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RESUME

Vi analyserer diskretionær finanspolitik i perioden 2004-2012 og sammenligner den faktisk førte finanspolitik med kontrafaktiske, regelbaserede alternative forløb. I Danmark er det finanspolitikken, der skal stabilisere fluktuationer i produktion og inflation, da pengepolitikken er bundet op på forsvaret af kronekursen over for euroen. Vi finder, at finanspolitikken i forløbet op til den seneste krise medvirkede positivt til efterspørgslen i økonomien, da konjunkturforløbet havde brug for det modsatte. Vi viser, at ifølge vores finanspolitiske regel, så burde finanspolitikken have været strammet med ca. 1½ pct. af BNP i hvert af årene 2006-08. Samtidig viser vi, at selv når vores analyse baseres på real tids data, der signifikant undervurderede størrelsen af overophedningen i disse år, så burde finanspolitikken have været betydeligt strammere. En strammere finanspolitik under opturen ville have gjort nedturen mildere og kortere og kunne have givet plads til yderligere lempelser, hvis det havde været ønsket.

ABSTRACT

We study fiscal policy in Denmark in the period 2004-2012 and compare the actual policy to counterfactual, rule-based alternatives. Given Denmark's fixed exchange rate towards the euro, it is the job of fiscal policymakers to stabilise fluctuations in output and inflation. However, we find that fiscal policy had the 'wrong sign' in the years leading up to the recent crisis, i.e. that fiscal policy contributed positively to the output gap when a contractionary policy was called for. In fact, our rule-based approach to fiscal policy would have prescribed a very substantial fiscal tightening by as much as 1.5 pct. of GDP in each of the years 2006-08. Furthermore, we show that even based on real-time data, which significantly underestimated the ongoing boom during those years, a substantial tightening of fiscal policy was called for. A tighter fiscal policy during the boom years would have helped Denmark avoid a large loss of competitiveness, thereby dampening and shortening the subsequent economic crisis in Denmark significantly, and could have made room for greater fiscal expansions during the crisis if desired.

A Taylor Rule for Fiscal Policy in a Fixed Exchange Rate Regime*

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June 2014

Abstract

We study fiscal policy in Denmark in the period 2004-2012 and compare the actual policy to counterfactual, rule-based alternatives. Given Denmark's fixed exchange rate towards the euro, it is the job of fiscal policymakers to stabilise fluctuations in output and inflation. However, we find that fiscal policy had the 'wrong sign' in the years leading up to the recent crisis, i.e. that fiscal policy contributed positively to the output gap when a contractionary policy was called for. In fact, our rule-based approach to fiscal policy would have prescribed a very substantial fiscal tightening by as much as 1.5 percent of GDP in each of the years 2006-2008. Furthermore, we show that even based on real-time data, which significantly underestimated the ongoing boom during those years, a substantial tightening of fiscal policy was called for. A tighter fiscal policy during the boom years would have helped Denmark avoid a large loss of competitiveness, thereby dampening and shortening the subsequent economic crisis in Denmark significantly, and could have made room for greater fiscal expansions during the crisis if desired.

JEL classification: E17, E32, E62, E65, F41.

Keywords: DSGE Models, Fiscal Policy, Fixed Exchange Rates, Real-Time Data.

*The views expressed in this paper are those of the authors, and do not necessarily correspond to those of Danmarks Nationalbank.

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1 Introduction

Fiscal policy has reassumed a central role in the international economic policy debate in recent years. With nominal interest rates at or close to their zero lower bound, fiscal policymakers across industrialised economies provided ample fiscal stimulus in the immediate aftermath of the recent crisis. In several countries, this was followed by fiscal austerity in the face of mounting sovereign debt concerns. In Denmark, however, with monetary policy devoted to maintain the fixed exchange rate towards the euro, discretionary fiscal policy never quite went out of fashion as an economic stabilisation tool.

In this paper, we review fiscal policy in Denmark during the period 2004-2012 through the lens of the estimated DSGE model described in Pedersen and Ravn [2013]. We begin with a general discussion of the role for fiscal policy in an economy with a fixed exchange rate. In the absence of a monetary policy rule to close the model and stabilise the rate of inflation, the currency peg assumes a role as the nominal anchor to which the economy must eventually return. In practice, this means that the price *level* in Denmark *relative* to that in the euro area is pinned down in the long run: Any temporary, relative increases in the Danish price level must be undone by a period of relative deflation, i.e. a period where the price level in Denmark grows at a slower rate than in the euro area. A similar requirement is faced by countries in a currency union, such as the member countries of the euro. This emphasises the importance of maintaining a low and stable inflation rate in order to avoid such potentially painful periods of relative deflation.

While this mechanism is sufficient to close the model and ensure long-run stability, it leaves room for stabilising the economy in the short and medium run. In Denmark, this room is filled by fiscal policy. Since the adoption of the fixed exchange rate in 1982, discretionary fiscal policy in Denmark has traditionally been conducted in a countercyclical and symmetric manner, as illustrated in figure (1). The years leading up to the recent crisis, however, represent a deviation from this practice, as the expansionary stance of fiscal policy contributed to or at least failed to counteract the 'overheating' of the Danish economy in the years 2005-2007. In other words, fiscal policy became asymmetric by stimulating the economy both in good times and in bad. This deviation, which was also pointed out in the so-called Rangvid-report on the causes of the financial crisis in Denmark, cf. Ministry of Business an Growth [2013], is the starting point of the present study.

We proceed with an analysis of how an alternative, systematic fiscal policy should have been conducted during the pre-crisis period, and how this would have affected the economic development in Denmark during the crisis. More specifically, we first compute a counterfactual interest rate as determined by a Taylor rule. Following Taylor [1993], this rule prescribes that the interest rate should be set with a view to stabilise the output gap around zero and the inflation rate around an inflation target. The implied 'Taylor rate' may thus be interpreted as a condensed measure of the business cycle situation at any given time. Many authors have computed counterfactual Taylor rates and used them as a benchmark against which to compare

actual monetary policy.[1] As an example, Taylor [2007] used such a comparison to argue that interest rates in the US were 'too low for too long' in the pre-crisis years. In the case of Denmark, however, given the fixed exchange rate, monetary policy can not be conducted through a Taylor-rule. Instead, as argued above, economic stabilisation must be obtained through other policies, in particular fiscal policy. This also applies to countries within a currency union. In our counterfactual experiment, we therefore set fiscal policy with the objective of stabilising the *implied* Taylor rate around its steady state, i.e. by tightening fiscal policy (cutting government spending and/or raising taxes) when the Taylor rate overshoots its steady state level, and vice versa. While a number of authors have previously studied rule-based fiscal policy, we are not aware of previous studies that use fiscal policy with the specific objective of closing the 'Taylor rate gap'.

Our results show that this rule-based approach to fiscal policy would have prescribed a substantial fiscal tightening by as much as 1.5 percent of GDP in each of the years 2006-2008. Not surprisingly, such a policy would have dampened the overheating and eased inflationary pressures. We demonstrate that if fiscal policy had been conducted according to our rule-based approach, the subsequent recession would have been much less severe, and, in particular, much more short-lived, as Denmark would have avoided a large loss of competitiveness. In addition, a tighter fiscal policy before the crisis could have made room for additional fiscal stimulus during the crisis, facilitating a faster economic recovery.

Our counterfactual analysis abstracts from various practical challenges associated with fiscal policy. As an example, fiscal policy works only with important implementation lags. While a systematic or rule-based approach to fiscal policy is likely to reduce these lags (in part because private agents may anticipate such systematic policy responses), this is a problem that in practice makes fiscal policy unsuitable for short-term economic fine-tuning. In addition, fiscal policy decisions are obviously based only on information available to policymakers at the time of the decision. This information set includes data that may be subject to substantial revisions, and economic forecasts which may not come true. As a result, one should be careful when evaluating fiscal policy decisions with the benefit of hindsight.

One approach to deal with such problems, which we take in the final section of this paper, is to base the evaluation of fiscal policy on the original 'vintage' data available at the time of each policy decision. Following Orphanides [2001], this *real time*-approach has been followed in a number of monetary policy studies, and more recently also in studies of fiscal policy (see Cimadomo [2011] for a survey). One general conclusion from this literature is that while fiscal policy is often found to be procyclical (or at least acyclical) in analyses based on *ex post* data, studies that employ real time (or *ex ante*) data find evidence of a countercyclical fiscal policy stance across a range of countries (see, e.g., Cimadomo [2012] or Bernoth et al. [2014]). This suggests that fiscal policymakers attempt to conduct a countercyclical fiscal policy, but that they are often not very successful, showcasing the perils of economic fine-tuning. In the case

[1] See Ravn [2012] for a recent example studying the case of Denmark.

of Denmark, we find little evidence of countercyclical fiscal policy even in real time during the period we consider. Rather, the results suggest that fiscal policy in the years leading up to the recent crisis was procyclical even when analysed with real-time data, and even more procyclical when ex post data is used. Based on real-time data, we find that fiscal policy had the 'wrong sign' in the years leading up to the crisis, i.e. that fiscal policy contributed positively to the output gap when a contractionary policy was called for. As an example, based on real-time accounts of economic activity, we find that fiscal policy in 2007 should have dampened economic activity by around 0.7 percent of GDP in order to avoid overheating and to curb inflation. This result illustrates that even without the benefit of hindsight, the economic situation in 2006 clearly called for a tightening of fiscal policy, as also pointed out at that time by Danmarks Nationalbank (see, e.g., Nationalbanken [2006]). More generally, our real-time analysis highlights the problems of using fiscal policy for economic fine-tuning, as the real-time accounts of economic activity and inflation, and hence the implications for fiscal policy, often differ quite substantially from their ex post counterparts.

The rest of this paper proceeds as follows. We briefly summarise the characteristics of the model in section (2), and then proceed with a discussion of stabilisation policy in section (3). The counterfactual scenarios and their economic consequences are described in section (4), while our real-time analysis is presented in section (5). Finally, we provide some concluding remarks in section (6).

2 Model Description

As already mentioned, our DSGE model for the Danish economy is presented in Pedersen and Ravn [2013]. We give only a brief account of some key features of the model here, and refer to that paper for a detailed outline. Denmark is modelled as a small open economy in the tradition of Gali and Monacelli [2005], and the model builds on previous work by, e.g., Adolfson et al. [2008] and Burriel et al. [2010]. We allow for trade with two different (and mutually independent) foreign economies of equal size; the euro area, towards which the Danish exchange rate is credibly fixed, and the rest of the world, towards which the exchange rate is floating.[2] As a result of the fixed exchange rate, we assume that the prevailing nominal interest rate in Denmark is given by the policy rate of the European Central Bank, which in turn is determined by a Taylor rule for the euro area, plus a country-specific risk premium which is increasing in the ratio of Danish foreign debt to GDP. We allow for imperfect exchange rate pass-through by introducing separate importing and exporting retail firms operating under monopolistic competition and facing sticky prices à la Calvo [1983].

The domestic economy features a range of real and nominal rigidities, including investment adjustment costs, habit formation, capital utilisation costs, sticky prices, etc. The labor market is modelled as in Galí et al. [2011], allowing households to act as wage-setters faced with a

[2] The size of each of the two foreign economies is in line with their trade-weights with Denmark.

nominal wage rigidity. In this way, the model incorporates involuntary unemployment. Finally, while there is no role for independent monetary policy, we include a range of fiscal policy tools including government spending, government investment (subject to decision and implementation lags), and taxes on labor and capital income, consumption, bond returns, and a lump-sum tax, which are adjusted to stabilise the ratio of government debt to GDP. We abstract from frictions in the housing and credit markets, and do not include a financial sector in the model.

The model is estimated using Bayesian techniques based on 23 macroeconomic data series covering the period 1990-2012.[3] We use 16 data series for the Danish economy plus the effective exchange rate towards the rest of the world, as well as 3 key macroeconomic variables (output, inflation, and the interest rate) for each of the two foreign economies, which are estimated separately. We include two trends in the model: a trend in total factor productivity and in investment-specific technology, allowing us to estimate the model without detrending the data.[4] The latter trend is included in the model to fit the observed decline in the relative price of investment goods. The historical shock decomposition is reported in figure (2), while other estimation results can be found in Pedersen and Ravn [2013].

3 Fiscal policy in DSGE models

The academic interest in discretionary fiscal policy received a comeback during the financial crisis with monetary policy rates hitting the zero lower bound. By discretionary fiscal policy, we mean temporary changes either on the revenue side of the public budget - changes in tax rates - or on the expenditure side - changes in public investments, public consumption or transfers. However, fiscal policy never really went out of fashion in Denmark, where it plays a key role in economic stabilisation policy due to the country's fixed exchange rate. In this section we will ask and try to answer a number of questions regarding fiscal policy and macroeconomic stabilisation for an economy with a fixed exchange rate regime. We will start out with the basic arguments behind macroeconomic stabilisation both inside and outside the DSGE framework. This will naturally lead to a discussion of rule-based as well as optimal monetary and fiscal policy. It also leads to a discussion of the importance of knowing which structural shocks have hit the economy. We start out with a theoretical discussion of how to stabilise an economy within a fixed exchange rate regime, an issue we already touched briefly upon in the introduction.

3.1 The role for fiscal policy in a fixed exchange rate regime

The main motivation behind a fixed exchange rate regime is to adopt the nominal anchor of the economy to which the currency is pegged. In a small open economy with a fixed exchange rate,

[3] In addition, we include Danmarks Nationalbank's economic forecast from 2012 for the years 2013-2015 so as to mitigate end-point problems related to the estimation of the underlying trend growth rate.

[4] Important exceptions from this rule are the foreign variables, as we do not estimate the growth rates of the foreign economies. Also, we remove the sample growth rate differentials between the exports and imports variables and Danish GDP.

monetary policy is dedicated to maintaining the currency peg. From a model perspective, this implies a lack of a monetary policy rule to ensure a determinate equilibrium. From a policy perspective, it implies that monetary policy can not be used to stabilise the business cycle.

Suppose the domestic and the foreign economy (to which the domestic currency is pegged) are expected to grow at the same underlying growth rate in the long run, and that the domestic economy is too small to affect the foreign economy in any significant way implying i.e. that prices in the foreign economy are unchanged in response to shocks from the domestic economy. In that case, what ensures a determinate equilibrium is the requirement that the relative price *level* in the domestic economy *relative* to the foreign economy must stay constant in the long run.[5] In other words, the terms of trade must be constant in the long run. If this was not the case, the domestic country would suffer a constant loss/gain of competitiveness, with a resulting continuous loss/gain of exports. Besides relative price deflation stemming from as an example lower wage growth or outright falling nominal wages, the domestic firms have two other and possibly harder options: To increase productivity or to enhance competition in the sector. As an example, in a model with monopolistic competition firms set their price as a markup over marginal costs. The markup depends on the structure of the economy including the degree of competition. Marginal costs are a function of wages and the marginal productivity of labour. Hence, competitiveness can be regained by enhancing competitition in the economy through structural reforms, i.e. to lower the markup, or by increasing producitivity. The bottom line is that any temporary increase in the domestic country's rate of inflation vís-a-vís the foreign country must be followed by a period of lower inflation; or *relative deflation* - bygones can not be bygones in a fixed exchange rate regime. Such a deflationary period can be painful if inflation in previous periods was relatively high or if there are strong nominal rigidities in the economy.

Figure (3) may help to understand the theory and its implications. We show the impulse response function for public consumption, G_t, in the DSGE model we apply to our analysis in this paper, see Pedersen and Ravn [2013]. We plot the response of inflation (PPI), export and GDP from a shock to G_t. We normalise the shock to 1 pct. of GDP so that the effects can be treated as fiscal multipliers for inflation, export and GDP, respectively. We refer to Pedersen [2012] for a treatment of the effects of fiscal policy within the DSGE framework in general and in small open economies in particular. Here we only give an overview with a focus on the firm side. GDP increases by approximately 0.7 in the first quarter, but is rapidly crowded out through a decline in exports and lower consumption (not shown). After 4 quarters the increase in government spending has caused a mild but long-lasting period with relatively low growth until the price *level* is back to its steady state value. The mechanisms behind this multiplier are as follows. The extra demand coming from the extra public consumption results partly in

[5] Strictly speaking, this condition is not sufficient to ensure a determinate equilibrium. In a small open economy there is also a need to ensure that domestic consumers can not borrow indefinitely in the international bond market and consume the proceeds. As an example, this can be ensured by introducing a risk premium on the risk free rate of interest which is increasing in the debt to GDP ratio, see also Schmitt-Grohé and Uribe [2003]. This assumption is used in the model we use in this paper, see also Pedersen and Ravn [2013].

extra production as some firms can not change (increase) their prices due to the assumption of sticky prices, resulting in lower margins. This gives rise to a suboptimal relationship between prices and marginal costs as seen from the firms' perspective, increasing the price pressure in the economy. In sum, production increases in the short run, while inflation picks up over time as more and more prices are adjusted. The higher prices implies that firms have lost competitiveness vís-a-vís their trading partners. The consequence of this is a crowding out through lower exports and higher imports (not shown in the figure). When firms reoptimise their prices they look not only at their current marginal costs but also at their expected future marginal costs, as they may again find themselves unable to change their price in the future. Observing that they have lost competitiveness, i.e. that they face relatively lower demand, they lower their prices and slowly regain competitiveness.

To summarise, figure (3) shows that the shifting of demand through time via public consumption has the consequence that inflation must be met one-for-one by future deflation or relative lower deflation. The crowding out mechanism works via changes in the terms of trade and consequently imports and exports. In the end, there is no free lunch: All expansionary shocks (fiscal or not) which increase inflation must be met by a period of depressed economic activity and falling (relative) prices, as the terms of trade must return to its nominal anchor - the foreign price level.

This line of reasoning implicitly involves some assumptions that are built into the DSGE model we use in this study, for example that all goods are traded across borders, such that the terms of trade are equivalent to the real exchange rate; that the foreign and domestic economies share the same underlying growth rate etc. We want to stress another key assumption: The model consists of forward-looking agents (firms and households) with model-consistent expectations. In addition, the currency peg is assumed to be 100 pct. credible. The agents can therefore precisely calculate by how much prices must fall after an inflationary expansion. As a result, firms therefore dampen their initial price increases, as they know that they must lower their prices later on. Relaxing these assumptions will change the picture in figure (3).

