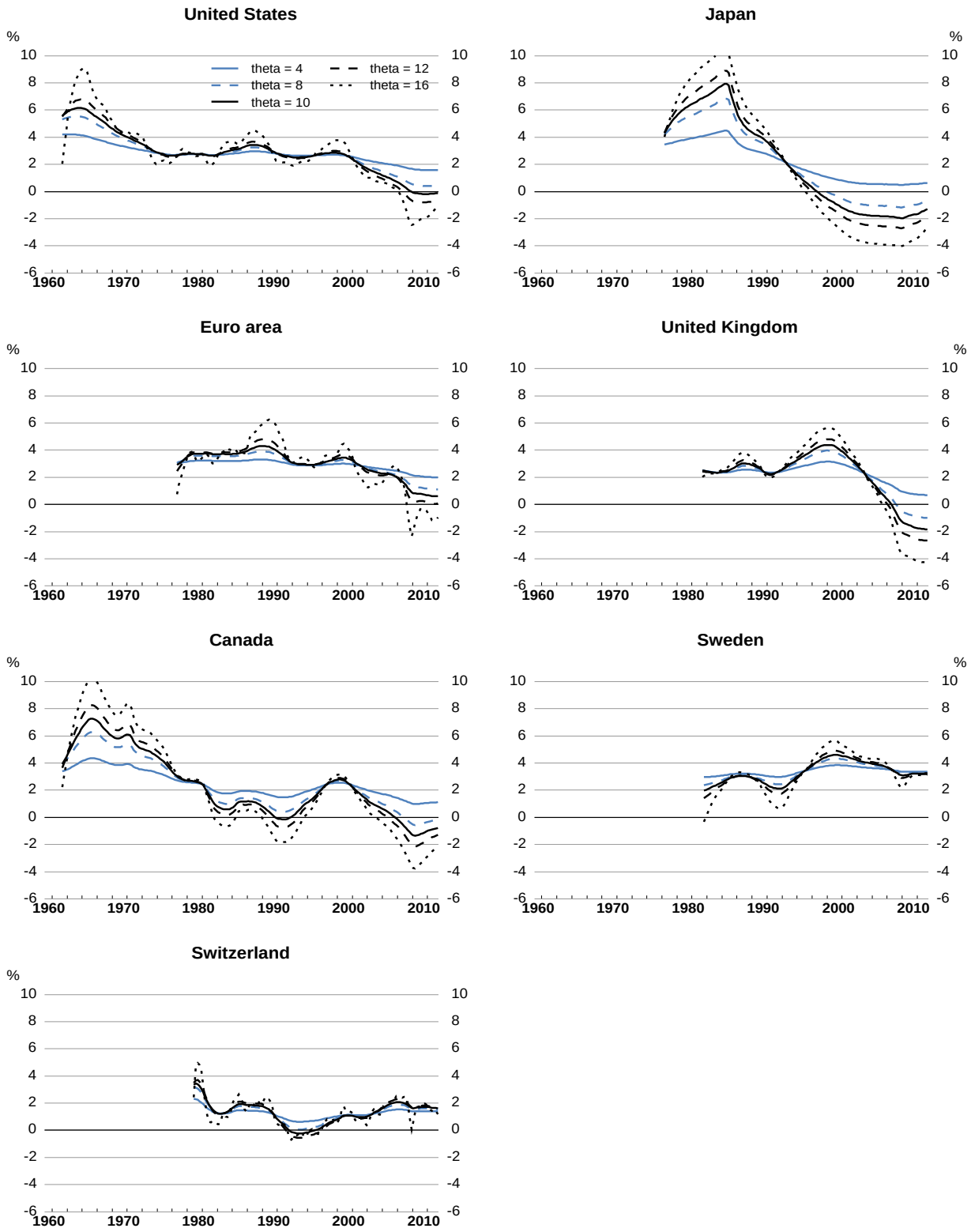
Source: Author's calculations.

Figure A2.3. Real natural interest rates for different thetas (based on CPI)



Source: Author's calculations.

Figure A2.4. Real natural interest rates for different thetas (based on GDP deflator)



Source: Author's calculations.

