Estimating the Relative Contributions of Supply and Demand Drivers to Inflation in Australia

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Abstract

Inflation has increased substantially since mid-2021. Understanding the relative contributions of supply and demand factors is important for determining the appropriate monetary policy response; a central bank may at least partly 'look through' the price effects of a supply shock if it is expected to be short lived and inflation expectations remain anchored. This article attempts to disentangle and explore the contributions of supply and demand factors to the recent inflationary episode, using three approaches. Similar to the experience of other advanced economies, our estimates suggest that supply-side factors have been the biggest driver of recent inflation outcomes in Australia. These supply-side factors have been persistent, with their contribution to inflation growing over 2022, leading to an extended period of inflation being above target and concerns that inflation expectations could become de-anchored. That said, demand has also played an important role.

Introduction

Inflation in Australia has picked up sharply since the second half of 2021, peaking at around 8 per cent at the end of 2022. Inflation has increased by significantly more than the Reserve Bank and other forecasters expected in mid-2021, similar to the experience overseas (RBA 2022a). The increase in inflation reflected a combination of both supply factors that reduced the global and domestic economy's capacity to produce as many goods and services at previous prices, and demand factors that increased the amount of goods and services

businesses and households wanted to buy. Supply-side factors included: disruptions resulting from the COVID-19 pandemic, which strained the ability of firms globally to produce and deliver goods; Russia's invasion of Ukraine, which led to sharp increases in the prices of energy and other commodities; and flooding on the east coast of Australia in the first half of 2022, which interrupted domestic supply chains (Graph 1) (RBA 2021).

Demand-side factors have also contributed to strong inflation outcomes. These included: the initial shift in demand from services towards goods due to pandemic-related restrictions on activity and a hesitancy among the population to participate in some social activities (Graph 2); the rapid economic recovery following the faster-than-expected development of effective vaccines; and the significant fiscal and monetary policy support provided during the pandemic.

It is important to try to disentangle the supply and demand contributions to the recent inflationary episode, as doing so can help inform the appropriate monetary policy response. However, separating the relative contributions of supply and demand is not straightforward. For example, the shift in demand towards goods and disruptions to global supply chains likely combined to push up prices for imported goods like consumer durables.

This article explores three approaches to gauge the relative importance of supply and demand factors in contributing to the current high levels of inflation, ranging from a data-driven approach to a structural model approach. Overall, these approaches suggest that supply factors have accounted for at least half of inflation in Australia over the past year or so.

Estimates of supply-side and demand-side contributions to inflation

To disentangle the supply- and demand-side contributions to inflation, we first need to make some simplifying assumptions about how the economy works. By imposing more assumptions about the 'structure' of the economy, we can generally get a more precise assessment of the contributions of supply and demand. But this comes at a cost: making more assumptions increases the risk that the results are, at least in part, driven by the particular set of assumptions that have been made.

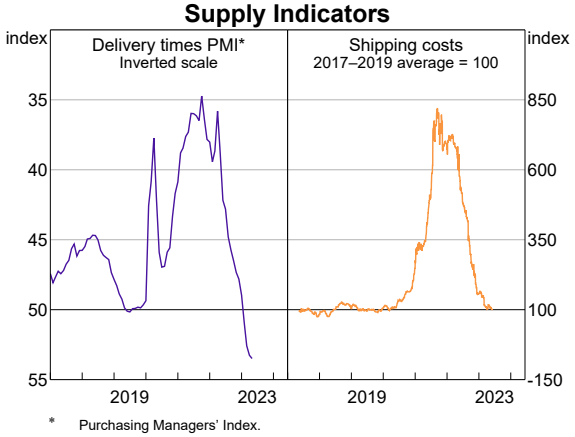
To mitigate this, we consider three different approaches to estimating the supply and demand contributions to inflation. Each approach places increasingly more structure, and so more assumptions, on the economy, starting with very little and ending with a full economic model of the Australian macroeconomy. The benefit of using three different approaches is that it allows us to check the robustness of the overall conclusions to the different assumptions used.