We stress two further points. Firstly, while a fixed exchange rate regime thus appears to impose quite strong requirements on the economy, this is exactly the point: It provides the economy with a nominal anchor by adopting a credible monetary policy regime. Secondly, a fixed exchange rate regime is not a substitute for structural reforms aimed at maintaining an underlying growth rate in line with that of the foreign economy without leading to inflationary pressures. This is a necessary requirement for a succesful currency peg in the long run.

We have argued that expansionary fiscal policy implies quite strong costs in terms of future relative deflation, and that this mechanism is sufficient to close the model and ensure long-run stability. Nevertheless, we have in the sections above not ruled out a role for stabilising the economy in the short and medium run in a fixed exchange rate regime. But how should policymakers do so and which motivations should drive them? In the following, we discuss the motivations behind macroeconomic stabilisation both inside and outside DSGE models,

drawing on the large literature on optimal monetary policy.

3.2 Macroeconomic stabilisation policy in a DSGE model

What is the scope for macroeconomic stabilisation policy? This is a complex topic and we do not aim for an in-depth exposition, but only discuss some main issues. A 'standard' or New-Keynesian DSGE model, such as the one used in this study, usually features monopolistic competition and nominal rigidities. These distortions give rise to inefficient outcomes which may call for stabilisation policy. Besides these distortions, the models typically contain a host of frictions like investment adjustment costs, capital utilisation costs etc., but these features are only included to help the model fit the empirics while allowing the model-builder to stick with optimising agents and equilibria determined through markets.

Monopolistic competition leads to prices which are set above marginal costs on the firm side and wages set too high in the labour market. This clearly leads to a distorted allocation of resources and thus production. But neither monetary policy nor discretionary fiscal policy should combat inefficiencies due to monopolistic competition; only structural reforms can mitigate these distortions.

On the contrary, nominal rigidities is a source of inefficiency that may be relieved through monetary or fiscal policy; see e.g. Galí [2009]. When firms are unable to adjust their prices continuously, the economy will either produce too much or too little compared to the efficient outcome. Furthermore, infrequent adjustment of prices leads to inefficient relative prices. In both cases the infrequent adjustment means that the prices lose their role as the provider of information to firms and households of the relative scarcity of various goods and the costs associated with producing and consuming these goods. These inefficiencies are the main, and sometimes only, motivation behind macroeconomic stabilisation within these type of models. If there are no nominal rigidities, then there is no role for economic stabilisation policy in these models as in that case, we are left with a Real Business Cycle model, in which the responses to economic shocks are efficient and hence leave no room for economic policy, see e.g. Kydland and Prescott [1982].

Households in DSGE models usually prefer to have a smooth path for their consumption over time. However, in many DSGE models, (a subset of) the households in the economy are faced with credit or liquidity constraints (see, e.g., Iacoviello [2005] or Galí et al. [2007]). In the presence of such impediments to consumption smoothing, economic fluctuations may give rise to unpleasant fluctuations in consumption over time, creating an additional motivation for stabilisation policies. The model used by Pedersen and Ravn [2013], however, does not include such frictions.

An often-cited motivation for macroeconomic stabilisation policies that is usually not included in DSGE models is so-called hysteresis both in the labour and capital markets. Consider as an example an unsustainable boom in house prices. The boom leads to increases in residential investments and to an inflow of workers to the construction sector. These workers might

then acquire skills that are in low demand after the boom, and may therefore need additional training to find new jobs after the bubble has burst. Likewise, physical capital used in housing construction may be hard to apply to other sectors. The story fits well with what has happened in countries like Spain and Ireland during the 2000's. Stabilisation policy can in such circumstances combat the boom, and thus mitigate investments in housing capital and the flow of workers into the construction sector, thereby easing the pain after the burst and perhaps preventing that the depreciated (physical and human) capital depresses the structural growth rate in the economy.

3.2.1 Monetary stabilisation policy in a DSGE model for the closed economy

In the previous section we discussed the motivations behind stabilisation of business cycles. In this section we discuss how this should be done within our model framework. In the most basic versions of the New Keynesian model, it is often assumed that monetary policy is conducted through changes in the short-term interest rate. The central bank is assumed to set its policy according to a simple monetary policy rule like the Taylor rule, see Taylor [1993]:

$$i_t = \overline{r} + \pi_t + \phi_\pi \left(\pi_t - \pi^*\right) + \phi_x x_t, \tag{1}$$

where we denote the monetary policy rate by i_t, the natural (or steady state) real interest rate by $\overline{r}$, inflation by π_t, the inflation target by π^*, and the output gap by x_t, and where ϕ_π and ϕ_x define how the policy rate is adjusted in response to changes in inflation and the output gap. The output gap is the difference between actual output and the output that would prevail in a model without nominal rigidities, which in the literature is called natural output. To avoid confusion with other measures of output gaps such as those computed from an HP-filter, or semi-structural measures as in Andersen and Rasmussen [2011], we denote this gap the DSGE-based output gap. Observe that in steady state, the Taylor rate equals the sum of the natural real interest rate and the steady state inflation rate. We assume that both of these are 2 percent per year, implying a Taylor rate of 4 percent. Equation (1) is sometimes extended to involve interest rate smoothing:

$$i_t = \rho_i i_{t-1} + (1 - \rho_i)\left(\overline{r} + \pi_t + \phi_\pi \left(\pi_t - \pi^*\right) + \phi_x x_t\right), \tag{2}$$

in which $\rho_i > 0$ determines the degree of smoothing. Interest rate smoothing is included to reflect that central banks usually only change their policy rate gradually in response to economic fluctuations.[6]

The advantage of this type of policy rule is that it is relatively simple to implement, as it does not require knowledge of the exact form of the shocks, parameters in the model etc.

[6] In addition, the reaction to current inflation π_t is sometimes replaced by a reaction to expected future inflation $E_t\pi_{t+1}$. Further changes to the Taylor rule, which may include reactions to exchange rates, asset or house prices are not treated here.

It is consequently often argued that a Taylor rule is a reasonable approximation of the way monetary policy is actually conducted, as well as mimicking 'optimal' monetary policy, as we explain next.[7]

Gerdesmeier et al. [2007] discuss some of the limitations of the Taylor rule. In particular, they point out, firstly, that by only considering (in the simplest form of the rule) the current inflation rate and output gap, a lot of information is ignored that could in principle be relevant for monetary policymakers, such as, for example, financial factors, exchange rates, or inflation and output forecasts. We will in what follows partly overcome this criticism by considering also the forecast of the output gap and inflation in the exercises we perform. Secondly, while different types of shocks (e.g., supply or demand shocks; transitory or permanent shocks) may warrant different policy reactions, this is not allowed for by the Taylor rule. We will discuss this in section (3.2.3).

In order to study optimal stabilisation policy, a loss function needs to be defined. In the literature, this function is typically derived from the representative consumer's utility function, and is therefore a *welfare* loss function. The welfare loss depends on the output gap and inflation, with weights determined by the structural parameters of the model. The reason why welfare depends on the output gap is that this is directly related to the availability of resources for consumption, from which agents derive utility, and of which they dislike fluctuations due to the consumption smoothing motive, as already discussed. The reason why it depends also on inflation is that price distortions are inefficient, as described above. The loss function depends on these two variables, and so does the Taylor rule. In other words, the Taylor rule may under some circumstances be considered an approximation to the optimal policy rule, with the parameters in the Taylor rule (ϕ_π and ϕ_x) set appropriately. This usually involves a strong policy reaction to inflation; a relatively high value for ϕ_π.[8] An implication of these insights is that a narrow focus on the output gap in economic stabilisation policy is not desirable. As a consequence, we will take a balanced approach between stabilising the output gap and stabilising inflation when we design our rule-based alternative fiscal policy in the next sections.

3.2.2 Stabilisation policy in a small, open economy with a fixed exchange rate: What we do

As already described, in an economy with a fixed exchange rate the monetary policy tool is dedicated to maintaining the currency peg, and can therefore not be used for stabilisation policy. This leaves fiscal policy as the main stabilisation tool. Many of the insights from our previous discussion of monetary policy may be applied to fiscal policy in that case. The benefit is that it provides a precise and welfare-based measure of optimal policy. It also provides a method to

[7] We refer to as an example Woodford [2003] or Galí [2009] for an in-depth treatment of optimal monetary policy.

[8] In particular, the so-called Taylor principle, which is necessary for the monetary policy rule to deliver a determinate equilibrium, requires that the central bank should raise the nominal interest rate more than one-for-one in response to an increase in inflation (i.e. that $\phi_\pi > 0$), so as to obtain an increase in the real interest rate.

minimise the welfare loss through the parameters ϕ_π and ϕ_x subject to the constraint that the policy rule is of the form in equation (1) or (2).

We build on the above analysis and aim at conducting fiscal policy through a Taylor rule. To this end, we include an artificial Taylor rule in our model, the only role of which is to provide a signal about the difference between the actual policy rate in Denmark (which largely follows that of the ECB) and the 'Taylor rate', which, in light of the discussion above, we take as a proxy for the 'optimal' policy rate. We will then try to limit or close this gap, which we will denote the *Taylor rate gap*, by setting a counterfactual path for discretionary fiscal policy.

In what follows we do not use the DSGE-based output gap, x_t. Instead, we follow Pedersen and Ravn [2013] and analyse the deviations of actual output from its trend, so as to facilitate comparison between the analysis in that paper and other studies of fiscal policy in Denmark.[9] Furthermore, we do not derive a welfare-based loss function for the main reason that it is a tedious and complex task for a large-scale DSGE model such as the one used here. As a result, we do not search for 'optimal' values of the policy parameters, ϕ_π, ϕ_x and ρ_i, but instead rely on existing (estimated or calibrated) values. Instead, what we do is to minimise the Taylor rate gap using discretionary fiscal policy, taking the parameters of the Taylor rule as given. We set the following parameter values: $\phi_\pi = 1.25$, $\phi_x = 0.25$, $\rho_i = 0.5$. The values of ϕ_π and ϕ_x are slightly different from those originally proposed by Taylor [1993] so as to give a slightly higher relative concern to fluctuations in the output gap relative to inflation fluctuations. The value of the smoothing parameter is somewhat lower than the value of 0.79 estimated by Clarida et al. [1999], as the necessity for policy smoothing is less urgent for fiscal than for monetary policy due to the inherent lags of fiscal policy discussed above.[10] While we do not perform any robustness checks with alternative values of these parameters, the evidence in Ravn [2012] suggests that the Taylor rate is not overly sensitive to moderate variations in the parameter values.

Finally, it should be noted that due to the different characteristics of fiscal and monetary policy, these are not perfect substitutes for each other. For instance, monetary policy can in practice be adjusted much faster than fiscal policy in the face of economic shocks. We attempt to address some of these differences in section (5). Nevertheless, we are aware that the institutional characteristics of fiscal policy render a rule-based approach much more difficult in practice than is the case for monetary policy. While we abstract from this in the following analysis, these are considerations that should be kept in mind when interpreting our results.

[9] The model we use in the paper does contain a DSGE-based output gap. We will postpone the analysis of this gap to future work. We believe that using the DSGE-based output gap for our current purposes would have led to similar conclusions, at least from a qualitative perspective.

[10] While the higher weight on output gap fluctuations tends to overstate the need for contractionary policy during the boom, the lower value of the smoothing parameter has the opposite effect.

3.2.3 Different shocks, different policy responses

In this subsection, we return to the question of stabilisation and the discussion about the output gap as the only signal of an 'overheated' economy which must be 'cooled down' through stabilisation policy. We define an overheating as a situation in which price and wage inflation are driven above their 'natural' or sustainable levels as a result of above-average economic activity. The many structural shocks in the DSGE framework can generally be divided into three groups: Supply shocks (e.g. productivity shocks), demand shocks (e.g. government spending shocks), and markup shocks (e.g. shocks to the difference between prices and marginal costs and hence the degree of competition in the economy).[11] These types of shocks have different effects on the output gap and inflation. A positive demand shock increases both the output gap and inflation, as illustrated in the case of government spending shocks in figure (3). A temporary positive productivity shock, on the other hand, puts downward pressure on prices but tends to increase the output gap. Intuitively, the increase in productivity enables the firms to increase production at an unchanged level of marginal costs. Output increases above its trend due to the expansion of the production possibilities. Hence, the trend-based output gap increases while inflation drops.[12] A positive markup shock works its way through the model more or less in the same way as a supply shock, but with the opposite sign: Inflation increases and the output gap decreases.

In turn, different types of shocks call for different policy responses. A positive demand shock leads to increases in the output gap *and* inflation and therefore naturally calls for contractionary demand management policies. But since both markup shocks and productivity shocks drive the output gap and inflation in different directions, it is not obvious how demand-management policies should respond to these shocks; there is a trade-off. In such cases, the optimal response generally depends on the model and the economy, although the theory about optimal stabilisation policy discussed above points to a relatively higher degree of inflation stabilisation (Galı et al. [2003]). In other words, stabilisation policies should accomodate positive productivity shocks and let output increase, which in itself will combat the drop in inflation over time. These differences underline the importance of identifying the fundamental drivers of the business cycle especially if policymakers wish to stabilise the output gap and inflation.

In Pedersen and Ravn [2013] the output gap was decomposed into these types of structural shocks, see figure (2). That analysis suggested that shocks to the supply side may have played a more important role during the pre-crisis boom in Denmark than previously thought, possibly due to an inflow of foreign workers. The years leading up to the recent crisis were characterised by a boom in output without an associated rise in inflation, as evidenced, for instance, by

[11] The markup shocks change the difference between natural output and efficient output. Efficient output is the output that would prevail if goods and labour markets were perfectly competitive implying that prices and wages are fully flexible, and in the absence of imperfect competition. Natural output is the output that would prevail if prices and wages were fully flexible.

[12] Note that the definition of the output gap is central for this result. For example, the DSGE-based output gap drops in response to a technology shock, as natural output increases faster than actual output due to nominal frictions.

the quarterly growth rates in Danish producer prices. Danish inflation took off only during the final part of the boom, i.e. from the second half of 2007 and onwards.[13] This resembles closely the effects of a supply shock as discussed in the previous paragraphs. In light of this, it is perhaps less surprising that the decomposition ascribed a substantial part of the boom in output to factors originating on the supply side. From a DSGE-perspective, productivity and capacity shocks during the build-up to the financial crisis in Denmark should not be interpreted as having contributed to the overheating of the Danish economy. Rather, according to the historical shock decomposition in Pedersen and Ravn [2013] the actual overheating of the Danish economy during these years may have been smaller than previously thought, as the economy seems to have been able to expand also potential production during that period. In other words, the size of the output gap was not equal to the size of the overheating.

In light of the above discussion, an optimally designed fiscal policy should thus not have aimed at counteracting the part of the pre-crisis boom that can be ascribed to technology shocks. Nevertheless, in order to allow comparison with other studies of the Danish economy, which are typically not based on DSGE models, we seek in the next section to design a fiscal policy that aims at closing the output and inflation gaps without taking the type of structural shock into consideration. Our results should therefore be interpreted with this caveat in mind.

4 Counterfactual analysis of fiscal policy during the 00's

In what follows we abstract from the practical problems involved in the conduct of fiscal policy: Timing, information, decision lags, etc. In other words, we assume that policy makers have complete information about the economy in particular about the size of the output gap, that there are no implementation lags in the conduct of fiscal policy, and no information lags with regards to data. In the next section, we relax these assumptions and look at discretionary fiscal policy in real-time. For now, we also abstract from the fact that the level of government spending is not necessarily an appropriate tool for economic stabilisation policy, as discussed, e.g., by the Ministry of Finance [2014], since the level of government spending is also a reflection of political preferences about what types of services the public sector should provide. In the final scenario, we use other fiscal policy tools along with government spending to make up for this shortcoming.

We address the way fiscal policy was conducted in the period from 2004 to 2012. That is, we address the political decisions taken during this period and the consequences for the economy and especially for how the Danish economy made it through the crisis. In what follows, we use the model in Pedersen and Ravn [2013] and change the way fiscal policy was conducted. That is, we substitute the block of shocks we ascribed to fiscal policy in the historical shock decomposition of the output gap from Pedersen and Ravn [2013], shown in figure (2), with another set of shocks; a counterfactual analysis. We consider the period 1^{st}quarter of 2006 to

[13] Even then, part of the increase in inflation was driven by a global rise in food and energy prices.

3^{rd}quarter of 2008 or 4^{th}quarter of 2012 depending on the scenario. We start in 1^{st}q. 2006 as this is where there is clear evidence of a positive output gap. In scenario (1) we stop in the 3^{rd}q. 2008 when Lehman Brothers went bankrupt. Danish GDP dipped beforehand but the acceleration occured after the collapse of Lehman. It is obvious that we can conduct counterfactual policy in an infinite number of ways, and we hence stick to all in all 3 analyses:

1. Public consumption only; 1^{st} q. 2006 - 3^{rd} q. 2008
2. Public consumption only; 1^{st} q. 2006 - 4^{th} q. 2012
3. All available fiscal instruments (tax on labour income, consumption and capital, and public consumption); 1^{st} q. 2006 - 4^{th} q. 2012

We note that we did not include a value-added tax (VAT) and capital taxes in our analysis in Pedersen and Ravn [2013]. We do, however, include these instruments in this analysis such that we have a wide range of instruments to use in scenario (3).

A necessity in the DSGE-model framework is debt stabilisation. Again, we have a range of choices and in what follows we stabilise debt through a mixture of lump sum taxes, which reacts to deviations of the public debt from its steady state (45 pct. of GDP) the period before with an elasticity of 0.5, and public spending reversals, which reacts to deviations of the public debt from steady state 5 years after with an elaticity of 0.05.

We set the respective fiscal instruments (or the combination thereof) such that the Taylor rate returns to its steady state value over the medium term, i.e. a situation in which the output gap and the inflation gap are closed. That is our definition of 'optimal' fiscal policy with the caveats discussed in section (3). As already mentioned, we do not consider which types of shocks that have hit the economy. We simply aim for closing both the output gap and the inflation gap using discretionary fiscal policy, see also the discussion in section (3). Also, we do not attempt to fine-tune the economy on a quarterly basis, but aim for a smooth development in discretionary fiscal policy over the period considered. In scenarios (2) and (3) we furthermore impose the constraint that public debt in percentage of GDP in the 4^{th}q. 2012, when we terminate our counterfactual analysis, is back at the level it had 1^{st}q. 2006, when we start our counterfactural analysis. In what follows we will focus on the output gap, inflation (as measured by producer prices), the Taylor interest rate and public debt.

