WORKING PAPER 15/2025 (ECONOMICS/STATISTICS)

On the Stability of Macroeconomic Relationships in Australia

Sune Karlsson and Pär Österholm

ISSN 1403-0586

Örebro University School of Business
SE-701 82 Örebro, Sweden

On the Stability of Macroeconomic Relationships in Australia*

Sune Karlsson[∀]
School of Business, Örebro University

Pär Österholm[◊]
School of Business, Örebro University
National Institute of Economic Research
New South Wales Treasury

Abstract

In this paper, we analyse whether two key macroeconomic relationships in Australia – Okun's law and the Phillips curve – have been stable over time. This is done by estimating hybrid time-varying parameter Bayesian VAR models using quarterly data from 1978 to 2024. Model comparison based on marginal likelihoods indicates that Okun's law has been stable, whereas the Phillips curve has not. Using the preferred specification of the BVAR for the unemployment rate and inflation, we also calculate trend values for both variables. The model's trend unemployment rate at the end of the sample is approximately five percent; estimated trend inflation at the same point in time is close to the Reserve Bank of Australia's inflation target.

JEL Classification: C11, C32, E32, E52

Keywords: Inflation, Unemployment, GDP growth, Bayesian VAR, Time-varying parameters

---

* The views expressed in this paper are the sole responsibility of the authors and do not necessarily reflect the views of New South Wales Treasury or the New South Wales government.

[∀] Corresponding author. Örebro University, School of Business, 701 82 Örebro, Sweden
e-mail: sune.karlsson@oru.se

[◊] Örebro University, School of Business, 70182 Örebro, Sweden
e-mail: par.osterholm@oru.se

1. Introduction

It is often a non-trivial task to explain historical macroeconomic developments or forecast future ones. Accordingly, economic policy makers, analysts and forecasters appreciate tools that can assist in doing that. Two such tools are Okun's law and the Phillips curve – relations which have become widely employed in macroeconomics since their introductions more than six decades ago (Okun, 1962; Phillips, 1958). While unique definitions do not exist of either Okun's law or the Phillips curve, the relations are often cast in bivariate settings where the former illustrates the covariation between GDP growth and the change in the unemployment rate, and the latter describes how inflation and the unemployment rate covary.[1]

From an empirical perspective, an important question to those involved with policy, analysis and forecasting is whether the economic relations employed are stable over time. If instabilities are present but are ignored when modelling, this could lead to incorrect conclusions being drawn and poor forecasting performance (e.g. Rossi, 2021). It hence comes as no surprise that the stability of both Okun's law and the Phillips curve have been subject to fairly widespread scrutiny.

Of the two relations, more attention has been paid to the stability of the Phillips curve – probably because of its more immediate connection to monetary policy. A substantial share of the more recent literature related to its stability has been focused on whether it has flattened (e.g. Bean, 2006; Kuttner and Robinson, 2010; Del Negro *et al.*, 2020; Inoue *et al.*, 2025). Of particular interest with respect to this has been the so-called "missing disinflation", that is, the smaller than expected fall in inflation associated with the global financial crisis in 2008-2009 (e.g. IMF, 2013; Coibion and Gorodnichenko, 2015; Ball and Mazumder, 2019). The potentially changing slope of the Phillips curve has also been discussed in relation to the most recent surge and fall in inflation (e.g. IMF, 2024).[2] While somewhat less attention has been given to the stability of Okun's law, there is still a substantial literature looking into this issue as well (e.g. Nguyen and Siriwardana, 1988; Watts and

---

[1] Many different specifications are used though. Concerning Okun's law, it is also common to relate the unemployment rate or unemployment gap to the output gap; see, for example, Ball *et al.* (2017). For the Phillips curve, Clark and McCracken (2006, p. 1127) suggest that it broadly can be defined as "*… a model relating inflation to the unemployment rate, output gap, or capacity utilization.*" Different measures of both inflation and the real economy are accordingly employed; see, for example, Karlsson and Österholm (2023). In addition to various bivariate settings being used, the Phillips curve is commonly also augmented with inflation expectations and/or variables such as exchange rates or oil prices when versions of it – such as the New-Keynesian Phillips curve or open-economy Phillips curve – are estimated; see, for example, Galí and Gertler (1999), Batini *et al.* (2005) and Conti (2021).

[2] The literature studying the stability of the Phillips curve is large. Some additional examples include Stock and Watson (1999), Gaiotti (2010), Gallegati *et al.* (2011), Ihrig *et al.* (2010), Berger *et al.* (2016), Knotek and Zaman (2017), Karlsson and Österholm (2020b, 2023), Hobijn *et al.* (2023) and Fitzgerald *et al.* (2024).

Mitchell, 1991; Knotek, 2007; Meyer and Tasci, 2012; Owyang and Sekhposyan, 2012; Zanin and Marra, 2012; Ball *et al.*, 2017; Karlsson and Österholm, 2020a). Among the more recent economic developments motivating such studies can be found, for example, the "jobless recoveries" in the United States since the 1990s and the falling US unemployment rate in the 2010s which occurred despite output growth being moderate (e.g. Ball *et al.*, 2017).

The purpose of this paper is to add empirical evidence regarding the stability of Okun's law and the Phillips curve in Australia. We do this by employing a Bayesian vector autoregression (BVAR) framework where we estimate bivariate models with stochastic volatility using quarterly data from 1978 to 2024. More specifically, we rely on the hybrid time-varying parameter BVAR framework of Chan and Eisenstat (2018). This allows us to – based on marginal likelihoods – formally assess whether there is time variation in the parameters of none, one, or both equations in the VAR. Our analysis largely follows that of Karlsson and Österholm (2023) who investigated the stability of the Okun's law and the Phillips curve in the United States.[3]

The econometric framework we rely upon for our analysis has not been applied to Okun's law or the Phillips curve in Australia before. We accordingly contribute to the literature that has studied Okun's law (e.g. Nguyen and Siriwardana, 1988; Watts and Mitchell, 1991; Lancaster and Tulip, 2015; Valadkhani, 2015) and the Phillips curve (e.g. Debelle and Vickery, 1998; Gruen *et al.*, 1999; McDonald, 2002; Matheson, 2008; Lim *et al.*, 2009; Abbas and Sgro, 2011; Paradiso and Rao, 2012; Abbas *et al.*, 2016; Gillitzer, 2016; Lie and Yadav, 2017; Chua and Robinson, 2018; Bishop and Greenland, 2021; Abbas, 2024; Mallick, 2024) in Australia.[4] While such analysis is of obvious interest to Australian policymakers and others who study the Australian economy, we also believe that it is useful to add empirical evidence based on a small, open economy such as Australia to the discussion regarding the stability of these macroeconomic relationships; this provides perspective to a literature which is otherwise largely focused on the United States.[5]

[3] Our analysis is also similar to that in Karlsson and Österholm (2020a) and Alanya-Beltran *et al.* (2024) who studied the Swedish and New Zealand Phillips curves respectively using Bayesian VARs with time-varying parameters.

[4] It can also be noted that there are a number of studies of Okun's law where Australia is one of several countries being analysed; see, for example, Ball *et al.* (2015), Guisinger and Sinclair (2015), Ball *et al.* (2017), An *et al.* (2019), Ball *et al.* (2019) and Kiss *et al.* (2023).

[5] Examples of studies analysing the stability of Okun's law and the Phillips curve in small, open economies reasonably closely related to Australia – such as Canada and New Zealand – include Beaudry and Doyle (2001), Huang and Chang (2005), Chletsos *et al.* (2016), Jalles (2019), Devaguptapu and Dash (2023) and Alanya-Beltran *et al.* (2024).

Briefly mentioning our results, we find that the estimated bivariate BVARs for the change in the unemployment rate and GDP growth lend support to a stable Okun's law during the sample; marginal likelihoods indicate that the model with constant parameters in both equations is the preferred one. In contrast, the Phillips curve has not been stable over time; for the bivariate BVARs for the unemployment rate and inflation, marginal likelihoods suggest that the equation describing inflation has time-varying parameters.

Using the preferred specification of the BVAR for the unemployment rate and inflation, we also calculate trend values for both variables.[6] The model's trend unemployment rate at the end of the sample – which can be seen as an indication of where the NAIRU might be presently – is approximately five percent. The estimated trend inflation rate at the end of the sample is close to the Reserve Bank of Australia's inflation target.

The rest of this paper is organised as follows: In Section 2, we present the modelling framework that we rely upon. We describe the data that we use in Section 3 and in Section 4, we present our results. Finally, Section 5 concludes.

2. Modelling framework

The models employed throughout the paper are bivariate Bayesian VAR models. We initially define $\boldsymbol{y}_t$ as the 2x1 vector of dependent variables being modelled. When analysing Okun's law, we set $\boldsymbol{y}_t = (g_t \quad \Delta u_t)'$ and for the Phillips curve, we set $\boldsymbol{y}_t = (u_t \quad \pi_t)'$. g_t is GDP growth, u_t is the unemployment rate, and π_t is inflation; we return to the exact definitions of these variables in Section 3. These transformations of the variables reflect the most commonly employed choices in the literature.

The most general specification of the model is that with time-varying parameters and stochastic volatility:

$$\boldsymbol{B}_{0t}\boldsymbol{y}_t = \boldsymbol{\mu}_t + \boldsymbol{B}_{1t}\boldsymbol{y}_{t-1} + \cdots + \boldsymbol{B}_{pt}\boldsymbol{y}_{t-p} + \boldsymbol{\varepsilon}_t \quad (1)$$

[6] The trend value is the value at which a model's forecast of a variable will converge. This definition is in line with, for example, Faust and Wright (2013), Clark and Doh (2014) and Karlsson and Österholm (2023).

where $\boldsymbol{B}_{0t}$ is a 2x2 lower triangular matrix with ones on the diagonal; $\boldsymbol{\mu}_t$ is a 2x1 vector of time-varying intercepts; $\boldsymbol{B}_{1t}, \dots, \boldsymbol{B}_{pt}$ are 2x2 matrices with the parameters describing the dynamics of the BVAR; $\boldsymbol{\varepsilon}_t$ is a 2x1 vector of disturbances, $\boldsymbol{\varepsilon}_t \sim N(\mathbf{0}, \boldsymbol{\Sigma}_t)$, where $\boldsymbol{\Sigma}_t = diag\big(exp(h_{1t}), exp(h_{2t})\big)$. It can be noted that we – in line with, for example, Cogely and Sargent (2005), Primiceri (2005) and Karlsson and Österholm (2020a, 2020b, 2023) – rely on a recursive structure when identifying the orthogonal disturbances of the model.

