



DP2016/09

**Inflation expectations and low inflation in
New Zealand**

Özer Karagedikli and C. John McDermott

June 2016

JEL classification: E31, E58

www.rbnz.govt.nz

Discussion Paper Series

ISSN 1177-7567

DP2016/09

**Inflation expectations and low inflation in New
Zealand***

Özer Karagedikli and C. John McDermott[†]

Abstract

This paper finds that the changing behaviour of inflation expectations can explain much of the unusually low inflation in New Zealand. Across several empirical specifications of the Phillips curve, we observe that inflation expectations have become more backward-looking. We also find that the speed of adjustment in inflation expectations, proxied by the spread between short- and longer-term inflation expectations, can explain the unusually low inflation.

* The views expressed in this paper are those of the author(s) and do not necessarily reflect the views of the Reserve Bank of New Zealand. The Reserve Bank of New Zealand Discussion paper series is externally refereed. We would like to thank Punnoose Jacob, Andrew Coleman, Dorian Owen, and seminar participants at the Reserve Bank of New Zealand, University of Auckland and University of Otago, Motu Economic and Public Policy Research, and the New Zealand Econometrics Study Group Meeting. We also thank two anonymous referees for very valuable comments on an earlier draft of the paper.

[†] Address: Economics Department, Reserve Bank of New Zealand, 2 The Terrace, PO Box 2498, Wellington, New Zealand. *email address*: ozer.karagedikli@rbnz.govt.nz
ISSN 1177-7567 ©Reserve Bank of New Zealand

Non-technical summary

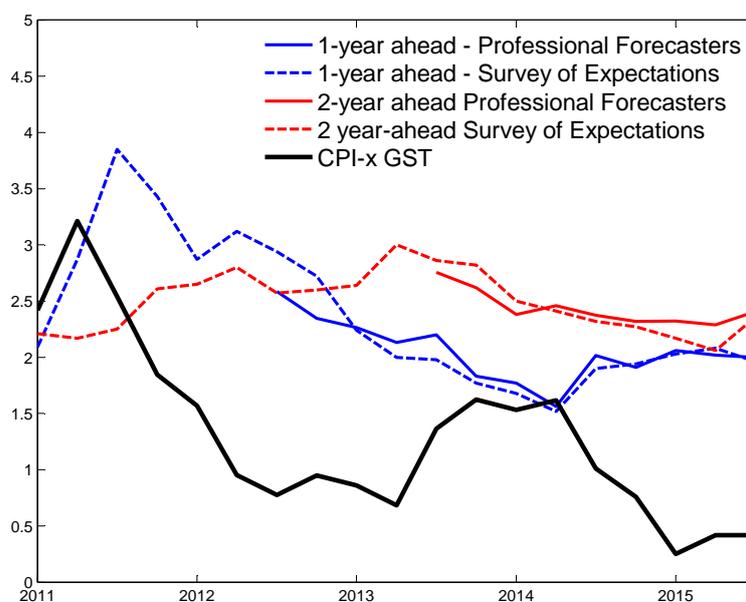
New Zealand's annual consumer price inflation (CPI) has remained low over the past several years. The observed persistence in low inflation has surprised both the Reserve Bank of New Zealand and the external/professional forecasters. Inflation has remained persistently low even as the economy grew faster than its potential and previously slack resources were increasingly being used.

We use a Phillips curve framework to account for the factors responsible for persistently low levels of inflation in New Zealand. We find a stronger role for unusually low inflation coming from the expectations channel in the Phillips curve. Inflation expectations in the Phillips curve appear to have become more backward-looking, or at the very least less forward-looking over recent years.

1 Introduction

New Zealand's annual consumer price inflation (CPI) has remained low over the past several years. In fact, inflation has been unusually lower given levels of economic activity and import price trends. The observed low inflation has surprised both the Reserve Bank of New Zealand (RBNZ) and the external/professional forecasters. Figure 1 shows that 1- and 2- year ahead inflation forecasts by both professional forecasters and businesses¹ significantly overshoot inflation out-turns over recent years.

Figure 1
Inflation forecasts 2011 - 2015



Notes: The thick black line shows the headline CPI inflation. Blue and red lines are the 1- and 2-year ahead expectations, respectively. Dashed lines refer to the overall survey, while thick lines are the professional forecasters' expectations, which are only available from 2011 onwards. 1-year and 2-year expectations are advanced by four and eight quarters, respectively.