Table A2.1. Estimation results for Canada

	Price index: GDP deflator				Price index: CPI		
	θ=4	θ=10	θ=16		θ=4	θ=10	θ=16
Φ_z	0.922	0.924	0.924	Φ_z	0.929	0.928	0.928
	(0.025)	*(0.025)*	*(0.025)*		*(0.025)*	*(0.025)*	*(0.025)*
	[0.024]	*[0.024]*	*[0.024]*		*[0.023]*	*[0.023]*	*[0.023]*
β	0.041	0.028	0.02	β	0.037	0.025	0.018
	(0.016)	*(0.013)*	*(0.01)*		*(0.02)*	*(0.015)*	*(0.012)*
	[0.015]	*[0.012]*	*[0.009]*		*[0.02]*	*[0.015]*	*[0.012]*
σ_z	0.762	0.764	0.766	σ_z	0.769	0.769	0.771
	(0.04)	*(0.04)*	*(0.04)*		*(0.04)*	*(0.04)*	*(0.04)*
	[0.04]	*[0.04]*	*[0.04]*		*[0.04]*	*[0.039]*	*[0.038]*
δ_1	1.307	1.289	1.302	δ_1	1.161	1.16	1.159
	(0.069)	*(0.069)*	*(0.069)*		*(0.073)*	*(0.073)*	*(0.073)*
	[0.058]	*[0.058]*	*[0.059]*		*[0.075]*	*[0.075]*	*[0.075]*
δ_2	-0.372	-0.289	-0.365	δ_2	-0.161	-0.16	-0.159
	(0.088)	*(0.069)*	*(0.088)*		*(0.073)*	*(0.073)*	*(0.073)*
	[0.07]	*[0.058]*	*[0.071]*		*[0.075]*	*[0.075]*	*[0.075]*
δ_3	-	-	-	δ_3	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
δ_4	0.065	-	0.063	δ_4	-	-	-
	(0.045)	-	*(0.045)*		-	-	-
	[0.038]	-	*[0.039]*		-	-	-
α	0.031	0.019	0.031	α	0.052	0.052	0.052
	(0.031)	*(0.03)*	*(0.031)*		*(0.023)*	*(0.023)*	*(0.023)*
	[0.039]	*[0.034]*	*[0.039]*		*[0.023]*	*[0.023]*	*[0.023]*
ζ	-	-	-	ζ	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
γ	-	-	-	γ	0.002	0.002	0.003
	-	-	-		*(0.002)*	*(0.002)*	*(0.002)*
	-	-	-		*[0.002]*	*[0.002]*	*[0.002]*
σ_π	0.943	0.947	0.943	σ_π	0.67	0.67	0.67
	(0.047)	*(0.047)*	*(0.047)*		*(0.034)*	*(0.034)*	*(0.034)*
	[0.034]	*[0.03]*	*[0.034]*		*[0.031]*	*[0.031]*	*[0.031]*
μ_g	0.797	0.797	0.797	μ_g	0.798	0.798	0.798
Φ_g	0.999	0.99	0.965	Φ_g	0.998	0.986	0.954
	(0.001)	*(0.005)*	*(0.015)*		*(0.001)*	*(0.007)*	*(0.018)*
	[0.002]	*[0.013]*	*[0.033]*		*[0.002]*	*[0.021]*	*[0.034]*
σ_g	0.039	0.044	0.052	σ_g	0.036	0.042	0.046
σ^*	0.214	0.214	0.214	σ^*	0.214	0.214	0.214
μ_r	2.491	2.491	2.491	μ_r	2.606	2.606	2.606

Note: The figures in parentheses refer to the estimate of 2 standard deviations based on the Hessian matrix of the log-likelihood and the figures in square brackets refer to the estimate of 2 standard deviations based on the outer-product estimate of the information matrix.

Source: Author's calculations.