The free parameters of the matrices $\boldsymbol{B}_{0t}, \dots, \boldsymbol{B}_{pt}$ are gathered – together with $\boldsymbol{\mu}_t$ – in the vector $\boldsymbol{\theta}_t = (\boldsymbol{\theta}'_{1t} \quad \boldsymbol{\theta}'_{2t})'$, where $\boldsymbol{\theta}_{1t}$ contains the parameters of the first equation of the model and $\boldsymbol{\theta}_{2t}$ contains the parameters of the second equation. We employ random-walk specifications for the processes for both the time-varying parameters and the log-volatilities:

$$\boldsymbol{\theta}_t = \boldsymbol{\theta}_{t-1} + \boldsymbol{\eta}_t \tag{2}$$
$$\boldsymbol{h}_t = \boldsymbol{h}_{t-1} + \boldsymbol{\zeta}_t \tag{3}$$

where $\boldsymbol{\eta}_t \sim N(\mathbf{0}, \boldsymbol{\Sigma}_{\boldsymbol{\theta}})$ and $\boldsymbol{\zeta}_t \sim N(\mathbf{0}, \boldsymbol{\Sigma}_{\boldsymbol{h}})$; $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}$ and $\boldsymbol{\Sigma}_{\boldsymbol{h}}$ are both diagonal matrices. Note that by restricting $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}$ to be zero, we get a model with constant parameters. Similarly, restricting $\boldsymbol{\Sigma}_{\boldsymbol{h}}$ to be zero, we get a model with homoskedastic disturbances. However, in line with the growing literature supporting the relevance of heteroskedastic disturbances when modelling macroeconomic time series (e. g. Cogley and Sargent, 2005; Sims and Zha, 2006; Clark, 2011; Stock and Watson, 2012; Carriero *et al.*, 2015; Chan, 2017; Trypsteen, 2017; Koop and Korobilis; 2019; Clark *et al.*, 2020; Karlsson and Österholm, 2020a, 2020b, 2023), we assume that $\boldsymbol{\Sigma}_{\boldsymbol{h}}$ is non-zero. As can be seen from Tables 1 and 2, this assumption receives overwhelming empirical support for both Okun's law and the Phillips curve.

The prior distributions are chosen to be relatively uninformative. The initial state of the regression parameters $\boldsymbol{\theta}_0$ is given a normal prior, $N(\mathbf{0}, 5\boldsymbol{I})$, which also serves as the prior for the constant parameter case. In the time-varying case, the diagonal elements of $\boldsymbol{\Sigma}_{\boldsymbol{\theta}}$ are endowed with inverse Gamma priors, $iG(5, 0.08)$ for the two intercepts and $iG(5, 0.0004)$ for the coefficients on the lags and the contemporaneous value of the variables. That is, the prior mean of the variance of the change of the regression parameters is 0.02 and 0.0001 with, a priori, a slower evolution of the dynamics than the levels of the variables. Regarding the stochastic volatility, the initial states of the log volatilities have normal priors, $h_{\mathrm{i},0} \sim N(\gamma_i, 0.25)$, with γ_i set to match the prior mean of $exp(h_{i,0})$ with the residual variance of a constant parameter AR(*p*) model. The evolution of the log volatilities is governed by the variance, $\boldsymbol{\Sigma_h}$, where the diagonal elements are given inverse Gamma, $iG(5,0.4)$ priors for a prior mean of the variance of 0.1.

Throughout our empirical analysis, we rely on bivariate models and there is special interest in the second equation of each model. For $\boldsymbol{y}_t = (g_t \quad \Delta u_t)'$, the second equation can be interpreted as Okun's law (e.g. Karlsson and Österholm, 2020a); and when $\boldsymbol{y}_t = (u_t \quad \pi_t)'$, the second equation can be given the interpretation of a Phillips curve (e.g. King and Watson, 1994). This is something to keep in mind when we compare and interpret the estimated BVAR models.

We estimate four different BVAR models when analysing Okun's law and four more for the Phillips curve. The four models for each relationship reflect different assumptions regarding time variation of the parameters of the model:

i) Both equations have constant parameters (that is, no time variation in $\boldsymbol{\theta}_{1t}$ or $\boldsymbol{\theta}_{2t}$)

ii) Time variation in the parameters of the first equation but not the second (that is, time variation in $\boldsymbol{\theta}_{1t}$ but not in $\boldsymbol{\theta}_{2t}$)

iii) Time variation in the parameters of the second equation but not the first (that is, time variation in $\boldsymbol{\theta}_{2t}$ but not in $\boldsymbol{\theta}_{1t}$)

iv) Both equations have time-varying parameters (that is, time variation in $\boldsymbol{\theta}_{1t}$ and $\boldsymbol{\theta}_{2t}$)

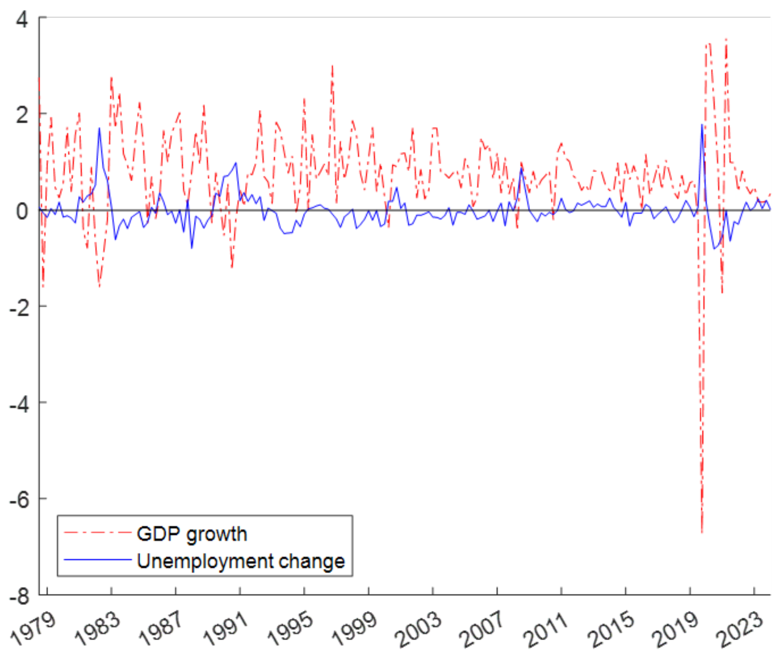
Given this setup, we conclude that Okun's law or the Phillips curve has been stable if model *i* or *ii* is preferred by the data; if data instead favour model *iii* or *iv*, we conclude that Okun's law or the Phillips curve has been unstable. Here it should be noted that also model *ii* implies that there is time variation in the dynamics between the two variables in the model. However, since it also indicates that the second equation of the system is stable, we conclude – in line with the fact that the second equation of the models have special interpretations (as pointed out above) – that Okun's law or the Phillips curve has been stable.

We rely on marginal likelihoods for model selection, where the model with the highest marginal likelihood is the one preferred by the data.[7] The marginal likelihoods are calculated using the methods of Chan and Eisenstat (2018).

3. Data

We use quarterly data on Australian unemployment rate, GDP growth, and CPI inflation. u_t is the seasonally adjusted unemployment rate (percent of the labour force aged 15 to 64 years). GDP growth is given as $g_t = 100(Y_t/Y_{t-1} - 1)$, where Y_t is seasonally adjusted GDP in constant prices. Finally, CPI inflation is given as $\pi_t = 100(P_t/P_{t-4} - 1)$, where P_t is the consumer price index. The unemployment rate and CPI inflation range from 1978Q2 to 2024Q4; GDP growth ranges from 1978Q3 to 2024Q3. Data are presented in Figures 1 and 2.

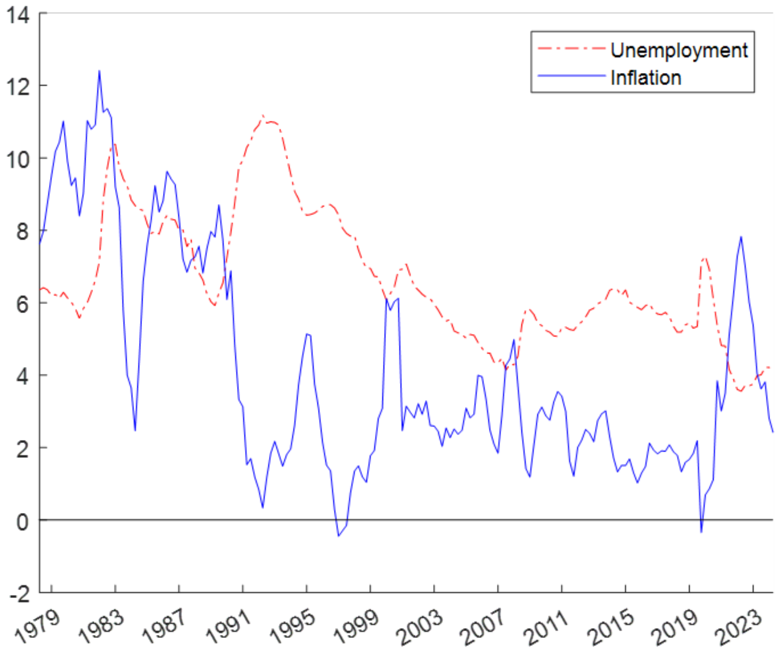
Figure 1. GDP growth and change in unemployment rate.



Note: Percent (GDP growth) and percentage points (change in unemployment rate) on vertical axis. Source: Federal Reserve Bank of St Louis.

[7] The marginal likelihood describes how well the model and priors agree with the data.