Approach 1: Changes in prices and quantities of each CPI expenditure group

The first approach, proposed by Shapiro (2022), places very little structure on the economy. It rests

Graph 1

Supply Indicators



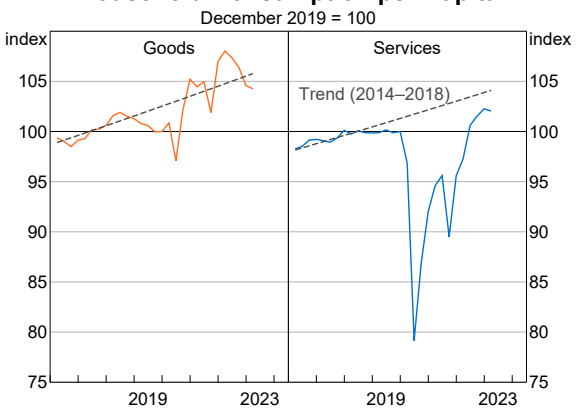
* Purchasing Managers' Index.

Sources: RBA; Refinitiv; S&P Global.

Graph 2

Household Consumption per Capita

December 2019 = 100



Sources: ABS; RBA.

on the simple and uncontroversial assumption that when demand for a good increases, the quantity consumed of this good will increase but so will its price. By contrast, when the ability of firms to supply a good decreases (or their costs of production increase), the quantity consumed falls but its price rises. This simple framework can be used to assign price movements in groups of similar items from the Consumer Price Index (CPI) in each quarter as being either supply or demand driven, as follows:

- **Demand-driven price movement**: The quantity consumed and the price move in the *same* direction.

  For example, if both the price and quantity of clothing rise over the CPI quarter, the higher prices for clothing are assessed as being driven by higher demand.

- **Supply-driven price movement**: The quantity consumed and the price move in the *opposite* direction.

  For example, if the price of clothing rises and the quantity sold falls over the CPI quarter, the higher prices for clothing are assessed as being driven by lower supply.

With each group-level price change labelled as either demand or supply driven, headline CPI inflation can then be decomposed into demand- and supply-driven contributions based on the weight of each group in the CPI basket.

To identify the demand and supply drivers of inflation since mid-2021, it is important to abstract from some longer term trends in prices and quantities, such as the fact that prices and quantities tend to grow over time as the economy expands. Returning to the earlier example, if clothing prices and quantities tend to increase over time, it might look like most changes are driven by demand – but this simply reflects longer term growth in the economy, rather than current supply and demand conditions. To this end, our analysis focused on *unexpected* changes in prices or quantities in any given quarter by estimating a vector autoregressive (VAR) model for each CPI expenditure group, which allowed us to abstract from these longer term trends. See Appendix A for further details of the VAR model.

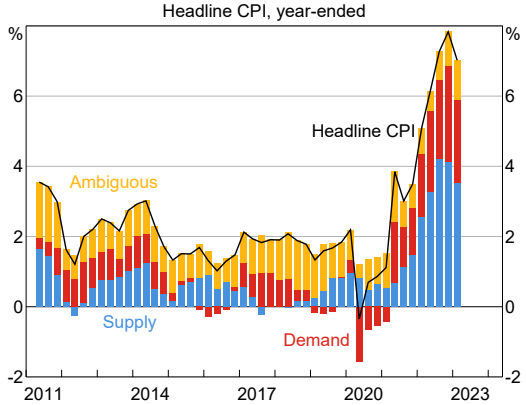
Moreover, rather than assigning all price changes to being supply or demand driven, we followed Shapiro (2022) and only classified changes if both the unexpected price and quantity change were sufficiently large. Otherwise, the price change was labelled 'ambiguous'. This reflected inherent uncertainty in the estimates. The choice of the threshold was arbitrary, and a larger threshold would have labelled more quarterly price changes as ambiguous. Further caveats of the approach are discussed in Appendix A.

Results

This approach suggests that supply-side factors have been responsible for around half of headline CPI inflation over the year to the March quarter of 2023, similar to results found for other advanced economies using this approach (Gonçalves and Koester 2022; Chen and Tombe 2023) (Graph 3). The contribution of supply-side factors to inflation peaked at around 4¼ percentage points over the year, and contributed 3½ percentage points over the year to March 2023. Demand-side factors were also found to be important, responsible for around one-third of inflation over the past year, equivalent to around 2½ percentage points of year-ended inflation. Around 1 percentage point of headline CPI inflation could not be classified by this approach.

Graph 3

Decomposition of Inflation – Approach 1*



* Based on the methodology of Shapiro (2022); 'ambiguous' indicates the contribution from components where the unexpected change in prices or quantities is within the 25 per cent prediction interval and the contribution from unmodelled components due to data limitations.