Table A2.2. Estimation results for the euro area

	Price index: GDP deflator				Price index: CPI		
	θ=4	θ=10	θ=16		θ=4	θ=10	θ=16
Φ_z	0.968	0.963	0.934	Φ_z	0.971	0.969	0.945
	(0.024)	*(0.024)*	*(0.029)*		*(0.024)*	*(0.024)*	*(0.029)*
	[0.028]	*[0.03]*	*[0.05]*		*[0.028]*	*[0.03]*	*[0.042]*
β	0.048	0.082	0.158	β	0.035	0.062	0.139
	(0.023)	*(0.028)*	*(0.04)*		*(0.023)*	*(0.028)*	*(0.047)*
	[0.029]	*[0.043]*	*[0.051]*		*[0.029]*	*[0.041]*	*[0.042]*
σ_z	0.528	0.514	0.441	σ_z	0.532	0.523	0.459
	(0.033)	*(0.033)*	*(0.045)*		*(0.033)*	*(0.033)*	*(0.051)*
	[0.023]	*[0.031]*	*[0.039]*		*[0.024]*	*[0.031]*	*[0.04]*
δ_1	1.192	1.192	1.184	δ_1	1.296	1.302	1.319
	(0.051)	*(0.051)*	*(0.05)*		*(0.085)*	*(0.085)*	*(0.085)*
	[0.051]	*[0.051]*	*[0.049]*		*[0.092]*	*[0.088]*	*[0.09]*
δ_2	-	-	-	δ_2	-0.199	-0.208	-0.237
	-	-	-		*(0.136)*	*(0.136)*	*(0.136)*
	-	-	-		*[0.128]*	*[0.126]*	*[0.125]*
δ_3	-0.433	-0.437	-0.407	δ_3	-0.235	-0.237	-0.238
	(0.103)	*(0.103)*	*(0.102)*		*(0.134)*	*(0.134)*	*(0.134)*
	[0.111]	*[0.11]*	*[0.107]*		*[0.127]*	*[0.126]*	*[0.127]*
δ_4	0.241	0.244	0.223	δ_4	0.138	0.143	0.156
	(0.08)	*(0.08)*	*(0.078)*		*(0.083)*	*(0.083)*	*(0.083)*
	[0.091]	*[0.09]*	*[0.086]*		*[0.07]*	*[0.07]*	*[0.07]*
α	0.048	0.048	0.037	α	0.044	0.044	0.045
	(0.016)	*(0.016)*	*(0.016)*		*(0.019)*	*(0.019)*	*(0.019)*
	[0.017]	*[0.017]*	*[0.018]*		*[0.02]*	*[0.019]*	*[0.019]*
ζ	-	-	-	ζ	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
γ	-	-	0.002	γ	-	-	-
	-	-	*(0.001)*		-	-	-
	-	-	*[0.001]*		-	-	-
σ_π	0.314	0.314	0.308	σ_π	0.371	0.371	0.372
	(0.019)	*(0.019)*	*(0.018)*		*(0.022)*	*(0.022)*	*(0.022)*
	[0.02]	*[0.02]*	*[0.021]*		*[0.019]*	*[0.019]*	*[0.02]*
μ_g	0.477	0.477	0.477	μ_g	0.477	0.477	0.477
Φ_g	0.999	0.994	0.937	Φ_g	0.999	0.994	0.93
	(0)	*(0.005)*	*(0.038)*		*(0)*	*(0.004)*	*(0.045)*
	[0.002]	*[0.015]*	*[0.062]*		*[0.002]*	*[0.017]*	*[0.07]*
σ_g	0.02	0.025	0.048	σ_g	0.019	0.024	0.05
σ^*	0.144	0.144	0.144	σ^*	0.144	0.144	0.144
μ_r	2.808	2.808	2.808	μ_r	2.134	2.134	2.134

Note: The figures in parentheses refer to the estimate of 2 standard deviations based on the Hessian matrix of the log-likelihood and the figures in square brackets refer to the estimate of 2 standard deviations based on the outer-product estimate of the information matrix.

Source: Author's calculations.