Figure 2. Unemployment rate and inflation.



Note: Percent on vertical axis.

Source: Federal Reserve Bank of St Louis.

A few features deserve to be pointed out. The unemployment rate appears to have had a downward trend since the introduction of inflation targeting in 1993.[8] Concerning the unemployment rate, we also note that the recessions of the early 1980s and early 1990s brought about sharp increases in the unemployment rate; there is also a non-negligible spike associated with the Covid-19 pandemic. Regarding GDP growth, it was typically more volatile in the first part of the sample, though the largest movements in GDP growth by far can be found around the Covid-19 pandemic. Finally, it can be noted that inflation – like the unemployment rate – tended to be higher before the introduction of inflation targeting. In the latter part of the sample, inflation has typically been hovering fairly closely around the inflation target, though substantial spikes are found related to the introduction of the GST in 2000 and the global inflation surge in 2022-2023.

[8] The Reserve Bank of Australia adopted inflation targeting as its monetary policy framework in 1993. While this was verbally endorsed by the government at that time, it was not formally endorsed by the government until 1996.

4. Results

We present results from the estimations related to Okun's law in Section 4.1 and those related to the Phillips curve in Section 4.2.

4.1 Okun's law

When analysing Okun's law, we – as pointed out above – set the vector of dependent variables to $\boldsymbol{y}_t = (g_t \quad \Delta u_t)'$; lag length in the model is set to $p = 1$.[9]

Looking at the results in Table 1, we find that the model with no time variation in the parameters is the preferred one. Using the commonly applied scale of two times the difference in log marginal likelihood and the terminology of Kass and Raftery (1995), we find that the evidence in favour of model *i* is "strong" when compared to model *ii* and "very strong" when compared to models *iii* and *iv*.[10] We accordingly conclude that Okun's law has been stable.

Table 1. Log marginal likelihoods from estimated models – Okun's law.

Model	Log marginal likelihood stochastic volatility	Log marginal likelihood homoskedastic model
i) Both equations are stable	**-228.5**	-288.7
ii) Time variation in equation for GDP growth	-232.8	-292.2
iii) Time variation in equation for change in unemployment rate	-245.1	-303.5
iv) Both equations are time varying	-249.3	-307.0

Note: Highest marginal likelihood given in bold.

In order to assess the dynamic properties of the model, we next turn to the impulse-response functions. The key impulse-response function is given by the effect that shocks to GDP growth has on the change in the unemployment rate; this is shown in Figure 3.[11] Note that the parameters describing the dynamics of the model are constant, which means that the *shape* of the response is constant over time. Due to the time-varying volatility though, the size of the one-standard deviation

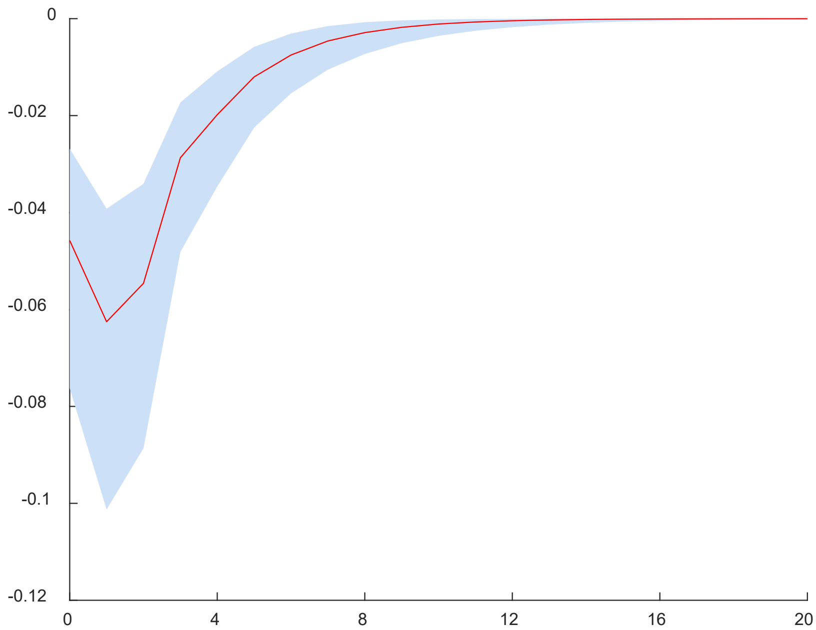
[9] This was based on based on the Schwarz (1978) information criterion applied to a VAR with homoscedastic disturbances, estimated with maximum likelihood.

[10] The cut off point for the category "strong" is six; for "very strong" – which is the highest category – it is ten.

[11] The remaining impulse-response functions of the model are given in Figures A1 to A3 in the Appendix.

shock varies and hence the *magnitude* of the response will vary. We illustrate the effect of a shock at 2024Q3.

Figure 3. Impulse-response function. Effect of shock to GDP growth on the change in the unemployment rate at 2024Q3.



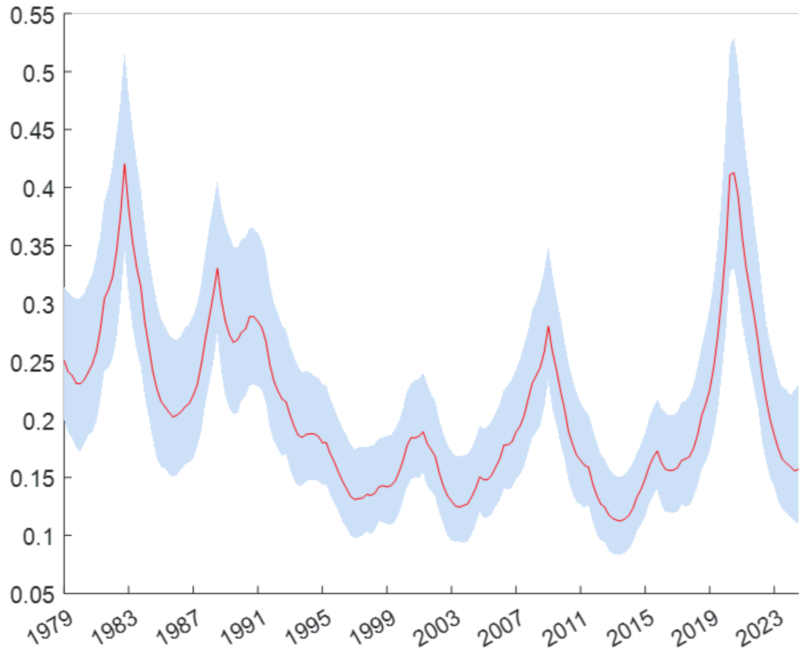
Note: Impulse-response function based on model *i*, that is, both equations are stable. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters on horizontal axis. Shaded band is a 68 percent credible interval.

Figure 3 shows that a shock to GDP growth is associated with a negative change in the unemployment rate. The effect is largest at the one-quarter horizon and has largely vanished after approximately two years; this is similar to the effects found in related studies using BVARs on Australian (Kiss *et al.*, 2023) and US (Karlsson and Österholm, 2020a) data.

Finally, we also present the estimated shock volatilities from the model. Figure 4 shows that of the change to the unemployment rate and Figure 5 that of GDP growth. As can be seen from Figure 4, shock volatility for the change in the unemployment rate was particularly high in the early 1980s, late 1980s and early 1990s, and around 2020 – that is, largely around the recessions mentioned above. A smaller peak can also be found in relation to the downturn associated with the global financial crisis of 2008. In Figure 5, we see a somewhat different profile. Shock volatility for GDP growth was experiencing a downward trend between the beginning of the sample and the late 2010s, which partly reflects the stability of the "Great Moderation". The spike associated with the

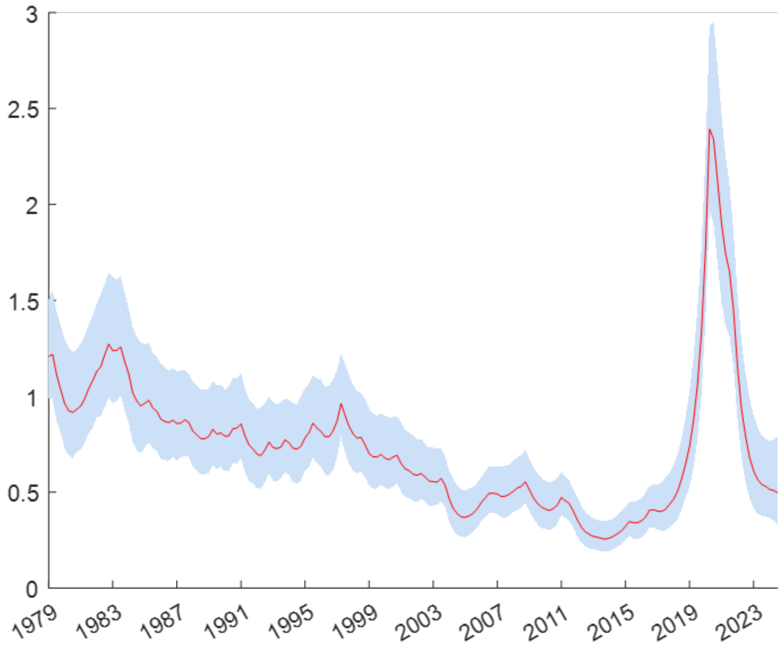
Covid-19 pandemic is – perhaps not surprisingly – very large, but volatility has come down since then and is by the end of the sample on par with that of the 2000s and the main part of the 2010s.

Figure 4. Standard deviation of shock to the change in the unemployment rate.



Note: Estimated standard deviation of structural shock based on model *i*, that is, both equations are stable. Shaded band is a 68 percent credible interval.

Figure 5. Standard deviation of shock to GDP growth.



Note: Estimated standard deviation of structural shock based on model *i*, that is, both equations are stable. Shaded band is a 68 percent credible interval.

The fairly large movements in shock volatility shown in Figures 4 and 5 confirm the message of the marginal likelihoods in Table 1: It seems important to employ a model with stochastic volatility. An assumption of homoskedasticity is not appropriate.