Sources: ABS; RBA.

Approach 2: Deviations from predictions of standard inflation models

The second approach compares actual inflation outcomes with what can be explained by the Bank's inflation models. These models generally best capture demand-driven inflation and so the unexplained part of inflation provides an indication of what might be due to supply factors (RBA 2022a). More specifically, we can compare actual outcomes with what the Bank's Phillips curve inflation model would have predicted if it had information on the actual outcomes for unemployment, inflation expectations and import prices (see Appendix B). This puts slightly more structure around how supply and demand affect the economy and inflation. In particular, it assumes that demand factors affect inflation by influencing unemployment, import prices and inflation expectations. All other changes in inflation are assumed to reflect supply factors.[1]

One limitation of this approach is that the Phillips curve model includes changes in the prices of imported goods and therefore the model will capture some supply-driven inflation coming from overseas. However, over recent decades consumer prices in Australia have not been very sensitive to changes in the prices of imported goods. As a result, the model attributes very little of the recent increase in inflation to import prices. Another reason to be cautious in interpreting these results is that they are sensitive to the assumption about the non-accelerating inflation rate of unemployment (NAIRU), as this determines how much spare capacity there is in the economy for a given unemployment rate. For example, a higher NAIRU assumption would imply less spare capacity in the economy and therefore higher demand-driven inflation in this framework (and vice versa for a lower NAIRU assumption). The NAIRU is unobservable and estimates of it are always subject to a high degree of uncertainty; the pandemic has further complicated efforts to construct these estimates. For this analysis, we assumed that the NAIRU is around 4.5 per cent, which is broadly in line with model estimates of the NAIRU prior to the onset of the pandemic (Ellis 2019).

Results

According to this approach, around one-half to two-thirds of inflation over the year to the March quarter of 2023 cannot be explained by the models – this is therefore our estimate of supply-driven inflation (Graph 4). The contribution of supply factors to inflation increased sharply over 2022. In the absence of supply factors, this approach suggests that inflation would have been 3.1 per cent over the year to the March quarter of 2023.[2]

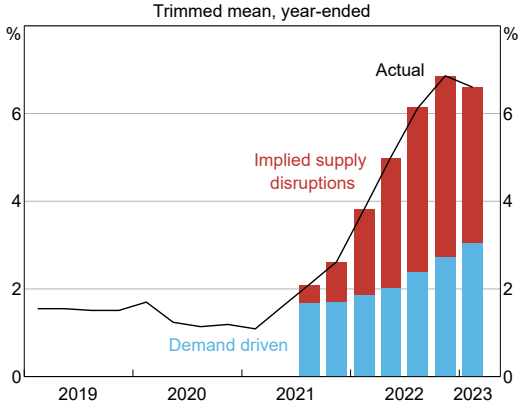
Approach 3: A structural model of the Australian economy

The third approach uses a macroeconomic model of the Australian economy to identify the role of supply-side and demand-side factors in economic outcomes. This approach places a large amount of structure around how supply and demand shocks affect inflation. In particular, this type of model has a set of equations predicting outcomes for each variable in the economy, based on all the other variables in the model. It also specifies shocks that move the variables away from their 'steady-state values' – that is, the values they would return to if no unusual fluctuations or shocks were occurring. These shocks are passed through to the rest of the model economy based on the relationships between all the variables. The model interprets all deviations from the steady-state values as ultimately stemming from some shocks. So, by fitting the model to the data, we can determine what shocks are most likely to explain the observed economic

Graph 4

Decomposition of Inflation – Approach 2

Trimmed mean, year-ended



Sources: ABS; RBA.

outcomes. This allows the model to precisely attribute outcomes to supply- and demand-side shocks; however, the downside is that the attribution may be model specific – any changes to the model could lead to different attributions.

One such model is the Reserve Bank's Dynamic Stochastic General Equilibrium (DSGE) model.[3] This is a large model of the Australian economy with several sectors, such as housing, mining, goods and services.

The DSGE has many different shocks, which we can group into three baskets:

- *Demand shocks:* Shocks that influence demand for goods in a sector, or in aggregate. These include surprise moves in monetary policy, or shocks to the willingness of households and firms to consume or invest.
- *Supply shocks:* Shocks that push up prices while lowering output. These include changes in productivity and increases in domestic firms' markups (and so profit margins) or input costs. The latter will partly capture higher imported input costs.
- *Foreign shocks:* Any supply and demand shocks occurring overseas.