Table A2.3. Estimation results for Japan

	Price index: GDP deflator				Price index: CPI		
	θ=4	θ=10	θ=16		θ=4	θ=10	θ=16
Φ_z	0.928	0.928	0.928	Φ_z	0.927	0.927	0.927
	(0.031)	*(0.031)*	*(0.031)*		*(0.031)*	*(0.031)*	*(0.031)*
	[0.038]	*[0.038]*	*[0.039]*		*[0.037]*	*[0.036]*	*[0.037]*
β	0.01	0.008	0.007	β	0	0	0
	(0.059)	*(0.032)*	*(0.021)*		*(0.002)*	*(0.003)*	*(0.004)*
	[0.072]	*[0.042]*	*[0.028]*		*[15872.937]*	*[1116.285]*	*[92.01]*
σ_z	0.977	0.976	0.976	σ_z	0.977	0.977	0.977
	(0.06)	*(0.06)*	*(0.06)*		*(0.06)*	*(0.06)*	*(0.06)*
	[0.045]	*[0.053]*	*[0.054]*		*[0.044]*	*[0.048]*	*[0.05]*
δ_1	1	1	1	δ_1	1	1	1
	(0)	*(0)*	*(0)*		*(0)*	*(0)*	*(0)*
	[0]	*[0]*	*[0]*		*[0]*	*[0]*	*[0]*
δ_2	-	-	-	δ_2	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
δ_3	-	-	-	δ_3	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
δ_4	-	-	-	δ_4	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
α	0.004	0.004	0.004	α	0.016	0.016	0.016
	(0.019)	*(0.019)*	*(0.019)*		*(0.02)*	*(0.02)*	*(0.02)*
	[0.022]	*[0.022]*	*[0.022]*		*[0.021]*	*[0.02]*	*[0.02]*
ζ	0.017	0.017	0.017	ζ	-	-	-
	(0.004)	*(0.004)*	*(0.004)*		-	-	-
	[0.003]	*[0.003]*	*[0.003]*		-	-	-
γ	-	-	-	γ	0.007	0.007	0.007
	-	-	-		*(0.001)*	*(0.001)*	*(0.001)*
	-	-	-		*[0.001]*	*[0.001]*	*[0.001]*
σ_π	0.563	0.563	0.563	σ_π	0.593	0.593	0.593
	(0.034)	*(0.034)*	*(0.034)*		*(0.035)*	*(0.035)*	*(0.035)*
	[0.028]	*[0.028]*	*[0.028]*		*[0.036]*	*[0.036]*	*[0.037]*
μ_g	0.568	0.568	0.568	μ_g	0.568	0.568	0.568
Φ_g	0.997	0.98	0.967	Φ_g	0.997	0.98	0.968
	(0.002)	*(0.01)*	*(0.011)*		*(0.002)*	*(0.01)*	*(0.012)*
	[0.002]	*[0.022]*	*[0.038]*		*[0.002]*	*[0.021]*	*[0.04]*
σ_g	0.047	0.048	0.038	σ_g	0.047	0.048	0.039
σ^*	0.271	0.271	0.271	σ^*	0.271	0.271	0.271
μ_r	2.15	2.15	2.15	μ_r	1.316	1.316	1.316

Note: The figures in parentheses refer to the estimate of 2 standard deviations based on the Hessian matrix of the log-likelihood and the figures in square brackets refer to the estimate of 2 standard deviations based on the outer-product estimate of the information matrix.

Source: Author's calculations.

Table A2.4. Estimation results for Sweden

	Price index: GDP deflator				Price index: CPI		
	θ=4	θ=10	θ=16		θ=4	θ=10	θ=16
Φ_z	0.943	0.941	0.936	Φ_z	0.926	0.926	0.926
	(0.026)	*(0.027)*	*(0.027)*		*(0.03)*	*(0.031)*	*(0.031)*
	[0.028]	*[0.03]*	*[0.031]*		*[0.034]*	*[0.037]*	*[0.038]*
β	0.068	0.063	0.059	β	0.102	0.093	0.082
	(0.025)	*(0.023)*	*(0.022)*		*(0.032)*	*(0.03)*	*(0.027)*
	[0.032]	*[0.031]*	*[0.03]*		*[0.046]*	*[0.044]*	*[0.038]*
σ_z	0.777	0.775	0.769	σ_z	0.841	0.838	0.834
	(0.052)	*(0.052)*	*(0.053)*		*(0.064)*	*(0.064)*	*(0.065)*
	[0.028]	*[0.03]*	*[0.033]*		*[0.035]*	*[0.04]*	*[0.048]*
δ_1	1.175	1.175	1.175	δ_1	1	1	1
	(0.057)	*(0.057)*	*(0.057)*		*(0)*	*(0)*	*(0)*
	[0.048]	*[0.048]*	*[0.048]*		*[0]*	*[0]*	*[0]*
δ_2	-	-	-	δ_2	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
δ_3	-0.275	-0.275	-0.275	δ_3	-	-	-
	(0.119)	*(0.12)*	*(0.12)*		-	-	-
	[0.105]	*[0.105]*	*[0.107]*		-	-	-
δ_4	0.1	0.1	0.1	δ_4	-	-	-
	(0.09)	*(0.09)*	*(0.09)*		-	-	-
	[0.093]	*[0.093]*	*[0.095]*		-	-	-
α	0.016	0.016	0.016	α	0.037	0.037	0.038
	(0.025)	*(0.025)*	*(0.025)*		*(0.03)*	*(0.03)*	*(0.03)*
	[0.032]	*[0.032]*	*[0.032]*		*[0.03]*	*[0.03]*	*[0.029]*
ζ	-	-	-	ζ	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
γ	0.005	0.005	0.005	γ	-	-	-
	(0.002)	*(0.002)*	*(0.002)*		-	-	-
	[0.003]	*[0.003]*	*[0.003]*		-	-	-
σ_π	0.728	0.728	0.728	σ_π	0.857	0.857	0.857
	(0.047)	*(0.047)*	*(0.047)*		*(0.063)*	*(0.063)*	*(0.063)*
	[0.05]	*[0.05]*	*[0.05]*		*[0.03]*	*[0.03]*	*[0.029]*
μ_g	0.566	0.566	0.566	μ_g	0.525	0.525	0.525
Φ_g	0.999	0.995	0.97	Φ_g	0.999	0.994	0.978
	(0)	*(0.004)*	*(0.025)*		*(0.001)*	*(0.005)*	*(0.021)*
	[0.002]	*[0.014]*	*[0.074]*		*[0.002]*	*[0.016]*	*[0.06]*
σ_g	0.023	0.028	0.041	σ_g	0.025	0.028	0.035
σ^*	0.211	0.211	0.211	σ^*	0.237	0.237	0.237
μ_r	3.423	3.423	3.423	μ_r	2.978	2.978	2.978