4.1 Scenario (1): Using public consumption to combat the boom in the Danish economy

4.1.1 Setting up the scenario

The only instrument we use in scenario (1) is public consumption of goods and services, G_t. In the model we do not explicitly have public production but we calibrate the steady state of G_t, which contains both public production and consumption of goods and services, to equal its

average over the sample period of 26 pct. of GDP. We start the counterfactual analysis 1^{st}q. 2006 and end it 3^{rd}q. 2008 That is, we substitute the sequence of structural shocks related to G_t in the historical shock decomposition of the output gap with a sequence of shocks which we determine and look at the consequences for the model economy. We determine this sequence such that the Taylor interest rate is brought to its steady state of 4 pct. over the medium term. After the 3^{rd}q. 2008, we let fiscal policy return to its actual path. This has the advantage that what happens in the model economy *after* 3^{rd}q. 2008 can be attributed *solely* to the repercussions of the alternative fiscal policy conducted from the 1^{st}q. 2006 until 3^{rd}q. 2008.

We show in figure (4) the actual output gap and the output gap in the counterfactual scenario. The Danish economy was booming from, according to our model, early 2005 to late 2008, see also the discussion in the introduction. That is, the output gap was clearly positive and inflation above target, as seen in figure (5(a)), though not by much. This situation would call for a contractionary fiscal policy. As also discussed in the introduction, this was not what the government pursued during that period: Discretionary fiscal policy was either slightly expansionary or neutral, but not contractionary, whether measured by the fiscal effects or the historical shock decomposition shown in figure (2). Before we comment on the effects of the counterfactual policy we first explain and show the counterfactual shocks.

What we aim for in the counterfactual is to close the output gap quite quickly and then counteract aggregate demand during the rest of the scenario. The resulting course for G_t as a percentage of GDP is a fairly large initial drop followed by a sequence of smaller shocks pushing G_t as a percentage of GDP from 26 pct. down to 11 pct., as can be seen from figure (5(b)). This is clearly not a realistic scenario. We will later adress whether the relationship between the course for G_t and the output gap makes sense within the model, while we analyse more realistic discretionary fiscal policies, in which both the expenditure side and the revenue side of the public budget are used to combat the large output gap, in scenario (3).

Our objective function, the Taylor rule for fiscal policy, is shown in figure (5(c)) together with its steady state level, the 'actual' Taylor rate, and the actual Danish monetary policy rate.[14] The boom in the Danish economy can clearly be seen in the figure in the form of a Taylor rate of around 9 pct. at its peak. This implies, as explained in section (3), that the monetary policy rate in Denmark should have been around 9 pct. in order stabilise the output gap and inflation, while in fact it was only around 4 pct. as its peak. The counterfactual discretionary fiscal policy aims at closing this gap. This is a big discrepancy and helps to explain the necessity of the large shocks for G_t shown in figure (5(b)). The sharp contrationary fiscal policy in the counterfactual scenario implies a brief undershooting of the interest rate, as can be seen from figure (5(c)). The subsequent course for G_t implies that the Taylor rate is close to though above its steady state. After the Lehman collapse, and hence after our counterfactual sequence of shocks ends, the Taylor rate falls sharply, though it does not become as low as the 'actual' Taylor rate. That difference can be attributed solely to a better way of conducting

[14] The Taylor rate is by construction an artificial variable, and there does not exist an actual Taylor rule. We use the term 'actual' to denote the Taylor rate computed from the actual series for output and inflation.

discretionary fiscal policy where the word 'better' must be seen with regards to our framework of stabilising a Taylor rate.

The effects of the counterfactual sequence of fiscal policy shocks in a historical shock decomposition of the Danish output gap are shown in figure (6(a)). These effects can be interpreted as multiperiod fiscal effects.[15] The first column in the first quarter 2006 is around -2.75 pct., which means that discretionary fiscal policy in that quarter contributed by -2.75 percentage points to the counterfactual output gap. We will discuss this number in greater detail in what follows so as to establish a link between the effects of fiscal policy, the fiscal multiplier in the model we use, and the course of G_t shown in figure (5(b)). The quarterly fiscal effects illustrated in figure (6(a)) amount to annual effects of around or slightly above 1.5 in each of the years 2006-2008, as also shown in figure (20).[16] In other words, these results indicate that fiscal policy should have been tightened by as much as 1.5 percent of GDP in each of these years, i.e. a very tight stance of fiscal policy. Finally, note that the effects from discretionary fiscal policy in the actual scenario are equal to the counterfactual after 3^{rd} quarter 2008 by construction.[17]

4.1.2 Economic consequences of the counterfactual fiscal policy

We now turn our attention to the effects of the countercyclical policy on the output gap. We already noticed that in the counterfactual analysis the output gap is a lot smaller and close to zero in some years. We also observe in figure (4) that the drop in the output gap following the collapse of Lehman in 2008 is a lot smaller in the counterfactual scenario, and that the crisis is much more shortlived. The difference between the output gaps in the two scenarios after the end of the counterfactual analysis in 3^{rd} q. 2008 can be attributed solely to differences in the conduct of discretionary fiscal policy in 2006-2008 in the two scenarios.

What can explain this pattern? We show the model's fiscal multiplier in figure (7(a)). In the model we use in this study, the effect of an increase in G_t equivalent to 1 pct. of steady state GDP implies an increase in GDP of approximately 0.7 pct. in the first quarter. In the figure, we also show the effects on aggregate private demand from the increase in G_t to get a picture of the crowding-out. Already in the second quarter, the multiplier is down to a half and after 4 quarters it is zero. Hence, the model implies quite strong crowding-out.[18] We refer to both Pedersen and Ravn [2013] and Pedersen [2012] for an in-depth analysis of the effects of expansionary fiscal policy within the DSGE framework in general and in the model we use in this analysis in particular.

[15] We translate the Danish term "finanseffekter" to fiscal effects, and the Danish term "flerårige finanseffekter" to multiperiod or multiannual fiscal effects.

[16] To be exact, figure (20) shows the yearly fiscal effects from scenario (2). However, while the composition of fiscal policy differs between scenario (1) and (2), the implied fiscal effects are the same.

[17] Observe that this is obtained by adding fiscal stimulus so as to neutralise the overhang from the contractionary fiscal policy during the counterfactual scenario.

[18] The strong crowding out in the model used in this paper can partly be attributed to a relative export price elasticity of around 15. While this value can be regarded as quite high, the estimated model does fit both data and impulse responses from structural VARs quite well, see also Pedersen and Ravn [2013].

To get a picture of the effects of the quite strong contractionary fiscal policy in the counterfactual analysis, we decompose the quarter-to-quarter growth rate in GDP in public demand and private demand. This is done in figure (6(b)) for the actual course, the counterfactual in figure (6(c)), and the difference between the figures in figure (6(d)). We note that the quarter-to-quarter growth rates are not very different in the two scenarios; the closing of the output gap is done in the first quarter of the counterfactual scenario. But the effects from private and public demand are a lot stronger in the counterfactual scenario. That is due, clearly, to the strong contractionary fiscal policy shocks but also to the strong crowding in and quite rapid decrease in the effects of fiscal policy on the output gap shown in (7(a)). We also point to the quite strong expansionary fiscal policy after the 3^{rd} quarter 2008. But this does not imply that fiscal policy is more expansionary in the counterfactual analysis, as shown in figure (6(a)). A 'sanity check' of the size of the shock to fiscal policy can be deducted from the first quarter in the counterfactual scenario. As noted above, the fiscal effect in figure (6(a)) in that quarter is -2.75. From figure (6(d)), public demand (i.e., government spending) falls by -4 pct. which is almost equal to the full effect in the counterfactual analysis, as actual discretionary fiscal policy in that quarter was almost neutral. The difference between private demand in the actual and counterfactual scenario is around 1.5 pct. Taken together this complies quite well with the fiscal multipliers: $\frac{2.75}{4} \approx 0.69$, $\frac{1.5}{4} \approx 0.38$.

4.1.3 Concluding remarks to scenario (1)

Our counterfactual fiscal policy calls for a very substantial tightening of fiscal policy in the years before the crisis. The fiscal effects in the counterfactual scenario are comparable to the fiscal effects the Danish economy experienced in the 1980's. The resulting dampening and shortening of the economic crisis can be attributed to the model's endogenous response to the smaller positive output gap before the crisis with consequently lower price- and wage-inflation in that period. As an example, consider again inflation in producer prices in the actual and counterfactual scenarios in figure (5(a)). The contractionary fiscal policy shocks imply that inflation is lower in the counterfactual scenario during the boom, and drops by less after the collapse of Lehman. Hence, Danish producer prices were relatively lower in the counterfactual scenario at the onset of the financial crisis, contributing to better export performance through an enhanced competitiveness of Danish producers.

In short, the way scenario (1) is set up implies that all differences between the output gaps in the factual and counterfactual courses can be attributed to differences in the conduct of fiscal policy during the period 1^{st}q. 2006 to 3^{rd}q. 2008. The 'cost' of having conducted the actual discretionary fiscal policy is that the output gap was between 1 and 2 percentage points of GDP lower during 2009 and 2010 than it would have been with a different fiscal policy. However, it is also clear that the area between the output gaps in the period before the boom, that can be thought of as the cost of stabilisation in terms of output, is bigger than the difference between

the output gaps during the slump, which can be thought of as the benefit of stabilisation.[19] But in scenario (1) we do not conduct discretionary fiscal policy according to our Taylor rule for fiscal policy after 3^{rd} q. 2008. As shown in figure (5(d)), the contractionary fiscal policy during the boom creates a room for expansionary fiscal policy during the bust. In other words, fiscal policymakers could have provided additional stimulus, had they wanted to, without a higher debt ratio in the longer run compared to the actual debt level. In scenario (2), we explore the implications for the output gap of conducting discretionary fiscal policy throughout 2012 according to our Taylor rule with the extra constraint that the debt ratio in the end of 2012 is back to its 2006 level. Lastly, we have also shown that stabilisation of the output gap during the build up to the financial crisis required large - possibly too large - contractionary shocks to G_t though the fiscal effects are not extremely large compared, e.g., to the austerity measures taken by the Danish government in the early 1980's, cf. figure (1). Also, it should be kept in mind that the positive output gap during the build up to the financial crisis was the largest in our sample, and the subsequent bust and the corresponding negative output gap was also the 'most negative' in our sample. Hence, in 'normal' times it is perhaps possible to close the Tayor-rate gap using more realistic adjustments in G_t.

4.2 Scenario (2): Using public consumption to combat the boom and the bust in the Danish economy

In this scenario we use the Taylor rule for counterfactual fiscal policy during the entire period 1^{st}q. 2006 to 4^{th}q. 2012. That is, we continue our counterfactual course after the outbreak of Lehman's collapse and until the end of 2012. Hence, we obtain a picture of the benefits from having a less overheated economy before the financial crisis as well as the greater ability to withstand the negative shocks which hit the Danish economy during the crisis both in terms of a lower level of wages and prices and in terms of the conduct of extra expansionary fiscal policy made available through lower debt and primary deficit during and after the crisis. As in scenario (1), we consider only government spending, G_t, as our economic instrument.

In figure (9(a)) we show that in this counterfactual scenario, G_t must exceed its actual level from around 2010 onwards. This is of course due to the desire to add fiscal stimulus after the onset of the financial crisis and the room to do so due to lower public debt in the counterfactual scenario. The Taylor rate in the counterfactual scenario almost reaches zero at the end of 2008 and the beginning of 2009, see figure (9(b)). Given the objective of bringing the Taylor rate back to its steady state, or 'optimal', level on a medium-term basis, an expansionary fiscal policy is called for. This is shown in figure (8), which illustrates that the output gap overshoots so as to 'lift' the Taylor rate back up to its steady state level of 4 pct. pr. year by the end of 2012.

This overshooting may perhaps seem unappealing, but it is in line with a standard monetary

[19] Part of the explanation for this finding is that some of the benefits of stabilisation have not yet been realised when the sample ends.

policy framework in which the monetary policy rate follows a Taylor rule, see e.g. Galí [2009] and the discussion in section (3). As an example, in a DSGE model for an economy with a flexible exchange rate, or for a closed economy, if inflation is above its steady state the central bank needs to increase the policy rate more than the increase in inflation, so as to increase the real interest rate, which in turn depresses aggregate demand and creates a negative output gap. Given that we apply the same type of Taylor rule for the conduct of fiscal policy, it is perhaps less surprising that we create a positive output gap in our counterfactual scenario.

We show in figure (9(d)) the multiperiod fiscal effects in the actual and the counterfactual scenarios. The counterfactuals are equivalent to the counterfactual fiscal effects shown in figure (6(a)), but after 3^{rd} quarter 2008 we observe much bigger positive fiscal effects, reflecting the more expansionary discretionary fiscal policy in scenario (2) in the post-Lehman period. The more expansive stance of fiscal policy does not imply breaching any debt limits, as shown in figure (9(c)). The more appropriate fiscal policy before the crisis makes room for more fiscal stimulus after the crisis.

Fundamentally, what we do in this scenario is to move economic activity from one point in time (at which demand was relatively high) to another point (at which demand was low) in such a way that our objective function, the Taylor rule, is as close to its optimum as possible. The benefits for the economy is a more smooth course for GDP throughout the period with less volatility in macroeconomic variables and more room for maneuvering through unforseen events, as an example another Lehman-event, using discretionary fiscal policy. Taken together, what scenario (1) and (2) also show is that this stabilisation requires unrealistic changes in government consumption though not unrealistic fiscal effects. In what follows, we address this issue by expanding the set of fiscal policy instruments we use in the counterfactual scenario.

4.3 Scenario (3): Using a range of fiscal instruments to combat the boom and the bust in the Danish economy

In our final scenario we will further expand our set of fiscal instruments and slightly change our goal and ask: What can we achieve in terms of Taylor rate stabilisation using the full set of fiscal instruments in the model subject to the following constraints: Firstly, as in scenario (2), the debt-to-GDP ratio in the 4^{th} q. 2012 equals its equivalent in 1^{st} q. 2006; secondly, the shocks to the fiscal policy instruments are 'realistic'. While the term 'realistic' is clearly loosely defined, what we try to do is to see how far we can get in terms of Taylor rate stabilisation through changes in the fiscal policy instruments within a narrow band.

We add to our set of fiscal instruments a tax on labor income, a value-added tax on consumption, or VAT, and a tax on capital. As seen from their impulse response functions in figure (7(b)), (7(c)), and (7(d)), respectively, these instruments (especially the latter two) have fairly small effects on output. We show the actual and counterfactual scenarios for the respective instruments in figures (12(a)) - (12(d)) and the fiscal effects for each instrument are shown in figure (11(a)), while the corresponding total yearly fiscal effects are shown in figure (11(b)).

These are not implausibly large. We aim for the best Taylor rate stabilisation without breaching the implicit limits shown in the figures for the respective instruments. That is, we want public consumption in percentage of GDP to reside within an interval of 21-29 pct., the tax on labour income to reside within an interval of $38\frac{1}{2}$-$43\frac{1}{2}$ pct. and the VAT-rate and tax rate on capital to stay within a limit of $22\frac{1}{2}$-$27\frac{1}{2}$ pct. We find these intervals to be plausible, although they are admittedly *ad hoc*. As verified in figure (11(c)), the debt-to-GDP returns to the desired level at the end of 2012.

As can been seen from the figures, we do not breach the interval limits, but we hit their boundaries to get as much stimulus and contractionary policy as possible. The consequences for the output gap are in figure (10), with the resulting Taylor rate in figure (11(d)). We observe the contractionary fiscal policy is not sufficient to close Taylor rate gap in the pre-crisis period. On the other hand, the fiscal contraction leaves room for more stimulus after the crisis, which makes it easier to close the Taylor rate gap in the post-crisis period without breaching our limits for the fiscal policy instruments. To bring the Taylor rate back to its steady-state we actually create a positive output gap of around 2 pct. Again, as in scenario (2), the course for the output gap in the counterfactual scenario can be taken as a measure of the advantage of conducting a tighter fiscal policy during the boom, leaving more room for output stabilisation during the subsequent crisis.

4.4 Summarising the conclusions from the counterfactual analysis

As discussed in the introduction, discretionary fiscal policy in Denmark during the period 2004-2012 was characterised by expansionary fiscal policy both during the boom and the bust. It it difficult to argue that this was an optimal way of conducting dicretionary fiscal policy; no matter the definition of 'optimal'. In this section we have adressed the consequences in terms of output of conducting such an asymmetric discretionary fiscal policy. We first showed that if fiscal policy had been conducted with a view to systematically stabilise the output gap and inflation only during the pre-crisis period, the Danish economy would have been in a better state to combat the financial crisis. This is primarily due to the fact that the Danish economy would have entered the financial crisis with lower levels of wages and prices, implying a more competitive stand vís-a-vís foreign economies. In addition, the state of public finances would have been more advantageous. In scenario (2), we exploited this more advantageous fiscal stance to conduct expansionary fiscal policy during the financial crisis. We showed that it would have been possible to get a much milder and shorter recession, although not to avoid it completely, if discretionary fiscal policy was conducted according to our Taylor rule.

We recall that the fluctuations in the Danish economy during the period 1^{st} q. 2006 - 4^{th} q. 2012 were quite large. Consequently, the fluctuations in the discretionary fiscal policy needed to stabilise the economy during that period were also unrealistically large. In scenario (3), we extended the set of fiscal instruments so as to obtain more realistic implications for the stance of fiscal policy. As we restricted the fiscal instruments to remain within pre-specified, realistic

bands in scenario (3), we were able to close only around half of the Taylor rate gap. In more normal times, smaller adjustments are likely to be sufficient. Another approach is to supplement the available fiscal tools with other economic policy instruments, such as macro-prudential regulation. This would have been particularly relevant during the period we analyse, which was characterised by large increases in asset prices, especially house prices, and subsequent large drops. Another option is to strengthen the automatic stabilisers.

5 Fiscal Policy in Real Time

As discussed in the introduction, real-time data and economic projections available to fiscal policymakers at the time of the policy decision are subject to numerous revisions which may sometimes be quite substantial. In this section, we therefore perform a real-time analysis of fiscal policy in Denmark during the period 2004-2012, where fiscal policy is based only on real-time information. We first re-estimate our DSGE-model based on vintage data from each year, and compare the resulting real time output gap in each year to the output gap for that year estimated using ex post data as in Pedersen and Ravn [2013]. We then evaluate actual fiscal policy year-by-year against a real-time, rule-based alternative, and demonstrate that even without the benefit of hindsight, actual fiscal policy had significant shortcomings in several of the years considered.