Results

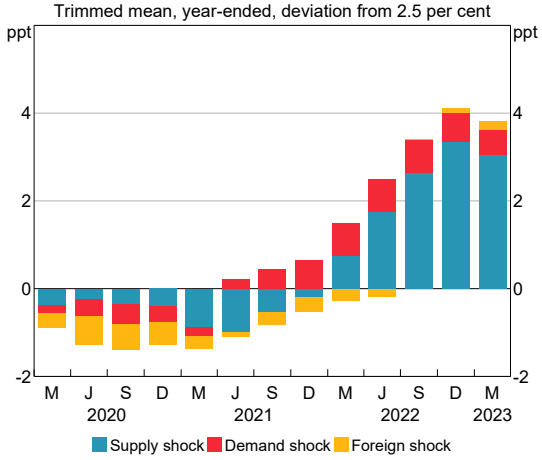
According to the DSGE model, supply-side shocks accounted for around three-quarters of the deviation of underlying inflation from its assumed steady-state level of 2½ per cent over the year ending March 2023 (Graph 5). The share has been broadly stable over time, though the contribution to the level of inflation has increased substantially. In the absence of supply-side shocks, the model implies that underlying inflation would have been around 3 percentage points lower in December 2022, or slightly below 3½ per cent. As such, inflation would still have been above the Bank's target range of 2–3 per cent.

The DSGE model can also be used to explore which sectors have contributed the most to supply-side inflation (Graph 6). The model suggests that supply shocks in the tradables goods sectors (both imports and domestically produced tradables) and the housing sector account for a large share of the pick-up in inflation to date. The former is likely to reflect high prices for imported goods, as well as increased energy prices. The latter is likely to reflect a combination of higher prices for imported construction goods and supply constraints in the construction sector (RBA 2022b). More recently, the non-traded sector has begun adding to inflationary pressure, consistent with a broadening of inflationary pressures to the services sector (RBA 2023).

Graph 5

Decomposition of Inflation – Approach 3*

Trimmed mean, year-ended, deviation from 2.5 per cent



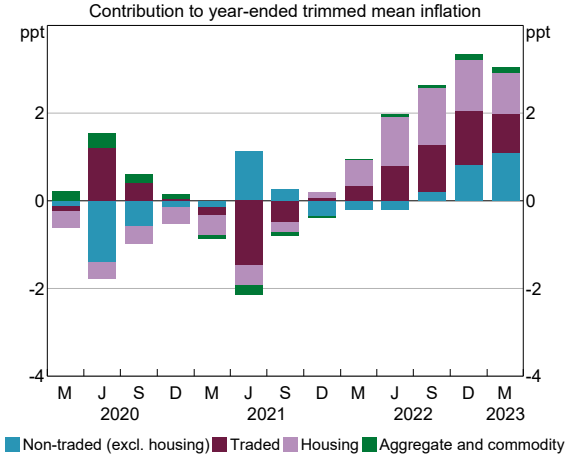
* Demand includes monetary policy, investment and consumption shocks. Foreign includes foreign demand and cost shocks. Supply includes markup, technology and labour supply shocks. Supply will capture some overseas cost shocks.

Source: RBA.

Graph 6

Decomposition of Supply Shock*

Contribution to year-ended trimmed mean inflation



* Supply shocks include markup, technology and labour supply shocks.

Source: RBA.

Table 1: Contribution of Supply-side Factors to Inflation

	Supply contribution Percentage points	Inflation without supply contribution Per cent
Approach 1[(a)]	3.5	3.5
Approach 2[(b)]	3.5	3.1
Approach 3[(c)]	3.1	3.5

(a) Headline CPI inflation. March 2023.

(b) Underlying CPI inflation. March 2023.

(c) Underlying CPI inflation. Supply contribution is contribution to deviation from 2.5 per cent inflation, rather than total inflation. March 2023.

Source: RBA.

Conclusion

The three approaches explored above suggest that supply factors have accounted for at least half of inflation in Australia over the past year or so (Table 1). Each of these methods has its limitations and so other possible approaches could yield different results. However, the fact that three very different methodologies tell a similar story give us confidence in this high-level conclusion.