Note: The figures in parentheses refer to the estimate of 2 standard deviations based on the Hessian matrix of the log-likelihood and the figures in square brackets refer to the estimate of 2 standard deviations based on the outer-product estimate of the information matrix.

Source: Author's calculations.

Table A2.5. Estimation results for Switzerland

	Price index: GDP deflator				Price index: CPI		
	θ=4	θ=10	θ=16		θ=4	θ=10	θ=16
Φ_z	0.948	0.946	0.944	Φ_z	0.946	0.945	0.945
	(0.031)	*(0.03)*	*(0.03)*		*(0.031)*	*(0.03)*	*(0.03)*
	[0.033]	*[0.029]*	*[0.029]*		*[0.031]*	*[0.025]*	*[0.027]*
β	0.027	0.028	0.035	β	0.021	0.028	0.033
	(0.028)	*(0.025)*	*(0.025)*		*(0.033)*	*(0.03)*	*(0.033)*
	[0.036]	*[0.032]*	*[0.029]*		*[0.034]*	*[0.034]*	*[0.032]*
σ_z	0.58	0.579	0.569	σ_z	0.581	0.58	0.575
	(0.037)	*(0.038)*	*(0.039)*		*(0.038)*	*(0.038)*	*(0.039)*
	[0.038]	*[0.036]*	*[0.032]*		*[0.037]*	*[0.033]*	*[0.032]*
δ_1	1.727	1.727	1.727	δ_1	1.351	1.353	1.354
	(0.083)	*(0.083)*	*(0.083)*		*(0.084)*	*(0.084)*	*(0.084)*
	[0.077]	*[0.077]*	*[0.077]*		*[0.086]*	*[0.084]*	*[0.083]*
δ_2	-0.758	-0.758	-0.758	δ_2	-0.446	-0.447	-0.448
	(0.171)	*(0.171)*	*(0.171)*		*(0.107)*	*(0.107)*	*(0.107)*
	[0.174]	*[0.175]*	*[0.177]*		*[0.095]*	*[0.093]*	*[0.093]*
δ_3	-0.299	-0.299	-0.3	δ_3	-	-	-
	(0.17)	*(0.17)*	*(0.17)*		-	-	-
	[0.181]	*[0.181]*	*[0.185]*		-	-	-
δ_4	0.33	0.33	0.331	δ_4	0.095	0.095	0.094
	(0.083)	*(0.083)*	*(0.083)*		*(0.052)*	*(0.052)*	*(0.052)*
	[0.078]	*[0.077]*	*[0.078]*		*[0.047]*	*[0.047]*	*[0.047]*
α	0.034	0.035	0.035	α	0.05	0.05	0.05
	(0.021)	*(0.021)*	*(0.021)*		*(0.03)*	*(0.03)*	*(0.03)*
	[0.021]	*[0.021]*	*[0.02]*		*[0.033]*	*[0.032]*	*[0.032]*
ζ	-	-	-	ζ	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
γ	-	-	-	γ	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
σ_π	0.381	0.381	0.381	σ_π	0.535	0.535	0.535
	(0.024)	*(0.024)*	*(0.024)*		*(0.033)*	*(0.033)*	*(0.033)*
	[0.021]	*[0.021]*	*[0.021]*		*[0.033]*	*[0.032]*	*[0.032]*
μ_g	0.433	0.433	0.433	μ_g	0.433	0.433	0.433
Φ_g	0.997	0.983	0.434	Φ_g	0.996	0.973	0.363
	(0.002)	*(0.013)*	*(0.281)*		*(0.002)*	*(0.025)*	*(0.302)*
	[0.003]	*[0.028]*	*[0.364]*		*[0.005]*	*[0.045]*	*[0.333]*
σ_g	0.034	0.035	0.107	σ_g	0.034	0.037	0.093
σ^*	0.157	0.157	0.157	σ^*	0.157	0.157	0.157
μ_r	1.192	1.192	1.192	μ_r	1.142	1.142	1.142

