Is Monetary Policy More Powerful in Recessions or Expansions?

<u>Evidence from Canada</u>

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Abstract

Using the local projection strategy of Jordà (2005) along the smooth transition regression of Granger and Teräsvirta (1993), this paper investigates whether the impact of monetary policy varies according to the state of the business cycle. To estimate the model, the paper uses a novel Canadian monetary policy shock series identified by Champagne and Sekkel (2017) and a "state variable" that captures the state of the business cycle. The paper finds that monetary policy tends to be more powerful in expansions than in recessions, particularly due to a higher sensitivity of business and housing investment and durable consumption to changes in the policy rate. While prices appear to be fairly "sticky" in expansions following a contractionary shock, the opposite is true in recessions when prices respond more vividly. The differences observed across expansionary and contractionary regimes emerge whether the "state variable" used in the empirical estimation captures the growth rate of economic activity (i.e. growth rate of GDP) or the level of resource utilization (i.e. output gap).

Section 1 | Introduction

Plenty of research has studied the impact of monetary policy on the broader economy often concentrating on the magnitude of the responses of different macroeconomic variables and the time it takes for these variables to respond to the change in policy. The collection of research that has been built in this field has given policy makers a better understanding of how their actions impact economic activity, allowing them to better tune their responses to exogenous shocks. For example, the Bank of Canada states in its Monetary Policy Report that their actions can take between "six to eight quarters-to work their way through the economy" (Bank of Canada, 2018). Knowing that the effectiveness of its policies can experience some delay, the Bank measures its actions within a longer time horizon, lowering in turn the odds of oversteering when the economy fails to show signs of improvement immediately after a policy intervention. Ultimately, this prudent and measured approach helps monetary policy be a source of economic prosperity and stability.

Despite the large literature considering the impact of monetary policy in Canada, few studies have evaluated the importance of the shock's timing.[1] Evidence from the U.S. and some European countries, however, has shown that the reaction of output and prices can depend significantly on the state of the business cycle. As will be described in the literature review, some studies have found that contractionary policy shocks during expansions tend to be more powerful than expansionary ones during recessions. Potential failures in financial markets as well as different sensitivity of real aggregates and prices to changes in the interest rate are some of the possible reasons why the effects of monetary policy might be different during the business cycle. Notwithstanding the justification behind previous findings, if these results hold for a given country, it would be important that policy decisions are taken under the understanding that changes in the policy stand do not have the same effect on an expanding or a contracting economy. Treating the policy instrument symmetrically across periods of high and low growth when empirical evidence points to the contrary can lead to unintended

[1] The meaning of "timing" of monetary policy varies across studies. By "timing", some studies, for example, may refer to different quarters of the year while others may refer to different states of the business cycle. This study considers the "timing" of monetary policy in the context of the business cycle. That is, whether the impact of monetary policy shocks varies between expansions and contractions.

consequences as the policy maker would not be able to accurately measure the adequacy of his/her actions under prevailing economic conditions.

With this in mind and using a framework that accounts for the stage of the business cycle, this paper hopes to learn if the uneven effects of monetary policy observed in other countries around the world can be corroborated in Canada. A modern empirical technique used by Tenreyro and Thwaites (2016) in the U.S. in conjunction with a novel (Canadian) monetary policy shock series identified by Champagne and Sekkel (2017), give this study an opportunity to explore confidently whether the effects of Canadian monetary policy are time-dependent. To do so, the paper considers how output and prices respond to monetary policy shocks that occur at different states of the business cycle by using a regime-switching local projection model that distinguishes between expansionary and contractionary regimes. Similar to several studies conducted in the U.S., this paper finds that output tends to react sensitively and persistently when monetary policy shocks occur in an expansion while the output response is smaller and short-lived when the shock takes place in a contraction. On the other hand, while the inflation response to a monetary policy shock that occurs in an expansion is initially subdued, prices appear to respond more quickly when the shock is introduced when the economy is contracting. To disentangle the output responses, the paper considers more disaggregated expenditure measures such as business investment, durable consumption, and government expenditure. In line with expectations, more durable aggregates such as business investment and expenditures in goods and housing tend to respond much more sensitively to a change in interest rates than other expenditure measures like non-durable consumption and services. Over the short term, fiscal policy seems to reinforce monetary policy in an expansion as government expenditures appear to decline. In a contraction, however, because government expenditures appear to decrease in the short run, fiscal policy seems to attenuate it. Over the medium to long-term, however, the government response is largely muted across both regimes. Finally, alternative indicator variables for the state of the business cycles are considered including the growth rate of real GDP and the output gap. They all provide evidence that monetary policy appears to be more powerful during expansions.

The remainder of the paper is structured as follows. The next section discusses some of the literature surrounding the identification of monetary policy shocks, the impact of monetary policy in general, and relevant literature surrounding the timing of monetary policy. Section 3 presents the empirical model with its parameters, the monetary policy shock series used to estimate the baseline results and the overall data. Section 4 describes the empirical results and provides some economic interpretation of them. Section 5 presents some robustness checks around the empirical findings and section 6 offers some concluding remarks.

Section 2 | Literature Review

The literature surrounding the impact of monetary policy shocks on economic activity is extensive and diverse both in terms of empirical methods used as well as sample periods and countries covered. Lawrence, Eichenbaum and Evans. (1999) and Ramey (2016) provide a comprehensive review of the research that has been completed in this area of macroeconomics. Despite the diverse set of studies available, they find that the literature has not yet converged on a set of assumptions for identifying the effects of an exogenous shock to monetary policy. Quantifying the sensitivity of economic activity to monetary policy shocks requires disentangling endogenous and exogenous changes in the policy instrument. The various set of identification techniques currently used in the literature highlight just how complex it can be for researchers to disentangled endogenous and exogenous changes. Studies by Romer and Romer (2004), Cloyne and Hurtgen (2016) and Champagne and Sekkel (2017), for example, apply narrative methods to identify monetary policy shocks in the U.S., U.K. and Canada, respectively. Alternative monetary policy shock measures have also been estimated by Boivin and Giannoni (2006) and Coibion and Gorodnichenko (2011) using Taylor rules. Much of the literature, however, has used standard vector autoregressions (VAR) which either rely on the assumption that policy innovations have no contemporaneous effects on macroeconomic variables (often referred to as the "recursiveness assumption"[2]) or use sign restrictions to identify the monetary policy shocks. Bernanke and Blinder (1992), Bernanke and Mihov (1998)

[2] See Christiano, Eichenbaum, and Evans (1999)

and Olivei and Tenreyro (2007) are just some of the papers that have used the VAR methodology to identify monetary policy shocks.

As can be seen in the empirical literature, the identification technique that is adopted in each study can considerably impact the estimated quantitative effects of monetary policy. For example, many of the studies that use VARs find that the effects of monetary policy for the U.S. are relatively modest with estimates ranging between 0.3 and 1 per cent.[3] Romer and Romer (2004) who used narrative evidence, on the other hand, estimate that a one-percentage-point monetary policy shock reduced industrial production in the U.S. by 4.3 per cent. In Canada, Champagne and Sekkel (2017), who used an identification approach similar to Romer and Romer (2004), find that output responds more moderately to the policy shock, falling by about 1 per cent.[4] While the baseline results from this study use the novel monetary policy shock series identified by Champagne and Sekkel (2017), the robustness section considers whether the baseline results hold when one utilizes a shock series identified using the popular "recursiveness assumption" under a VAR framework. Overall, the results emerging from the two identification techniques appear to be qualitatively consistent.

Although the timing of monetary policy shocks has received limited coverage, some important and interesting work has been completed. Some researchers have looked at whether monetary policy has been more effective during different historical periods. For example, using a factor-augmented VAR (FAVAR), Boivin, Kiley, and Mishkin (2010) investigate how output and inflation responded to monetary innovations that occurred pre-1973Q3 and post-1984Q1. They find that both variables tended to react more aggressively pre-1973Q3 and claim that the differences observed across the periods can be explained by changes in the policy behaviour and the impact that this had on expectations. Other type of research in this field has investigated if the impact of monetary policy depends on the time of the year in which the shock occurs. In particular, motivated by the existence of contractual rigidities in the U.S., Olivei and Tenreyro (2007) examined whether the effects of monetary policy are uneven across

[3] See Champagne and Sekkel (2017)

[4] Despite the differences across the identification techniques, Coibion (2012) finds that accounting for three factors, namely different contractionary impetus, the period of reserves targeting and lag length selection can generate consistent real effects of policy shocks across identification techniques for the U.S.

different quarters of the year. They find that shocks that occur in the first two quarters, when wage-contracts are unable to quickly adjust, tend to have larger effects than those that occur in the last two quarters of the year. Olivei and Tenreyro (2010) find similar results for Japan where uneven-wage contract patterns are also apparent. Theoretical work by Christiano et al. (2005) supports the reasoning behind Olivei and Tenreyro's (2007, 2010) work, finding that wage-rigidities in dynamic stochastic general equilibrium (DSGE) models help match the movements that macroeconomic variables experience after monetary policy shocks. Using disaggregated data from labor intensive sectors in the U.S., Paneva (2013) confirms the uneven effects of monetary policy across quarters observed by Olivei and Tenreyro (2007). She suggests, however, that something other than irregular wage-setting practices might be responsible for explaining the uneven impact of monetary policy given the fact that, following a monetary policy shock, the output responses that she estimates for more labour-intensive sectors (where wage contracts are more prevalent) do not appear to be significantly different to those from less labour-intensive sectors.

While the previous studies have clearly helped explore if "timing" of monetary policy matters, most of the work in this field has looked at whether the effectiveness of monetary policy depends on the state of the business cycle. Recent work by Tenreyro and Thwaites (2016), which this paper follows closely, investigates if U.S. monetary policy shocks have different effects in an expanding or a contracting economy. After examining a range of U.S. real and nominal variables, they find that monetary policy is less powerful in recessions than in expansions. Like this study, they conjecture that the typical responses estimated from time-independent (i.e. linear) models tend to be the by-product of output responses that are particularly sensitive during expansions and interestingly unresponsive during contractions. The decomposition of the output responses estimated in either an expansionary or a contractionary regime, however, continue to show a familiar picture with durable and business investment responding much more sensitively to monetary shocks than non-durable consumption and services. To undergo the time-dependent analysis presented in their paper, Tenreyro and Thwaites (2016) must choose a variable that measures the state of the economy. Because the estimated results can depend significantly in which variable is chosen, Tenreyro and Thwaites

(2016) test a variety of options including the growth rate of gross domestic product (GDP) and the output gap. While the state variable related to how fast the economy is growing (i.e. the growth rate of GDP) supports the asymmetric impact of monetary policy that they observed across regimes, measures related to resource utilization (i.e. the output gap) seem to provide little backing for their baseline results. In comparison, while the baseline results in this study use the same indicator variable as Tenreyro and Thwaites (2016) (i.e. the growth rate of GDP), the resource utilization indicator considered in the robustness section also appears to provide some support for my results.