While a central bank may 'look through' the price effects of a supply shock if it is expected to be short lived, in the recent episode supply shocks have resulted in an extended period of inflation being well above the inflation target in many advanced economies (RBA 2022a). In this environment, there have been concerns globally that inflation expectations could become de-anchored if inflation is not returned to target in a reasonable period of time (Adrian 2022). The contribution of supply factors to inflation outcomes in Australia continued to grow throughout 2022. Demand has also been an important driver of recent inflation outcomes; measures of capacity utilisation have been very high and labour market spare capacity has been at multi-decade lows. Taken at face value, these results suggest that inflation would still have been above the Reserve Bank's target range even if the contribution of supply factors was excluded in the estimates above.

Appendix A: Approach 1 – The vector autoregressive (VAR) model

A VAR model can be used to describe the dynamic relationship between two or more (economic) variables. Here we use VARs to model the relationship between the (log) price *p* of a group of goods and services in the CPI and the (log) quantity *q* of that group of goods and services (measured by volumes from Household Final Consumption Expenditure (HFCE) in the national accounts). This dynamic relationship can be represented as follows:

$$p_{i,\,t} = c_{1i} + d_{1i}t + a_{11i}p_{i,\,t-1} + a_{12i}q_{i,\,t-1} + u_{1i,\,t}$$

$$q_{i,\,t} = c_{2i} + d_{2i}t + a_{21i}p_{i,\,t-1} + a_{22i}q_{i,\,t-1} + u_{2i,\,t}$$

Where *i* is a group, *t* is the time period (here quarter), *u* is the one-quarter ahead forecast error, *c* is a constant, and *d* and *a* are parameters that capture the effect of deterministic (time) trends and past prices and quantities on current prices and quantities. The model above is written with one lag of past prices and quantities, but further lags can be included.

Following this approach, we estimated 15 two-variable VARs – one for each HFCE expenditure category for which a mapping exists with a group of CPI items. These 15 groups account for 90–97 per cent of the consumption basket underlying the CPI over the sample. The VARs were estimated over rolling windows of 12 years to allow for changes in the model parameters. For each iteration of rolling-window estimates, we used the Hannan-Quinn information criterion to determine the optimal number of lags in past prices and quantities up to a maximum of 12 lags.

We then used the estimated VARs to obtain the expected price level and quantity for each group based on the estimated constant, time trend, and dynamics in both prices and quantities. If realised prices and quantities deviated in the same direction from their expected values and to a sufficiently large extent (e.g. both price and quantity were *above* their 25 per cent prediction intervals), we labelled the group as 'demand driven' in that quarter. If realised prices and quantities deviated in *opposite* directions from their expected values and to a sufficiently large extent (e.g. the price was *above* the 25 per cent prediction interval but the quantity was *below* the 25 per cent prediction interval), we labelled the group as 'supply driven' in that quarter. If either price or quantity were within their 25 per cent prediction intervals, the group was labelled as 'ambiguous'.

After assigning labels to each category, headline CPI inflation was then decomposed using the most recent expenditure weights. That is, the contribution of supply shocks to headline CPI inflation was taken as the sum of all component-level inflation rates that were classified as supply driven, multiplied by their weight in the CPI basket. The contribution of demand shocks was obtained similarly.

In addition to the arbitrariness in the choice of the threshold in labelling a share of shocks as 'ambiguous', there are further shortcomings to this approach that are important to note:

- The approach assumes that all of the price change for a particular expenditure group stems from either a shift in demand or a shift in supply, rather than allowing for both supply and demand to have an effect in a given period. In any given quarter, each expenditure group is likely to experience changes to both demand and supply, but the approach can, at best, only identify which force dominates *on net*.
- Our primary objective was to identify *new* shocks to supply and demand that occurred during and after the COVID-19 pandemic. As such, we sought to abstract from longer run structural changes to the supply and demand balance for individual expenditure groups. Prices for communications equipment, for instance, have generally fallen over the past decades as supply increased alongside increased global production and trade. Similarly, some price changes during and after the pandemic may be the delayed response to shocks occurring before 2020. We abstracted from such trends and past shocks by including expenditure group-specific deterministic trends and lags of price and quantity changes. However, this implies that demand or

supply shocks happening early during the pandemic were not captured in our estimates of demand and supply shocks in 2021 and 2022.