Note: The figures in parentheses refer to the estimate of 2 standard deviations based on the Hessian matrix of the log-likelihood and the figures in square brackets refer to the estimate of 2 standard deviations based on the outer-product estimate of the information matrix.

Source: Author's calculations.

Table A2.6. Estimation results for the United Kingdom

	Price index: GDP deflator				Price index: CPI		
	θ=4	θ=10	θ=16		θ=4	θ=10	θ=16
Φ_z	0.954	0.95	0.945	Φ_z	0.955	0.955	0.954
	(0.022)	-	*(0.022)*		*(0.021)*	*(0.021)*	*(0.022)*
	[0.024]	-	*[0.025]*		*[0.024]*	*[0.023]*	*[0.023]*
β	0.011	0.033	0.046	β	0	0	0.017
	(0.021)	*(0.023)*	*(0.022)*		*(0.002)*	*(0.004)*	*(0.022)*
	[0.022]	*[0.023]*	*[0.022]*		*[848.613]*	*[41.272]*	*[0.023]*
σ_z	0.622	0.615	0.604	σ_z	0.622	0.622	0.62
	(0.042)	*(0.041)*	*(0.042)*		*(0.042)*	*(0.042)*	*(0.042)*
	[0.04]	*[0.047]*	*[0.056]*		*[0.039]*	*[0.039]*	*[0.046]*
δ_1	0.876	0.877	0.876	δ_1	1.215	1.215	1.253
	(0.068)	*(0.068)*	*(0.068)*		*(0.093)*	*(0.093)*	*(0.088)*
	[0.069]	*[0.069]*	*[0.068]*		*[0.091]*	*[0.091]*	*[0.081]*
δ_2	-	-	-	δ_2	-0.215	-0.215	-0.253
	-	-	-		*(0.093)*	*(0.093)*	*(0.088)*
	-	-	-		*[0.091]*	*[0.091]*	*[0.081]*
δ_3	0.124	0.123	0.124	δ_3	-	-	-
	(0.068)	*(0.068)*	*(0.068)*		-	-	-
	[0.069]	*[0.069]*	*[0.068]*		-	-	-
δ_4	-	-	-	δ_4	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
α	0.076	0.075	0.075	α	0.075	0.075	0.068
	(0.029)	*(0.029)*	*(0.029)*		*(0.022)*	*(0.022)*	*(0.021)*
	[0.032]	*[0.032]*	*[0.032]*		*[0.019]*	*[0.019]*	*[0.019]*
ζ	0.024	0.023	0.023	ζ	0.013	0.013	-
	(0.014)	*(0.014)*	*(0.013)*		*(0.01)*	*(0.01)*	-
	[0.016]	*[0.016]*	*[0.016]*		*[0.009]*	*[0.009]*	-
γ	-	-	-	γ	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
σ_π	0.792	0.792	0.792	σ_π	0.562	0.562	0.566
	(0.051)	*(0.051)*	*(0.051)*		*(0.036)*	*(0.036)*	*(0.036)*
	[0.048]	*[0.047]*	*[0.047]*		*[0.027]*	*[0.027]*	*[0.025]*
μ_g	0.624	0.624	0.624	μ_g	0.624	0.624	0.624
Φ_g	0.999	0.996	0.988	Φ_g	0.999	0.996	0.989
	(0)	*(0.002)*	*(0.006)*		*(0)*	*(0.002)*	*(0.006)*
	[0.001]	*[0.009]*	*[0.025]*		*[0.001]*	*[0.009]*	*[0.027]*
σ_g	0.036	0.037	0.039	σ_g	0.036	0.036	0.038
σ^*	0.177	0.177	0.177	σ^*	0.177	0.177	0.177
μ_r	2.352	2.352	2.352	μ_r	2.439	2.439	2.439

Note: The figures in parentheses refer to the estimate of 2 standard deviations based on the Hessian matrix of the log-likelihood and the figures in square brackets refer to the estimate of 2 standard deviations based on the outer-product estimate of the information matrix.