From a methodological point of view, Tenreyro and Thwaites (2016) use the smooth transition regression method of Granger and Teräsvirta (1993) along with the local projection method of Jordà (2005), just like I use in this paper. While Auerbach and Gorodnichenko (2011) and Ramey and Zubairy (2014) also employed the same strategy to study fiscal policy, previous monetary policy studies in this field have used different empirical techniques. For example, unlike this study which uses local projections, Weise (1999) and Thoma (1994) both implement VAR methodologies that take into account the state of the business cycle. Weise (1999) does so by using a smooth-transition technique much like it is done in this paper whereas Thoma (1994) allows some coefficients in his nonlinear-VAR to depend on output growth. Despite the differences in their empirical models, they also find that monetary policy shocks have a larger impact when output growth is high in the U.S. In contrast to the results in Weise (1999) and Thoma (1994), Lo and Piger (2005) and Smets and Peersman (2001) find monetary policy to be more powerful in recessions than expansions. However, their empirical estimations, as pointed in Tenreyro and Thwaites (2016), seem to have important shortfalls. For example, the variable that Lo and Piger (2005) use to capture the state of the business cycle is unable to adjust during certain periods of the impulse horizon, limiting the feedback mechanism in the model. Similarly, Smets and Peersman (2001) place significant judgment on the behaviour of the economy by imposing that policy innovations spread identically across both expansionary and contractionary regimes.[5] Taken together, the regime-switching local projection model

[5] See Lo and Piger (2005) and Smets and Peersman (2001) for more details on their methodologies.

employed below helps overcome some of the obstacles encountered in previous studies.[6] On the one hand, unlike a VAR, local projections place little restrictions on the behavior of the variables or their interactions. They also require the estimation of less parameters, increasing the degrees of freedom and often helping prevent the loss of valuable observations.[7] Moreover, as pointed by Tenreyro and Thwaites (2016), the estimation of the local projection model in conjunction with a regime-switching strategy frees the researcher from having to impose potentially inaccurate judgment on how the economy changes states. Instead, as it will become clear in the empirical section, the model is able to independently capture how a given shock impacts the *future* state of the economy by allowing the coefficients that measure the effect of a shock to depend directly on the state of the business cycle.

While the studies above employed different empirical techniques and their results might not always coincide, they all find that the impact of monetary policy does in fact depend on the state of the business cycle, interesting result in and of itself. Because the overwhelming majority of the research has concentrated in the U.S., however, the results found in the existing literature can not be corroborated in other geographical regions. This paper will attempt to fill this gap by studying whether the effects of ***Canadian*** monetary policy depend on the state of the business cycle while looking at the behaviour of both aggregate and disaggregate variables. Canada is a particularly good place to test the results of the existing literature after the emergence of a novel (Canadian) monetary policy shock series created by Champagne and Sekkel (2017) which can nicely be used within the set of modern empirical techniques recently implemented by Tenreyro and Thwaites (2016).

Section 3 | Empirical Framework and Data Description

3.1 Econometric Method and Inference

A smooth transition-local projection model (STLPM) is used in this paper to understand if the impact of monetary policy varies throughout the business cycle. The same empirical

[6] See Tenreyro and Thwaites (2016) for a more technical discussion on the advantages of the regime-switching local projection method.

[7] See Jordà (2005) for details

model was used recently by Tenreyro and Thwaites (2016) to study the same question in the U.S. The model takes the following form:

$$(1)\quad \boldsymbol{y_{t+h}} = \boldsymbol{\tau t} + \boldsymbol{F(z_t)}\left(\boldsymbol{\alpha_h^b} + \boldsymbol{\beta_h^b \varepsilon_t} + \boldsymbol{\gamma^{b'} x_t}\right) + \left(\boldsymbol{1} - \boldsymbol{F(z_t)}\right)\left(\boldsymbol{\alpha_h^r} + \boldsymbol{\beta_h^r \varepsilon_t} + \boldsymbol{\gamma^{r'} x_t}\right) + \boldsymbol{u_t}$$

where $\boldsymbol{y_t}$ represents a dependent variable, the superscripts $\boldsymbol{b}$ and $\boldsymbol{r}$ indicate a boom and a recession, respectively, and the response of $\boldsymbol{y_t}$ at horizon $\boldsymbol{h}$ to a monetary policy shock ,$\boldsymbol{\varepsilon_t}$, is estimated using the coefficient $\boldsymbol{\beta_h^j}$. $\boldsymbol{\tau}$ and $\boldsymbol{\alpha_h^j}$ represent a linear trend and a constant, respectively, while $\boldsymbol{x_t}$ is a vector of controls which does not contain values that are contemporaneous to the monetary policy shock. The set of controls include real GDP, total CPI and four aggregate expenditure measures which together represent the non-policy variables. For these variables, three lags are included in the specification of the model. Furthermore, only one lag of the policy variable , namely the nominal 3-month treasury bill, is included in the base case. Further details related to these set of variables are discussed in the following sub-section. The lag structure just discussed for both the policy and non-policy variables were informed by the Akaike information criterion. Having said that, the robustness section considers the implications of adopting an alternative lag selection. Because the model needs to be able to determine the state of the business cycle, a "state" indicator variable, $\boldsymbol{z_t}$, which will be discussed later in the section, must be selected**.** This state variable**,** in turn, is fed into the smooth transition function, $\boldsymbol{F(z_t)}$ **,** from equation 1 which takes the following form[8]:

$$(2)\quad \boldsymbol{F(z_t)} = \frac{\mathbf{exp}\left(\boldsymbol{\theta}\,\frac{(\boldsymbol{z_t} - \boldsymbol{c})}{\boldsymbol{\sigma_z}}\right)}{\mathbf{1} + \mathbf{exp}\left(\boldsymbol{\theta}\,\frac{(\boldsymbol{z_t} - \boldsymbol{c})}{\boldsymbol{\sigma_z}}\right)}$$

where $\boldsymbol{c}$ and θ are tuned parameters and $\boldsymbol{\sigma_z}$ is the standard deviation of the state variable. More specifically, while $\boldsymbol{c}$ determines how much of the sample of the economy is in a boom or a recession, $\boldsymbol{\theta}$ regulates whether the economy slowly moves from one state to another or if does so abruptly. Now that the model has been presented, it is important to remark that, as pointed

[8] The specification of $\boldsymbol{F(z_t)}$ uses the logistic function from Granger and Teräsvirta (1993)

by Tenreyro and Thwaites (2016), the average effect of a monetary policy shock (i.e. $\boldsymbol{\beta_h^j}$ in equation 1) "encompasses the average effect of the shock on the future change in the economy's state" (Tenreyro and Thwaites, 2016). As a result, the impulse responses estimated with the smooth transition-local projection model do not have to implicitly assume no change in the state of the economy as other models (e.g. regime switching VAR models) do.[9]

To estimate the impulse responses for the policy and non-policy variables, the equations at horizons zero to twenty quarters for each variable of interest, $\boldsymbol{y_t}$, are estimated as a system of seemingly unrelated regression (SUR) equations. For clarity, it is worth noting that a strategy that estimates equation 1 at each horizon separately by OLS would provide the same set of coefficients, $\boldsymbol{\beta_h^j}$, as the ones obtained by SUR given that the set of controls included across equations remains constant.[10] Following Tenreyro and Thwaites (2016), two methods are used to make inferences on the set of impulse responses estimated. The first approach uses the Driscoll and Kray (1998) method and estimates Newey-West standard errors for the parameters in equation 1 so as to correct for correlation in the residuals. The second approach bootstraps a statistic that tests the null hypothesis that the difference between the coefficient in an expansion and a recession is zero ($\text{i.e. } \boldsymbol{\beta_h^b - \beta_h^r = 0}$). In particular, the bootstrap procedure takes 10,000 samples of size $\boldsymbol{T}$ with replacement which are then used to estimate a p-value defined as the share of samples where the null hypothesis failed. The p-value obtained is then used to estimate the t-statistic presented within the figures in the following section.[11]

3.2 Data

As mentioned earlier, the set of non-policy variables used to estimate the local projection model include the log of real GDP, the annualized log difference of total CPI and the log of four aggregate expenditure measures, namely business investment, durable consumption & housing investment, non-durable consumption & services and government expenditures. The log specification of the expenditure variables is chosen to remain consistent with many

[9] The impact of the monetary policy shocks on the probability measure F(z) could in principle also be examined, but this analysis goes beyond the scope of the paper and is left for future research.
[10] For technical details related to the estimation procedure, see Tenreyro and Thwaites (2016).
[11] For more technical details about the two approaches please see Tenreyro and Thwaites (2016).

macroeconomic studies including Tenreyro and Thwaites (2016), Champagne and Sekkel (2017), Cloyne and Hurtgen (2016) and Olivei and Tenreyro's (2007, 2010). The four aggregate expenditure measures used in this study also coincide with those used by Tenreyro and Thwaites (2016). It is worth noting that while different economic activity and price level measures like the unemployment rate and the GDP-deflator could have been employed to conduct the study, real GDP and Total CPI have been widely used both in the empirical literature and by policy makers. Total CPI, in particular, is looked at closely at the Bank of Canada as it allows the Bank to determine if inflation is close to its 2 per cent target. The nominal 3-month treasury bill constitutes the policy variable used in all estimations, which closely reflects the behavior of the target for the overnight rate (the Bank of Canada policy rate) but is available over a longer time horizon.[12] The aggregates measures that do not correspond directly with published series are constructed according to the specifications set out in table 1 below. All the variables are in quarterly frequency and are downloaded directly from CANSIM, Statistics Canada's main time-series database.

The sample period covered in this study goes from 1974Q1 to 2013Q1, when the monetary policy shocks are introduced in the model. Having said that, the response of variables are measured 20 quarters after the shock (i.e. 2018Q1) which means that the study covers both the great recession as well as the oil price shock of 2014. Details about the state variable and the monetary policy shock series used in the estimation of the model are presented below.

3.3 Specification of the Logistic Function ($F(z_t)$), the State Variable and Parameters

Similar to Tenreyro and Thwaites (2016), Ramey and Zubairy (2014), and Auerbach and Gorodnichenko (2011), the baseline specification in this paper includes as a state variable, z_t, an eight-quarter moving average of the quarter-over-quarter growth rate of real GDP.[13] The

[12] While the target for the overnight rate is available since 1992, the nominal 3-month treasury bill is available since 1962

[13] Similar to Auerbach and Gorodnichenko (2011), the state variable z_t is normalized to have unit variance, making the variable an index of the business cycle where positive values mark an expansion and negative values a recession. This is true for both the baseline and alternative specifications of z_t. Unlike Auerbach and

remaining parameters in the logistic function, $\boldsymbol{\theta}$ and $\boldsymbol{c}$, are set to 3 and 46, respectively. For example, a very high value of θ would imply that, in each period *t,* the economy is either in an expansion or a contraction, while a low level would mean that the economy takes longer to move across regimes. In line with Tenreyro and Thwaites (2016), the parameter $\boldsymbol{\theta}$ is calibrated so as to give a moderate degree of intensity to the regime switching, helping smooth the transition between regimes. As for $\boldsymbol{c}$, larger values of this parameter imply that a higher share of the sample of the economy is in a recession (e.g. $\boldsymbol{c}$=60 would imply that the economy is about 60% of the time in a recessionary regime), while smaller values indicate that a larger share is in an expansion. Following Auerbach and Gorodnichenko (2011) who use the NBER recession indicator for the US, $\boldsymbol{c}$ is calibrated so as to be consistent with Canada's OECD Recession indicator between 1961Q1 and 2018Q1. With that being said, alternative specifications of the logistic function and the state variable are considered in the robustness section. In particular, two alternative specification of the state variable are considered, namely the output gap, and Canada's OECD Recession indicator. The output gap measure is computed as the percentage difference between real GDP and a Hodrick–Prescott-filtered (HP-filtered henceforth) estimate of potential GDP.[14] The OECD Recession indicator is retrieved from FRED, Federal Reserve Bank of St. Louis' main macroeconomic database.

