Reserve Bank of New Zealand Analytical Notes

The flattening of the Phillips curve: Rounding up the suspects

AN2019/06

Punnoose Jacob and Thomas van Florenstein Mulder

May 2019

RESERVE BANK
OF NEW ZEALAND
TE PŪTEA MATUA

NON-TECHNICAL SUMMARY

The Phillips curve embodies the relationship between measures of inflation and economic activity. This correlation has declined over time in New Zealand and other developed economies, a phenomenon commonly known as the flattening of the Phillips curve.

This paper provides a framework to think about the potential causes of the waning correlation between inflation and activity in New Zealand. Does this declining correlation imply that prices have become less volatile due to price-setting by firms becoming less sensitive to demand pressures? Has demand become less volatile due to households becoming less responsive to the interest rate? Have the random disturbances influencing aggregate supply and demand changed?

We first run computational experiments in a simple model of demand and supply to demonstrate how the declining correlations observed in the data can be generated by two causal mechanisms: changes in the behaviour of economic actors or changes in the composition of random business cycle disturbances hitting the economy. The key message of the experiment is that if disturbances influencing the supply side of the economy are more potent than those affecting the demand side, the correlation between inflation and activity can diminish.

In the next step, we estimate an extended version of the model on New Zealand data to point out potential reasons for the flattening of the Phillips curve over the inflation targeting era. Our methodology does not isolate any particular feature as a single dominant driver of the diminishing correlations observed in the data. Instead, we identify a number of potential mechanisms that contribute to the flattening of the Phillips curve. Our results suggest that changes in the structure of the economy have been fairly mild. However, business cycle disturbances on the supply side have been become much more variable than those influencing the demand side. These supply-side disturbances are very influential in driving the waning correlation between inflation and activity.

_____

1   Introduction

The relationship between measures of inflation and economic slack (or activity), otherwise known as the Phillips curve, has been documented to have weakened over time in several developed economies.[1] Figure 1 and Figure 2 show that the Phillips curve in New Zealand also 'flattened' over the inflation targeting era. Figure 1 illustrates the diminishing correlation between core inflation and unemployment. Figure 2 presents other facets of the relationship between inflation and economic slack; panel (a) uses 10-year rolling window samples to demonstrate that the correlation between inflation and the Reserve Bank's output gap has declined and panel (b) examines the same correlation using an extended window approach to show how the same correlation has fallen drastically since the global financial crisis (GFC) and has since plateaued at a lower level. Compared to the past decades, a more substantial movement in economic slack is necessary to generate a given level of inflation. This paper identifies potential explanations for the flattening of New Zealand's Phillips curve.

We proceed in two stages. First, using a simple theoretical model in which business cycle dynamics are generated by supply and demand disturbances, we demonstrate that the Phillips curve flattens when supply shocks become more powerful. Supply shocks push inflation and economic activity in opposite directions, i.e. generating a negative correlation, while demand shocks drive inflation and activity in the same direction. The overall correlation between inflation and activity observed in the data depends on which type of shock dominates. If the supply shock becomes relatively more volatile over time, it exerts more influence on the correlation between inflation and activity. When changes in the structure of the economy weaken the transmission of demand shocks, supply shocks again dominate. As a consequence, the correlation between inflation and economic activity falls and the observed Phillips curve flattens.

In the second stage of this paper, we estimate a structural model recursively, using an expanding window over the inflation targeting era to assess the reasons for the flattening of New Zealand's Phillips curve. We detect mild changes in economic structure that may have contributed to the waning correlation between inflation and activity. Moreover, the estimated volatilities of several types of supply shocks are much larger than those of demand shock. Furthermore, the volatility of the demand shocks have declined over time. Hence, the flattening of New Zealand's Phillips curve also seems to have been influenced by the increasing sizes of the supply shocks affecting the economy.

The rest of the paper is organised as follows. Section 2 introduces the conceptual framework and explores how the correlation between inflation and activity is influenced by structural change as well

_____

[1] See Kuttner and Robinson (2010) for the case of Australia, Iakova (2007) for the United Kingdom, Roberts (2006) for the United States, and Beaudry and Doyle (2000) for Canada. In the general equilibrium macroeconomics literature (e.g. Gali, 2015), the term 'Phillips curve' refers to a supply-side relationship relating the price-setting behaviour of firms to movements in demand and inflation expectations. However, later in this *Note*, we will instead refer to this behavioural relationship simply as the price-setting equation or aggregate supply. We refer to the observed correlation between inflation and economic activity in the data as the 'Phillips curve'. This is in accordance with the terminology typically used in speeches by policy-makers (Spencer, 2017; Cunliffe, 2017; Constancio, 2015) and the media (The Economist, 2017).

_____

as the composition of shocks. Section 3 sets up the New Keynesian structural model used in the estimation exercise and outlines the data used. Section 4 details the estimation results. Section 5 draws the main conclusions.