4.2 The Phillips curve

We set the vector of dependent variables to $\boldsymbol{y}_t = (u_t \quad \pi_t)'$ and lag length to $p = 2$.[12] As can be seen from Table 2, model *iii* – that is, the model with time variation in the equation for inflation – has the highest marginal likelihood. The evidence in favour of this model is substantial; we find that it is "very strong" regardless of which model we compare it to.

It can be noted that the fact that we find time variation in one of the equations of the system means that the dynamic relationship between the variables is changing over time. And since the equation that is found to have time-varying parameters is the equation for inflation – which specifically can be given the interpretation of a Phillips curve – we accordingly conclude that the Phillips curve has not been stable during the sample.

[12] Again, lag length was based on based on the Schwarz (1978) information criterion.

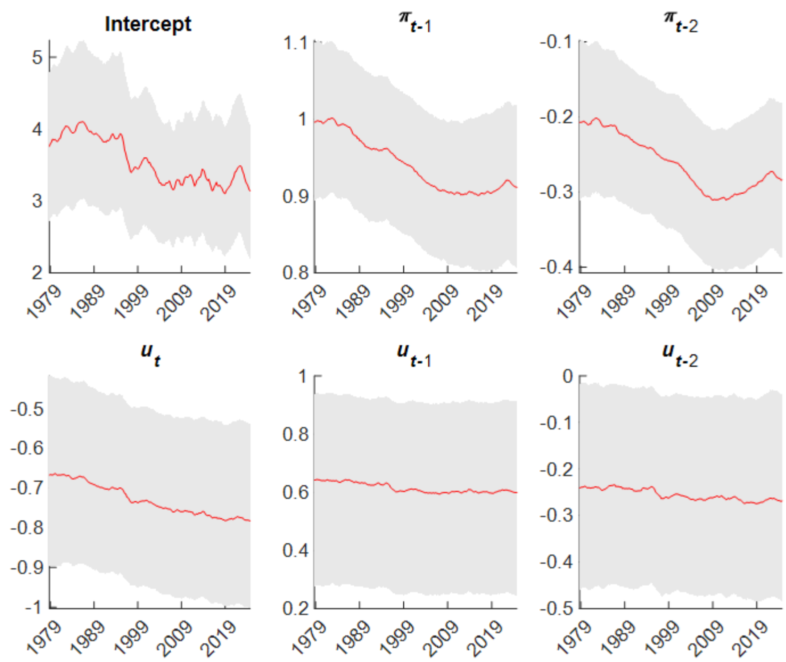
Table 2. Log marginal likelihoods from estimated models – Phillips curve.

Model	Log marginal likelihood stochastic volatility	Log marginal likelihood homoskedastic model
i) Both equations are stable	-254.0	-298.7
ii) Time variation in equation for unemployment rate	-261.3	-296.5
iii) Time variation in equation for inflation	**-248.8**	-292.4
iv) Both equations are time varying	-255.8	-290.2

Note: Highest marginal likelihood given in bold.

Figure 6 shows the estimated parameters of the inflation equation of model *iii*. The visual impression is that the time variation in the inflation equation primarily comes from the intercept, the coefficients on the own lags and the coefficient on the contemporaneous unemployment rate.

Figure 6. Estimated parameters from inflation equation of bivariate VAR with unemployment rate and inflation – structural form.



Note: Coefficients from model *iii*, that is, the model with time variation in the equation for inflation. Dates on horizontal axis. Shaded bands are 68 percent credible intervals.

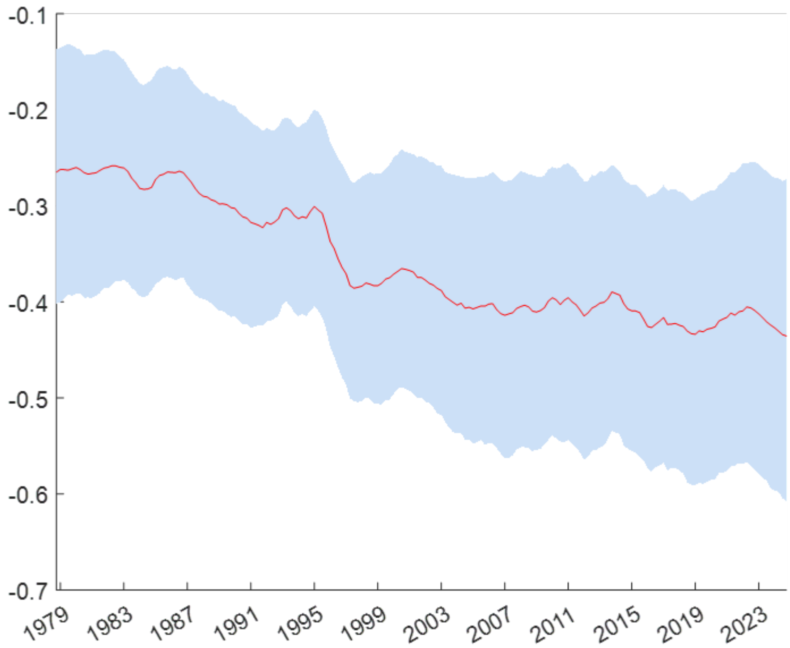
Turning to the question of whether the established instability of the Australian Phillips curve also concerns its slope, it should be noted that the slope typically is defined as the sum of the coefficients on the lags of the unemployment rate in the reduced form of the model (e.g. Karlsson and

Österholm, 2020b, 2023). The reduced form of the model is achieved by premultiplying the structural form in equation (1) with $\boldsymbol{B}_{0t}^{-1}$. This yields:

$$\boldsymbol{y}_t = \boldsymbol{\delta}_t + \boldsymbol{A}_{1t}\boldsymbol{y}_{t-1} + \cdots + \boldsymbol{A}_{pt}\boldsymbol{y}_{t-p} + \boldsymbol{e}_t \tag{4}$$

where $\boldsymbol{\delta}_t = \boldsymbol{B}_{0t}^{-1}\boldsymbol{\mu}_t$, $\boldsymbol{A}_{it} = \boldsymbol{B}_{0t}^{-1}\boldsymbol{B}_{it}$ and $\boldsymbol{e}_t = \boldsymbol{B}_{0t}^{-1}\boldsymbol{\varepsilon}_t$. The slope is shown in Figure 7. Unlike what is typically the case in the literature discussing the slope of the Phillips curve internationally – including the closely related study of Karlsson and Österholm (2023) on US data – the Australian Phillips curve has, if anything, become steeper over time.

Figure 7. Estimated slope of the Phillips curve.



Note: Sum of coefficients on lagged values of the unemployment rate from reduced form of model *iii*, that is, the model with time variation in the equation for inflation. Dates on horizontal axis. Shaded band is a 68 percent credible interval.

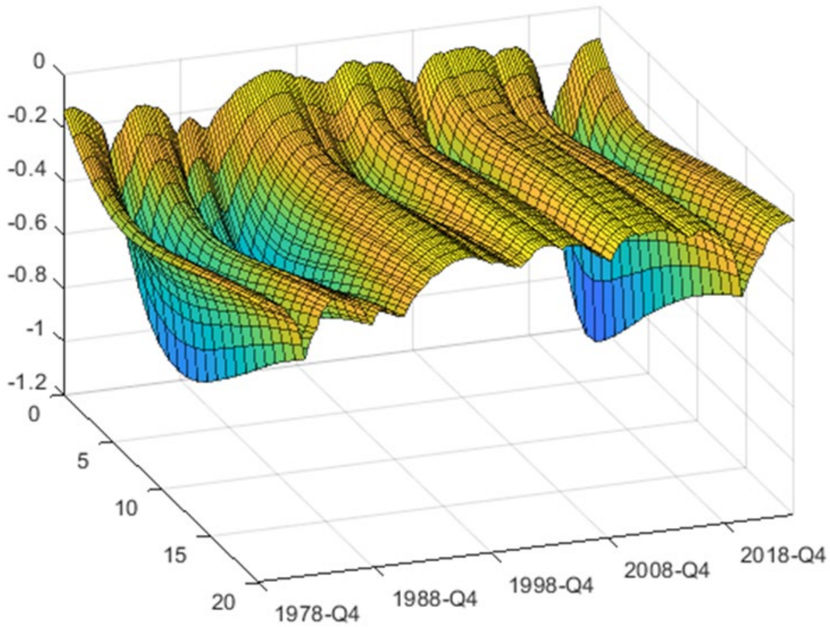
Regarding the dynamic properties of the estimated model, Figure 8 shows the key impulse-response function from model *iii*, namely the effect that a one-standard-deviation shock to the unemployment rate has on inflation.[13] As can be seen from the figure, a shock to the unemployment rate lowers inflation – a result in line with a "traditional" (short-run) Phillips curve which associates

[13] The remaining impulse-response functions of the model are given in Figures A4 to A6 in the Appendix.

high values of the unemployment rate with low values of inflation and vice versa. It can also be noted that the effect tends to be fairly persistent.[14]

The response varies somewhat over time. This is partly due to the model's drifting parameters shown in Figure 6 above. However, it is also related to the fact that the size of the shock to the unemployment rate is not constant over time (since it is a one-standard-deviation shock).[15] The estimated shock volatility for the unemployment rate is shown in Figure 9.[16] Not surprisingly, the profile is similar to the estimated shock volatility for the change in the unemployment rate in the model for Okun's law in Figure 4

Figure 8. Impulse-response function. Effect of shock to unemployment rate on inflation.