Phillips curves, equations that relate some measure of aggregate economic

¹ Survey of Expectations, by the Reserve Bank of New Zealand.

activity to inflation, have been a major tool used to explain and forecast inflation for many decades in macroeconomics. Our contribution is to determine whether a New Keynesian Phillips curve (NKPC) framework can be used to account for the factors responsible for unusually low levels of inflation in New Zealand.² Across several empirical specifications of Phillips curves, we find that the expectations channel plays a strong role in accounting for the unusually low inflation. Inflation expectations appear to become more backward-looking over recent years. This finding is consistent with Coibion and Gorodnichenko (2015), who find a strong role for the expectations channel in explaining recent inflation out-turns in the US context. Our findings are also consistent with Ehrmann (2015) who finds that when inflation is persistently below target, inflation expectations are not well-anchored and inflation expectations become more backward-looking.

We find only a limited role for other potential classes of explanations for the unusually low inflation environment, such as the changes to the slope of the Phillips curve and the role of imported inflation. Coibion and Gorodnichenko (2015) also find little role coming from changes in the slope of the Phillips curve.

In recent years, a number of countries have experienced extended periods of time where inflation outcomes were not consistent with the conventional Phillips curve forecasts. In the US for example, there has been a puzzle as to why much lower inflation ('missing inflation') was not observed given the depth of the recession (Clark 2014), while in the UK, the puzzle was more about a lack of inflation in the face of the recent recovery (Haldane 2015). Constancino (2015) considers similar questions for euro area inflation. Our paper is related to this literature. However, our findings differ in a key dimension: we identify inflation expectations as the main explanation of the unusually low inflation, while this literature typically focuses on measures of aggregate economic activity.

The remainder of the paper is structured as follows. Section 2 introduces our empirical framework. Section 3 discusses the role of expectations in Phillips curves. Section 4 discusses data and the empirical model, section 5 presents the results, and section 6 concludes.

² See Kergozou and Ranchhod (2013), and Reserve Bank of New Zealand's December 2013 Monetary Policy Statement for discussions around the likely sources of low inflation. In this paper we are trying to explain the unusual inflation (i.e. below forecast out-turns) given information on aggregate economic activity and changes in relative import prices.

2 Empirical framework

The NKPC is one of the key building blocks of modern monetary theory (see Gali 2015). In a nutshell, the NKPC is a consequence of nominal pricing frictions that monopolistically competitive firms face when they set prices to maximise the discounted sum of future profits under uncertainty. The representative firm optimally changes the price, i.e. inducing inflation, as an increasing function of current real marginal cost and the change in price expected in the following period. Thus higher expectations of future inflation can generate current inflation, over and above that is implied by the level of current marginal cost.

Since the real marginal cost is assumed to be proportional to the unemployment/output gap, the NKPC can be expressed in terms of unemployment/output gap and inflation expectations. Furthermore, in the open-economy literature, the NKPC has been augmented by international relative prices, such as oil prices (Gordon 1975) or terms of trade (Gali and Monacelli 2005).

A typical NKPC curve can be expressed as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t + \gamma \Delta p_{m,t} + \varepsilon_t \quad (1)$$

where β is the discount factor, $E_t \pi_{t+1}$ is the expected inflation, y_t is the unemployment or output gap, Δp_m is the open-economy variable that controls for changes in the relative price of foreign goods to domestically produced goods (Δ is the change operator), and ε_t is the shock term.

3 Expectations in the Phillips Curve

The empirical treatment of inflation expectations is crucial for the purpose of this paper. While the theoretical literature has predominantly employed rational expectations, empirical studies have found that typical rational expectations models struggle to generate the persistence observed in inflation.³ Roberts (1995) suggests that the use of survey expectations may be a bet-

³ Cogley and Sbordone (2008) argue that the forward-looking NKPCs cannot match the inflation persistence in the data.

ter way of capturing inflation persistence.⁴ Fuhrer (2011) for example, finds that short-term inflation expectations appear to have a significant role in explaining US inflation, while long-term (ten-year) expectations do not appear to have a direct influence over the same period. More recently, Coibion and Gorodnichenko (2015) also find evidence that survey expectations fit Phillips curve better.

The departure from rational expectations has also been analysed by Fuster, Laibson and Mendel (2010, 2012). They use ‘natural expectations’ where agents’ expectations are a weighted average of their intuition (i.e. past inflation) and rational expectations. Agents with this kind of expectations tend to overestimate the persistence in inflation and consequently overreact to news.