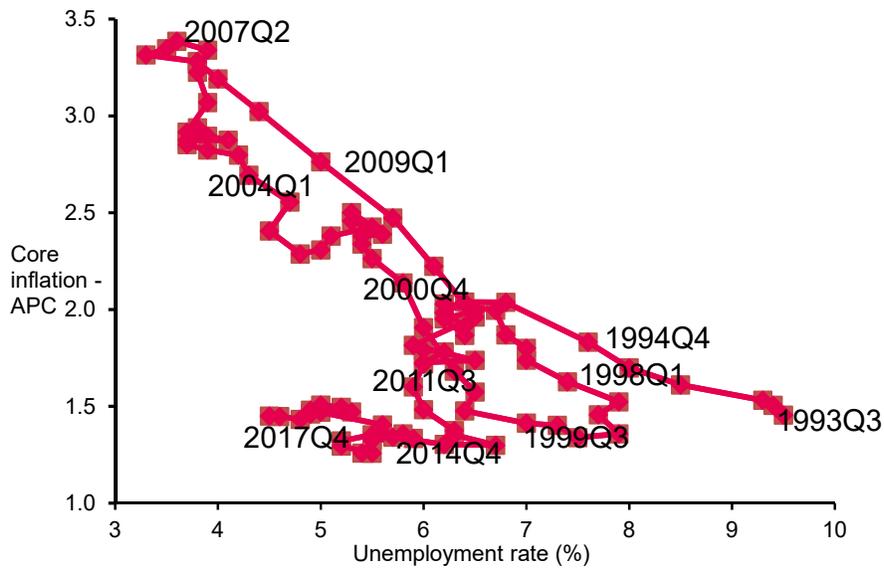Figure 1: Correlation between core inflation and unemployment in New Zealand
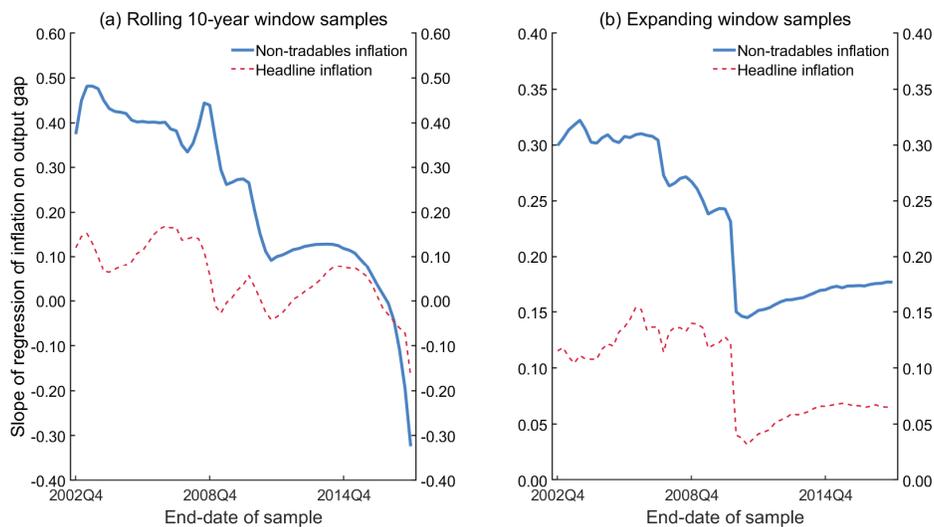

Figure 2: Correlation between inflation and the RBNZ output gap

_____

2   Conceptual framework: Artificial data from a simple model of demand and supply

In this section, we demonstrate how the correlation between inflation and activity can be influenced by a variety of factors, within a structural framework. We use the simplest version of the New Keynesian model for our purpose (See Gali, 2015). The model is linear in the variables, and all variables are expressed in terms of deviations from their trends. We use 'hats' above variables to indicate that they are deviations from trends.

In any period, t, the central bank follows a rule to set the interest rate ($\hat{r}_t$) in response to deviations of expected price inflation ($E_t\hat{\pi}_{t+1}$) from its target.[2] The parameter $r_\pi > 1$ measures the sensitivity of the central bank towards inflation:

$$\hat{r}_t = r_\pi E_t\hat{\pi}_{t+1}. \tag{1}$$

The aggregate demand side of the economy is given by:

$$\hat{y}_t = E_t\hat{y}_{t+1} - m_d(\hat{r}_t - E_t\hat{\pi}_{t+1}) + \varepsilon_t^d, \tag{2}$$

$$\varepsilon_t^d = \rho_d\varepsilon_{t-1}^d + \eta_t^d, \qquad \eta_t^d \sim iid\ N(0, \sigma_d). \tag{3}$$

The output gap ($\hat{y}_t$) co-varies negatively with the expected real interest rate ($\hat{r}_t - E_t\hat{\pi}_{t+1}$), for a given stance of expectations ($E_t\hat{y}_{t+1}$). The slope of the demand curve, $m_d > 0$, which may be influenced by risk-averse behaviour by consumers, moderates the sensitivity of demand to the interest rate. The demand shock ε_t^d captures several features of the economy that our simple framework abstracts from: random shifts in the economy's rate of time preference so that households shift the time profile of their consumption expenditures; frictions in the financial sector that alter the effective interest rate facing households; and changes in demand components such as government spending, investment or export demand.

Finally, the aggregate supply side of the economy is given by the relation between inflation and the output gap:

$$\hat{\pi}_t = \beta E_t\hat{\pi}_{t+1} + m_s\hat{y}_t + \varepsilon_t^s, m_s > 0, \tag{4}$$

$$\varepsilon_t^s = \rho_s\varepsilon_{t-1}^s + \eta_t^s, \qquad \eta_t^s \sim iid\ N(0, \sigma_s) \tag{5}$$

For any given path of expected inflation ($E_t\hat{\pi}_{t+1}$), a higher output gap will lead to higher inflation. $\beta \in (0,1)$ is the reciprocal of the rate of discount at which the economy evaluates future consumption and profits. The slope parameter $m_s > 0$ moderates the sensitivity of inflation to the output gap. The

_____

[2] In April 2019, the monetary policy objectives of the Reserve Bank of New Zealand moved from inflation targeting to a dual mandate that places equal emphasis on price stability and maintaining employment around its maximum sustainable level. This *Note* focusses on a sample period that ends before the introduction of the dual mandate and hence abstracts from an interest rate response to economic activity in the policy rule.

slope is lower, or the aggregate supply curve is flatter, when firms face frictions that affect their ability to change prices in response to movements in demand. ε_t^s is a cost-push aggregate supply shock that can be associated with several factors: changes in firms' market power, labour market frictions, variations in import prices, or random shifts in price or wage inflation expectations.