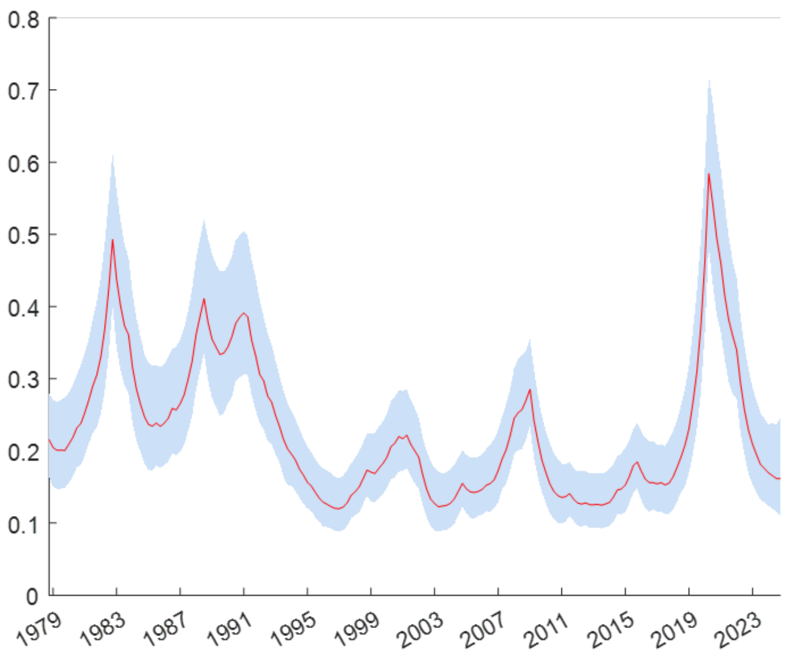
Note: Impulse-response function based on model *iii*, that is, the model with time variation in the equation for inflation. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.

[14] Figure 8 only reports the point estimate. However, the negative effect that a shock to the unemployment rate has on inflation is typically significantly negative. As an illustration, Figure A7 in the Appendix shows the effect in 2024Q4 together with a 68 percent credible interval.

[15] As a comparison, Figure A8 in the Appendix shows the effect that a unit shock to the unemployment rate has on inflation.

[16] The estimated shock volatility for inflation is shown in Figure A9 in the Appendix.

Figure 9. Standard deviation of shock to the unemployment rate.



Note: Estimated standard deviation of structural shock based on model *iii*, that is, the model with time variation in the equation for inflation. Shaded band is a 68 percent credible interval.

As a final exercise related to the Phillips curve, we calculate trend values of the unemployment rate and inflation based on the model. As was pointed out above, the trend value is the value at which a model's forecast of a variable will converge – something that should be of interest to forecasters, analysts and policy makers. For example, if trend inflation is high, this can be seen as a high inherent inflationary pressure in the economy. And the difference between the actual value and the trend value for the unemployment rate says something about slack in the labour market.

Since there is one equation in the BVAR that has time-varying parameters, we will get a time series of the trend value for each variable. These time series are calculated as follows: Using the reduced form of the model in equation (4), we write the VAR in companion form as

$$\widetilde{\boldsymbol{y}}_t = \widetilde{\boldsymbol{\delta}}_t + \boldsymbol{A}_t \widetilde{\boldsymbol{y}}_{t-1} + \widetilde{\boldsymbol{e}}_t \qquad (5)$$

where $\widetilde{\boldsymbol{y}}_t = \left(\boldsymbol{y}'_t, \boldsymbol{y}'_{t-1}, \dots, \boldsymbol{y}'_{t-p+1}\right)'$, $\widetilde{\boldsymbol{\delta}}_t = (\boldsymbol{\delta}'_t, \boldsymbol{0}', \dots, \boldsymbol{0}')'$,

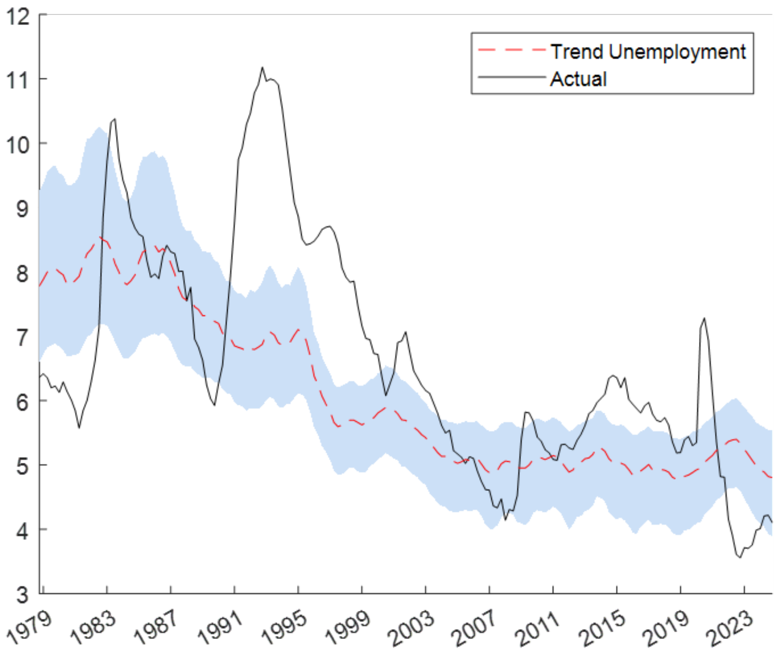
$$
\boldsymbol{A}_t = \begin{pmatrix} \boldsymbol{A}_{1t} & \boldsymbol{A}_{2t} & \cdots & \boldsymbol{A}_{p-1,t} & \boldsymbol{A}_{pt} \\ \boldsymbol{I} & \boldsymbol{0} & \cdots & & \boldsymbol{0} \\ \boldsymbol{0} & \ddots & & & \\ \vdots & & \ddots & & \vdots \\ \boldsymbol{0} & \cdots & \boldsymbol{0} & \boldsymbol{I} & \boldsymbol{0} \end{pmatrix}, \tag{6}
$$

and $\tilde{\boldsymbol{e}}_t = (\boldsymbol{e}_t', \boldsymbol{0}', \ldots, \boldsymbol{0}')'$. We finally solve for the trend values as

$$
\boldsymbol{\phi}_t = (\boldsymbol{I} - \boldsymbol{A}_t)^{-1}\widetilde{\boldsymbol{\delta}}_t \tag{7}
$$

The estimated trend values for the unemployment rate and inflation can be found in Figures 10 and 11.[17]

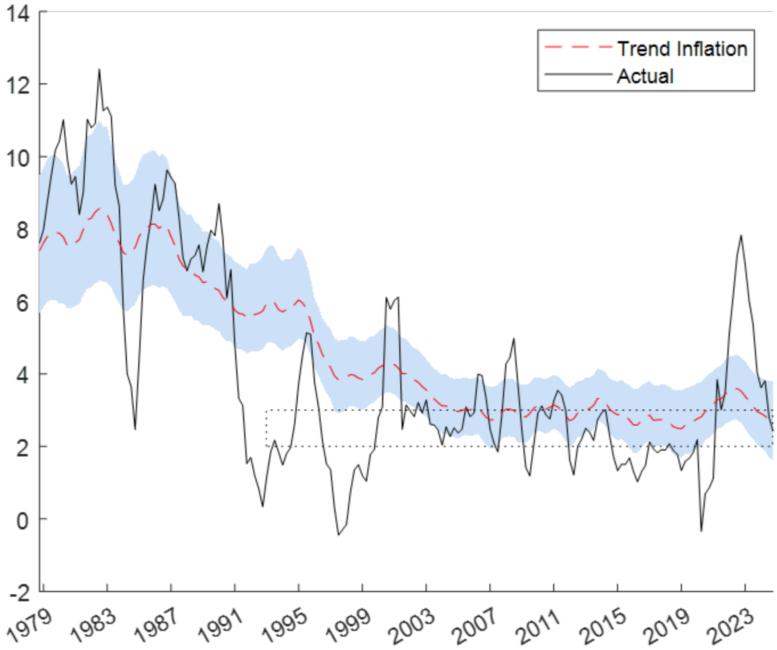
Figure 10. Estimated trend unemployment rate.



Note: Estimated trend unemployment rate based on model *iii*, that is, the model with time variation in the equation for inflation. Percent on vertical axis. Shaded band is a 68 percent credible interval.

[17] This analysis requires that the VAR is stationary. We have accordingly used only draws in which the model is stationary. This turns out to be the case approximately 99 percent of the time.

Figure 11. Estimated trend inflation.



Note: Estimated trend inflation based on model *iii*, that is, the model with time variation in the equation for inflation. Percent on vertical axis. Shaded band is a 68 percent credible interval. The dotted lines indicate the Reserve Bank of Australia's inflation target.

As can be seen from Figure 10, the trend unemployment rate had a downward trajectory from the beginning of the sample until approximately the mid-/late 2000s. During the last 15 years of the sample, it has hovered around five percent.[18] Judging by the point estimate, the unemployment rate is below its trend value at the end of the sample. As the trend unemployment rate can be seen as an indication of the NAIRU, this indicates that the labour market is providing some upward pressure on inflation.

Turning to trend inflation in Figure 11, it also had a downward trajectory during the first part of the sample as the high-inflation regime of the 1970s and 1980s was left behind with the shift to inflation targeting. Since the mid-2000s, it has mostly stayed close to the Reserve Bank of Australia's inflation target, though it did experience a non-negligible increase in association with the recent inflation surge. At the end of the sample, it is, however, again close to the inflation target.

[18] This is roughly in line with the findings of Ballantyne and Cusbert (2025) and Gross (2025).

5. Concluding remarks

In this paper we have assessed the stability of two relations that are frequently employed when analysing and forecasting the macroeconomy: Okun's law and the Phillips curve. Estimating BVAR models using Australian data, Bayesian model selection suggests that Okun's law has been stable whereas there has been time variation in the Phillips curve.

The stability of Okun's law is in line with the conclusion of Ball *et al.* (2017, p. 1439) that Okun's law "… *is strong and stable by the standards of macroeconomics*". It does, however, stand in contrast to Karlsson and Österholm's (2020a) finding of an unstable Okun's law in the United States when using the same methodology. It should be noted though that they also point out that the "*change in the dynamic relationship between the two variables is quantitatively very modest*" (Karlsson and Österholm, 2020a, p. 1).