5.1 Real-time accounts of economic activity

In each estimation, we use the same data series and prior distributions as described in Pedersen and Ravn [2013]. We obtain the different data vintages from previous MONA databases from Nationalbanken.[20] As an example, the 2004-estimation is based on the 2004-vintage of the MONA database, which includes forecasts for the years 2005 and 2006. As in Pedersen and Ravn [2013], we include the forecasts in the estimation so as to mitigate potential end-point problems, as also discussed below. For each year, we use data from 1990 onwards. We do not report parameter estimates for each year, although these are available from the authors upon request. Instead, we summarise the information from the range of estimations in figure (13), which shows the estimated series for the output gap from each year's estimation, with dotted lines representing forecast periods.

As the figure illustrates, the estimated output gap series differ substantially between estimations. In particular, the arrival of new data tends to lead to an upward revision of the size of the boom in the years 2005-2008, and to a downward revision of the size of the subsequent recession (i.e., that the recession was less deep than previously thought).[21] The main reason for

[20] Mona is Nationalbanken's main model used for forecasting and policy evaluation, see also Nationalbanken [2003].

[21] A similar comparison of ex ante and ex post data from the OECD yields the same result, i.e. that the ex ante measure tends to underestimate the pre-crisis boom and overestimate the post-crisis recession. This evidence is available from the authors upon request.

these systematic revisions is that the estimated trend growth rate is also revised as new data arrives. More specifically, the post-crisis years have been characterised by low growth rates in Danish GDP, giving rise to downward revisions of the estimated average or trend growth rate for the entire period back to 1990. As the trend growth rate is adjusted downwards, periods of high growth (such as the pre-crisis boom) will appear as larger positive deviations from trend, while recessions (such as the crisis years) will appear smaller. More fundamentally, this is a typical end-point problem: Whether the slow growth rates in the post-crisis period are temporary deviations from an unchanged underlying trend or represent a move to a regime of permanently lower growth rates remains an open question at this stage. Yet the answer to this question has fundamentally different implications for the way this period should be treated from a statistical viewpoint as well as an economic viewpoint.

Before analysing the implications for fiscal policy, it is helpful to compare the estimated real-time output gaps to other real-time accounts of economic activity in Denmark. For each data vintage, the corresponding panel in figure (14) plots the estimated output gap in the current and next year (t and $t+1$) from the estimated DSGE model against three alternative real-time output gap measures: The current and projected future output gap published in the OECD's *Economic Outlook* database from the relevant year, and the output gap computed using a Hodrick-Prescott (HP) filter or a linear trend applied to the same vintage dataset used to estimate the DSGE model for that year. In other words, the top left panel in figure (14) compares four different (current and projected) output gap measures for 2004 and 2005 based on information available in the third quarter of 2004, and so forth. We focus on the third quarter, as this is the latest available information at the time when policy decisions are typically made. As the figure illustrates, there are substantial differences between the various real-time output gaps, although the DSGE-, OECD- and HP-based output gaps have the same sign in most years, with the linear trend often being somewhat of an outlier. For the estimated output gaps in the current year (year t), the DSGE-based output gap tends to be numerically smaller than the OECD's estimate, but larger than (or close to) the HP-filtered output gap. For the projected output gap next year (year $t+1$), the OECD usually projects numerically larger output gaps than those based on other measures. The 2007-panel is an illustrative example of these tendencies: In 2007, most available evidence (with the exception of the linear trend gap) pointed to a clearly positive current and future output gap. According to the DSGE model, the boom was smaller than anticipated by the OECD, but larger than an HP-filter would suggest.

Having established that the DSGE-based trend output gap accords well with other contemporary estimates and projections in most years, the next step is to compare this ex ante measure with ex post estimates of the output gap. This is done in figure (15), which shows the ex ante current and projected future output gap in each year alongside the ex post trend output gap from the DSGE-model estimated with 2013-data, as well as the output gap from the most recent OECD-database, and the most recent estimate of Danmarks Nationalbank's output gap measure, see Andersen and Rasmussen [2011]. A number of patterns emerge from this figure.

First, note that the ex post DSGE trend output gap appears to be numerically smaller than the other two output gap measures throughout the sample. However, it is important to keep in mind that the various output gaps are computed using fundamentally different methods. In this light, it is reassuring that the three ex post measures tell broadly the same story about Denmark's recent economic history, and that for example, with one exception in 2004, they always have the same sign. Second, figure (15) illustrates the difficulties associated with economic fine-tuning in real time: The ex ante DSGE trend output gap often differs substantially from the various ex post measures, posing a serious challenge for fiscal policymakers, as we discuss below. Third, it is again instructive to consider the years just before the recent crisis: In 2006 and 2007, while real-time estimates from a DSGE model (as well as other real-time measures, as seen in figure (14)) underestimated the ongoing economic boom, they did indicate that the economy was operating above potential. In other words, the pre-crisis boom was large enough to be identified even in noisy real-time accounts of economic activity.

These findings have implications for economic stabilisation policy, which in Denmark primarily refers to fiscal policy. At the same time as real-time estimates of economic activity in 2006 indicated a substantial positive current and projected future output gap, inflation was around 2 pct. and projected to increase throughout the forecast period. As a result, the blue curve in the 2006-panel of figure (16) shows that the implied Taylor rate was projected to overshoot its steady state level significantly. Altogether, this situation would call for a contractionary fiscal policy.

5.2 Real-time fiscal policy

To analyze in detail the implications for fiscal policy, we conduct the following exercise taking 2006 as an example: Based on information available in the third quarter of 2006, we adjust the stance of fiscal policy in 2007 and 2008 so as to achieve a Taylor rate as close as possible to its steady state value of 4 percent at the end of the forecast period, i.e. the fourth quarter of 2008. We do this by adjusting government spending and labor income taxes, with spending adjustments accounting for the bulk of total adjustments as recommended several times by the IMF (see, e.g., IMF [2010]). In particular, government spending accounts for 2/3 of the adjustment and taxes for the remaining 1/3. We assume, realistically, that changes to fiscal policy decided in the third quarter of 2006 only impact the economy beginning in 2007, i.e. with a one-quarter lag. Moreover, we do not allow for quarterly fiscal policy adjustments; the stance of fiscal policy must be the same in all four quarters of 2007, etc. Finally, when we re-do the exercise for 2007, fiscal policymakers are of course allowed to change the stance of fiscal policy for 2008, etc. In the following, we therefore focus on fiscal policy one year ahead.

The blue columns in figure (17) illustrate the contractionary stance of fiscal policy (as measured by the size of the fiscal effect) in 2007 and 2008 needed to bring the Taylor rate to its steady state level; along with the ex post counterfactual fiscal policy studied in section (4) and the actual fiscal policy as estimated by Pedersen and Ravn [2013]. The black curve in the

2006-panel of figure (16) verifies that the counterfactual Taylor rate is indeed very close to its steady state level (as indicated by the dotted green line) by the end of 2008. The black lines in the 2006-panels of figures (18) and (19) show the resulting sequences for the output gap and inflation. As a result of the counterfactual fiscal policy, economic activity is dampened significantly, while the projected rise in inflation is mitigated.

Our counterfactual exercise implies that a fiscal effect of around -0.75 would have been appropriate in 2007, i.e. that fiscal policy should have been tightened substantially. This emphasises that even without the benefit of hindsight, the economic situation in 2006 clearly called for a tightening of fiscal policy, as also recommended by Danmarks Nationalbank at that time (see, e.g., Nationalbanken [2006]). Nevertheless, actual fiscal policy was slightly expansionary with a fiscal effect of around 0.2 according to the DSGE model or 0.1 according to the Ministry of Finance [2011]. Once the model is estimated with ex post data, an even stronger negative fiscal effect (around -1.8) is called for, indicating that the boom in 2006 and 2007 turned out to be much stronger than anticipated in real time. In other words, the actual fiscal policy for 2007 had the 'wrong sign' when evaluated both in real time and using ex post data.

We have summarised the results from similar exercises for each of the years 2006-2012 in figure (20), with the implied series for the Taylor rate, fiscal policy, the output gap and inflation for each year in figures (16)-(19). We emphasise that, as indicated by the vertical grey lines in figure (20), the results from this analysis should be evaluated on a year-by-year basis. That is, the counterfactual fiscal effect for 2007 is *not* conditional on the counterfactual real-time fiscal policy for 2006 having been implemented. It is rather conditional on data available in 2006, which in turn is generated (among other factors) by the *actual* fiscal policy in 2006. If fiscal policy for 2006 had been conducted in a different manner, the economic development would have been different, and so would the appropriate fiscal policy for 2007.

Figure (20) clearly shows that actual fiscal policy had the 'wrong sign' in each of the years 2006-2008: While real-time accounts of economic activity and inflation would have called for a significant fiscal contraction, fiscal policymakers did the opposite. Obviously, based on ex post data, actual fiscal policy was even further off. In other words, during these years fiscal policy was procyclical when evaluated with real-time data, and even more procyclical when ex post data is used. At the same time, figure (20) illustrates the problems of using fiscal policy for economic fine-tuning: In 2010-2012, ex ante and ex post counterfactual fiscal policy had opposite signs. In the fall of 2009 Nationalbanken projected an economic recovery, with output growth and inflation picking up over the forecast period, giving rise to a very substantial increase in the Taylor rate, as illustrated by the blue line in the 2009-panel of figure (16). Viewed through the lens of our fiscal rule, this would suggest that a mildly contractionary fiscal policy was needed in 2010. Eventually, however, this forecast proved too optimistic, so that based on ex post data, an expansionary fiscal policy for 2010 would have been appropriate. Likewise, real-time counterfactual fiscal policy for 2011 and 2012 was based on a projected rise in inflation that

eventually did not materialise in ex post data, as shown in figure (19). Dam and Brandt [2013] discuss in further detail the challenges associated with Nationalbanken's economic forecasts during the years 2008-2012. Real-time fiscal policy is based (among other things) on such forecasts, and is therefore subject to many of the same problems.

6 Conclusion

In this paper, we have evaluated actual fiscal policy in Denmark in the 2000's against a counterfactual, rule-based benchmark, and studied the implications for economic activity. Our main findings can be summarised as follows. Compared to an alternative policy that seeks to stabilise the implied Taylor interest rate around its steady state level, we find that, with the benefit of hindsight, fiscal policy was too expansionary in the pre-crisis years. In particular, fiscal policy should have been tightened by as much as around 1.5 percent of GDP in each of the years 2006-2008. We demonstrated that with this type of alternative fiscal policy in place only during the pre-crisis period, the subsequent economic crisis would have been significantly dampened and shortened. This can be attributed to a relatively better competitiveness of Danish firms at the onset of the crisis relative to the actual scenario. Fiscal policy in the 2000's was therefore conducted in an asymmetric way; as policymakers were unwilling to tighten fiscal policy during the boom, but very willing to conduct expansionary fiscal policy when the crisis hit. Furthermore, a more contractionary policy before the crisis would have created room for additional fiscal stimulus during and after the crisis if desired. Finally, based on a study of real-time data, we conclude that even without the benefit of hindsight, the economic situation in the mid-2000's clearly called for a tightening of fiscal policy. That is, discretionary fiscal policy during the period 2005-2008 was too expansionary even when we take the uncertainty about the size of the boom and bust in real time into account.

The period we have considered in this study was characterised by large fluctuations seen in the perspective of Denmark's recent economic history, and therefore required large and perhaps unrealistic fiscal policy responses. While less dramatic policy changes may be sufficient in more 'normal' times, this raises concerns about the ability of Danish policymakers to cope with large economic fluctuations - or avoid them entirely by dealing with imbalances as they arise - with the economic instruments available today. One potential solution to this problem would be to strengthen the automatic stabilisers in the economy. Another option is to exploit the potential of macroprudential regulation.

Finally, our study has pointed out some of the problems associated with fiscal policy. In particular, while our study showed that the pre-crisis boom was large enough to be detected in real time, it also showed that real-time accounts and projections of current and future economic activity, and the resulting fiscal policy implications, are often significantly different from ex post measures. This underlines that fiscal policy is not an appropriate tool for economic fine-tuning.

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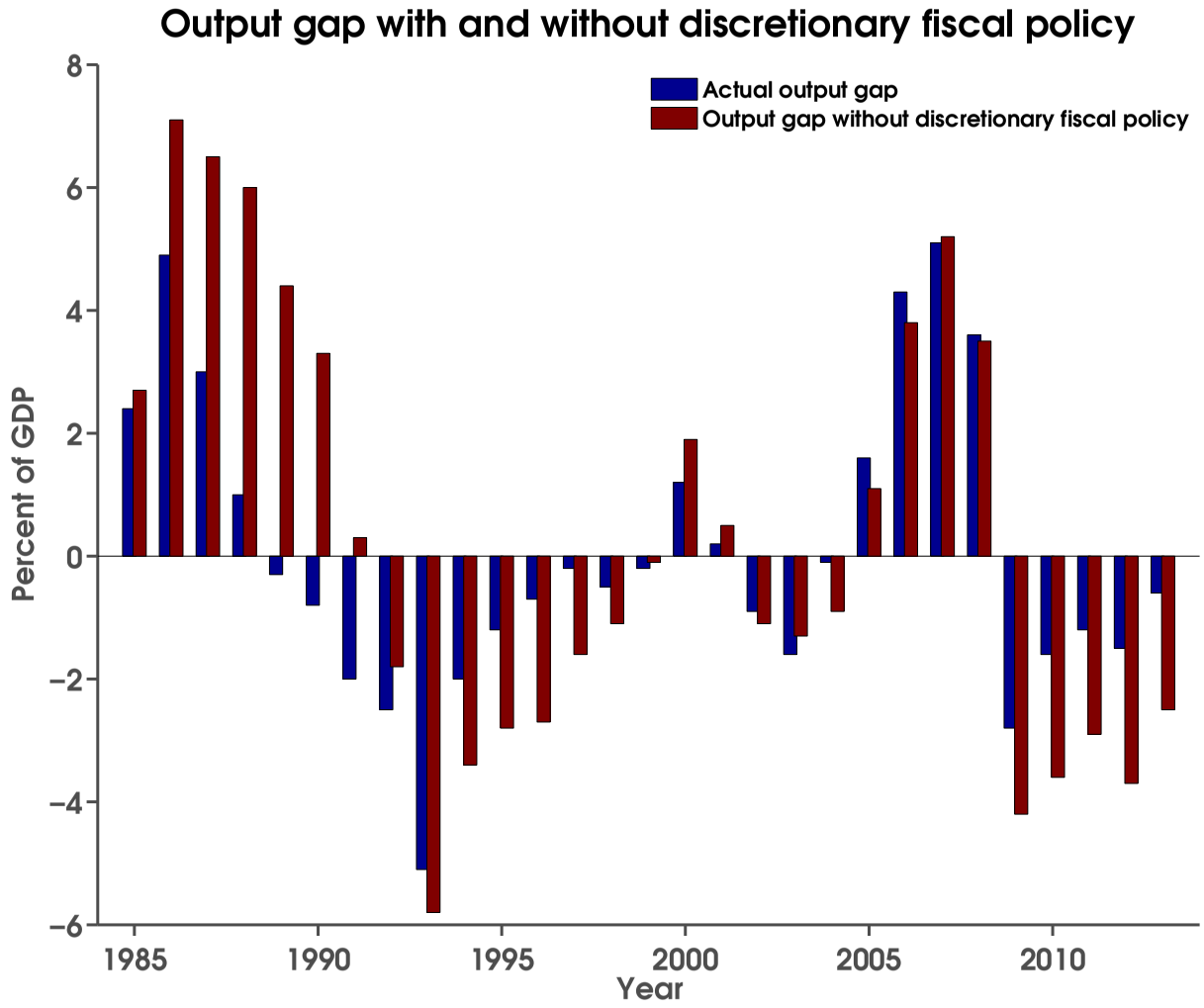

Figure 1: **Output gap with and without discretionary fiscal policy**
This figure shows the output gap as calculated in Andersen and Rasmussen [2011] and the same gap adjusted by one-year fiscal effects calculated in the macroeconometric model ADAM. See also Ministry of Business and Growth [2013].

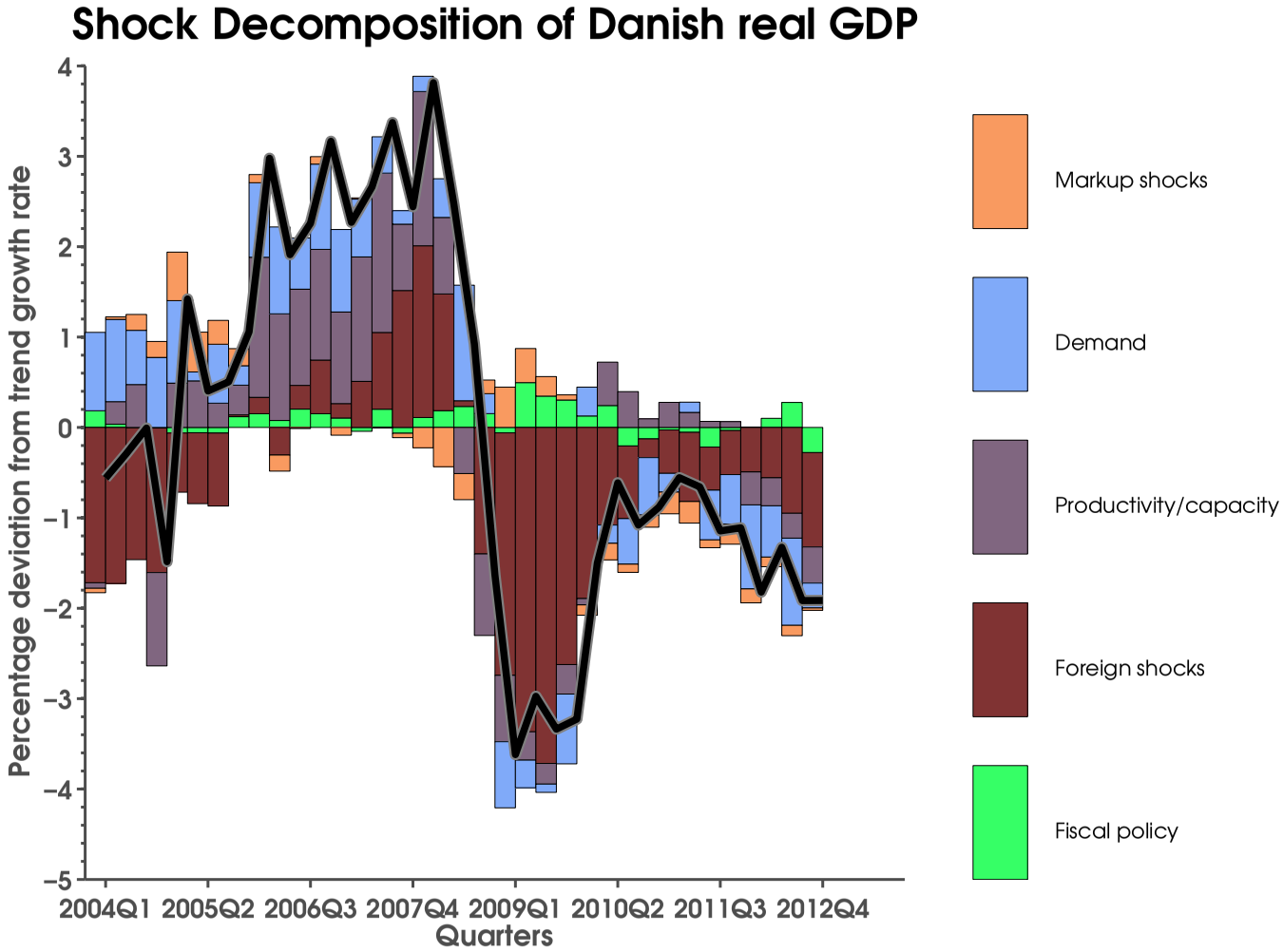

Figure 2: **Historical Shock Decomposition for real GDP in Pedersen and Ravn [2013].**
This figure shows the historical quarter to quarter growth rates in Danish real GDP (solid lines) decomposed into the structural shocks in the model. The 22 shocks are grouped into 5 categories as explained in the text. Real GDP growth is reported in deviation of the steady-state mean growth rate of approximately 0.4 percent per quarter. Residual contributions, which capture the influence of the initial state of the economy and measurement errors, are not shown. The decomposition have been computed using the posterior mode estimates of the model's structural parameters.