Table 1: Parameter values used for baseline simulation

Parameter	Description	Value
m_s	Response of inflation to demand	1
m_d	Response of demand to interest rate	1
r_π	Response of interest rate to inflation	1.5
β	Discount factor	0.99
ρ_s	Persistence of supply shock	0.75
ρ_d	Persistence of demand shock	0.75
σ_s	Standard deviation of supply shock	1
σ_d	Standard deviation of demand shock	1

Assuming an initial set of numerical values listed in Table 1, we now generate artificial data, by subjecting the model economy to a sequence of shocks to demand (η_t^d) and supply (η_t^s). The shocks are random numbers drawn from a Normal distribution, and they are assumed to disturb the model economy over 100 quarters.

A positive demand shock raises aggregate demand and leads to an increase in the prices set by the firms, resulting in a positive covariance between inflation and activity. Panels (a) and (b) of Figure 3 depict the dynamic responses of inflation and the output gap, conditional on a one-time, one standard deviation demand shock. Panel (c), on the other hand, presents a scatter plot of the artificial data generated when the business cycle is solely driven by demand shocks. We obtain an upward-sloping 'Phillips curve' in this scenario.

Panels (d) and (e) present the dynamics when the economy is disturbed by a one-time supply shock. Here, an exogenous rise in costs leads to a decline in production by the firms and pushes prices up, i.e. a negative covariance between inflation and activity. In Panel (f), we consider the inflation-activity scatterplot from an economy driven solely by supply shocks. In contrast to the other extreme of the demand-shock driven world, here the Phillips curve is downward-sloping.

Having considered the two opposite cases, we now move to the more realistic world where both types of shocks are allowed to generate business cycle fluctuations. As a first step, we consider the case in which supply shocks are, on average, less volatile than demand shocks. Formally, the ratio of the volatility of demand shocks to supply shock volatility, $\frac{\sigma_d}{\sigma_s}$ is fixed at 3.

The solid blue circles in Figure 4 depict the data simulated from this world, and the solid blue line, the Phillips curve, is the line that best fits the data. Note that the Phillips curve is still upward-sloping, even though the mix of demand and supply shocks implies that the circles do not align perfectly as in the extreme scenarios presented earlier in Figure 3.

Figure 3: Dynamics triggered by demand and supply shocks
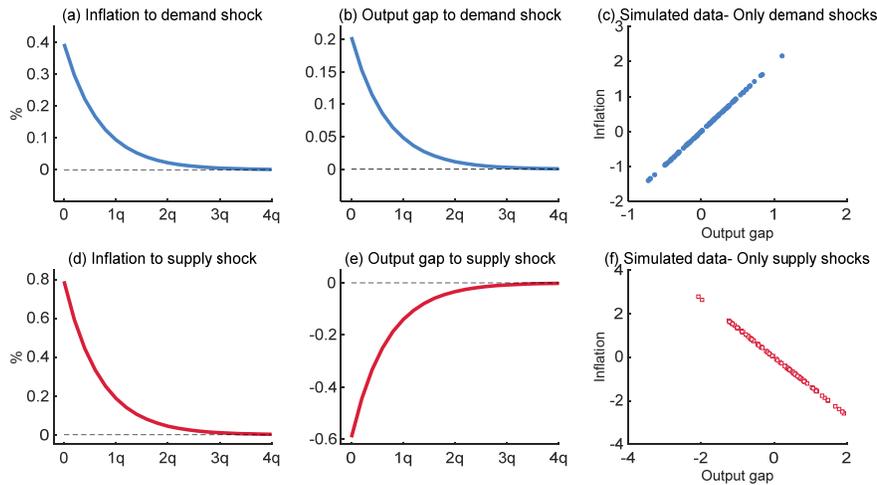
Retaining the same values for the other structural elasticities governing aggregate demand and supply relationships in the economy, we now increase the relative volatility of the supply shock by lowering $\frac{\sigma_d}{\sigma_s}$ to 0.7.

Figure 4: The relative volatility of shocks and the Phillips curve in the artificial data
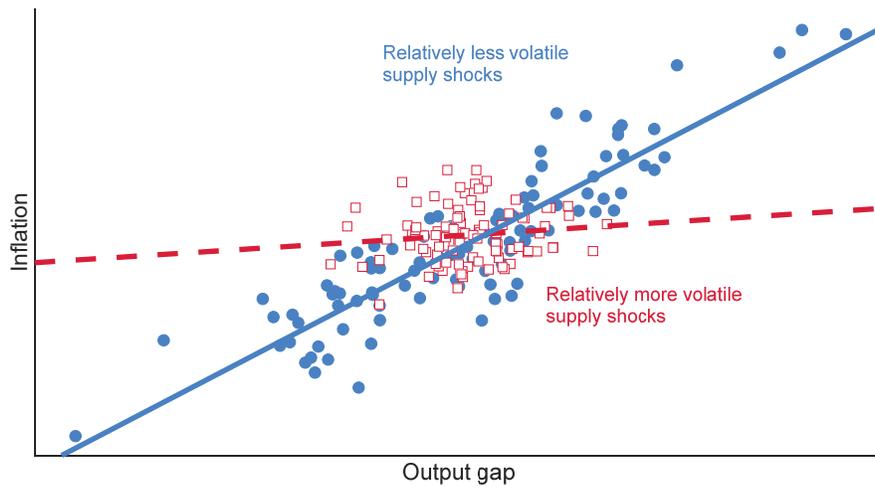

Note how the Phillips curve, now indicated by the dashed red line, has flattened, despite the fact that the three structural elasticities – the sensitivity of consumers to the interest rate, price-setters to demand-pressures or central bank behaviour – have remained the same. Merely altering the volatility of the supply shock has changed the pattern of the data generated from this world.