An unstable Phillips curve is not an unusual finding in the literature; this includes the study most closely related to the present one, namely Karlsson and Österholm's (2023) on US data. However, our results do not lend any support to a flattening of the Australian Phillips curve; flattening is otherwise a common finding in the international literature.[19] If anything, we find evidence of the contrary. The estimated model gives us no reason to believe that the sacrifice ratio – that is, the increase in the unemployment rate needed to bring down inflation one percentage point – is higher nowadays than it was earlier in the sample. One should obviously be careful with basing policy conclusions on a model which does not lend itself to structural interpretations, but we nevertheless note that there is no indication that the Reserve Bank of Australia – at least in some respects – is acting in an environment that is less favourable than what was the case 15 or 30 years ago.

---

[19] It can be noted though that Hobijn *et al.* (2023) found support of a steepening Phillips curve in many countries since the start of the recovery from the Covid-19 pandemic (compared to the seven years before the pandemic).

References

Abbas, S. K. 2024. "The New Keynesian Phillips Curve and r*" *Australian Economic Review* 57, 294-301.

Abbas, S. K., Bhattacharya, P. S., Mallick, D. and Sgro, P. (2016) "The New Keynesian Phillips Curve in a Small Open Economy: Empirical Evidence from Australia", *Economic Record* 92, 409-434.

Abbas, S. K. and Sgro, P. (2011), "New Keynesian Phillips Curve and Inflation Dynamics in Australia", *Economic Modelling* 28, 2022-2033.

Alanya-Beltran, W., Brennan, M. and Jacob, P. (2024), "The Resurgence of the New Zealand Phillips Curve", *Analytical Notes* 2024-02, Reserve Bank of New Zealand.

An, Z., Ball, L., Jalles, J. and Loungani, P. (2019), "Do IMF Forecasts Respect Okun's Law? Evidence for Advanced and Developing Economies", *International Journal of Forecasting* 35, 1131-1142.

Ball, L., Furceri, D., Leigh, D. and Loungani, P. (2019), "Does One Law Fit All? Cross-Country Evidence on Okun's Law", *Open Economies Review* 30, 841-874.

Ball, L., Jalles, J. and Loungani, P. (2015), "Do Forecasters Believe in Okun's Law? An Assessment of Unemployment and Output Forecasts", *International Journal of Forecasting* 31, 176-184.

Ball, L., Leigh, D. and Loungani, P. (2017), "Okun's Law: Fit at 50?", *Journal of Money, Credit and Banking* 49, 1413-1441.

Ball, L. and Mazumder, S. (2019), "A Phillips Curve with Anchored Expectations and Short-Term Unemployment", *Journal of Money, Credit and Banking* 51, 111-137.

Ballantyne, A. and Cusbert, T. (2025), "The NAIRU Under Anchored Inflation Expectations", *Australian Economic Review* 58, 224-235.

Batini, N., Jackson, B. and Nickell, S. (2005), "An Open-Economy New Keynesian Phillips Curve for the U. K.", *Journal of Monetary Economics* 52, 1061-1071.

Bean, C. (2006), "Globalisation and Inflation", *Bank of England Quarterly Bulletin* 46, 468-475.

Beaudry, P. and Doyle, M. (2001), "What Happened to the Phillips Curve in the 1990s in Canada?" In: *Price Stability and the Long-Run Target for Monetary Policy*, 51–82, Proceedings of a seminar held by the Bank of Canada, June 2000, Bank of Canada, Ottawa.

Berger, T., Everaert, G. and Vierke, H. (2016), "Testing for Time Variation in an Unobserved Components Model for the U.S. Economy", *Journal of Economic Dynamics and Control* 69, 179-208.

Bishop, J. and Greenland, E. (2021), "Is the Phillips Curve Still a Curve? Evidence from the Regions", Research Discussion Paper 2021-09, Reserve Bank of Australia.

Chan, J. C. C. (2017), "The Stochastic Volatility in Mean Model with Time-Varying Parameters: An Application to Inflation Modeling", *Journal of Business and Economic Statistics* 35, 17-28.

Chan, J. C. C. and Eisenstat, E. (2018), "Comparing Hybrid Time-Varying Parameter VARs", *Economics Letters* 171, 1-5.

Chletsos, M., Drosou, V. and Roupakis, S. (2016), "Can Phillips Curve Explain the Recent Behavior of Inflation? Further Evidence from USA and Canada", *Journal of Economic Asymmetries* 14, 20-28.

Chua, C. L. and Robinson, T. (2018), "Why Has Australian Wages Growth Been So Low? A Phillips Curve Perspective", *Economic Record* 94, 11-32.

Clark, T. E. (2011), "Real-Time Density Forecasts from VARs with Stochastic Volatility", *Journal of Busi-ness and Economic Statistics* 29, 327-341.

Clark, T. E. and Doh, T. (2014), "Evaluating Alternative Models of Trend Inflation", *International Journal of Forecasting* 30, 426-448.

Clark, T. E. and McCracken, M. W. (2006), "The Predictive Content of the Output Gap for Inflation: Resolving In-Sample and Out-of-Sample Evidence", *Journal of Money, Credit and Banking* 38, 1127-1148.

Coibion, O. and Gorodnichenko, Y. (2015), "Is the Phillips Curve Alive and Well after All? Inflation Expectations and the Missing Disinflation", *American Economic Journal: Macroeconomics* 7, 197-232.

Conti, A. M. (2021), "Resurrecting the Phillips Curve in Low-Inflation Times", *Economic Modelling* 96, 172-195.

Debelle, G. and Vickery, J. (1998), "Is the Phillips Curve a Curve? Some Evidence and Implications for Australia", *Economic Record* 74, 384-398.

Del Negro, M., Lenza, M., Primiceri, G. and Tambalotti, A. (2020), "What's Up with the Phillips Curve?", *Brookings Papers on Economic Activity* Spring 2020, 301-357.

Devaguptapu, A. and Dash, P. (2023), "Phillips Curve in Canada: A Tale of Import Tariff and Global Value Chain", *Review of Economic Analysis* 15, 285-302.

Faust, J. and Wright, J. H. (2013), "Forecasting Inflation", In: Elliott, G., Granger, C. and Timmermann, A. (eds), *Handbook of Economic Forecasting*, Vol. 2A, North-Holland, Amsterdam.

Fitzgerald, T., Jones, C., Kulish, M. and Nicolini, J. P. (2024), "Is There a Stable Relationship between Unemployment and Future Inflation?", *American Economic Journal: Macroeconomics* 16, 114-142.

Gaiotti, E. (2010), "Has Globalization Changed the Phillips Curve? Firm-Level Evidence on the Effect of Activity on Prices", *International Journal of Central Banking* 6, 51-84.

Gallegati, M., Gallegati, M., Ramsey, J. B. and Semmler, W. (2011), "The US Wage Phillips Curve across Frequencies and over Time", *Oxford Bulletin of Economics and Statistics* 73, 489-508.

Gillitzer, C. (2016), "The Sticky Information Phillips Curve: Evidence for Australia", *Economic Record* 92, 548-567.

Gross, I. (2025), "The NAIRU in Australia", *Australian Economic Review* 58, 242-245.

Gruen, D., Pagan, A. and Thompson, C. (1999), "The Phillips Curve in Australia", *Journal of Monetary Economics* 44, 223-258.

Guisinger, A. Y. and Sinclair, T. M. (2015), "Okun's Law in Real Time", *International Journal of Forecasting* 31, 185-187.

Hobijn, B., Miles, R., Royal, J. and Zhang, J. (2023), "The Recent Steepening of Phillips Curves", *Federal Reserve Bank of Chicago Letter* No. 475.

Huang, H. and Chang, Y. (2005), "Investigating Okun's Law by the Structural Break with Threshold Approach: Evidence from Canada", *Manchester School* 73, 599-611.

Ihrig, J., Kamin, S. B., Lindner, D. and Marquez, J. (2010), "Some Simple Tests of the Globalization and Inflation Hypothesis", *International Finance* 13, 343-375.

IMF (2013), *World Economic Outlook* April 2013.

IMF (2024), "The Great Tightening: Insights from the Recent Inflation Episode", *World Economic Outlook* October 2024.

Inoue, A., Rossi, B. and Wang, Y. (2025), "Has the Phillips Curve Flattened?", Manuscript.

Jalles, J. T. (2019), "On the Time-Varying Relationship between Unemployment and Output: What Shapes It?", *Scottish Journal of Political Economy* 66, 605-630.

Karlsson, S. and Österholm, P. (2020a), "A Hybrid Time-Varying Parameter Bayesian VAR Analysis of Okun's Law in the United States", *Economics Letters* 197, 109622.

Karlsson, S. and Österholm, P. (2020b), "A Note on the Stability of the Swedish Phillips Curve", *Empirical Economics* 59, 2573-2612.

Karlsson, S. and Österholm, P. (2023), "Is the US Phillips Curve Stable? Evidence from Bayesian VARs", *Scandinavian Journal of Economics* 125, 287-314.

Kass, R. E. and Raftery, A. E. (1995), "Bayes Factors", *Journal of the American Statistical Association* 90, 773-795.

Kiss, T., Nguyen, H. and Österholm, P. (2023), "Modelling Okun's Law – Does non-Gaussianity Matter?", *Empirical Economics* 64, 2183-2213.

Knotek, E. S. (2007), "How Useful is Okun's Law?", *Federal Reserve Bank of Kansas City Economic Review* 92, 73-103.

Knotek, E. S. and Zaman, S. (2017), "Have Inflation Dynamics Changed?", *Federal Reserve Bank of Cleveland Economic Commentary* 2017-21.

Koop, G. and Korobilis, D. (2019), "Forecasting with High-Dimensional Panel VARs", *Oxford Bulletin of Economics and Statistics* 81, 937-959.

Kuttner, K. and Robinson, T. (2010), "Understanding the Flattening Phillips Curve", *North American Journal of Economics and Finance* 21, 110-125.

Lancaster, D. and Tulip, P. (2015), "Okun's Law and Potential Output", Research Discussion Paper 2015-14, Reserve Bank of Australia.

Lie, D. and Yadav, A. S. (2017), "Time-Varying Trend Inflation and the New Keynesian Phillips Curve in Australia", *Economic Record* 93, 42-66.

Lim, G. C., Dixon, R. and Tsiaplias, S. (2009), "Phillips Curve and the Equilibrium Unemployment Rate", *Economic Record* 85, 371-382.