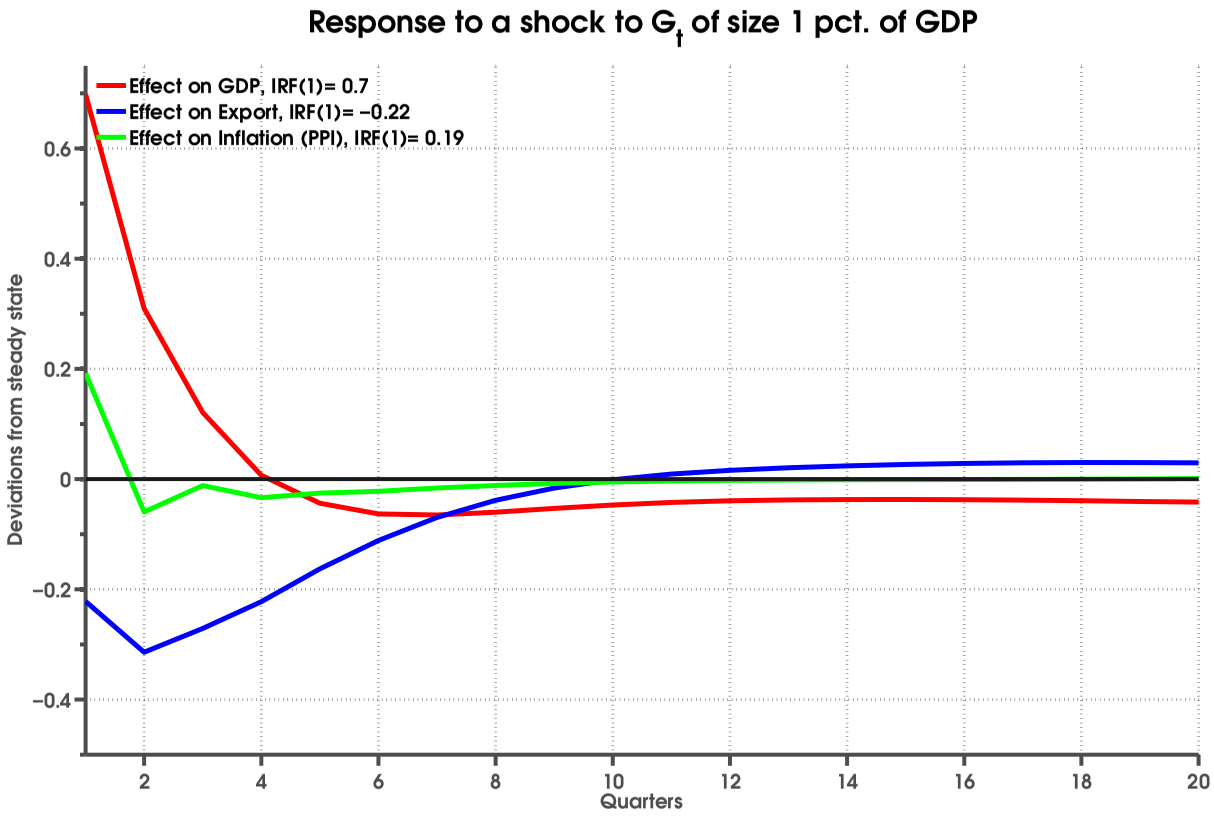

Figure 3: **Effect of a shock to public consumption**
This figure shows the impulse response of selected variables to a shock to public consumption equivalent to 1 pct. of steady state real GDP.

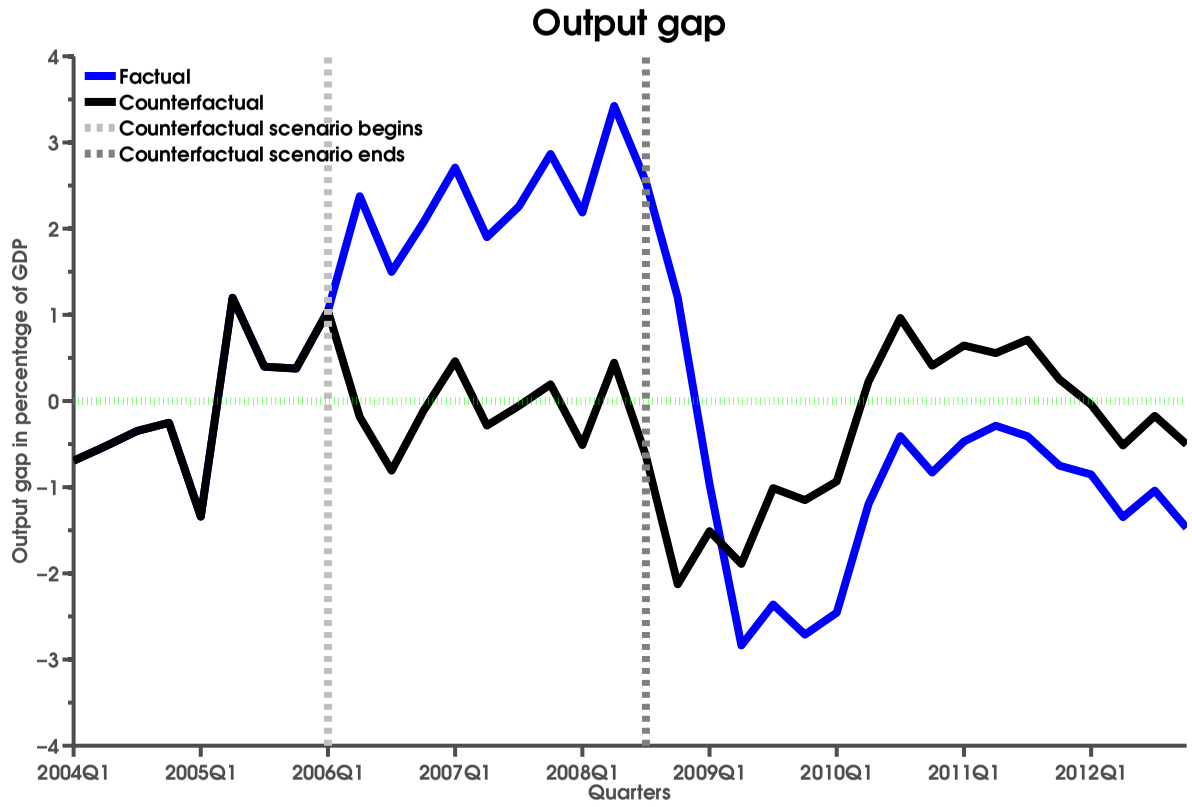

Figure 4: **Scenario (1): Output gap**
This figure shows the actual output gap defined as the difference between actual real GDP and a trend, see also Pedersen and Ravn [2013], and the output gap in the counterfactual scenario (1).

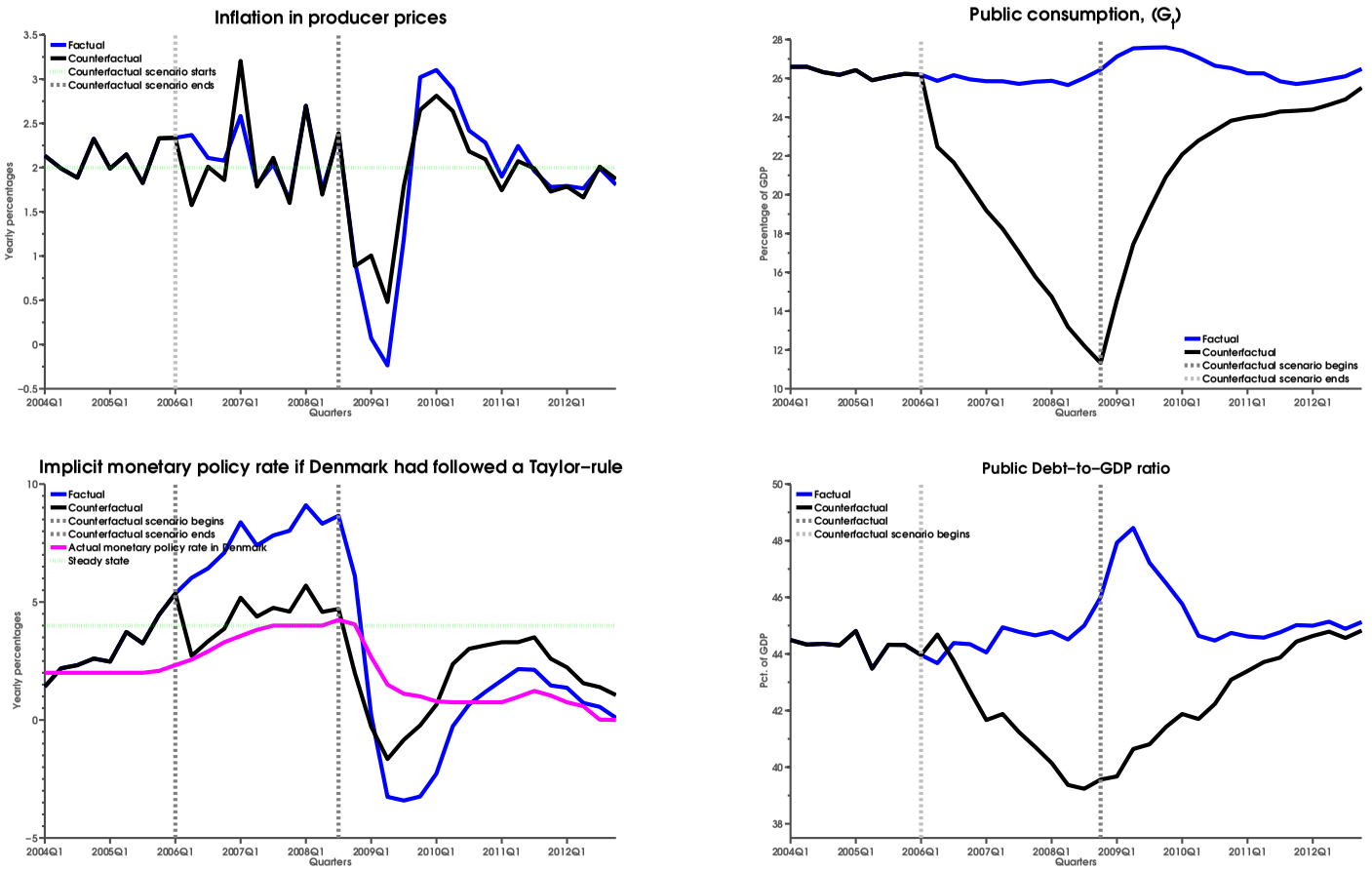

Figure 5: **Scenario (1): Inflation, Government spending, Taylor-rate and Debt-to-GDP**
The top left figure shows actual inflation in producer prices and inflation in the counterfactual scenario (1).
The top right figure shows factual and counterfactual public expenditures as a percentage of GDP in scenario (1). The steady state rate value is 26 pct. of GDP determined as the mean of the variable in the sample considered in this paper.
The bottom left figure shows the factual and counterfactual Taylor-rate in scenario (1) together with the monetary policy rate in Denmark. We refer to section (3) for the presentation of the Taylor-rate.
The bottom right figure shows factual and counterfactual public debt as a percentage of GDP in scenario (1). The steady state rate value is 46 pct. of GDP determined as the mean of the variable in the sample considered in this paper.

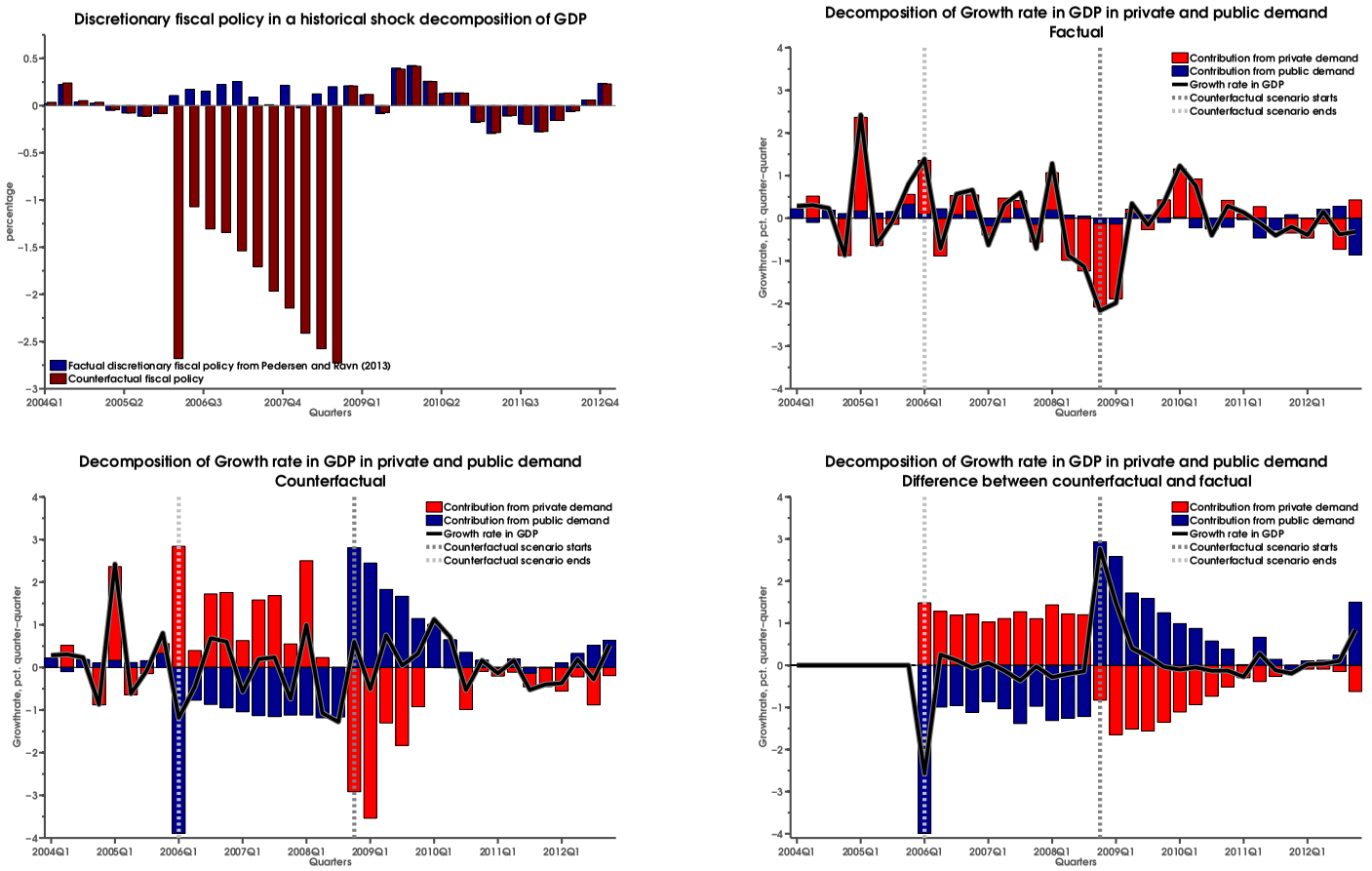

Figure 6: **Scenario (1): Actual and counterfactual effects of fiscal policy in a historical shock decomposition of the Danish output gap and growth decomposition**
The top left figure shows the actual contributions from fiscal instruments to movements in the output gap in a historical shock decomposition in Pedersen and Ravn [2013] together with the counterfactual shocks in scenario (1). The contribution can be compared to the multiperiod fiscal effects calculated by Ministry of Finance or The Economic Councils. This is explained in Pedersen and Ravn [2013]. The other three figures show a quarter-to-quarter growth decomposition of real GDP in private demand and public demand. Public demand consists of government purchuses of goods and services and investments. Private demand consists of export, private consumption of goods and services, and investments. The top figure to the right shows the actual scenario. The bottom figure to the left shows the counterfactual scenario (1). The bottom figure to the right shows difference between the counterfactual scenario (1) and the actual scenario.