Can central bank behaviour influence the observed Phillips curve? Keeping shock volatilities and other structural elasticities constant, we consider the data from a world in which the central bank does not aggressively target inflation. We set the policy rule coefficient r_π to 1.01, reflecting a relatively less aggressive monetary policy stance towards inflation. We indicate the inflation-activity combinations generated from this world with blue circles in Figure 5. The steeply upward-sloping blue Phillips curve suggests that demand shocks are more *powerful* in this world, even though they have been assigned exactly the same volatility as the supply shocks.

In this case, the central bank is not actively pursuing demand-management by stabilising inflation and stimulating the real interest rate. What happens when we assume that the central bank adopts a more aggressive stance towards inflation stabilisation? We achieve this by increasing the policy rule coefficient r_π to 3. The variance of inflation is now lower and the covariance between inflation and economic activity is also weaker. This results in the flattening of the observed Phillips curve, now indicated using the dashed red line. Thus, even a more active inflation targeting regime may change the observed patterns in the data.

Figure 5: Inflation targeting and the Phillips curve in the artificial data
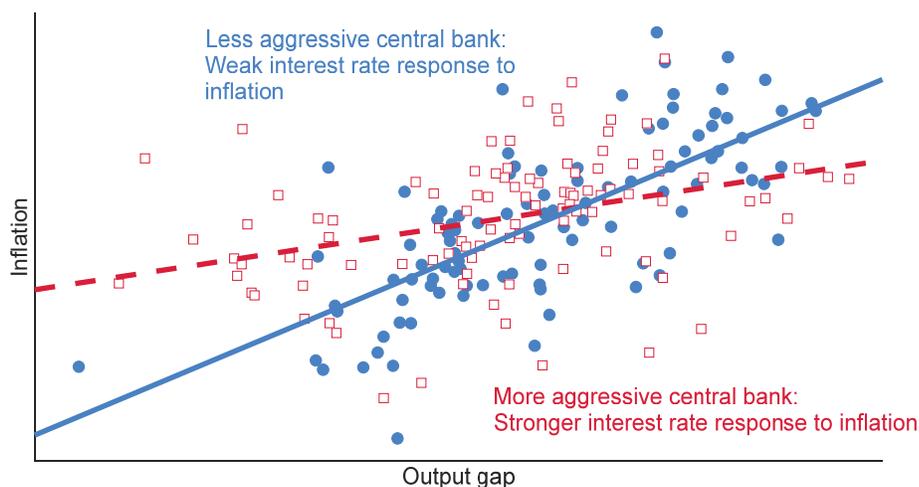
We now examine how rigidities on the demand side can influence the data generated from the model economy (figure 6). In a world where the demand from households responds flexibly to the real interest rate, with m_d set at 5, the Phillips curve appears relatively steep as demand shocks appear to be quite influential (blue circles). While retaining shock volatilities and other structural elasticities at their original calibrated values, we switch to a different regime where households are more risk averse and resist quickly adjusting demand to respond to the interest rate. Formally, we scale down m_d by a factor of 10 to 0.5. As depicted by the dashed red line, the Phillips curve appears flatter when the economy faces rigidities on the demand side. A key implication is that the movements in the output gap are now greatly diminished in response to shocks.

Figure 6: Demand rigidities and the Phillips curve in the artificial data
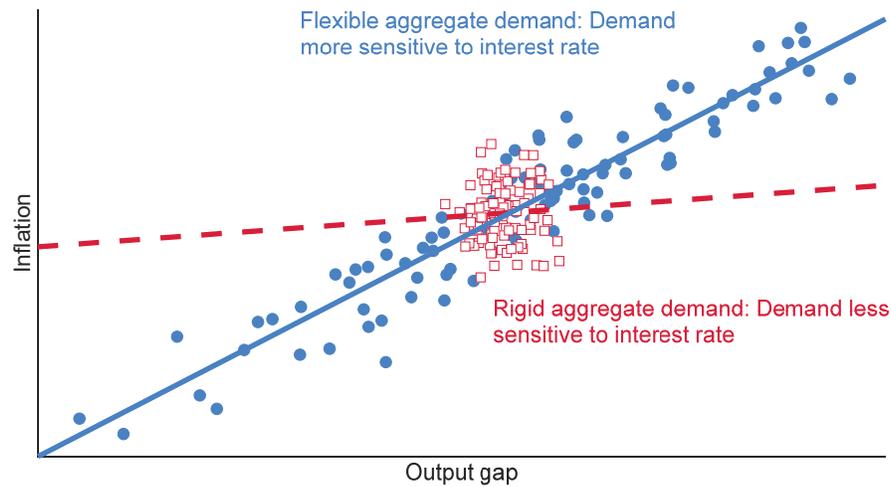
Finally, we examine the influence of the aggregate supply side of the economy (figure 7). Consider a world in which firms can change prices relatively flexibly to respond to demand, with the associated elasticity m_s fixed at 1. The Phillips curve in the data, indicated in blue, appears quite steep. Now we assume that changes in prices are more costly and suppress firms' profits. We cut the supply elasticity m_s by a factor of 10 to 0.1. Observe how the volatility of price inflation diminishes drastically. As a result, the Phillips curve, denoted in red, appears flatter as the inflation response to demand shocks is weakened with the new parametric configuration.