Mallick, D. (2024), "The Phillips Curve in Australia in the Era of Inflation Targeting", *Australian Economic Review* 57, 272-282.

Matheson, T. D. (2008), "Phillips Curve Forecasting in a Small Open Economy", *Economics Letters* 98, 161-166.

McDonald, I. M. (2002), "Equilibrium Unemployment: Theory and Measurement in Australia Using the Phillips Curve", *Economic Record* 78, 451-470.

Meyer, B. and Tasci, M. (2012), "An Unstable Okun's Law, Not the Best Rule of Thumb", *Economic Commentary* No. 2012-08, Federal Reserve Bank of Cleveland.

Nguyen, D. T. and Siriwardana, A. M. (1988), "The Relationship between Output Growth and Unemployment: A Re-Examination of Okun's Law in Australia", *Australian Economic Review* 81, 16 27.

Okun, A. M. (1962), "Potential GNP: Its Measurement and Significance", In: *Proceedings of the Business and Economics Statistics Section*, Washington DC, American Statistical Association.

Owyang, M. T. and Sekhposyan, T. (2012), "Okun's Law over the Business Cycle: Was the Great Recession All That Different?", *Federal Reserve Bank of St. Louis Review* September/October 2012, 399-418.

Paradiso, A. and Rao, B. B. (2012), "Flattening of the Phillips Curve and the Role of the Oil Price: An Unobserved Component Model for the USA and Australia", *Economics Letters* 117, 259-262.

Phillips, A. W. (1958), "The Relationship between Unemployment and the Rate of Change of Money Wages in the United Kingdom 1861-1957", *Economica* 25, 283-299.

Rossi, B. (2021). "Forecasting in the Presence of Instabilities: How Do We Know Whether Economic Models Work and How to Improve Them", *Journal of Economic Literature* 59, 1135-1190.

Schwarz, G, (1978), "Estimating the Dimension of a Model", *Annals of Statistics* 6, 461-464.

Stock, J. H. and Watson, M. W. (1999), "Forecasting Inflation", *Journal of Monetary Economics* 44, 293-335.

Stock J. H. and Watson M. W. (2012), "Disentangling the Channels of the 2007-09 Recession", *Brookings Papers on Economic Activity* 44, 81-156.

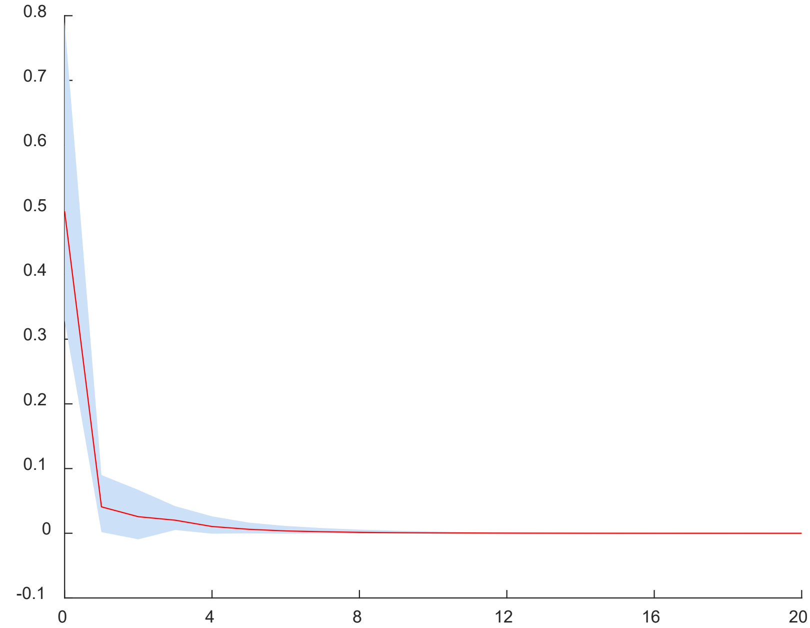
Valadkhani, A. (2015), "Okun's Law in Australia", *Economic Record* 91, 509-522.

Watts, M. and Mitchell, W. (1991), "Alleged Instability of the Okun's Law Relationship in Australia: An Empirical Analysis", *Applied Economics* 23, 1829-1838.

Zanin, L. and Marra, G (2012), "Rolling Regression versus Time-Varying Coefficient Modelling: An Empirical Investigation of the Okun's Law in Some Euro Area Countries", *Bulletin of Economic Research* 64, 91-108.

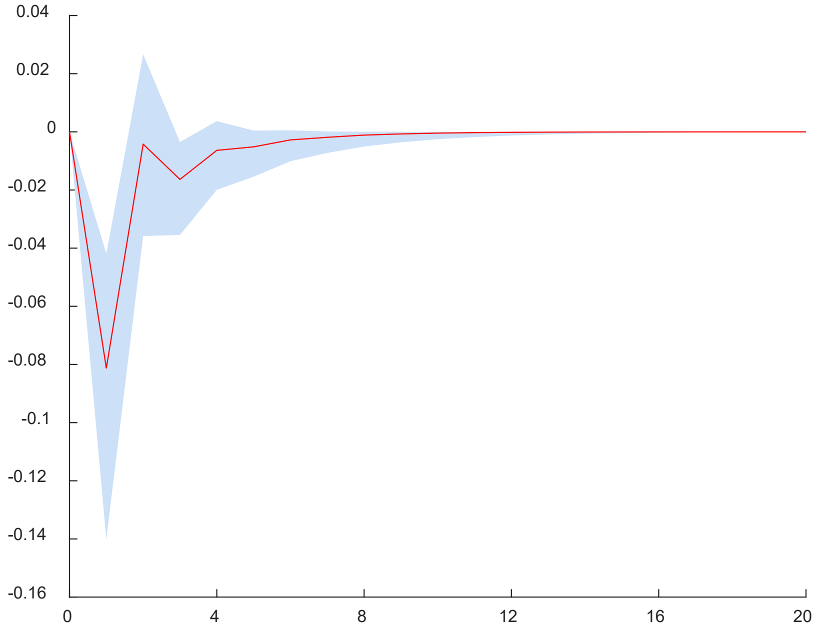
Appendix

Figure A1. Impulse-response function. Effect of shock to GDP growth on GDP growth at 2024Q3.



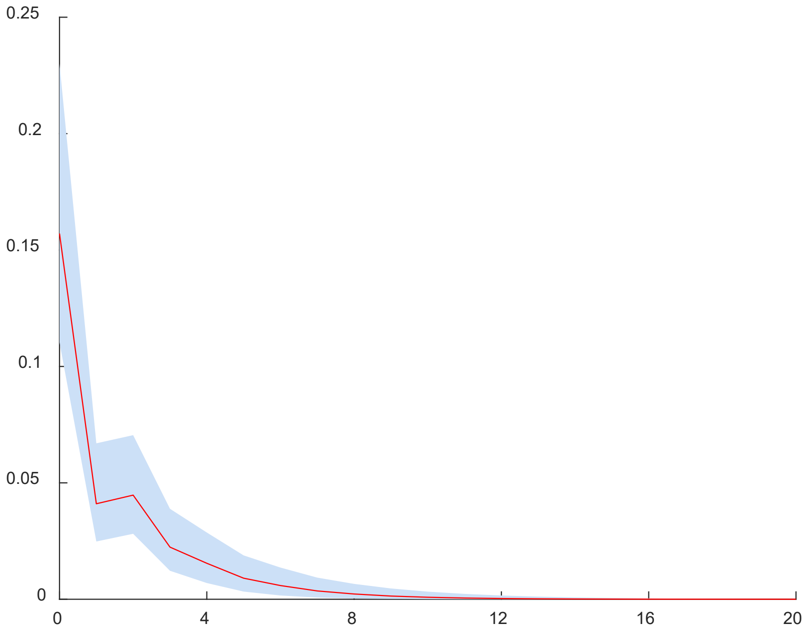
Note: Impulse-response function based on model *i*, that is, both equations are stable. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters on horizontal axis. Shaded band is a 68 percent credible interval.

Figure A2. Impulse-response function. Effect of shock to change in the unemployment rate on GDP growth at 2024Q3.



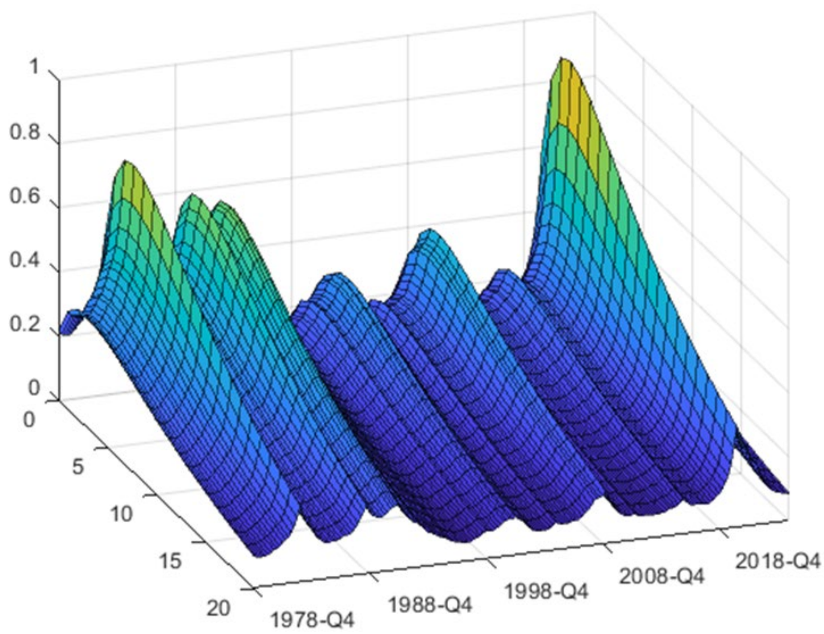
Note: Impulse-response function based on model *iii*, that is, both equations are stable. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters on horizontal axis. Shaded band is a 68 percent credible interval.

Figure A3. Impulse-response function. Effect of shock to the change in the unemployment rate on the change in the unemployment rate at 2024Q3.