3.4 The Monetary Policy Shock Series

Champagne and Sekkel (2017) identify a monetary policy shock series for Canada applying a narrative approach similar to Romer and Romer (2004). Furthermore, they use a real-time projection database that helps "isolate the innovations to the intended policy changes that are orthogonal to the policy-makers' information set" (Champagne and Sekkel ,2017). Ultimately, their estimated regression equation takes the following form:

$$\boldsymbol{\Delta i_t = \beta' X_t + \varepsilon_t}$$

where the depended variable, Δi_t, is the change in the intended policy rate, and X_t is the same vector of controls included by Romer and Romer (2004) with the addition of the U.S. federal

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Gorodnichenko (2011), however, the moving average term z_t used in the baseline specification is lagging rather than centered to avoid having future values of response variables on the right-hand side of the regression.

[14] λ is set to 1600.

funds rate and the USD/CAD nominal exchange to account for the fact that Canada is a small open economy and the Bank of Canada can possibly react to policy changes in the U.S. The estimated residual, ε_t , represents the new monetary policy shock series which this study uses widely. Figure 1 plots the Champagne and Sekkel (2017) monetary policy shock series, along with the transformed state variable $1 - \boldsymbol{F}(\boldsymbol{z_t})$ (i.e. probability of a recession) computed using the parameters described above.

While Tenreyro and Thwaites (2016) build a non-linear monetary policy shock series that depends on the state of the economy, I use the original shock series estimated by Champagne and Sekkel (2017) for two reasons. First, the real-time projection database used in Champagne and Sekkel (2017) is not publicly available making it difficult to re-estimate their measure in a non-linearized fashion. Second, most importantly, Tenreyro and Thwaites (2016) find that it makes "very little difference" in their baseline results if one uses either the original Romer and Romer (2004) series or the non-linear one. Therefore, using the original series from Champagne and Sekkel (2017) should still be able to provide reliable results.

Section 4 | Results

Figure 2 presents the impulse responses of real GDP, total inflation and short-term interest rates to an identified monetary policy shock that increases the nominal interest rate by 1 percentage point. The first column reports the responses obtained from the point estimates of the parameter of the model in expansions (green), recessions (red) and the standard linear specification (blue line) which does not account for expansions and recessions.[15] Columns two to four report the responses obtained from the point estimates of the parameter of the model under the linear, expansionary and recessionary specifications, respectively, along with confidence bands. The y-axis for all the figures in columns one to four indicate the estimated response of each variable to the monetary policy shock (i.e. the coefficient $\boldsymbol{\beta}^{\mathbf{h}}$ equation 1). The

[15] As in Tenreyro and Thwaites (2016), all the impulse response functions (IRFs) are smoothed and scaled so that the shocks result in a 1 per cent increase in the short-term interest rates in all three regimes. "Smoothed" means the three-period centered moving average of the IRFs, except for the endpoints of the horizon for which the responses are computed. The standard errors of these moving averages are computed taking into account the covariance between the estimated parameters of the response functions at different horizons, as explained in the previous section.

x-axis in all the figures denotes the horizon (i.e. $\boldsymbol{h}$) range from the first quarter in which the monetary policy contraction occurs to 20 quarters thereafter. All the figures are accompanied by a gray shaded area and dotted gray lines representing 68 and 90 per cent confidence levels, respectively.[16] The last column reports the value of the t-statistic which tests if the coefficient in an expansion and a recession are equal (i.e. $\boldsymbol{\beta_h^b - \beta_h^r = 0}$).[17] The purple and yellow lines in the figures in the last column are calculated using the Driscoll-Kraay method and the bootstrap approach, respectively (see section 3 for details).

The responses estimated by the linear model and reported in the second column of figure 2 present a well known pattern. Real GDP significantly falls by almost one per cent 8 quarters after the contractionary monetary policy shock and stays there for about 6 quarters. It takes over one year for output to come back to its initial level. While prices remain sticky over the initial quarters of the response, inflation eventually slows down by 0.6 per cent about 12 quarters after the shock. The inflation rate returns to its original level only at the end of the response horizon. After an initial increase, the short-term interest rate displays a relatively high degree of persistence, returning back to its initial level roughly 15 quarters after the shock.[18] It is worth noting that these responses share quantitative and qualitative resemblances with those obtained by Champagne and Sekkel (2017) for the sample period between 1974 and 2015.

The first row of figure 2 shows clearly how the impact of monetary policy on output depends on whether the economy is expanding or contracting. After a contractionary policy shock that occurs during an expansion, output significantly falls 7 quarter after the shock by about 0.8 per cent and then falls sharply an additional 0.8 per cent 8 quarters after. That is, 16 quarter after the monetary policy shock hits the economy, output declines almost 1.6 per cent from its initial level. In contrast, when the same shock occurs at a time when the economy is contracting, real GDP falls 0.7 per cent 7 quarters after the shock and then quickly recovers 6

[16] The confidence levels coincide with published work by Olivei and Tenreyro (2007), Olivei and Tenreyro (2010) and Peneva (2013). As they mentioned, while much of the applied work uses higher confidence levels, work by Sims and Zha (1995) state that using high-probability intervals camouflages the occurrence of large errors of over-convergence and thus promote the use of smaller intervals.

[17] The approach used to construct this t-statistic was discussed in section 3.

[18] Similar dynamics in the behaviour of interest rates are observed in Tenreyro and Thwaites (2016)

quarters after, displaying little persistence. In addition, even the marginal decline in the output response observed in a recession appears to be mostly insignificant throughout the impulse horizon. Taken together, two notable differences emerge between the output responses across regimes. First, once the contractionary shock has had its full effect, the output of an economy that is expanding appears to decline twice as much as the output of an economy that is contracting. The prominent output decline that is observed about 14 quarters after the shock in the expansionary regime appears to be significantly different to the response at that horizon under the contractionary regime whether one considers the Driscoll-Kraay or the bootstrap method. Second, while output does appear to decline slightly in a recession, this decline is much less persistent compared to the case of an expansion.

As can be observed in Panel B from figure 2, some differences are also prominent in the inflation responses across regimes. When one considers the lower confidence level, a contractionary shock that occurs in an expansion appears to generate a slight "price puzzle" in the initial quarters of the response, something which we did not observed with the linear model.[19] At the higher confidence level, however, prices in the expansionary regime remain sticky for most of the impulse horizon and inflationary pressures only begin to emerge more than a year after the shock. In particular, inflation falls sharply by about 1 per cent towards the end of the impulse horizon. The inflation responses in a recession display somewhat different dynamics. First, unlike in an expansion, the inflation response in a recession shows no signs of a significant "price puzzle". Second, disinflationary pressures in a recession emerge just 7 quarters after the contractionary shock, that is 6 quarters earlier than what is observed in the expansionary regime. For example, although the price level has already fallen 0.3 per cent 7 quarters after the shock in a recession, no significant decline in the price level arises over the same horizon in an expansion. Having said that, while inflation does appear to slow down earlier in a recession after the policy shock, the magnitude of its decline is lower than the one observed in an expansion. Broadly speaking, therefore, inflation appears to respond more quickly but less pronouncedly when the monetary policy shock occurs in a recession while the opposite holds in an expansion.

[19] "Price puzzle" refers to an increase in the price level despite a contractionary monetary policy shock

Finally, the behaviour of short-term interest rate following the monetary policy shock does not seem to explain the differences in the output and inflation responses that we observe across regimes (see Panel C in figure 2). More specifically, the response of the nominal interest rate is not much weaker in a recession than an expansion and the small differences that emerge are confirmed to be insignificant by the bootstrap approach. Furthermore, similar to the results found in Tenreyro and Thwaites (2016), interest rates in an expansion decline sharply and significantly below their initial starting level just over half-way through the impulse horizon, unlike in a recession when they never fall significantly below their starting point. In any case, one element looks clear: following a contractionary shock, the nominal interest rate response towards the end of the horizon in an expansion is not higher than the one observed in a contraction. After looking at the short-term interest rate dynamics throughout the entire impulse horizon, therefore, it does not appear like the interest rate are driving the differences between the output and inflation responses that we observed previously. It does, however, appear that the responses estimated by a linear model (which fail to account for the state of the business cycle) camouflage important underlying differences in the impact of monetary policy during expansions and contractions.

To explore whether the uneven effects of monetary policy observed earlier are also prominent at a more disaggregated level, I estimate the impulse responses of four expenditure aggregates to the same contractionary policy shock described earlier. In particular, panels A to D in figure 3 present the responses of business investment, durable consumption & housing investment, non-durable consumption & services and government expenditures, respectively. The responses of business investment, durable consumption & housing investment and non-durable consumption & services (top 3 rows) paint a familiar picture. In line with the results seen at the aggregate level, all three components react considerably more in an expansion than in a recession both in terms of persistence and magnitude. The responses in a recession across the three sub-aggregates are mostly insignificant while those in an expansion are either significant soon after the initial shock, or become so not too long thereafter. Surprisingly, however, business investment in an expansion appears to react positively in the initial quarters after the shock, creating somewhat of a puzzle over the short term which could be the study of future research. Having said that, the initial response in this expenditure component is largely insignificant and eventually contracts following the increase in the policy rate. It is also worth noting that in an expansion the differences across the responses of the three expenditure aggregates are noticeable. For example, while business investment suffers the highest decline contracting by roughly 4.3 per cent, non-durable consumption & services falls only by about 0.9 per cent. Durable consumption & housing investment experiences a slightly smaller decline than business investment, decreasing 3.8 per cent 7 quarters after the shock. Overall, it appears that monetary policy impacts aggregate output in an expansion primarily through business and housing investment and durable consumption, results that are qualitatively similar to those observed for the U.S.[20]

The responses of government expenditures, reported on the last row of figure 3, also present an interesting picture. While this variable decreases in an expansion immediately following the contractionary policy shock, the opposite is true in a recession where we see government expenditures increase. Over both the medium and long horizon, however, the response of government expenditures in an expansion or a recession do not appear to be statistically significant. With this in mind, one could say that the behavior of fiscal variables in the very short term appears to be slightly reinforcing monetary policy in an expansion while attenuating it in a recession. Having said that, because the response of government expenditures is mostly insignificant over the impulse horizon in both regimes, fiscal variables appear to remain largely unaffected by monetary policy shocks.

A possible simple explanation for the observable differences in the impact of monetary policy across regimes, however, could have to do with the distribution of the shocks themselves. That is, if contractionary shocks are more prevalent during an expansion than expansionary shocks are in a contraction, then the results estimated in figures 2 and 3 could be driven by this difference alone and not by the fact that monetary policy, per se, is in fact more powerful in booms. Following Tenreyro and Thwaites (2016), I estimate the probability distribution function (PDF) and the cumulative distribution function (CDF) of the shocks overall

[20] See Tenreyro and Thwaites (2016) for more information about the responses of expenditure aggregates observed for the U.S.

and as a function of the state of the business cycle.[21] As seen in figure 4, there are very minor differences between the means of the distributions of the expansionary and contractionary shocks and the distributions also do not appear to be significantly more variable in one regime than another. Contractionary shocks, therefore, do not seem to prevail in expansions, implying that something else must explain the uneven impact of monetary policy. While the shock's distributions can not help explain the overall discrepancy in the impact of monetary policy in expansions and recessions, additional work in the future could explore this issue further.