We have demonstrated that even in an extremely simple model of the economy, compositional effects of demand and supply shocks, as well as structural changes, can alter patterns in the data. In the next section, we estimate a more sophisticated version of the model on New Zealand data, to examine which features of the economy have changed over time, influencing the waning correlation between inflation and economic activity.

_____

Figure 7: Price rigidities and the Phillips curve in the artificial data
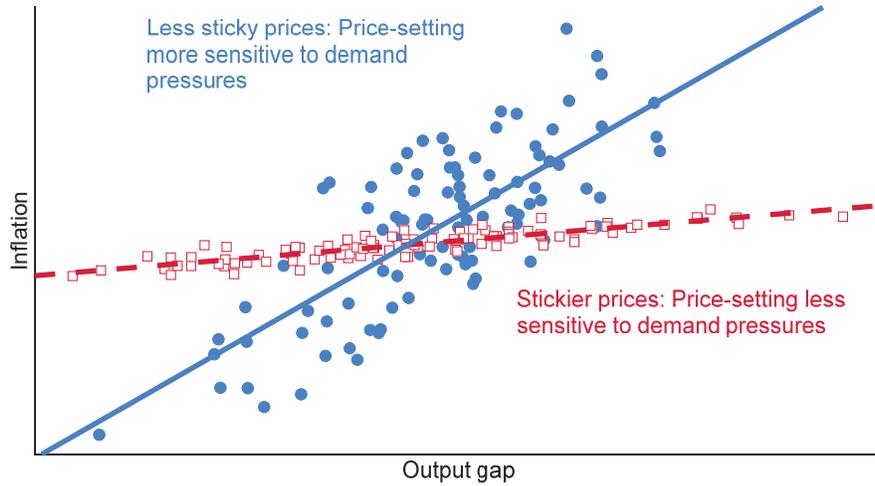
3   Empirical strategy

In this section we detail the empirical approach that we adopt. We first present the model that we estimate using New Zealand data. The economy designed for the estimation exercise is richer than the one we have considered so far. The estimated model is history-dependent rather than purely forward-looking, to fit the persistence of the data that we use for the estimation. As in the Reserve Bank's official forecasting model (see Kamber *et al* 2015), we also incorporate wage rigidities and assume that expectation formation for price and wage inflation are adaptive, rather than rational. In the notation that we use below, Δ denotes a change in a model variable whereas an upper hat represents a deviation of the variable from its trend. All shocks are normally distributed.

Aggregate demand. The output gap $\hat{y}_t$ is negatively correlated with the excess of the nominal short-term interest rate $(\hat{r}_t)$ over the expected inflation rate $\left(\hat{\pi}_t^{pe}\right)$, given the expected value of the output gap as well as its history:

$$\hat{y}_t - h\hat{y}_{t-1} = (E_t\hat{y}_{t+1} - h\hat{y}_t) - (1-h)\left(\hat{r}_t - \hat{\pi}_t^{pe}\right) + \varepsilon_t^{dem}. \tag{6}$$

The parameter $h \in [0,1)$ influences the history-dependence of aggregate demand due to habit-formation. ε_t^{dem} is a demand shock which is assumed to be autoregressive of order 1.

Price-setting. CPI price inflation $(\hat{\pi}_t)$, for a given stance of expectations $(\hat{\pi}_t^{pe})$ and past inflation, is positively correlated to the real wage $(\hat{w}_t)$:

$$\hat{\pi}_t - \iota_p \hat{\pi}_{t-1} = \beta(\hat{\pi}_t^{pe} - \iota_p \hat{\pi}_t) + \frac{\bar{\mu}_p - 1}{\varphi_p} \widehat{w}_t + \eta_t^{cpi}, \; \eta_t^{cpi} \sim iid \; N(0, \sigma_p). \tag{7}$$

The price elasticity of demand $\bar{\mu}_p > 1$ and the price stickiness parameter $\varphi_p > 0$ influence the response of inflation to the real wage. $\beta \in (0,1)$ is the economy's discount factor and $\iota_p \in [0,1]$ measures the degree of history dependence of inflation through price indexation. The process for CPI inflation expectation formation is adapted from Kamber *et al.* (2015). Inflation expectations are specified as a combination of past expectations, past inflation, and the rational expectations forecast:

$$\hat{\pi}_t^{pe} = \rho_{pe} \hat{\pi}_{t-1}^{pe} + (1 - \rho_{pe})(x_{pe} E_t \hat{\pi}_{t+1} + (1 - x_{pe}) \hat{\pi}_{t-1}) + \eta_t^{pe}, \eta_t^{pe} \sim iid \; N(0, \sigma_{pe}), \tag{8}$$
$$\text{where } x_{pe} \in [0,1], \; \rho_{pe} \in [0,1).$$