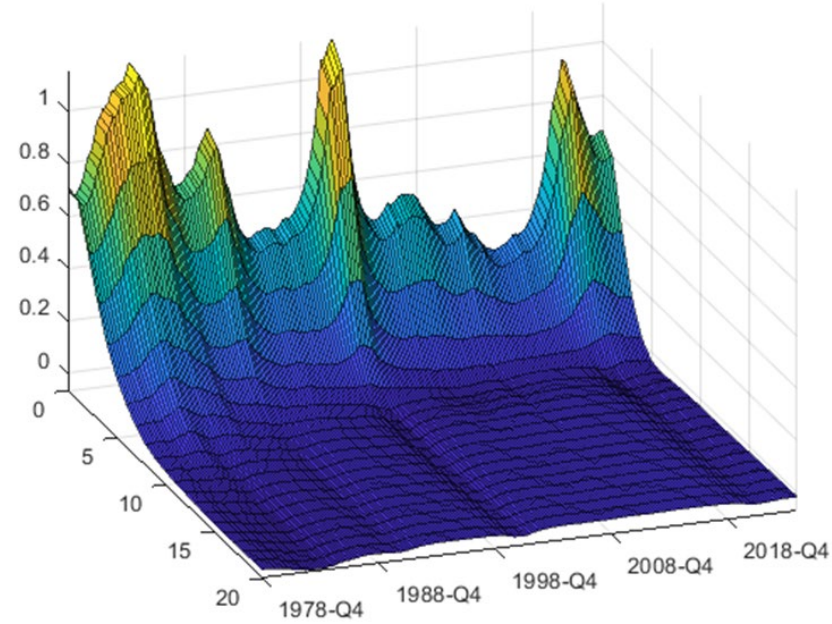
Note: Impulse-response function based on model *iii*, that is, both equations are stable. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters on horizontal axis. Shaded band is a 68 percent credible interval.

Figure A4. Impulse-response function. Effect of shock to the unemployment rate on the unemployment rate.



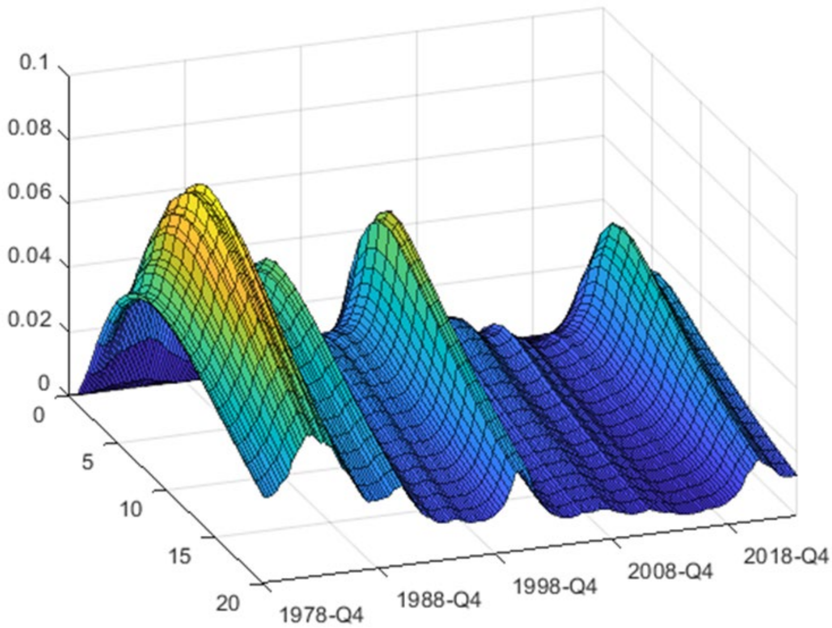
Note: Impulse-response function based on model *iii*, that is, the model with time variation in the equation for inflation. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.

Figure A5. Impulse-response function. Effect of shock to inflation on inflation.



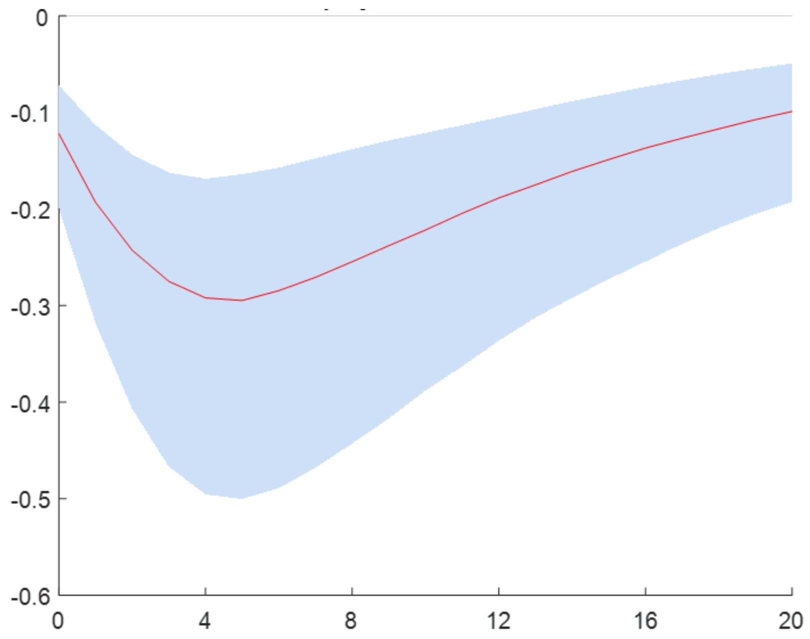
Note: Impulse-response function based on model *iii*, that is, the model with time variation in the equation for inflation. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.

Figure A6. Impulse-response function. Effect of shock to inflation on the unemployment rate.



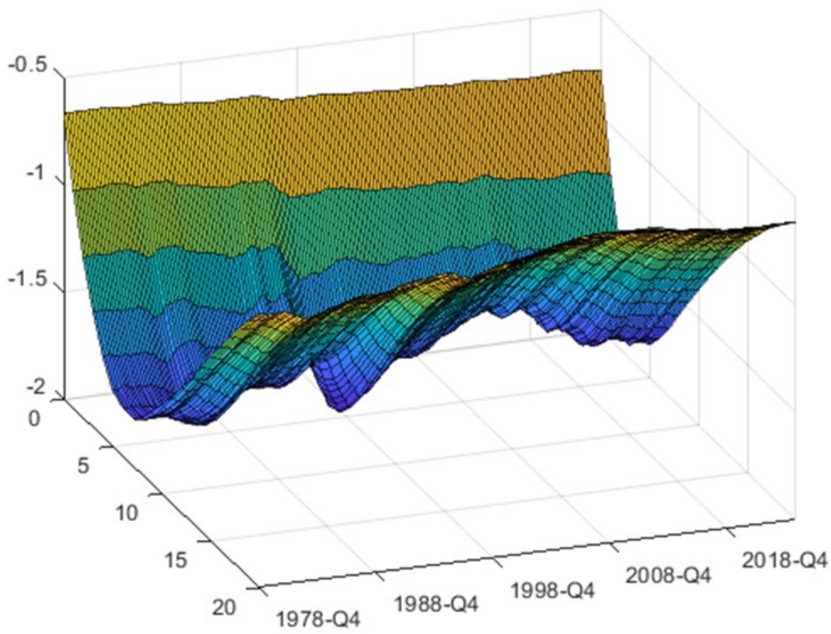
Note: Impulse-response function based on model *iii*, that is, the model with time variation in the equation for inflation. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.

Figure A7. Impulse-response function. Effect of shock to the unemployment rate on inflation at 2024Q4.



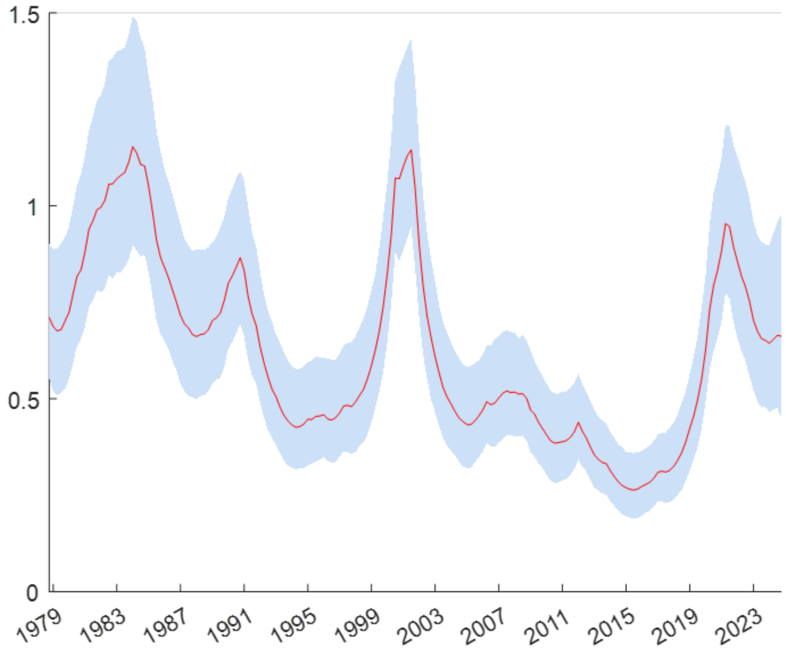
Note: Impulse-response function based on model *iii*, that is, the model with time variation in the equation for inflation. The size of the impulse is one standard deviation. Effect in percentage points on vertical axis. Horizon in quarters on horizontal axis. Shaded band is a 68 percent credible interval.

Figure A8. Impulse-response function. Effect of unit shock to the unemployment rate on inflation.



Note: Impulse-response function based on model *iii*, that is, the model with time variation in the equation for inflation. The size of the impulse is one percentage point. Effect in percentage points on vertical axis. Horizon in quarters and dates on horizontal axes.

Figure A9. Standard deviation of shock to inflation.



Note: Estimated standard deviation of structural shock based on model *iii*, that is the model with time variation in the equation for inflation. Shaded band is 68 percent credible interval.