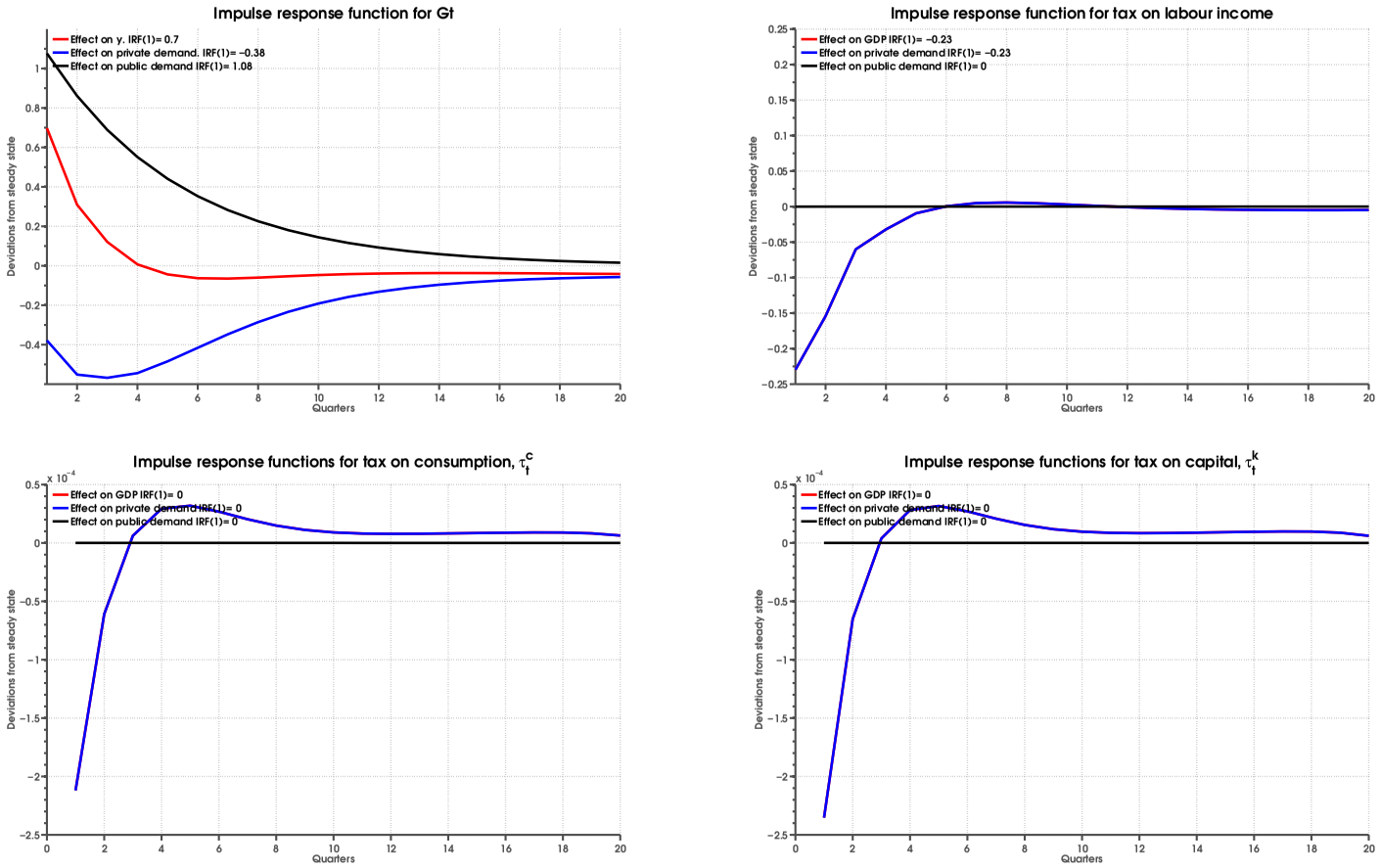

Figure 7: **Impulse Response Functions: Government spending, tax on labour income, consumption and capital.**
Public demand consists of government purchuses of goods and services and investments. Private demand consists of export, private consumption of goods and services, and investments.
The top figure to the left shows the impulse responses of private and public demand to a shock to public consumption equivalent to 1 pct. of steady state real GDP.
The top figure to the right shows shows the impulse response of private and public demand to a shock to the tax rate on labour income equivalent to 1 pct. point increase.
The bottom figure to the left shows the impulse response of private and public demand to a shock to the tax rate on consumption equivalent to 1 pct. point increase.
The bottom figure to the right shows the impulse response of private and public demand to a shock to the tax rate on capital income equivalent to 1 pct. point increase.

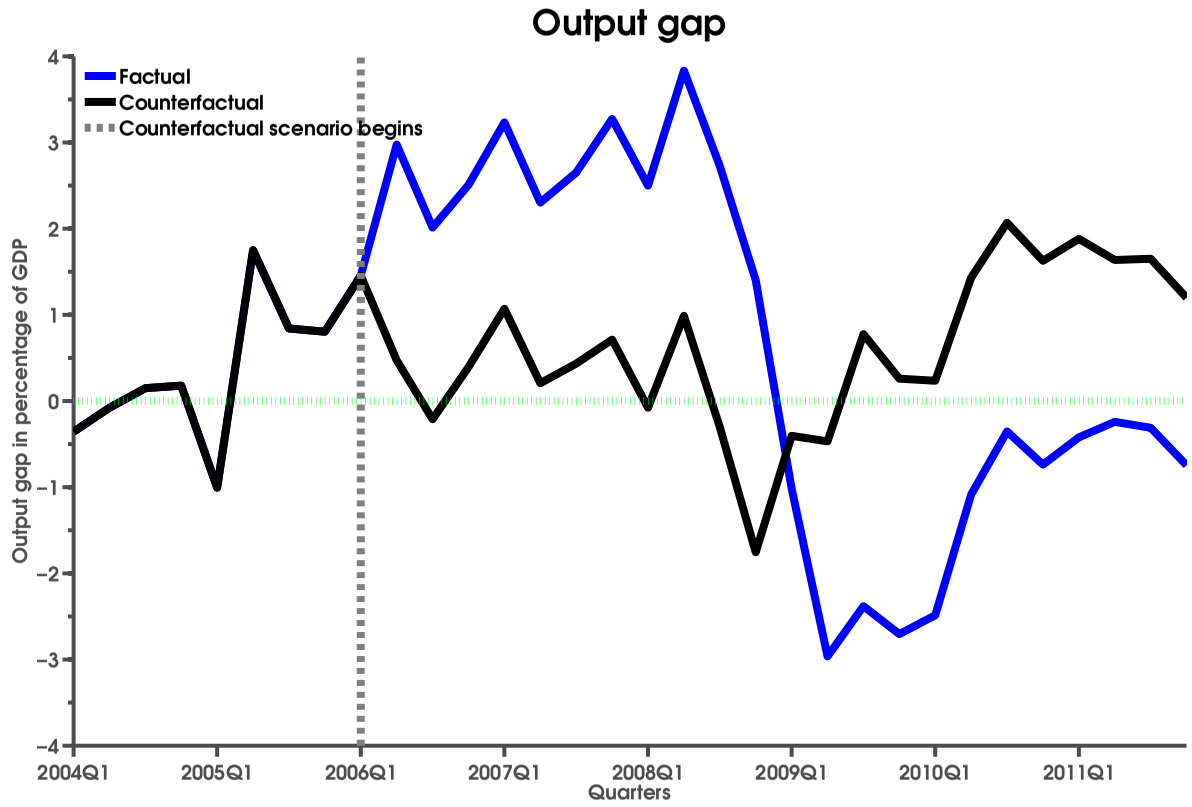

Figure 8: **Scenario (2): Output gap**
This figure shows the actual output gap defined as the difference between actual real GDP and a trend, see also Pedersen and Ravn [2013], and the output gap in the counterfactual scenario (2).

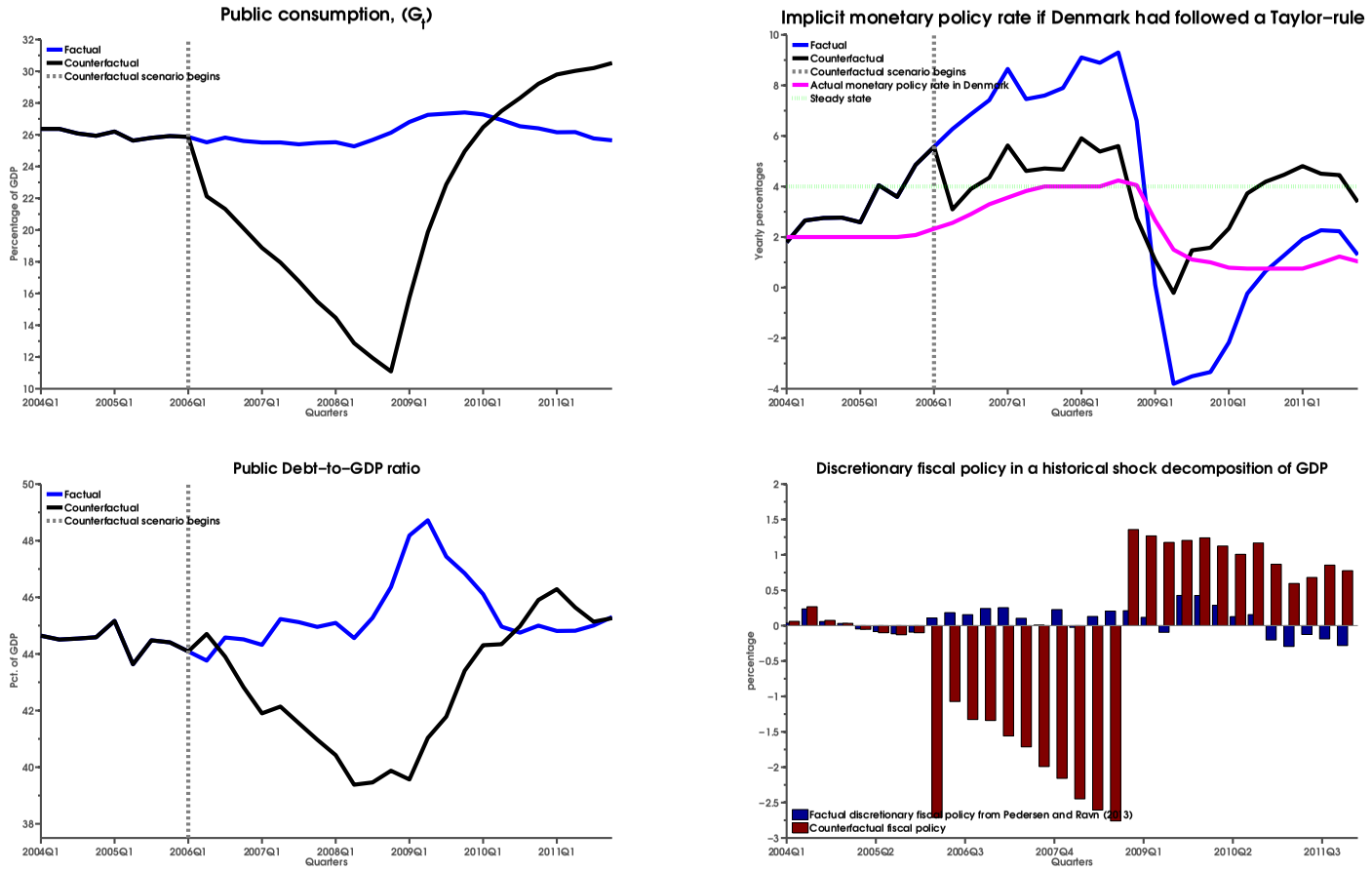

Figure 9: **Scenario (2): Public spending, Taylor-rate, Debt-to-GDP and Fiscal effects**
The top left figure shows factual and counterfactual scenario (2) public expenditures as a percentage of GDP. The steady state rate value is 26 pct. of GDP determined as the mean of the variable in the sample considered in this paper.
The top right figure shows the factual and counterfactual Taylor-rate in scenario (2) together with the monetary policy rate in Denmark. We refer to section (3) for the presentation of the Taylor-rate.
The bottom left figure shows factual and counterfactual public debt as a percentage of GDP in scenario (2). The steady state rate value is 46 pct. of GDP determined as the mean of the variable in the sample considered in this paper.
The bottom right figure shows the actual contributions from fiscal instruments to movements in the output gap in a historical shock decomposition in Pedersen and Ravn [2013] together with the counterfactual shocks in scenario (2). The contribution can be compared to the multiperiod fiscal effects calculated by Ministry of Finance or The Economic Councils.This is explained in Pedersen and Ravn [2013].

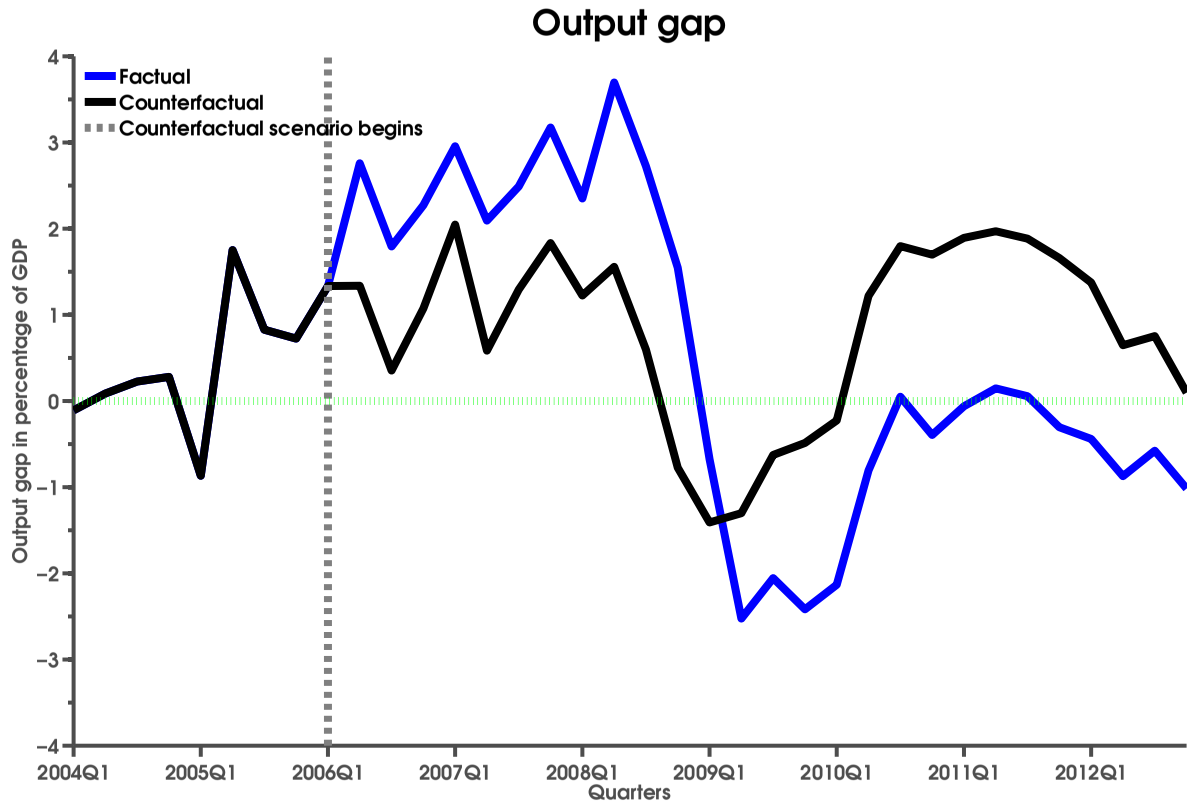

Figure 10: **Scenario (3): Output gap**
This figure shows the actual output gap defined as the difference between actual real GDP and a trend, see also Pedersen and Ravn [2013], and the output gap in the counterfactual scenario (3).

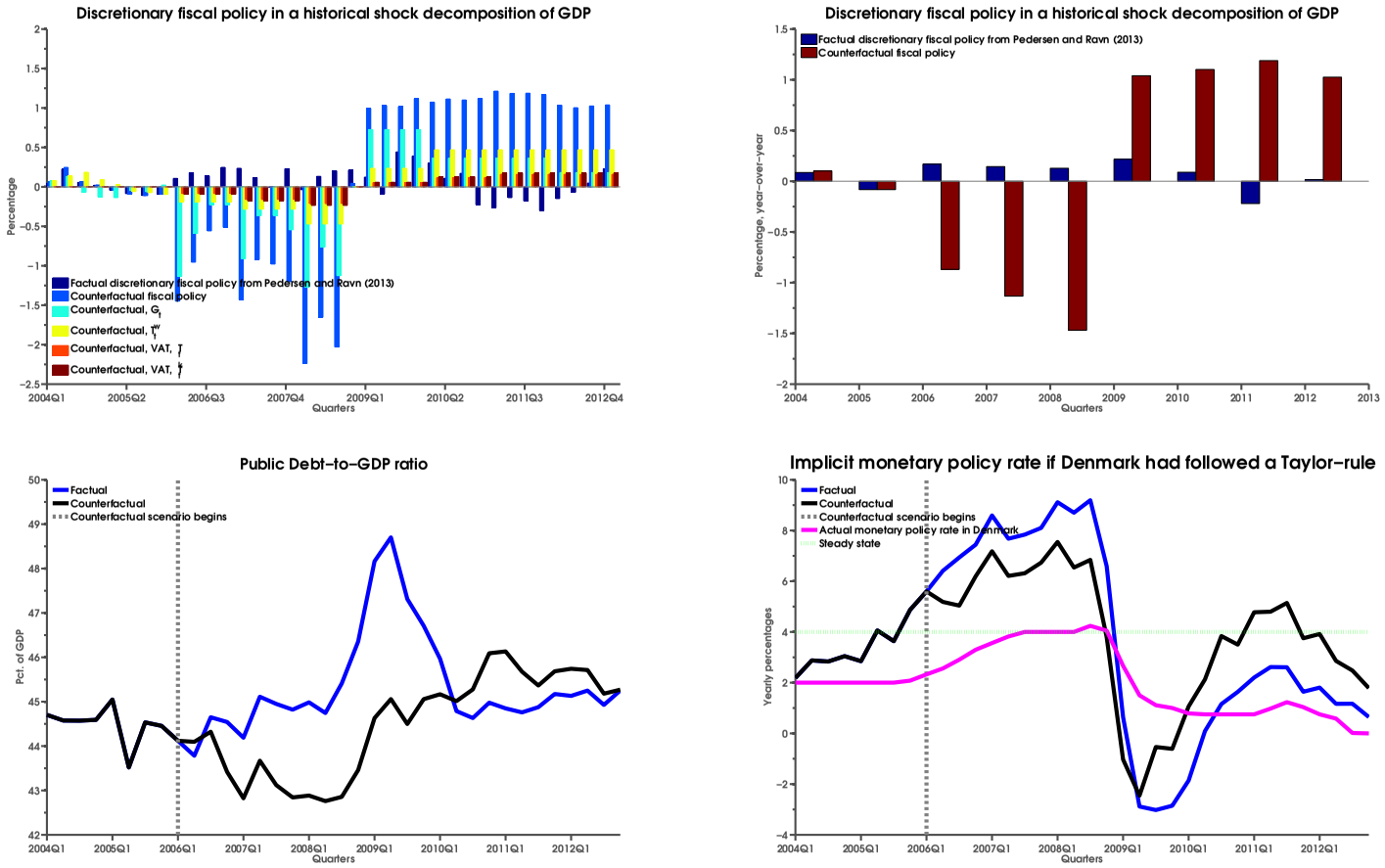

Figure 11: **Scenario (3): Fiscal effects, Debt-to-GDP and Taylor-rate**
The top left figure shows the actual contributions from fiscal instruments to movements in the output gap in a historical shock decomposition in Pedersen and Ravn [2013] together with the counterfactual shocks in scenario (3). The contribution can be compared to the multiperiod fiscal effects calculated by Ministry of Finance or The Economic Councils. This is explained in Pedersen and Ravn [2013].
The top right figure shows the actual contributions on a yearly basis from fiscal instruments to movements in the output gap in a historical shock decomposition in Pedersen and Ravn [2013] together with the counterfactual shocks in scenario (3).
The bottom left figure shows factual and counterfactual public debt as a percentage of GDP in scenario (3). The steady state rate value is 46 pct. of GDP determined as the mean of the variable in the sample considered in this paper.
The bottom right figure shows the factual and counterfactual Taylor-rate in scenario (3) together with the monetary policy rate in Denmark. We refer to section (3) for the presentation of the Taylor-rate.