- The approach cannot identify the fundamental demand or supply shocks to the same extent as the DSGE model. That is, it cannot determine whether changes to demand were due to changes to monetary or fiscal policy or the willingness of households to consume, or whether changes to supply were due to changes in productivity, markup or input cost shocks.
- Shocks hitting only one sector may spill over to other sectors and be captured as shocks to these sectors. For instance, shutdowns of restaurants during the pandemic would represent a supply shock to the hospitality sector. As a result of this shock, however, demand for groceries increased as households shifted to cooking at home. While this would be labelled as a demand shock to the food and drink CPI expenditure group, the fundamental shock was a supply shock to the travel services, hotels and dining expenditure group.
- Similarly, overseas demand shocks (e.g. for furniture, home exercise equipment or electronics during the pandemic) could raise (global) prices but reduce supply available to Australia. While the underlying shock may have been an increase in global demand, the model would classify this as a supply shock to Australia.
- The demand or supply shock to each expenditure group is defined based on the *unexpected* price (and quantity) change alone. However, the *entire* price change (the expected and the unexpected parts) are then labelled as demand or supply driven even though the expected part of a price change is due to deterministic factors, long-run trends and past demand or supply shocks *not identified* by this model. In practice, it can even be the case that the unexpected parts of an expenditure group's price and quantity changes are both negative (indicating a negative demand shock) – but, as long as the entire price change is positive, the approach would incorrectly label this category to exert upwards pressure on total inflation due to a *positive* demand shock.

Appendix B: Approach 2 – Phillips curve model specification

The Phillips curve model estimates a relationship between inflation, inflation expectations, a measure of labour market spare capacity and import prices. The following variables are included in the model, which estimates quarterly inflation:[4]

- Inflation in the previous quarter (π_{t-1}), which can be interpreted as representing the component of inflation expectations that is backward looking.
- Inflation expectations ($\frac{trend\ expectations_t}{4}$), because theory suggests that inflation expectations play a role in price-setting behaviour.
- The 'unemployment gap' ($\frac{u_{t-2} - u^*_{t-2}}{u_{t-2}}$) – that is, the difference between the unemployment rate and an estimated measure of the NAIRU (a measure of spare capacity in the economy).
- Changes in the prices of imported goods ($\frac{\%\ \Delta^{ye}\ (consumerIPI_{t-1})}{4}$), recognising Australia's relatively open economy. Australian consumers and businesses use imported goods and imported goods compete with many domestically produced goods.

Table B1: Philips Curve Model

Estimated June 1993 – December 2019

	Estimate[(a)]	Standard error
Intercept	−0.104	(0.130)
π_{t-1}	0.207*	(0.093)
$\frac{trend\ expectations_t}{4}$ (b)	0.963***	(0.221)
$\frac{u_{t-2} - u^*_{t-2}}{u_{t-2}}$ (b)	−0.691***	(0.116)
$\frac{\%\ \Delta^{ye}\ (consumerIPI_{t-1})}{4}$	0.010	(0.010)
Adjusted R2	0.48	

(a) Statistical significance marked as * = 0.05, ** = 0.01, *** = 0.001.

(b) The standard errors on these variables are incorrect due to the generated regressors problem.

Source: RBA.

To generate an estimate of what inflation would have been in the absence of supply factors, we forecasted ahead with the Philips curve model from September 2021 (the beginning of the pick-up in inflation in Australia). Actual outcomes were used for the independent variables, such as import prices and the unemployment rate. Inflation in the previous quarter was determined by the model, not actual CPI outcomes (which capture the impact of supply factors). Supply-driven inflation was calculated as the difference between actual inflation outcomes and the model predictions.

Endnotes

[*] The authors are from Economic Group.

[1] This approach assumes that supply shocks do not affect unemployment or inflation expectations. If supply shocks do affect these variables, which in turn influence inflation, this indirect influence will be treated as demand-driven inflation not supply-driven inflation.

[2] Most of the inflation predicted by the Philips curve model can be explained by inflation expectations, which remained anchored around the midpoint of the Bank's target range. Unemployment below the NAIRU has pushed inflation outside the Bank's target range, according to the model.

[3] For further details on the DSGE model, see Gibbs, Hambur and Nodari (2018).

[4] For more details, see Cassidy *et al* (2019).

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