Wage-setting. Nominal wage inflation ($\hat{\pi}_t^w$), for a given stance of expectations ($\hat{\pi}_t^{we}$) and past wage inflation, co-varies positively with the output gap. The positive covariation arises because the wage elasticity of labour demand $\bar{\mu}_n > 1$ and the nominal wage stickiness parameter $\varphi_w > 0$. Wage inflation expectations are assigned a law of motion similar to that for CPI inflation expectations (see equation 8).

$$\hat{\pi}_t^w - \iota_w \hat{\pi}_{t-1}^w = \beta(\hat{\pi}_t^{we} - \iota_w \hat{\pi}_t^w) + \frac{\bar{\mu}_n - 1}{\varphi_w}\left(\hat{y}_t + \frac{h}{1-h}\Delta \hat{y}_t\right) + \eta_t^w, \; \eta_t^w \sim iid \; N(0, \sigma_w), \tag{9}$$
$$\hat{\pi}_t^{we} = \rho_{we} \hat{\pi}_{t-1}^{we} + (1 - \rho_{we})(x_{we} E_t \hat{\pi}_{t+1}^w + (1 - x_{we}) \hat{\pi}_{t-1}^w) + \eta_t^{we}, \; \eta_t^{we} \sim iid \; N(0, \sigma_{we}), \tag{10}$$
$$\text{where } x_{we}, \iota_w \in [0,1], \; \rho_{we} \in [0,1).$$

Monetary policy: The monetary policy authority follows an empirical rule to set the interest rate, in response to expected CPI inflation:

$$\hat{r}_t = \rho_r \hat{r}_{t-1} + (1 - \rho_r) E_t \hat{\pi}_{t+1} + \eta_t^r, \; \; \rho_r \in [0,1), \; \eta_t^r \sim iid \; N(0, \sigma_r). \tag{11}$$

In this augmented framework, 4 shocks originate on the supply-side of the economy, the price-setting and wage-setting equations and associated laws of motion for expectations. These supply shocks $\eta_t^{cpi}, \eta_t^{pe}, \eta_t^w$ and η_t^{we} push prices and activity in opposite directions. In contrast, the monetary shock (η_t^r) and the demand shock (η_t^{dem}) push prices and activity in the same direction.

The model is fitted on six quarterly data series using an expanding window over 1993Q1-2017Q4. These observable data series are, production GDP growth, CPI inflation, Labour cost index nominal wage inflation, the 90-day interest rate, and the RBNZ 2-year ahead CPI and wage inflation expectations. The first sample we consider spans 1993Q1-2002Q4 and the sample size is increased one quarter at a time. None of the data series are pre-processed using statistical filters.

We estimate the model using Bayesian methods. The Bayesian approach involves supplementing the likelihood function of the data with prior information about the parameters to formulate the

posterior distribution of the parameters, where these 'posterior' beliefs are formed 'after' the data has been observed. The posterior distribution is then sampled by Markov Chain Monte Carlo methods.[3]

4   Results

Our empirical analysis suggests that changes in economic structure and shock composition have *both* contributed to the declining correlation between inflation and economic activity/slack in the data. Figures 8 through 11 present the various structural elasticities that we have estimated over the expanding window samples.

The two supply-side elasticities in Figures 8 and 9, sensitivities of price inflation to the real wage and wage inflation to the output gap, have declined slightly over time, beginning from the GFC of 2007-2008. If wages respond to less to demand pressures, and prices react less to wages, the reduced volatility of prices can induce a flattening of the Phillips curve. The intuition is quite similar to that of the analogous experiment in section 2. However, prices and wages are quite sticky, i.e. the supply side relationships have been quite 'flat', even in the earlier sample periods, and the declines in slopes have been mild.

In Figure 10, we note that the response of the central bank to inflation has mildly increased from about 2 for the first sample to about 2.7 at the end of history.[4] As we have shown in section 2, an increased sensitivity of the central bank to inflation can reduce the influence of demand shocks, and lead to a decline in the correlation between inflation and output. However, the increase in the coefficient on inflation has not been drastic.

In Figure 11, the sensitivity of aggregate demand to the real interest rate has also diminished, particularly after the GFC. This change on the demand side makes the output gap less volatile, as demonstrated in section 2, and has also contributed to the flattening of the Phillips curve in New Zealand.

The direction of these structural changes on the demand- and supply-sides of the economy has contributed to the diminishing correlation between inflation and activity. However, the degree of the changes is quite mild in comparison to the evolution of estimated volatilities of the shocks, which we discuss next.

In Figure 12, we present the ratio of the average volatilities of the four supply shocks to the average volatility of the two demand shocks. The estimated volatilities of both demand shocks (η_t^r, η_t^{dem}) have

---

[3] Herbst and Schorfheide (2016) provide a formal introduction to the methodology and a less technical overview is available in Jacob and Munro (2018). The estimation is implemented in the Matlab-based toolbox Dynare Version 4.5.4 (Adjemian et al, 2011).

[4] We note that increased inflation targeting by the central bank does not necessarily imply a lower level of targeting of deviations from potential output/unemployment.

_____

declined over time, particularly after the GFC. On the supply side, the estimated volatilities of the expectations shocks (η_t^{pe}, η_t^{we}) have remained stable over time, while the cost-push shocks (η_t^{cpi}, η_t^{w}) influencing the price- and the wage-setting equations, have increased since the GFC. In sum, the changing volatilities of these shocks implies that the *relative* average volatility of the supply shocks has increased almost two-fold over the sample period.