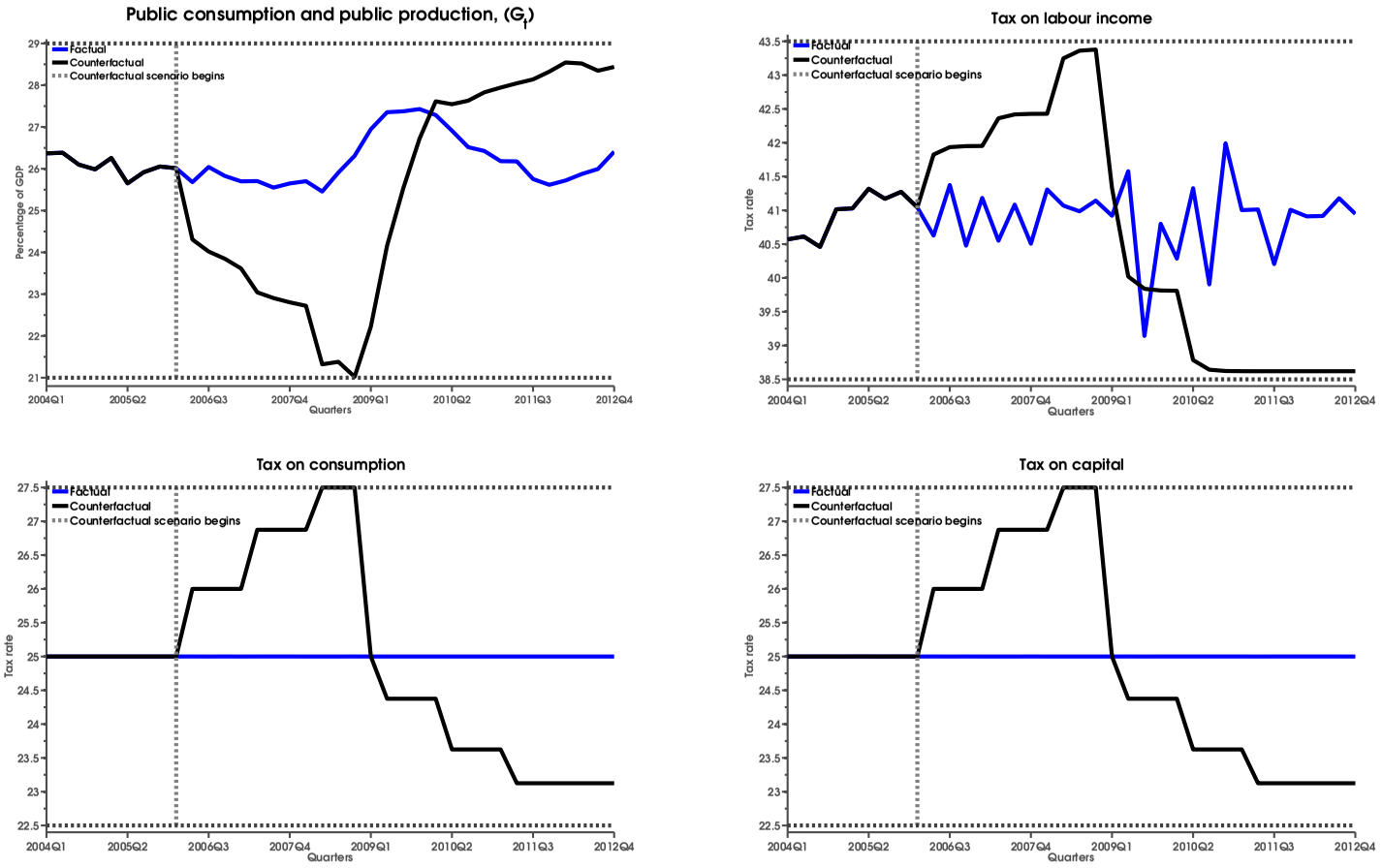

Figure 12: **Scenario (3): Fiscal instruments - Public spending, tax on labour income, consumption and capital**
The top left figure shows factual and counterfactual public expenditures as a percentage of GDP in scenario (3). The steady state rate value is 26 pct. of GDP determined as the mean of the variable in the sample considered in this paper.
The dotted lines below and above the figures denote the intervals which we restrict movements in the respective instruments to reside within.
The top right figure shows factual and counterfactual implicit tax rate on labour income in scenario (3). The steady state rate value is 41 pct. determined as the mean of the variable in the sample considered in this paper including contributions to social security.
The bottom left figure shows factual and counterfactual tax rate on consumption in scenario (3). The steady state rate value is 25 pct., which is the actual rate.
The bottom right figure shows factual and counterfactual implicit tax rate on labour income scenario (3). The steady state rate value is 25 pct. which is close to its actual value.

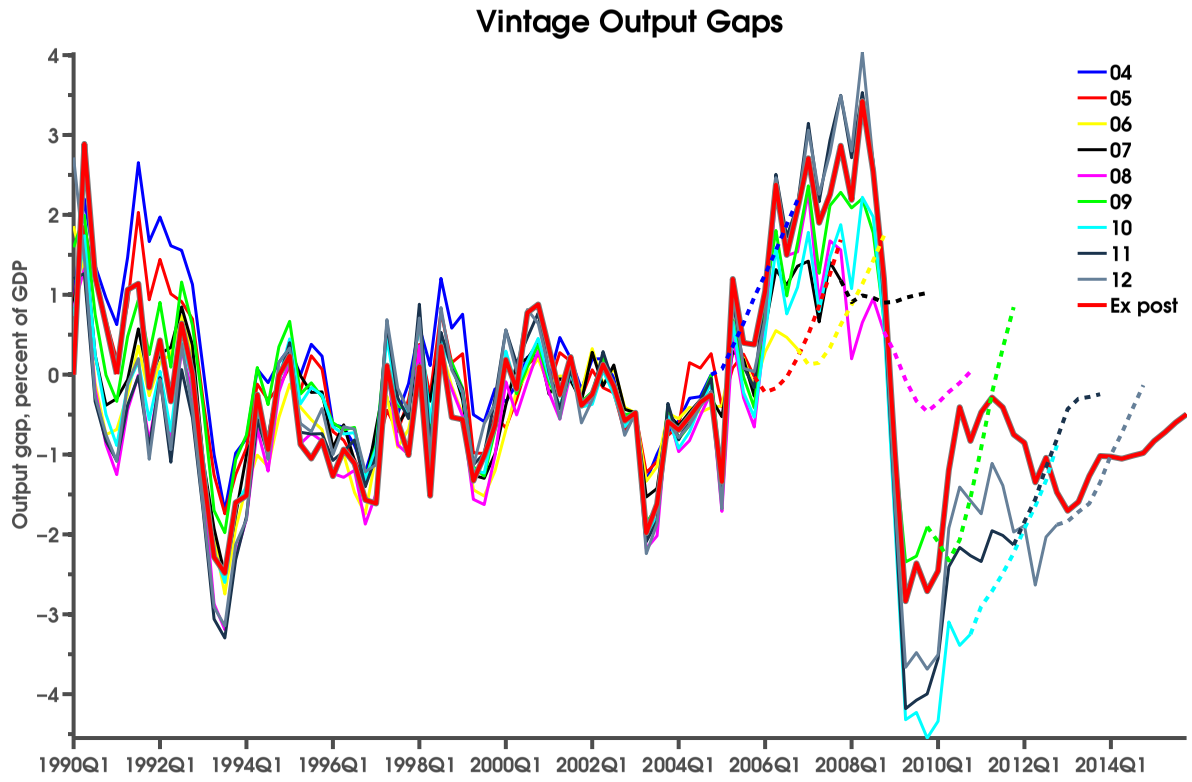

Figure 13: **Estimated output gap from different data vintages.**
This figure shows the output gaps from various data vintages. The output gap is defined as the difference between actual real GDP and an estimated trend following Pedersen and Ravn [2013]. The thick red line, denoted 'Ex post', is the output gap estimated in Pedersen and Ravn [2013] using data from 1990-2014. The output gap for, as an example, vintage 2004 is the output gap estimated in the same model used in Pedersen and Ravn [2013] using data from 1990 to 3^{rd} quarter 2004. We use forecast for the period after the 3^{rd} quarter for the respective vintages to mititage end point problems in the estimation, and because the forecasts is the information the policy makers had avaible to the conduct of fiscal policy for the respective vintages. The dotted lines show the forecast for the respective vintages.

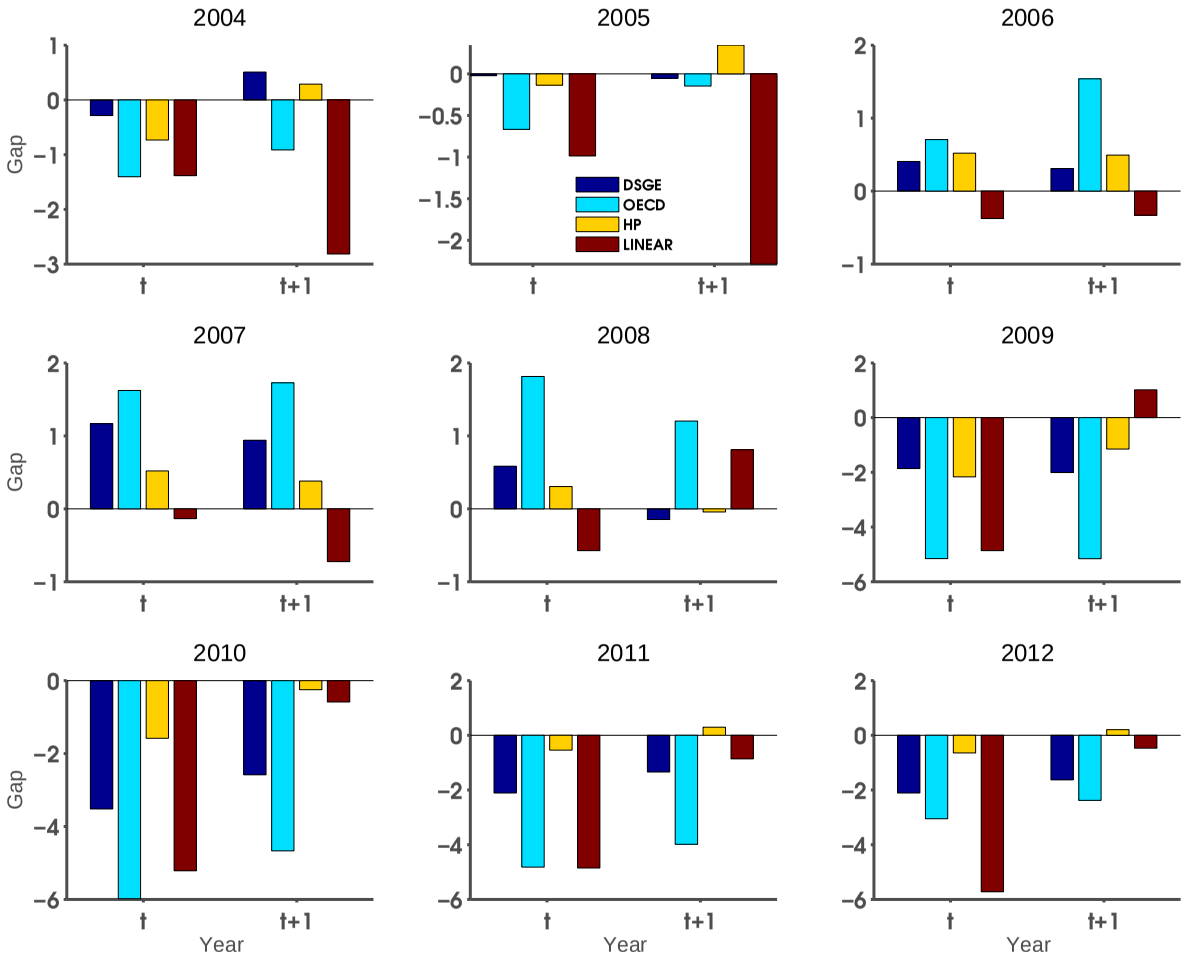

Figure 14: **Comparison of Real-Time Output Gaps.**
This figure shows a comparison of various real-time measures of economic activity as measured by the output gap. The dark blue columns show the output gaps obtained from each estimation of the DSGE model based on different data vintages. The yellow and red columns show, respectively, the output gap obtained with an HP-filter and as the deviation from a linear trend, both using the same data vintages as in the corresponding DSGE-estimation. Finally, the light blue columns show the real-time output gaps taken from vintage versions of the OECD's Economic Outlook database.

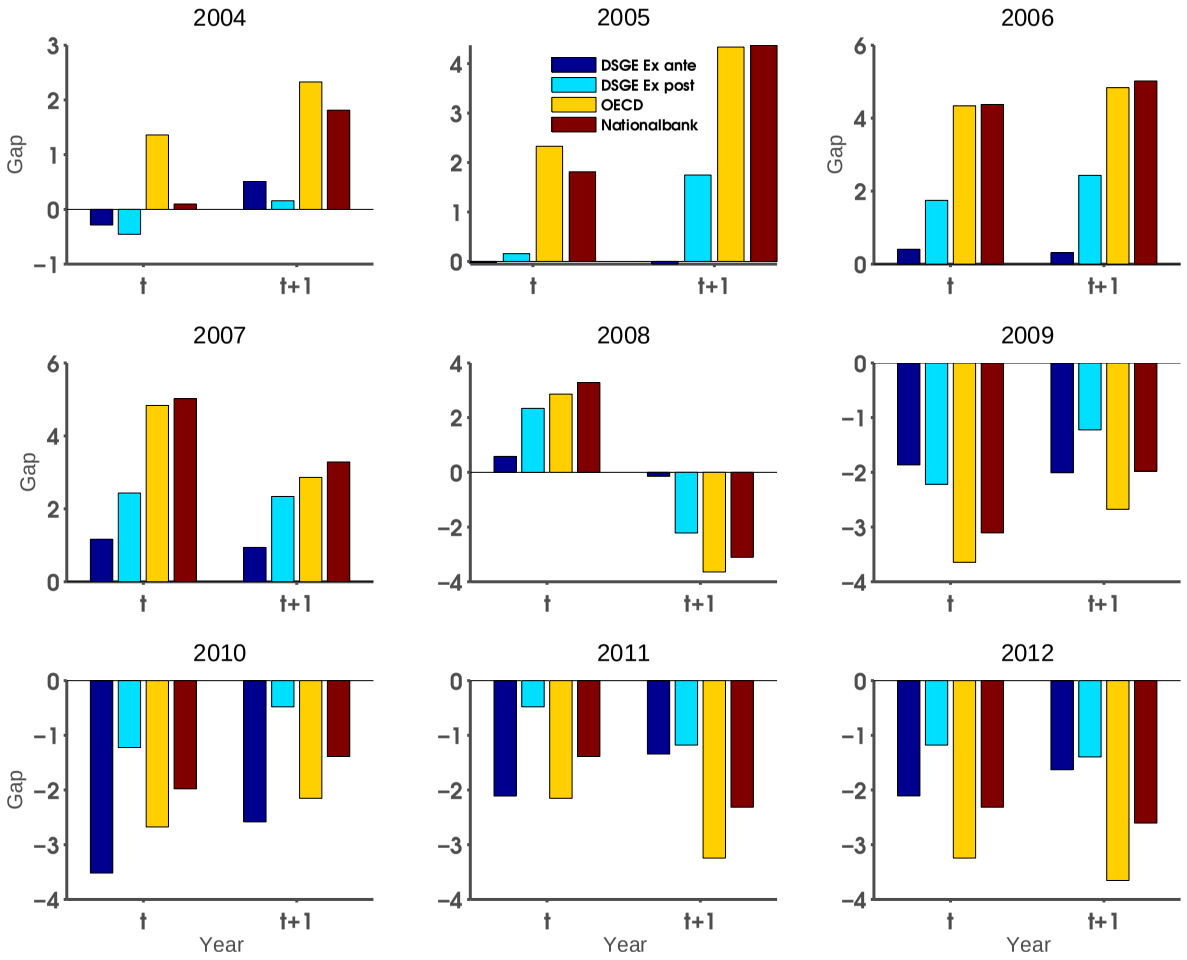

Figure 15: **Comparison of various Output Gaps.**
This figure compares the ex ante or real time DSGE-based output gap to three different ex post output gap measures: The DSGE model estimated with the most recent data, the OECD's output gap from the most recent Economic Outlook database, and the most recently available measures of the output gap computed by Danmarks Nationalbank following the method outlined in Andersen and Rasmussen [2011].