Section 5 | Robustness

5.1 Alternative State Variable Specification

The baseline results presented earlier were estimated using a moving average of GDP growth as the state variable. However, the state of the business cycle can be represented using a variety of different measures, two of which are considered next. Figure 5 and 6 both present the response of GDP, inflation and short term interest rates to the same contractionary policy shock as before. The former figure uses as a state variable, $\boldsymbol{z_t}$, a moving average of a {0, 1} recession indicator produced by the OECD (See section 3 and Table 1 for details).[22] The latter figure uses a HP–filtered output gap as the state variable (i.e. a measure for the level of resource utilization), as described in the empirical section.[23]

As one can see, the output responses estimated with either of the alternative state variables do not deviate meaningfully from those observed in the baseline specification. Whether one considers the OECD recession indicator (Figure 5) or the HP-filtered output gap (Figure 6), output seems to respond much more sensitively in an expansion than a recession. In

[21] A normal kernel function is used to obtain smoothed PDF and CDF estimates. The "average" estimate of the distributions shown in figure 4 is computed using the actual shocks from Champagne and Sekkel (2017). The expansion and recession estimates are calculated by weighting the kernel function with the $F(z_t)$ and $1 - F(z_t)$, respectively.

[22] In line with Tenreyro and Thwaites (2016) and in an effort to treat all state variable specifications consistently across the study, the state variable specification that uses the OECD recession indicator is smoothed using the smooth transition function described in section 3.1 (i.e. equation 2)

[23] Despite the output gap being a variable that we can compute, it can be prone to some level of uncertainty since potential GDP is not observable and can only be estimated. As a result, it still seems reasonable to employ $F(z_t)$ in the analysis, which in this case can be interpreted as a measure of the probability of Real GDP exceeding potential GDP

fact, while in the baseline specification output responded slightly during a contractionary period, the output responses estimated using the alternative state variables are entirely insignificant during a recession, further supporting previous findings. The inflation responses estimated with the alternative state variables, however, do seem to show different dynamics compared to those observed in the baseline results. Like output, prices appear to be more sensitive during an expansion when one uses the alternative state variables. The price response just observed under the alterative measures is not unique to this study. Tenreyro and Thwaites (2016) also finds that the inflation response is more pronounced in an expansion, suggesting that monetary policy might in fact be more powerful in that regime not only because of its effect on the real side (i.e. output) but also on the nominal one (i.e. inflation). Having said that, the results estimated with the alternative state variables might not be as adequate as the ones obtained using the baseline case. When the OECD recession measure is used, for example, the short term interest rate appears to increase considerably more in an expansion than in a recession which might help explain why disinflationary pressures are more apparent during a boom (last panel of figure 5). Furthermore, because the HP-filtered output gap inherently contains information about future output (i.e. future values of the response variable are present on the right-hand-side of the regression), the results estimated using this measure can be prone to misspecification. Given the shortfalls that are present in the results estimated using both of the alternative state measures, this study opts to utilize GDP growth in the baseline analysis, as it is also done by a large part of the literature.

5.2 Alternative Monetary Policy Shocks

The baseline results in this study use the monetary policy shock series identified by Champagne and Sekkel (2017) presented in the empirical section. Many monetary policy studies have estimated the impact of monetary policy using shocks that are retrieved using the "recursiveness assumption" under a VAR framework. With this in mind, I estimate a parsimonious VAR with the log-level of GDP, the annualized log difference of total CPI and the level of the nominal 3-month treasury bill. In the estimation, a Cholesky decomposition is used where interest rates are ordered last. Figure 7 presents the structural shocks recovered from the previously described VAR and figure 8 shows the impulse responses of the headline variables when the baseline model is estimated using these shocks. The responses for the linear model in figure 8 are estimated using shocks retrieved from a linear VAR while those for the state-dependent model use shocks from a non-linear VAR which takes into account the state of the business cycle. While the differences that we observed in the base case are larger and more significant, output dynamics remain largely unchanged using the new set of shocks. More specifically, Output continues to slow down steeply during an expansion and only slightly during a contraction, and the magnitude of the fall during an expansion is considerable, falling by almost twice as much than when the shock occurs in a contraction. As observed when the alternative state variables were considered, price responses are mostly muted during a contraction but tangible disinflationary pressures do emerge about halfway through the impulse horizon in a boom. It would be remiss not to mention, however, that the results estimated with the VAR shocks occur against the backdrop of two significantly different interest rate profiles across regimes which might, in part, be driving the output and inflation differences that we observed.

5.3 Trends and Lags in the Regression Equation

In the baseline case, the model is estimated with a linear time trend and three lags of the dependent variables. I investigate below the impact of altering these specifications. Figure 9 presents the responses for the main variables when the model is estimated without a time trend. As in Tenreyro and Thwaites (2016), the results are qualitatively similar to the original ones when one excludes the time trend from the estimation, suggesting that monetary policy shocks still tends to be more effective in an expansion than in a contraction. However, the imprecision of the responses (especially those for the interest rate) and their unrealistic magnitudes point to possible misspecification issues when the model is estimated without a time trend. Any interpretation of the results from this specification should, therefore, be taken with caution.

As mentioned earlier, the inclusion of three lags for the dependent variables is supported by the Akaike information criterion.[24] The Schwartz Bayesian Criterion, however,

[24] See Akaike (1974) for details

recommends including only one lag.[25] Taking this into account, figure 10 presents the results after the model is estimated using one lag. Aside from a more attenuated inflation response in the initial quarters in the baseline case, the results of both specifications are almost identical. The results obtained in the baseline case, therefore, do not seem to depend on the number of lags that one opts to adopt.

5.4 Intensity of Regime Switching

As explained above, the parameter $\boldsymbol{\theta}$ in equation 3 determines how quickly the model switches between expansionary and contractionary regimes. The baseline case uses a specification where the parameter is set equal to 3, giving the model an intermediate degree of intensity to the regime switching. Figures 11 and 12 depict the impulse responses of the headline variables when the degree of intensity of regime switching is higher (i.e. $\boldsymbol{\theta = 10}$) and lower (i.e. $\boldsymbol{\theta = 1}$) than the baseline specification, respectively. Whether the model is estimated with a more or less aggressive switching parameter, the economic interpretation of the results remains the same as in the baseline case: a monetary policy shock that occurs in an expansion tends to move real economic activity more pronouncedly than if it occurs in a contraction, and disinflationary pressures emerge faster in the contractionary regime than in the expansionary one. Modifying the regime switching parameter, therefore, does not seem to meaningfully alter the results.

Section 6 | Conclusion

Understanding if the effects of monetary policy are different throughout the business cycle can help policy makers better gauge how their actions impact economic activity. While some studies have in fact found that the impact of monetary policy shocks depend on the state of the business cycle, none, to my knowledge, have corroborated whether this is the case in Canada. Using a regime-switching local projection model employed by Tenreyro and Thwaites (2016) to study the U.S., this paper explores if monetary policy is more powerful in expansionary or contractionary periods. To estimate the model, the recently identified (Canadian) monetary policy shock series from Champagne and Sekkel (2017) is used. The paper

[25] See Schwarz (1978) for details

finds that the typical impulse responses estimated by time-independent models, as it is usually done in the literature, tend to camouflage apparent differences in the impact of monetary policy within the business cycle. Specifically, this study finds that output tends to decline far more sharply and persistently following a monetary policy shock that occurs in an expansion than one that occurs in a contraction. In contrast to the output responses, prices in a boom tend to show disinflationary pressures later than in a recession. After disentangling the output responses estimated across both regimes, the paper finds that expenditures on durable goods and business investment seem to be more responsive to a monetary policy shock than are non-durable consumption and services. Furthermore, government expenditure is found to reinforce monetary policy in the very short run in an expansion but attenuates it in a recession. In the long run, however, government spending does not respond significantly to the monetary policy shock. The distribution of the shocks considered in the study does not appear to explain the uneven effects of monetary policy between booms and recessions as it is found that contractionary shocks do not predominate in booms. Several alternative model specifications and a different set of monetary policy shocks identified using a VAR were considered in the robustness section. Broadly speaking, the results derived from the alternative specifications support the main conclusion of the paper: **Monetary policy shocks that take place in an expansion tend to be more powerful than those that occur in a contraction**.

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Tables

Table 1: Data Description			
Variable	**Specification**	**Mnemonic**	**Source**
Variables of interest:			
Real GDP*	log	V62305752	Statistics Canada
Total CPI^	log diff. (annualized)	v41690973	Statistics Canada
Fixed business investment*	log	V62305735 + V62305738 + V62305739	Statistics Canada
Consumption of durables and housing investment*	log	v62305734 + v62305726	Statistics Canada
Consumption of nondurables and services*	log	v62305728 + v62305729	Statistics Canada
Government consumption*	log	V62305731	Statistics Canada
Policy variable:			
3-month treasury bill^	level	V122531	Statistics Canada
Monetary policy shock variable:			
Identified monetary policy shocks (Canada)^ ~	level	ChampagneSekkel	Champagne's website
State variables:			
8-Quarter moving average (MA) - real GDP growth	log diff. (MA)	n/a	Author's calculations
Output gap	Hodrick–Prescott-filtered	n/a	Author's calculations
OECD based Recession Indicators for Canada^	level	CANRECDM	FRED

* indicates Chained (2007) dollars; Chained series are aggregated using chained-weighed methodology
^ indicates series was converted to quarterly frequency from monthly by averaging;
~ Monetary policy shocks are introduced between 1974Q1 and 2013Q1
All variables used in the study covered the period between 1974Q1 and 2018Q1 unless otherwise stated.