To capture some of these ideas, we formulate inflation expectations in the Phillips curve as a weighted average of the past inflation ($\bar{\pi}_t$) and the survey of expectations (π_t^s):

$$E_t\pi_{t+1} = \theta\bar{\pi}_t + (1 - \theta)\pi_t^s. \quad (2)$$

We consider three different measures of past inflation in our Phillips curve: last period’s inflation ($\bar{\pi}_t^1$), a weighted average of the inflation in the past two periods, $\bar{\pi}_t^2$, and a weighted average of the past three periods, $\bar{\pi}_t^3$.⁵ This specification is similar to the one used by Ball and Mazumder (2011), who approximate the expected inflation with a weighted average of the last four quarters’ inflation.

Substituting equation (2) into equation (1) yields

$$\pi_t = \beta(\theta\bar{\pi}_t + (1 - \theta)\pi_t^s) + \kappa y_t + \gamma\Delta p_{m,t} + \varepsilon_t. \quad (3)$$

We take this final specification of the NKPC to the data.

⁴ Recently, the role of survey expectations in Phillips curves has gained further attention: Del Negro and Eusepi (2010), Adam and Padula (2011), Fuhrer (2011), Mavroeidis, Plagborg-Møller and Stock (2014) are examples of this.

⁵ Because we use annual data, which are overlapping by nature, we average the 1st, 5th and the 9th lags of inflation (they are the inflation in the previous quarter, a year ago, and 2 years ago).

4 Estimation and Data

4.1 Estimation

There are three ways the unobserved inflation expectations term can be incorporated into the NKPC of equation (3) so that it can be estimated: generalised instrumental variables, where the expectation term is replaced by the realisations of future inflation (π_{t+1}); the VAR approach, where the expectations term is replaced by a forecast from a VAR; and the survey approach where the expectations term is replaced by a direct measure of expectations from a survey. We use a survey approach because this allows us to capture the idea of natural expectations and other non-rational expectations concepts.

To estimate equation (3) we use a GMM estimator. GMM is usually used because survey of expectations generate endogeneity problems. However, the timing of the survey we use does not strictly require GMM because the survey is conducted within the quarter. For example, the March quarter survey is conducted around mid-February, at which point this figure is not available to the survey respondents. That said, the potential endogeneity of the unemployment/output gap necessitates a GMM estimation procedure.

4.2 Data

The time series that we use in our analysis are shown in figure 2.⁶ Inflation is the annual percentage change in the headline CPI series. In 2010:4 the Goods and Services Tax (GST) was increased by 2.5 percent. We subtract this GST increase from the headline CPI.

Inflation expectations come from the RBNZ's Survey of Expectations. The Survey of Expectations is one of the oldest expectations surveys in New Zealand and specifically targets businesses. This survey is conducted in February, May, August and November by the Nielsen Company on behalf of the RBNZ. The number of businesses surveyed has varied over the years: when the survey first started in 1987 the sample was around 200 businesses. However, over more recent years this number has fallen to around 70.

The survey asks the respondents '*what annual percentage change do you expect in the Consumer Price Index for the year to YYYY-QQ (one-year*

⁶ The appendix A describes the data in more detail.

ahead) and year to YYYY-QQ (two-year ahead)'. Mean responses to these questions are what we use as the 1- and 2-year ahead inflation expectations.

We use two alternative measures of aggregate economic activity: an unemployment gap and an output gap. The unemployment gap is estimated with a Hodrick-Prescott filter with a smoothing parameter (λ) of 500000. The choice of λ is to allow the natural rate of unemployment to be smooth. A typical value of λ of 1600 used by macroeconomists would imply a NAIRU of above 9 percent in the early 1990s, which we find implausible. We use a significantly higher λ to allow the NAIRU not to follow the actual unemployment rate. This is consistent with Phillips and Jin (2015) suggestion that one needs 'prior' economic information about choosing a (λ). The second aggregate activity measure is an estimate of the output gap used by the RBNZ in its forecasts (Lienert and Gilmore 2015).

The open economy dimension of the Phillips curve requires a measure of the relative price of imported goods and domestically produced goods. We use the ratio of the import price deflator to the GDP deflator from the national accounts published by Statistics New Zealand.