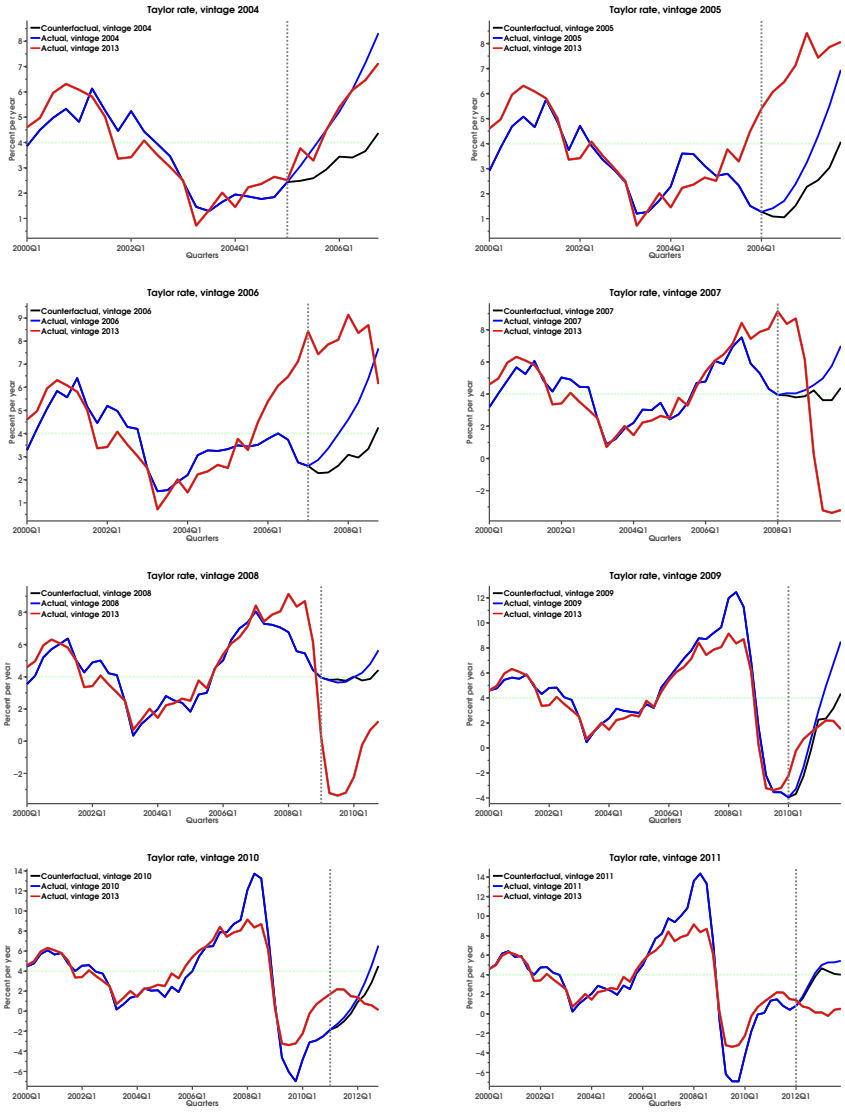

Figure 16: **Actual and counterfactual implied Taylor rate.**
These figures show the actual and counterfactual implied Taylor rates from various data vintages. The Taylor rate can be thought of as how a monetary policy interest rate should have been if a monetary policy rate should stabilise the Danish economy. See also text, section (3). The thick red line is the Taylor rate based on data from 1990-2014. The Taylor rate for, as an example, vintage 2004 is the implied Taylor rate estimated in the same model used in Pedersen and Ravn [2013] using data from 1990 to 3^{rd} quarter 2004. The vertical dotted line denote the beginning of the forecast for the respective vintages. The forecasts are the actual forecasts conducted by Nationalbanken for the vintage. We define the forecasts as the information set the policy makers had avaible to the conduct of fiscal policy for the respective vintages.

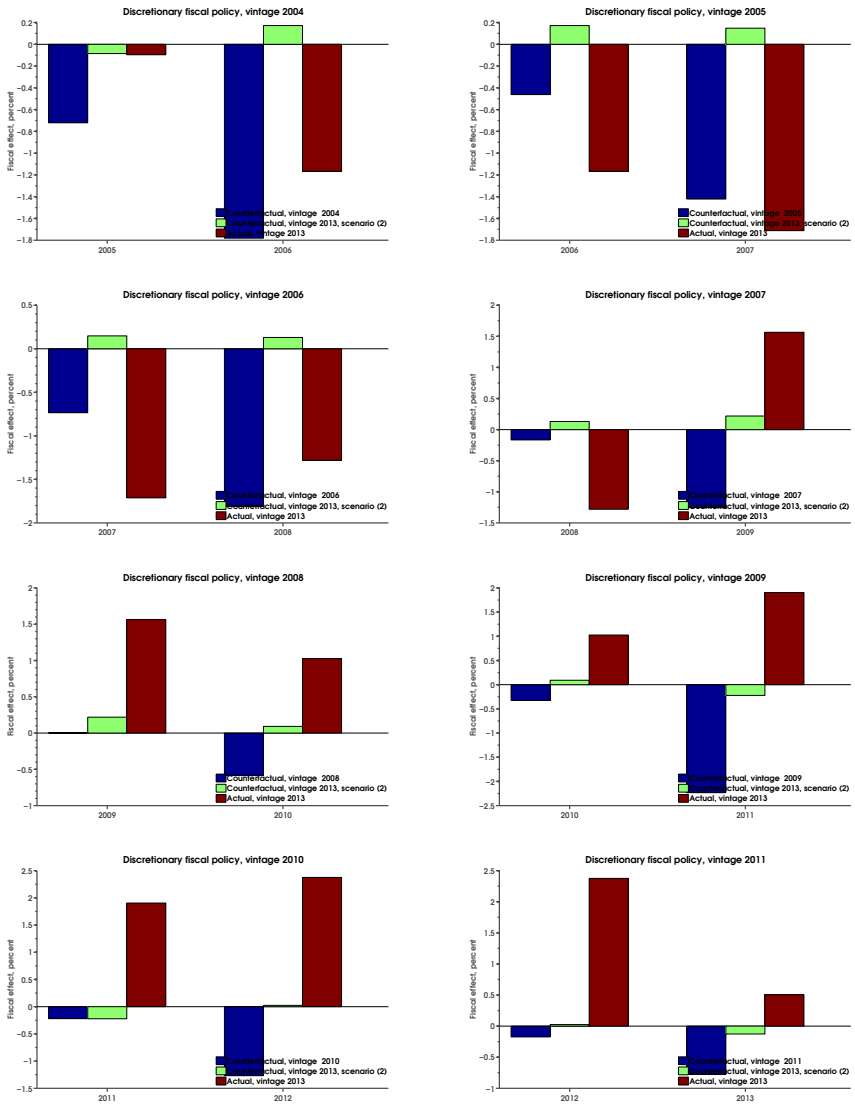

Figure 17: **Actual and counterfactual discretionary fiscal policy.**
These figures show the actual and counterfactual discretionary fiscal policy measured by yearly fiscal effects. The fiscal effects denote the effect on output from discretionary fiscal policy. We calculate the yearly fiscal effects as the average quarterly effects through the respective years. The first column denotes the fiscal effect in the counterfactual scenario based upon information in the respective vintage. As an example, fiscal policy in the year 2005 in the 2004-vintage is counterfactual fiscal effect based upon the forecast conducted in 2004. The second column denotes the counterfactual fiscal effect based on full information from 1990-2014. The figure shows the fiscal effects from scenario (2) in section (4). In both counterfactuals, fiscal policy is conduced according to the Taylor-rule. See also section (3). The third column denotes actual fiscal effects based on the estimation in Pedersen and Ravn [2013].

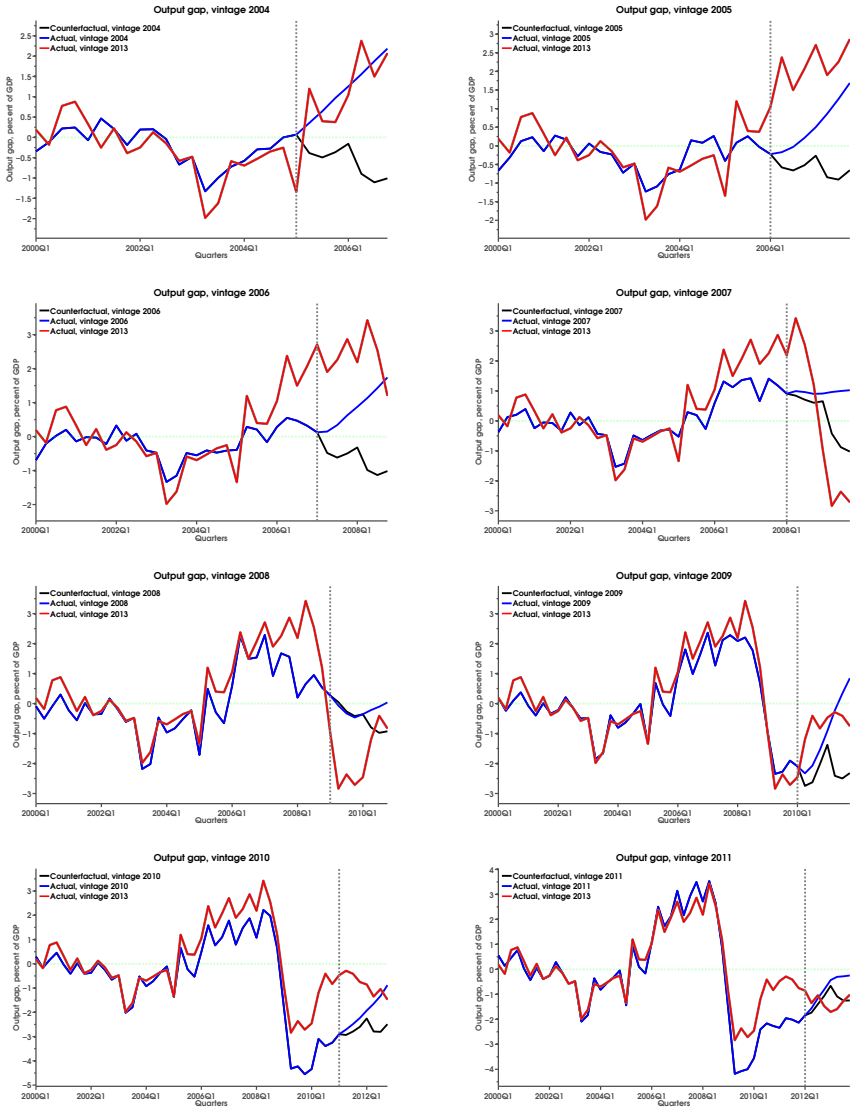

Figure 18: **Actual and counterfactual implied output gap.**
This figure shows the output gaps from various data vintages. The output gap is defined as the difference between actual real GDP and an estimated trend following Pedersen and Ravn [2013]. The thick red line is the output gap estimated in Pedersen and Ravn [2013] using data from 1990-2014. The output gap for, as an example, vintage 2004 is the output gap estimated in the same model used in Pedersen and Ravn [2013] using data from 1990 to 3^{rd} quarter 2004. We use forecast for the period after the 3^{rd} quarter for the respective vintages to mititage end point problems in the estimation, and because the forecasts is the information the policy makers had avaible to the conduct of fiscal policy for the respective vintages. The forecasts are the actual forecasts conducted by Nationalbanken for the vintage. The vertical dotted lines show the beginning of the forecast period for the respective vintages.

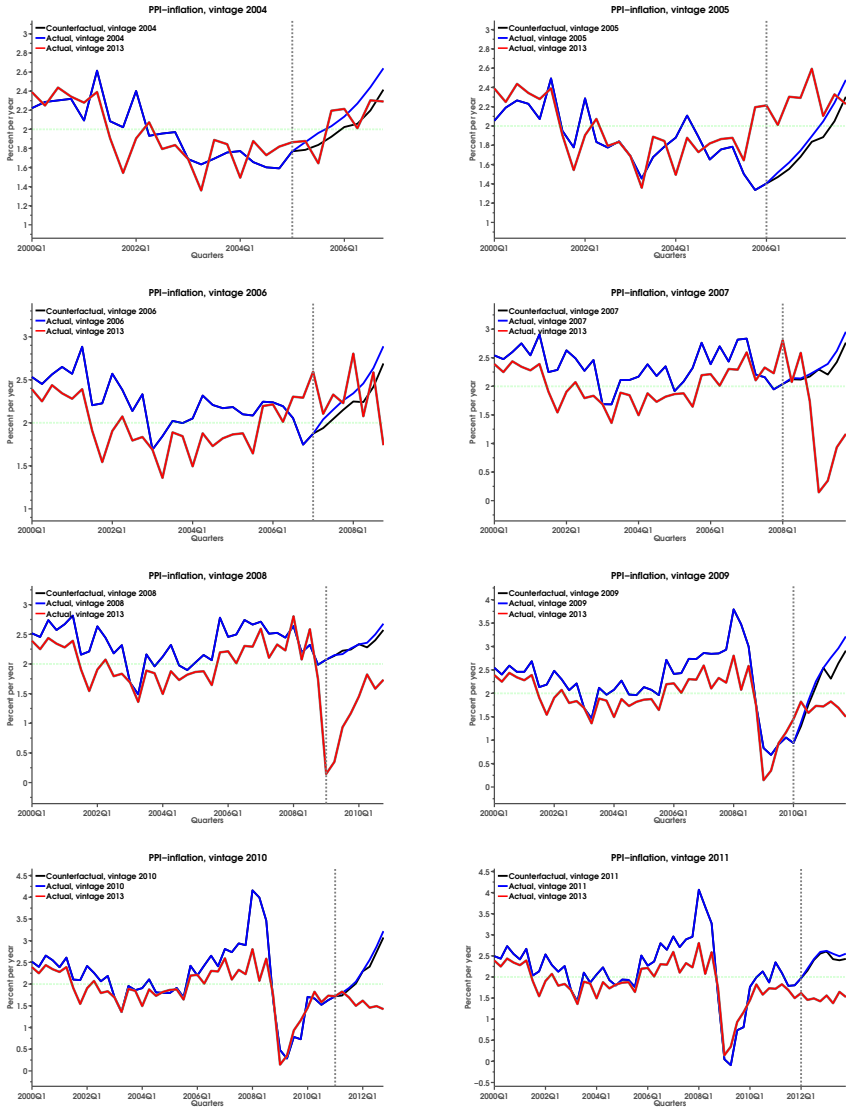

Figure 19: **Actual and counterfactual implied inflation rate.**
This figure shows inflation in producer prices from various data vintages. The thick red line inflation estimated in Pedersen and Ravn [2013] using data from 1990-2014. Inflation for, as an example, vintage 2004 is inflation estimated in the same model used in Pedersen and Ravn [2013] using data from 1990 to 3^{rd} quarter 2004. We use forecast for the period after the 3^{rd} quarter for the respective vintages to mititage end point problems in the estimation, and because the forecasts is the information the policy makers had avaible to the conduct of fiscal policy for the respective vintages. The forecasts are the actual forecasts conducted by Nationalbanken for the vintage. The vertical dotted lines show the beginning of the forecast period for the respective vintages.

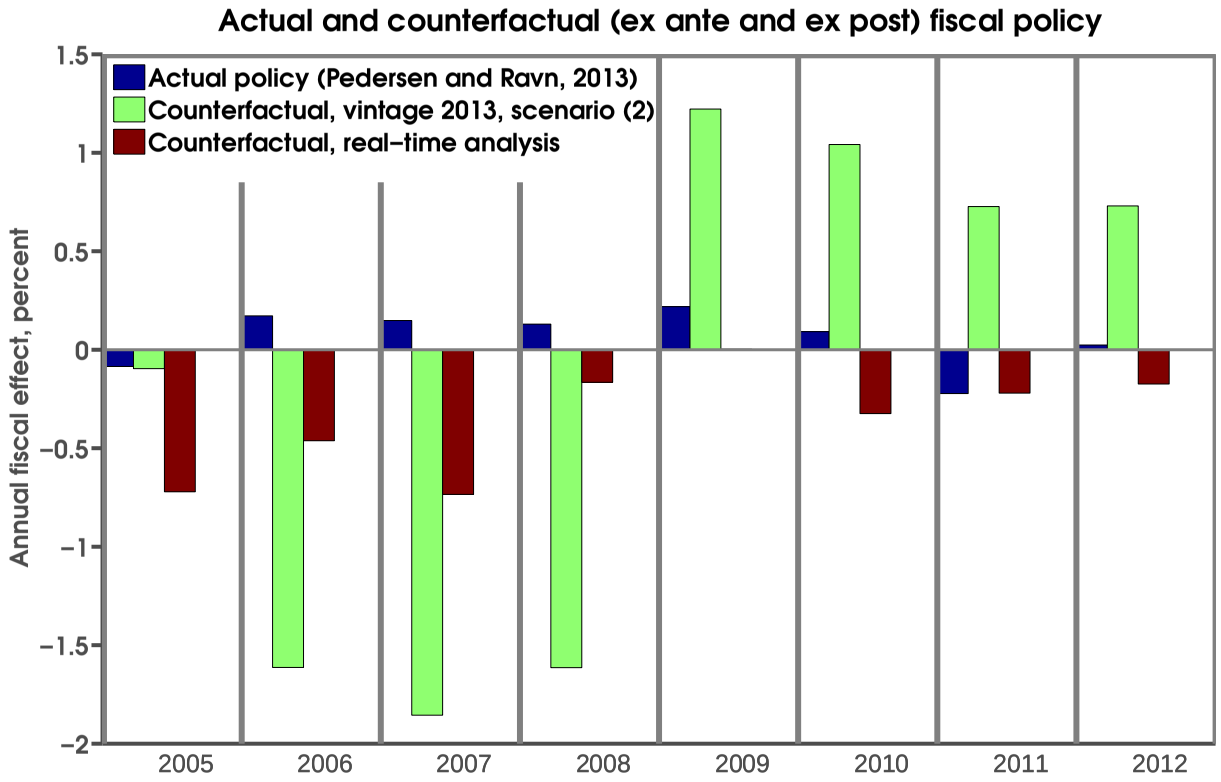

Figure 20: **Actual and counterfactual discretionary fiscal policy from different data vintages.**
This figure shows the actual and counterfactual discretionary fiscal policy measured by yearly fiscal effects for all the vintages. The fiscal effects denote the effect on output from discretionary fiscal policy. We calculate the yearly fiscal effects as the average quarterly effects through the respective years. The first column denotes actual fiscal effects based on the estimation in Pedersen and Ravn [2013]. The second column denote the counterfactual fiscal effect based on full information from 1990-2014. The figure shows the fiscal effects from scenario (2) in section (4). The third column denotes the fiscal effects shown in figure (17) in the counterfactual real-time scenario based upon information in the respective vintage. As an example, fiscal policy in the year 2005 in the 2004-vintage is counterfactual fiscal effect based upon the forecast conducted in 2004. In both counterfactuals, fiscal policy is conduced according to the Taylor-rule. See also section (3).