Figures

Figure 1: Monetary Policy Shocks and the State of the Economy

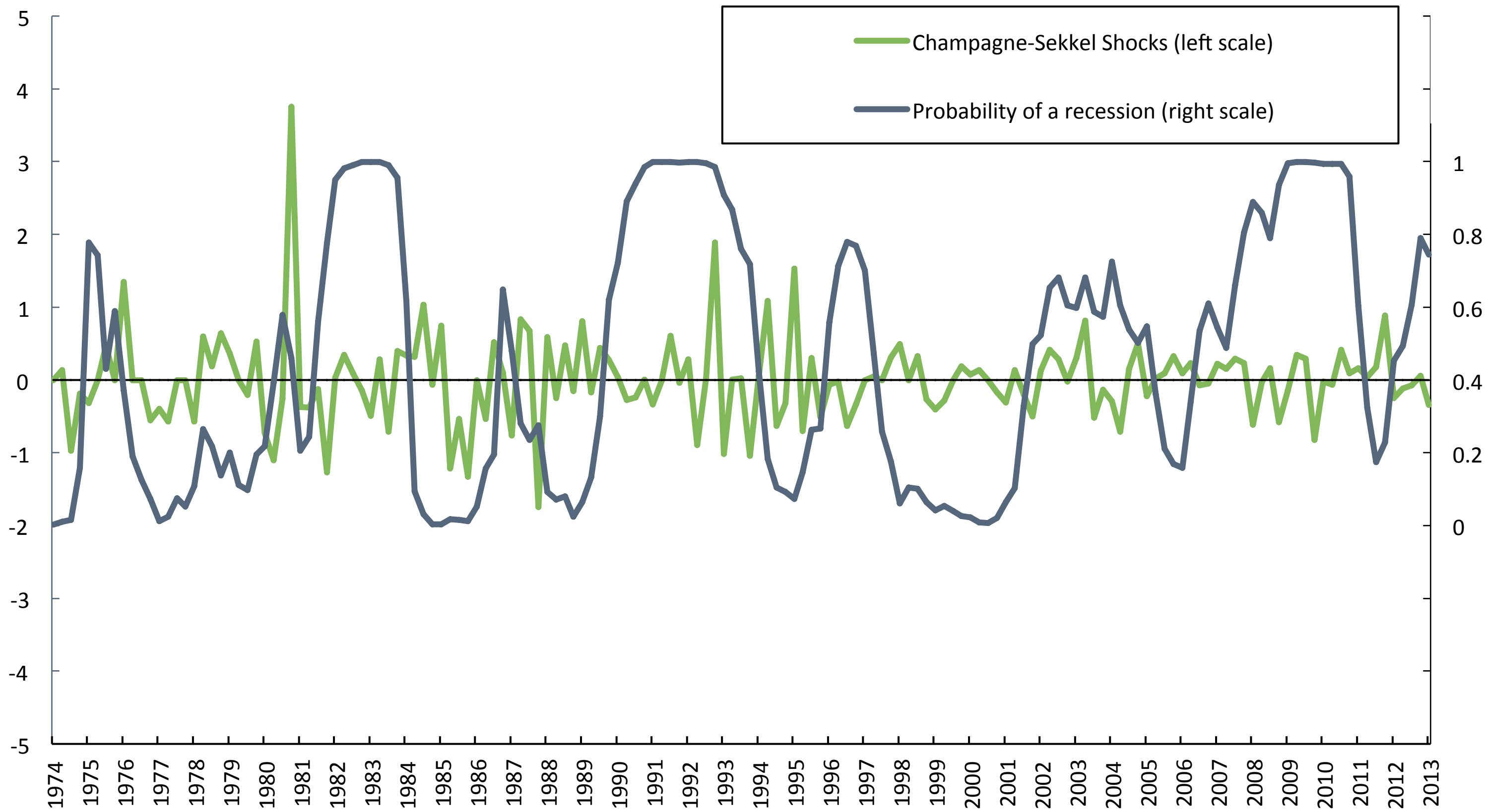
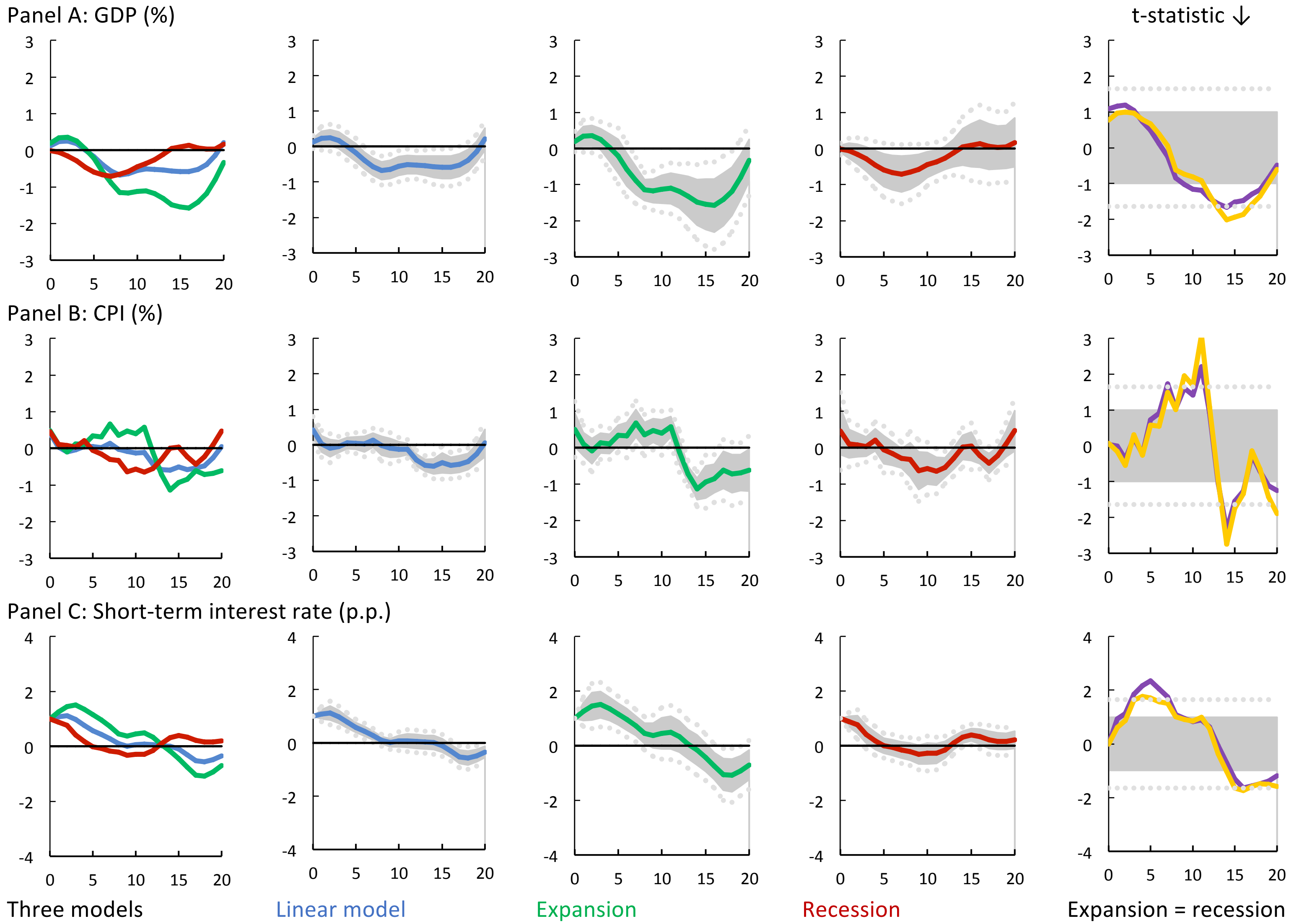
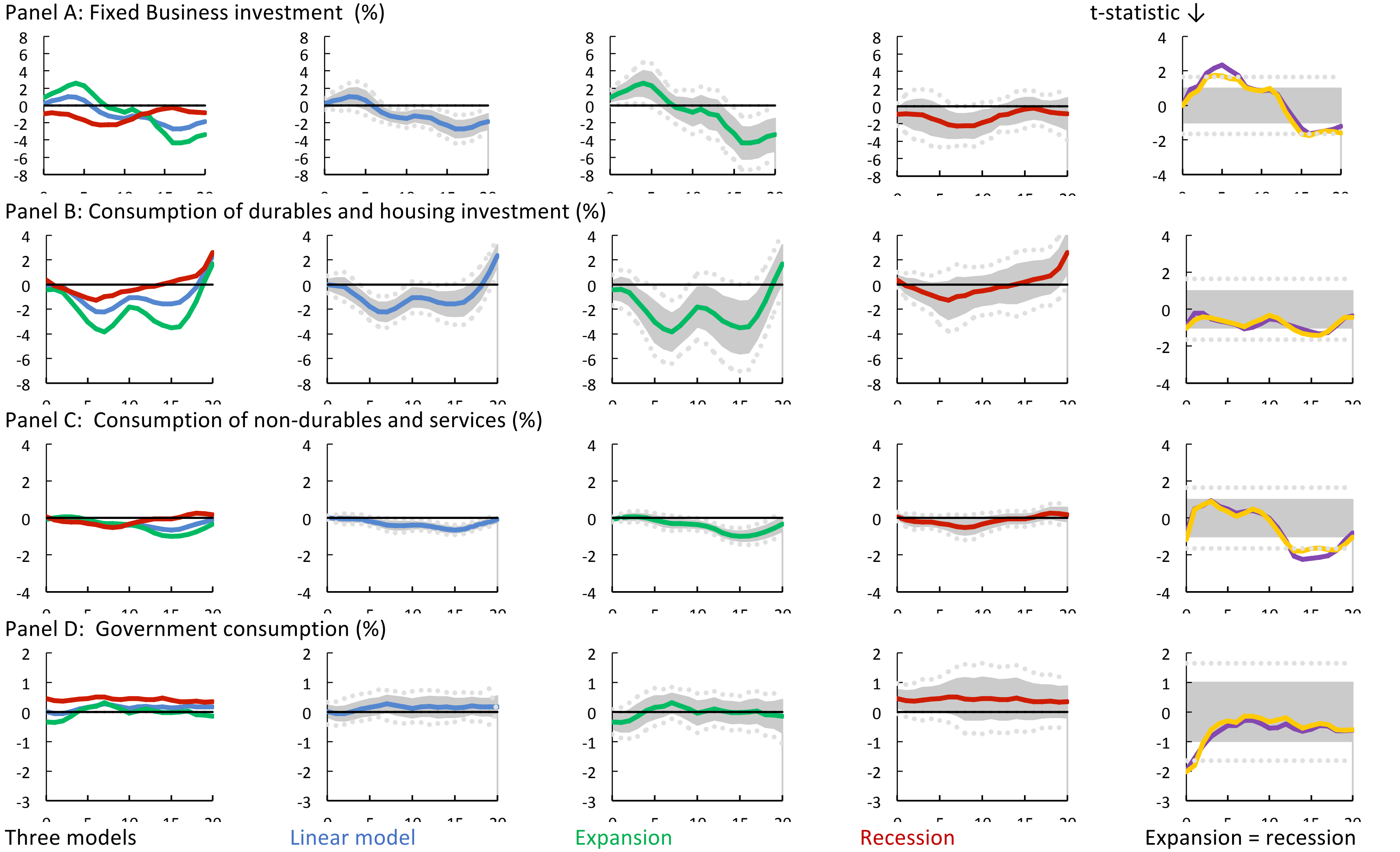


Figure 2: Impulse Response of Headline Variables – Base Case



Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels
The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see the main text for details)

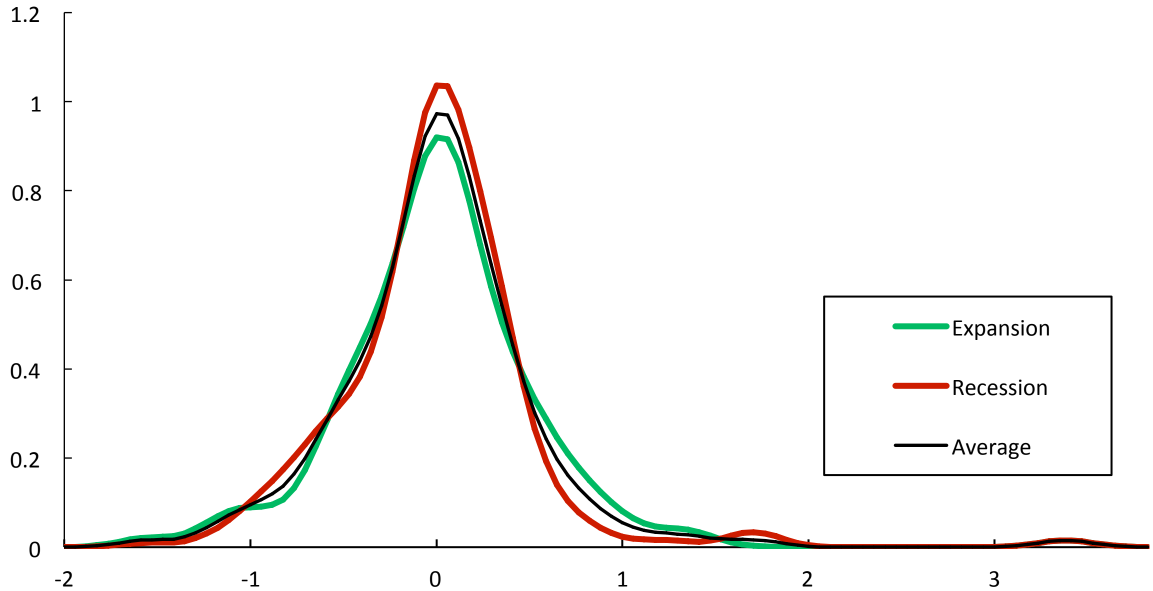
Figure 3: Impulse Response of Expenditure and Fiscal Aggregates



Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels
The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see the main text for details)

Figure 4: PDFs and CDFs of the Regime-specific Shocks – The Black Line Indicates the Average of the Two Regimes.