The evidence of the increased relative volatility of supply-side disturbances affecting the New Zealand economy is particularly striking, in comparison to the much milder changes observed for the structural elasticities. A limitation of our methodology is that it does not allow us to isolate a single feature of the economy as the *dominant* contributor to the flattening of the Phillips curve in New Zealand. Changes in shock composition as well as economic structure have occurred simultaneously through history, and the individual effects are difficult to disentangle.

Figure 8: Sensitivity of price inflation to the real wage
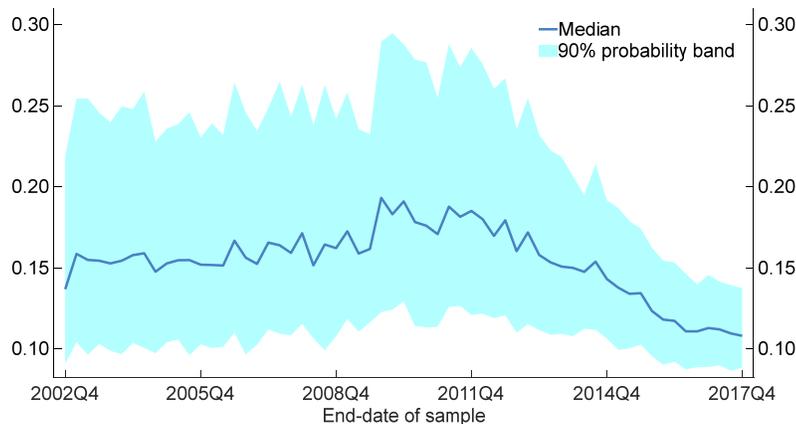
Note: The response of price inflation to the real wage is mainly determined by the price adjustment cost parameter (φ_p) and the price indexation parameter (ι_p). While the adjustment cost has increased after the GFC, the indexation parameter has remained stable (not exhibited).

_____

Figure 9: Sensitivity of wage inflation to the output gap
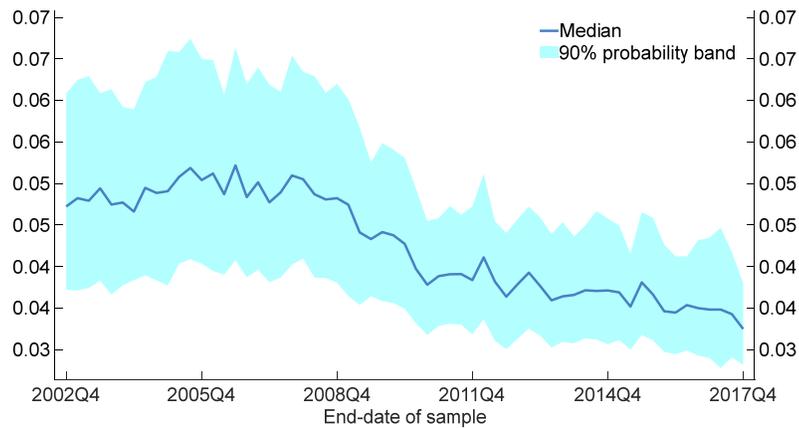
Note: The response of wage inflation to the output gap is mainly determined by the wage adjustment cost parameter (φ_w) and the wage indexation parameter (ι_w). As in the case of the price-setting equation, the adjustment cost parameter has increased over time, the indexation parameter has remained stable (not exhibited).

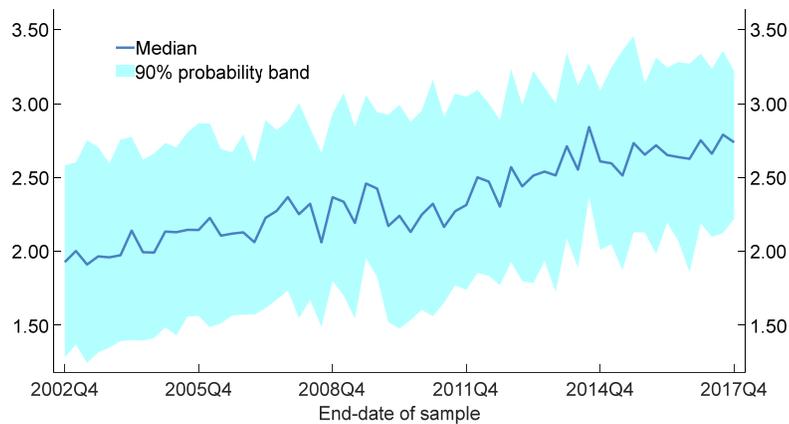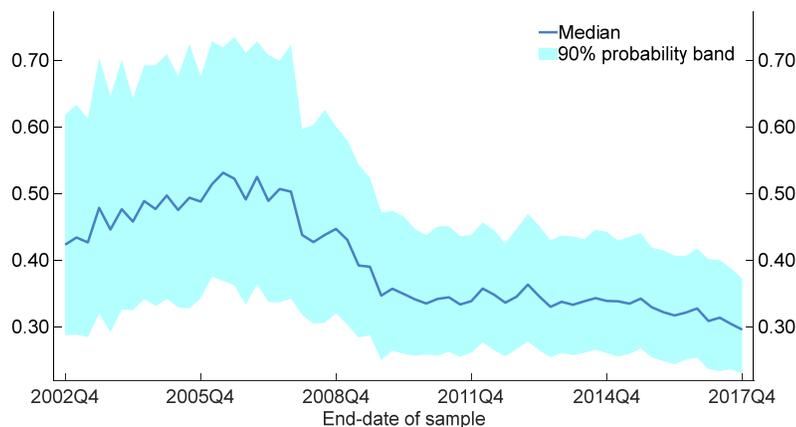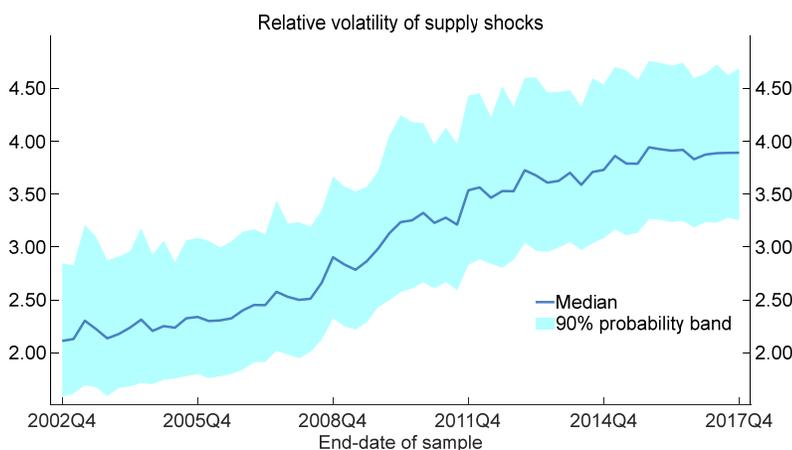Figure 10: Monetary policy response to price inflation