Source: Author's calculations.

Table A2.7. Estimation results for the United States

	Price index: GDP deflator				Price index: CPI		
	θ=4	θ=10	θ=16		θ=4	θ=10	θ=16
Φ_z	0.954	0.947	0.929	Φ_z	0.953	0.95	0.94
	(0.022)	*(0.022)*	*(0.024)*		*(0.023)*	-	*(0.024)*
	[0.025]	*[0.026]*	*[0.025]*		*[0.027]*	-	*[0.022]*
β	0.065	0.076	0.088	β	0.014	0.028	0.043
	(0.025)	*(0.025)*	*(0.027)*		*(0.026)*	*(0.026)*	*(0.027)*
	[0.024]	*[0.023]*	*[0.02]*		*[0.025]*	*[0.023]*	*[0.018]*
σ_z	0.794	0.786	0.765	σ_z	0.81	0.808	0.799
	(0.041)	*(0.041)*	*(0.043)*		*(0.042)*	*(0.042)*	*(0.042)*
	[0.032]	*[0.032]*	*[0.033]*		*[0.034]*	*[0.033]*	*[0.032]*
δ_1	1.339	1.338	1.337	δ_1	1.289	1.288	1.287
	(0.071)	*(0.071)*	*(0.071)*		*(0.069)*	*(0.069)*	*(0.069)*
	[0.064]	*[0.063]*	*[0.063]*		*[0.073]*	*[0.073]*	*[0.072]*
δ_2	-0.339	-0.338	-0.337	δ_2	-0.289	-0.288	-0.287
	(0.071)	*(0.071)*	*(0.071)*		*(0.069)*	*(0.069)*	*(0.069)*
	[0.064]	*[0.063]*	*[0.063]*		*[0.073]*	*[0.073]*	*[0.072]*
δ_3	-	-	-	δ_3	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
δ_4	-	-	-	δ_4	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
α	0.037	0.037	0.037	α	0.061	0.061	0.062
	(0.009)	*(0.009)*	*(0.009)*		*(0.019)*	*(0.019)*	*(0.019)*
	[0.009]	*[0.009]*	*[0.009]*		*[0.02]*	*[0.019]*	*[0.019]*
ζ	0.009	0.009	0.009	ζ	-	-	-
	(0.003)	*(0.003)*	*(0.003)*		-	-	-
	[0.003]	*[0.003]*	*[0.003]*		-	-	-
γ	-	-	-	γ	-	-	-
	-	-	-		-	-	-
	-	-	-		-	-	-
σ_π	0.314	0.314	0.313	σ_π	0.649	0.649	0.649
	(0.016)	*(0.016)*	*(0.016)*		*(0.032)*	*(0.032)*	*(0.032)*
	[0.016]	*[0.016]*	*[0.016]*		*[0.019]*	*[0.019]*	*[0.018]*
μ_g	0.745	0.745	0.745	μ_g	0.743	0.743	0.743
Φ_g	0.999	0.994	0.934	Φ_g	0.999	0.995	0.929
	(0)	*(0.003)*	*(0.039)*		*(0)*	*(0.003)*	*(0.051)*
	[0.002]	*[0.011]*	*[0.042]*		*[0.002]*	*[0.012]*	*[0.04]*
σ_g	0.025	0.027	0.054	σ_g	0.024	0.024	0.055
σ^*	0.213	0.213	0.213	σ^*	0.213	0.213	0.213
μ_r	2.702	2.702	2.702	μ_r	2.268	2.268	2.268

Note: The figures in parentheses refer to the estimate of 2 standard deviations based on the Hessian matrix of the log-likelihood and the figures in square brackets refer to the estimate of 2 standard deviations based on the outer-product estimate of the information matrix.

Source: Author's calculation.

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