Panel A: PDF



Panel B: CDF

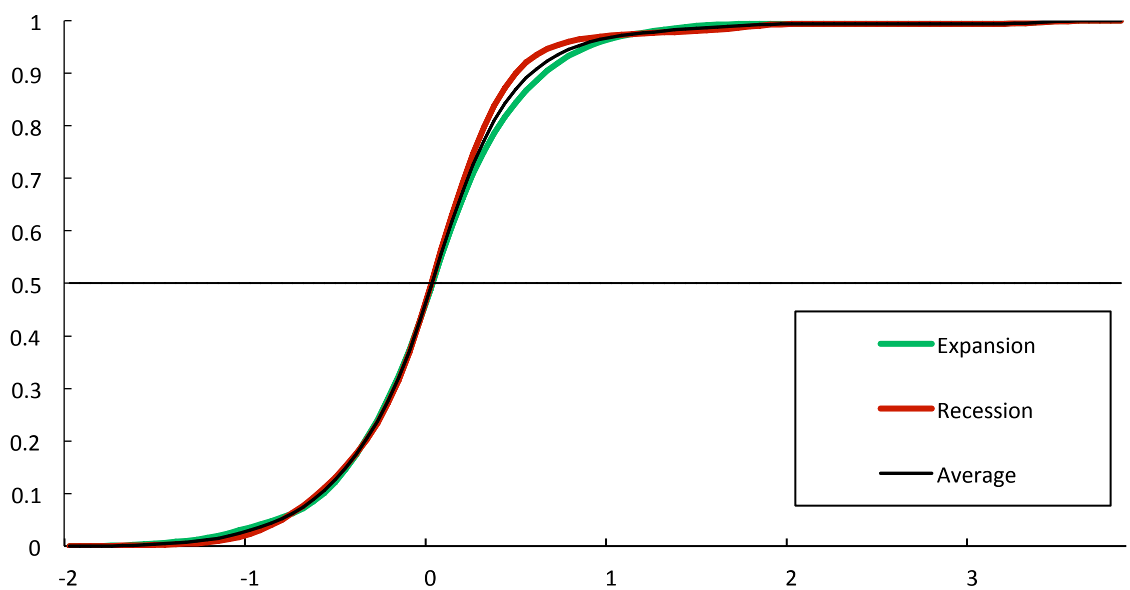
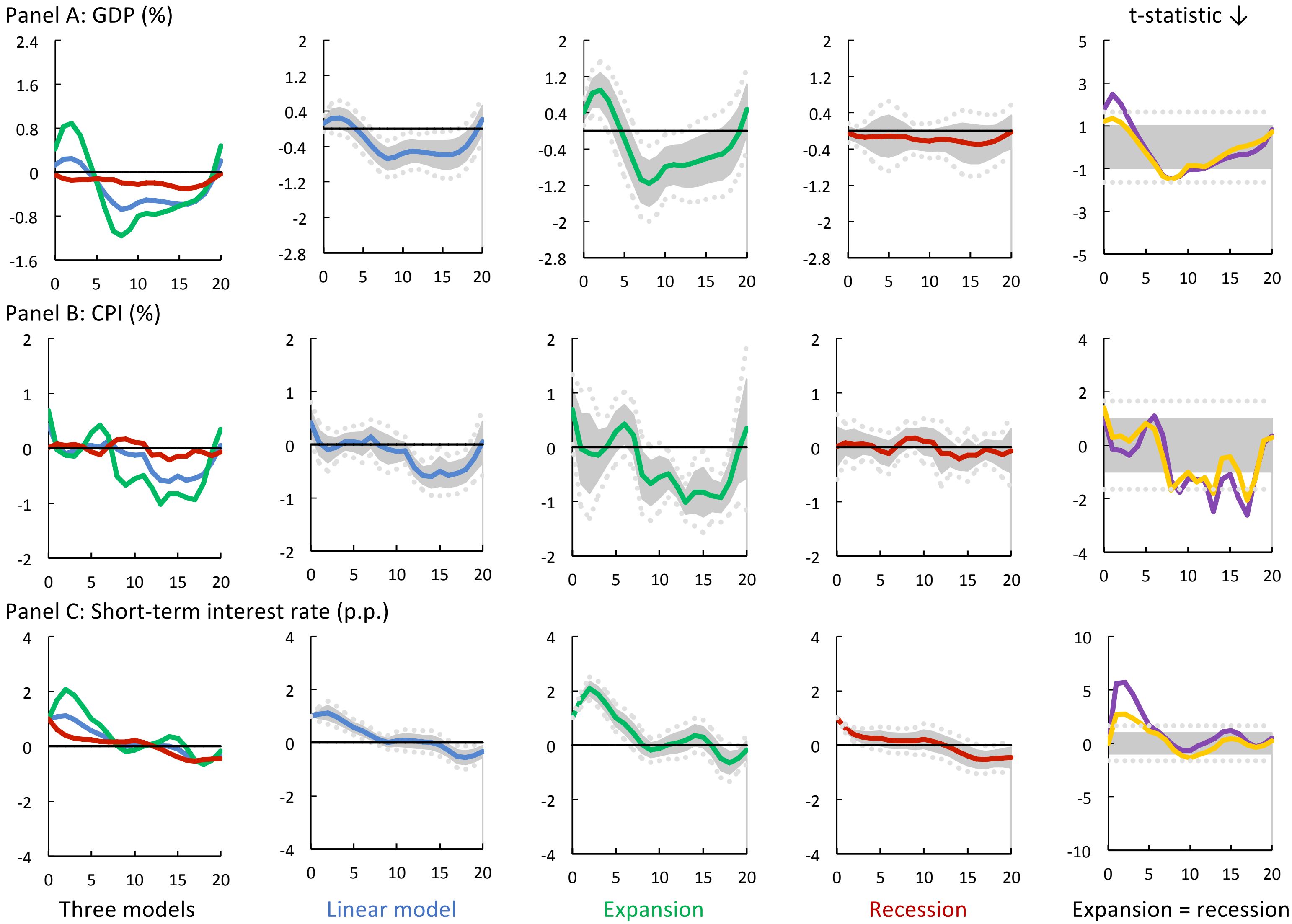
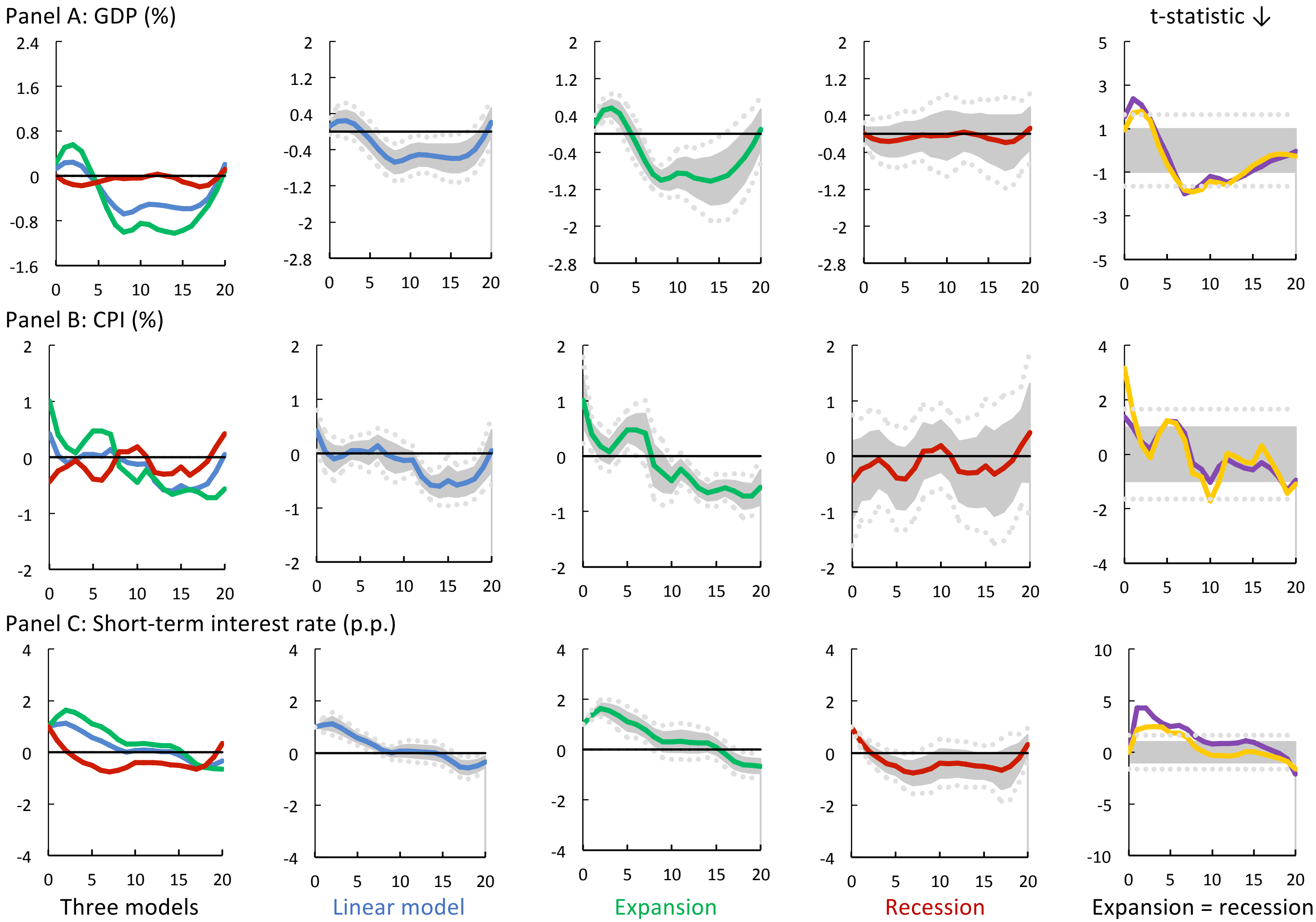


Figure 5: Impulse Response of Headline Variables with OECD Recessions State Variable



Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see the main text for details)

Figure 6: Impulse Response of Headline Variables with Output Gap State Variable



Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels
The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see the main text for details)