Figure 11: Sensitivity of the output gap to the real interest rate

Note: The response of the output gap to the real interest rate $(1-h)/(1+h)$ is determined by the habit persistence parameter (h) which has increased since the GFC.

Figure 12: The volatility of supply shocks relative to demand shocks

5   Conclusion

This paper investigates the potential causes of the flattening of the New Zealand Phillips curve. Our framework relies on a simple structural model of the New Zealand economy in which inflation and economic activity move in the same direction conditional on demand shocks, and in opposite directions conditional on supply shocks. Supply shocks may capture random shifts in firms' market power, labour market frictions, in import prices, or in price or wage inflation expectations. On the other hand, demand shocks may reflect random changes in the economy's rate of time preference, in the financial sector or monetary policy, or in demand components such as government spending, investment or export demand. The overall correlation between inflation and activity in the model is influenced by the relative strength of the two types of shocks, which in turn is determined by (a) the

respective volatilities of the shocks and (b) structural features of the economy that amplify or weaken shock transmission. We demonstrate that the Phillips curve can flatten in an economy in which supply shocks are more dominant.

Estimating an extended version of the model recursively on expanding-window samples in the inflation targeting era, we find that the volatilities of the supply shocks hitting the New Zealand economy have increased drastically over time while demand shocks have become less volatile. The changes in the slopes of the aggregate supply and demand curves as well as central bank behaviour, which also influence shock transmission have been fairly mild.

We emphasise that our methodology does not pinpoint a particular feature of the economy as the dominant contributor to the flattening of the Phillips curve in New Zealand. The increased relative volatility of supply shocks over history is the most striking result of our estimation strategy, and is likely to have played an important role in dampening the correlation between inflation and economic activity. However, changes in the composition of demand and supply shocks affecting the economy, have occurred simultaneously with the evolution of the aggregate demand and supply curves. Disentangling these individual effects provides a challenging avenue for future empirical research.

REFERENCES

Adjemian, S, H Bastani, F Karamé, M Juillard, J Maih, F Mihoubi, G Perendia, J Pfeifer, M Ratto, S Villemot (2011) 'Dynare: Reference Manual Version 4', *Dynare working papers*, CEPREMAP.

Constancio, V (2015) 'Understanding inflation dynamics and monetary policy'. Speech at the Federal Reserve Bank of Kansas City Economic Policy Symposium, Jackson Hole, 29-8-2015.

Cunliffe, J (2017) 'The Phillips curve: Lower, flatter or in hiding?' Speech to the Oxford Economics Society, 14/11/2017.

Doyle, M and P Beaudry (2000) 'What happened to the Phillips curve in the 1990s in Canada?'. *Staff General Research Papers Archive*, 10286, Iowa State University, Department of Economics.

Gali, J (2015) *Monetary policy, inflation, and the business cycle: An introduction to the New Keynesian framework and its applications,Second edition*,. Princeton University Press, Princeton NJ.

Herbst, E and F Schorfheide (2016) *Bayesian Estimation of DSGE Models*, Princeton University Press, Princeton NJ.

Iakova, D (2007) 'Flattening of the Phillips curve: Implications for monetary policy', *International Monetary Fund Working Papers*, 07/76.

Jacob, P and A Munro (2018) 'Technical Appendix to A Prudential Stable Funding Requirement and Monetary Policy in a Small Open Economy'. https://sites.google.com/site/reubenpunnoosejacob/research.

Kamber, G, C McDonald, N Sander and K. Theodoridis (2015) 'A structural model for policy analysis and forecasting: NZSIM', *Reserve Bank of New Zealand Discussion Paper*, DP2015/05.

Kuttner, K and T Robinson (2010) 'Understanding the flattening Phillips curve', *The North American Journal of Economics and Finance*, 21(2), 110-125.

Roberts, J (2006) 'Monetary policy and inflation dynamics', *International Journal of Central Banking*, 2(3).

Spencer, G (2017) 'Low inflation and its implications for monetary policy', speech delivered to the Institute of Directors in Auckland, 5 December 2017. https://www.rbnz.govt.nz/research-and-publications/speeches/2017/speech-2017-12-05

The Economist 2017. 'The Phillips curve may be broken for good', *The Economist,* 1 December 2017.