Figure 7: VAR Shocks and the State of the Economy

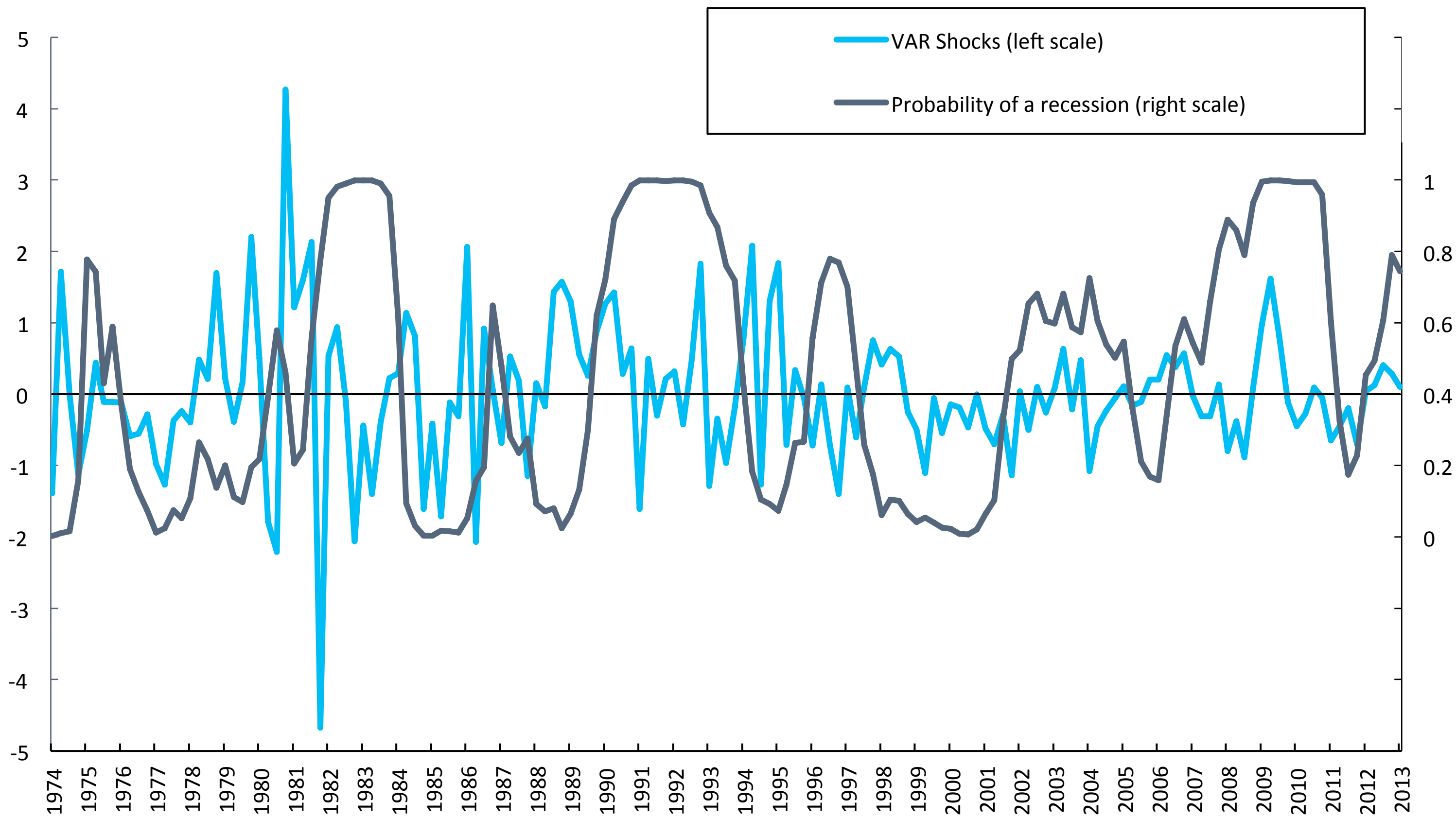
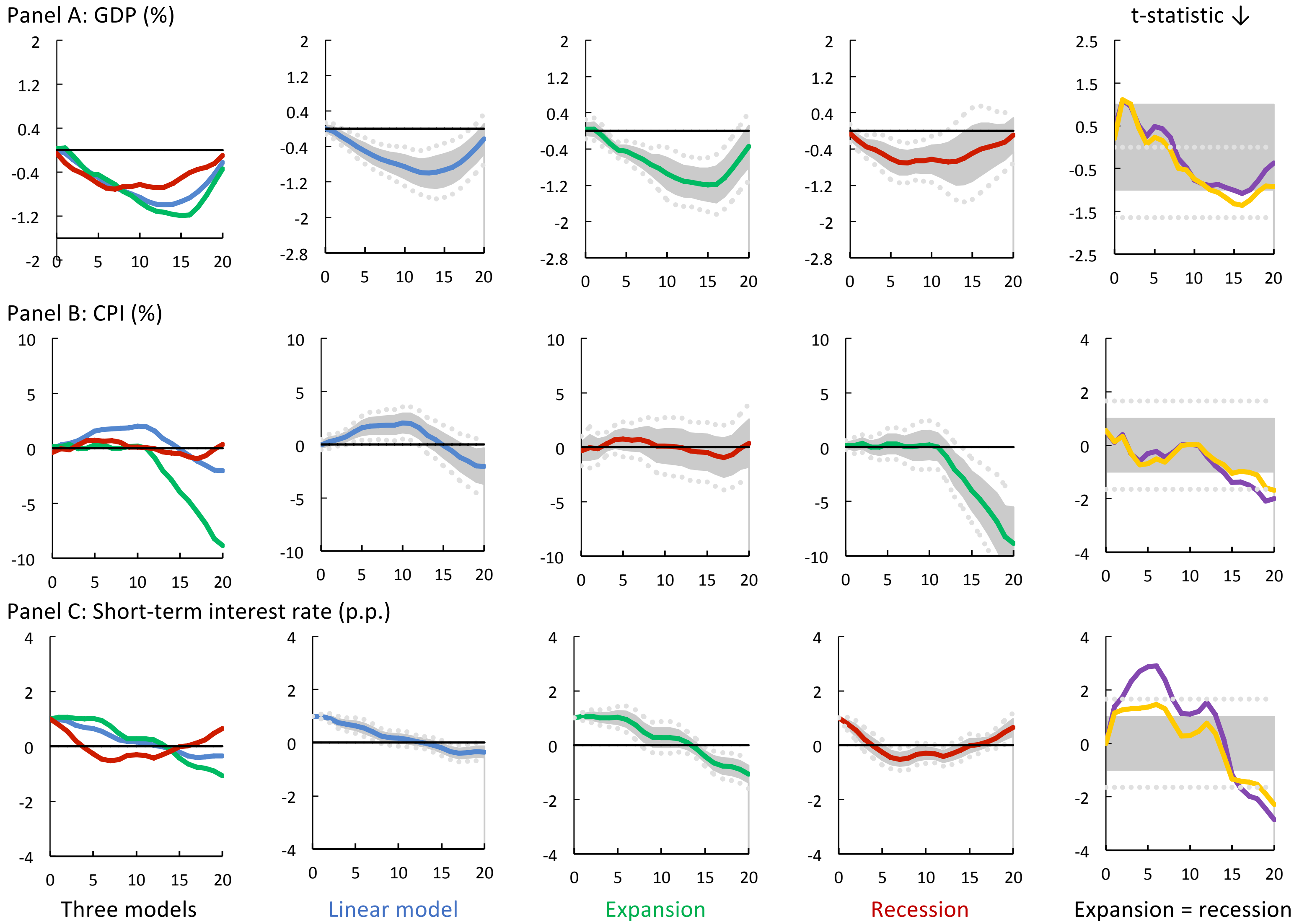
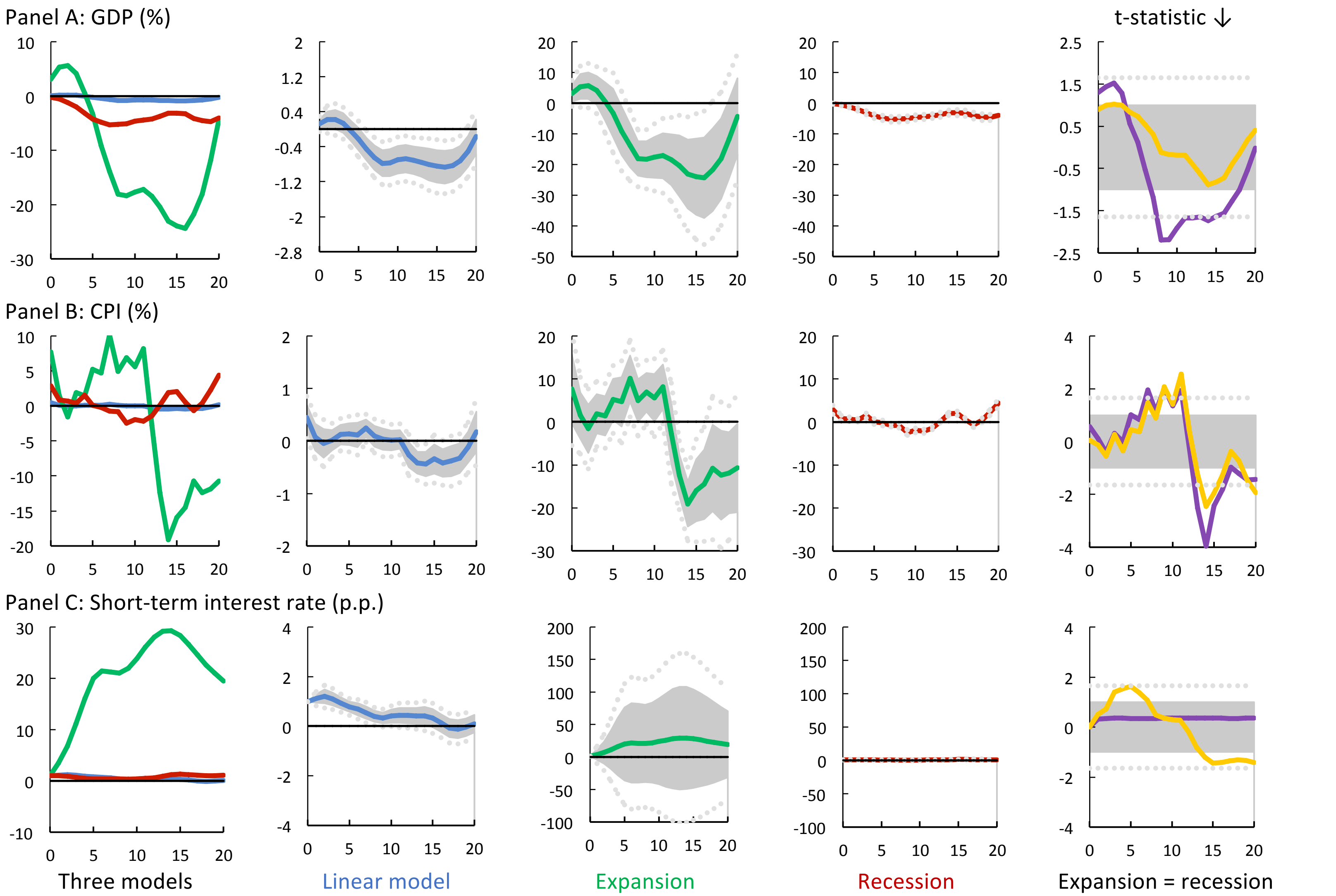


Figure 8: Impulse Response of Headline Variables Using Shocks Identified with a VAR



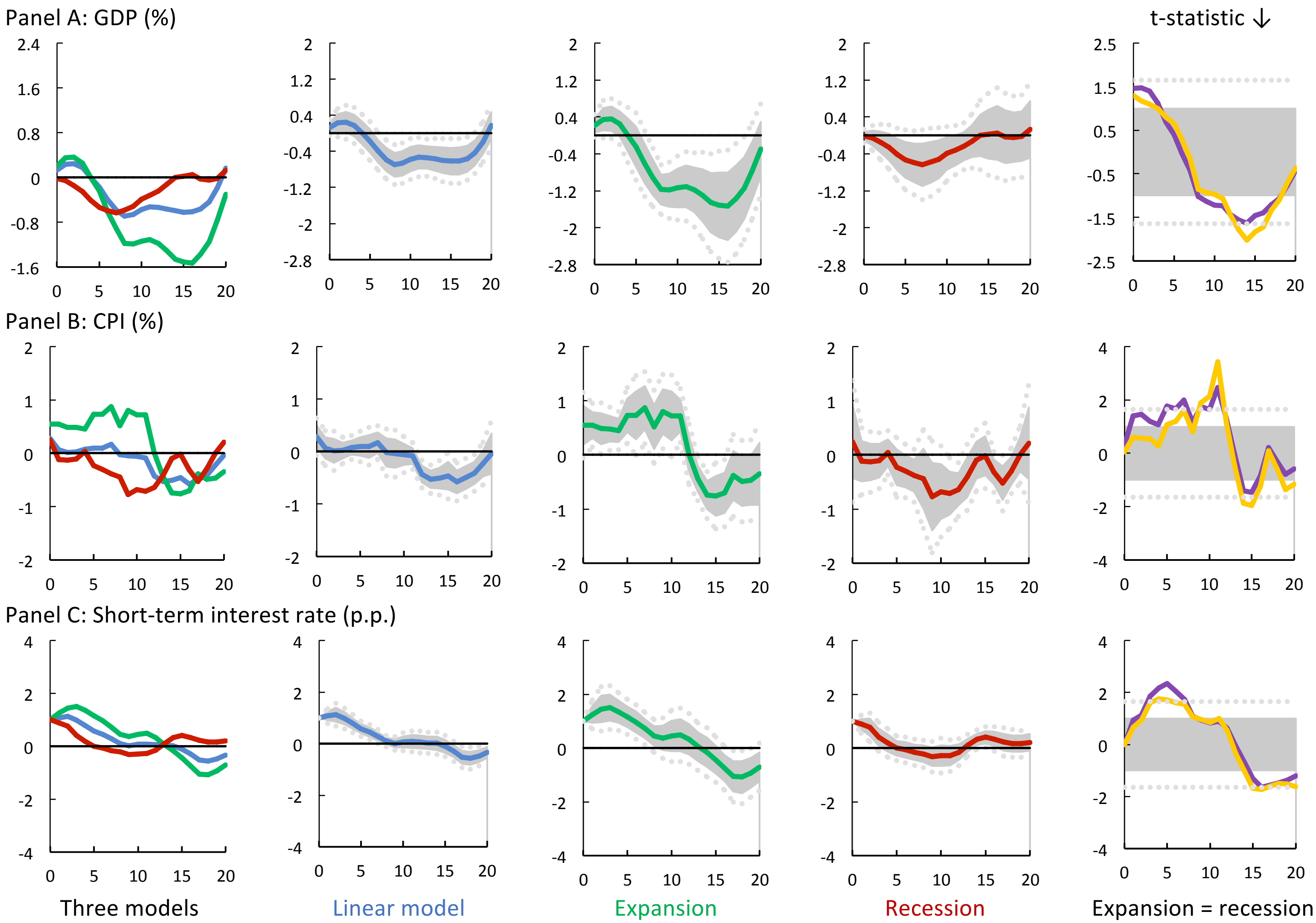
Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see text for details). The linear model is estimated using shocks retrieved from a linear VAR, while the models in an expansion and recession use shocks from a non-linear VAR (see the main text for details).

Figure 9: Impulse Response of Headline Variables Without a Time Trend



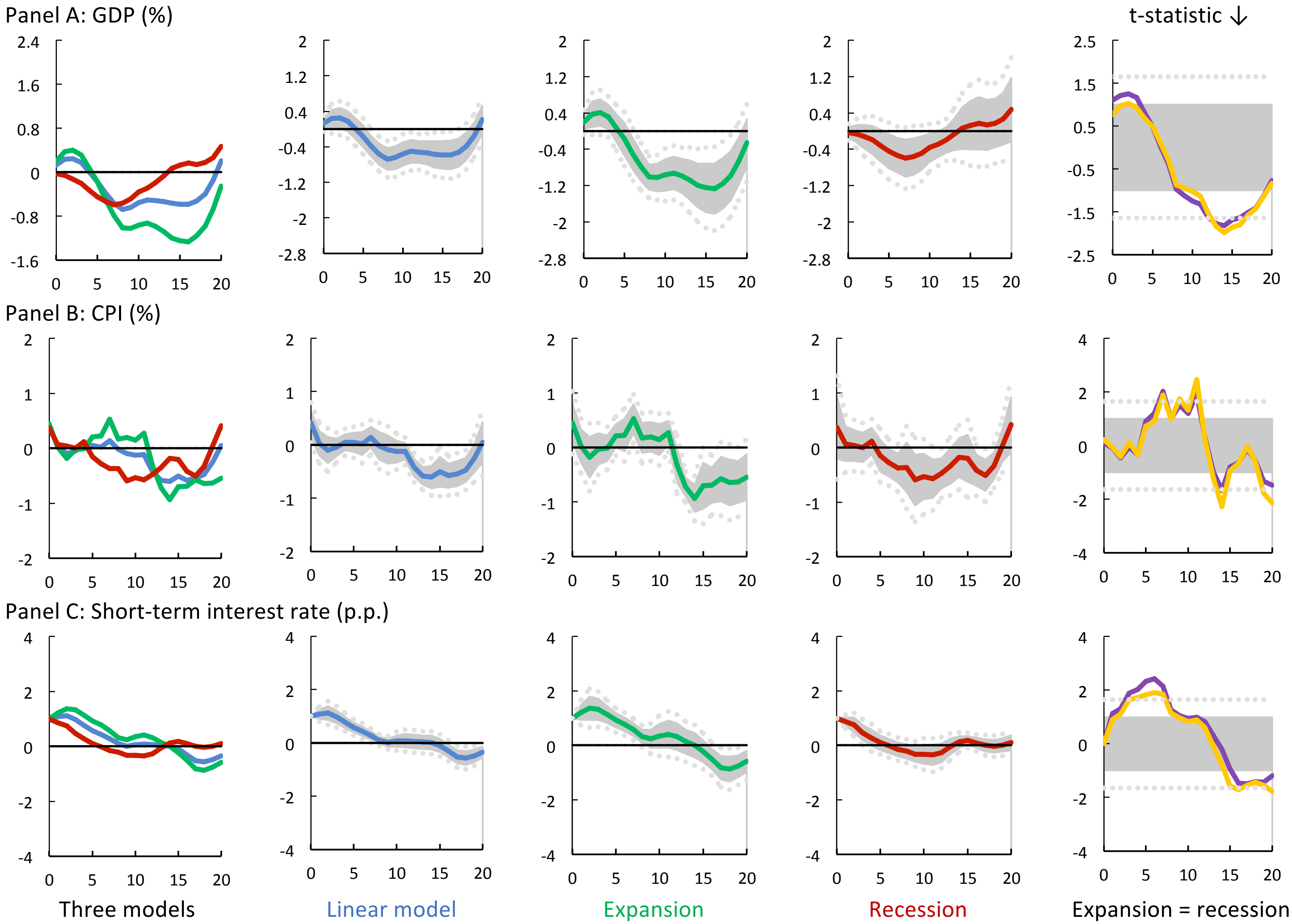
Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels
The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see the main text for details)

Figure 10: Impulse Response of Headline Variables with One Lag in Regression Equation



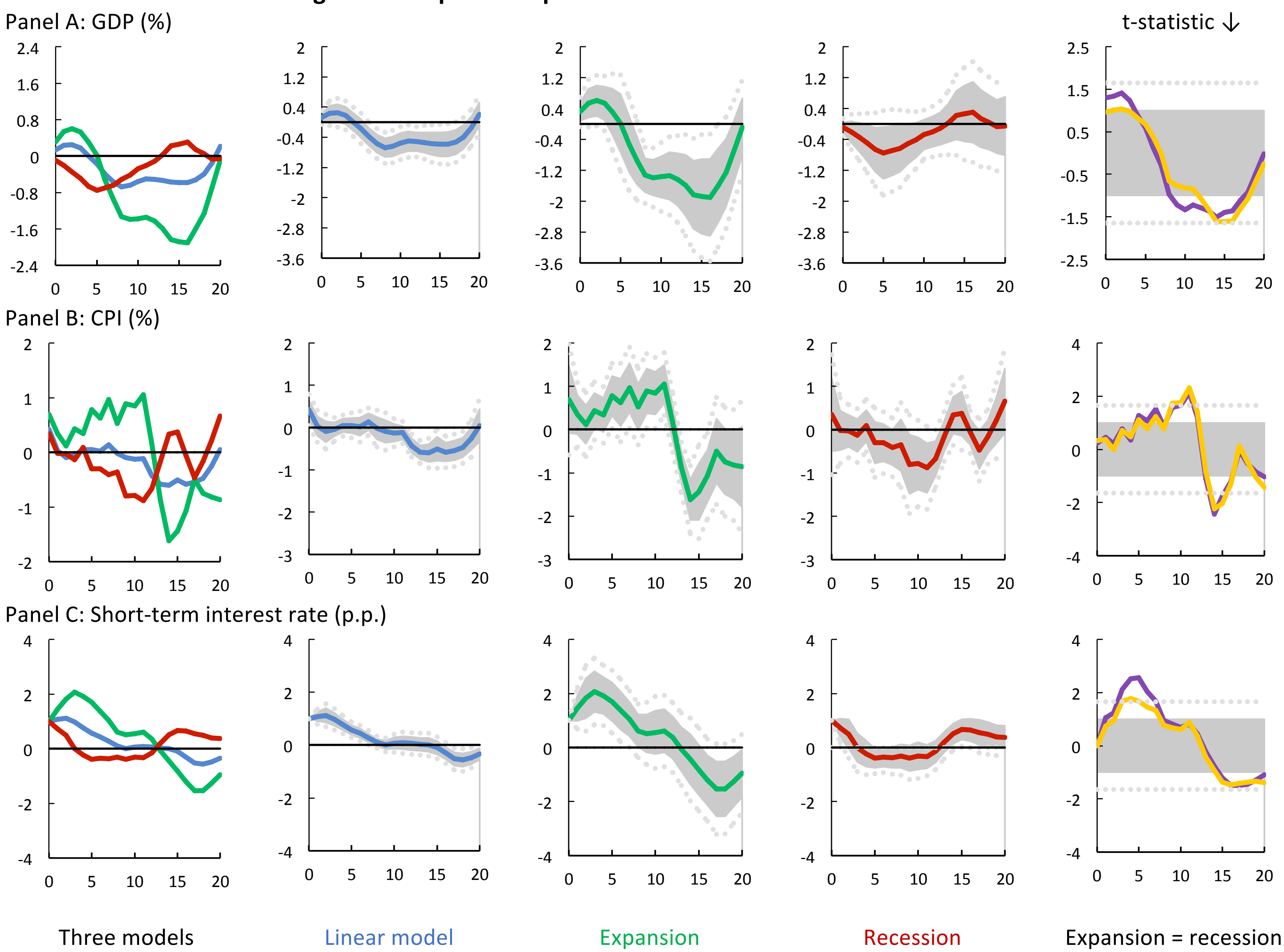
Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels
The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see the main text for details)

Figure 11: Impulse Response of Headline Variables Where $\theta = 10$



Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels
The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see the main text for details)

Figure 12: Impulse Response of Headline Variables where $\theta = 1$



Note: Impulse responses to a monetary policy shock that increases the nominal interest rate by 1 percentage point along 68 and 90 per cent confidence levels
The last column shows t-statistics testing coefficient in an expansion and a recession are equal (see the main text for details)