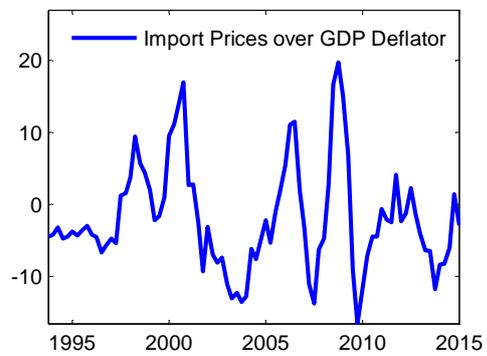
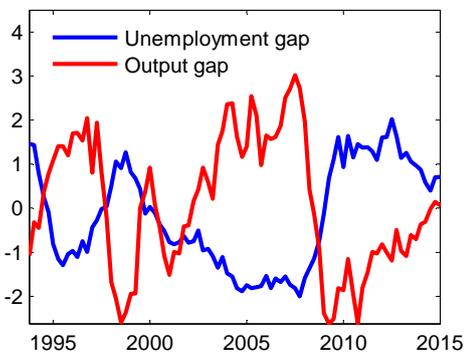
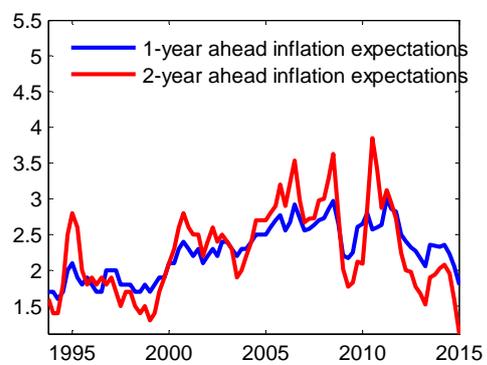
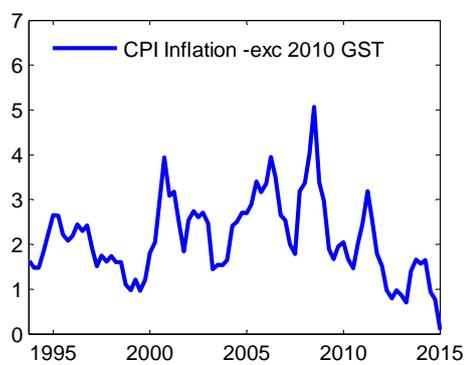
We use quarterly data from 1994:1 through 2015:1, which means that the start of the estimation period is a few years after the adoption of the inflation targeting regime. There are two main reasons for starting our sample in 1994. First, inflation was stabilised after 1993 following a period of disinflation at the beginning of the inflation targeting regime. Second, this sample avoids much of the structural reform period where the unemployment rate reached 11 percent in 1991.

5 Results

Columns 1-3 in table 1 show the estimation results when the unemployment gap is used in the Phillips curve. Each of these columns corresponds to a particular way of weighting past inflation in the inflation expectations measures ($\bar{\pi}_t^1$, $\bar{\pi}_t^2$ and $\bar{\pi}_t^3$).

The discount parameter, β , is estimated to be between 0.978 and 0.995 across specifications and is precisely estimated. Over the sample, the weight attached to past inflation in the formation of inflation expectations, θ , varies between 0.55 and 0.76, suggesting a high degree of backwardness in the formation of expectations.

Figure 2
Data



The coefficient κ which links the unemployment gap to inflation is estimated to be between -0.040 and -0.18 across the three specifications implying that a one percent deviation of the unemployment rate from the NAIRU leads to around 0.04 to 0.18 percentage points change in headline inflation. At face value, this coefficient suggests that to explain a 1 percent weakness in inflation at least a 5 percent deviation from the NAIRU would be needed.

The coefficient γ shows the impact of import prices on inflation in New Zealand, and it is economically and statistically significant. Over the sample, the Δp_m has declined around 37 percent, implying an 0.44 percent decline per quarter. The declining trend in import prices has been a major source of disinflationary pressure in New Zealand. Nevertheless, even knowing about this trend has still led to forecasts of inflation being high relative to out-turns.

Columns 4-6 in table 1 show the estimation results when the output gap is used in the Phillips curve. Results from these specifications are similar to the results when the unemployment gap is used. The past inflation coefficient, θ , in the inflation expectations term, varies between 0.63 and 0.78.

Using either the unemployment gap or the output gap, the best fitting specifications are where the past inflation enters into the expectations term with one lag only.

If we compare the κ parameters estimated with the unemployment gap and the output gap specifications (columns 1 and 4), their ratio is around 2. This ratio, also known as the Okun's law coefficient, maps the output gap to the unemployment rate gap. So a 1 percent fall in unemployment gap is associated with a 2 percent increase in the output gap.

5.1 Time-varying parameter estimates

To check the robustness of the results we presented in the previous section, we estimate a time-varying parameter version of the Phillips curve using the unemployment gap.⁷ That is, we examine if the parameters we discussed in the previous section have been stable overtime and whether any time variation can account for the low inflation. We restrict our inflation expectations measure to only one lag, $\bar{\pi}_t^1$. Our Phillips curve specification is non-linear, therefore we fix the β parameter at 0.99 and allow other parameters to vary overtime. Equations (4) - (7), show the model we estimate

⁷ We get similar results when we use the output gap instead of the unemployment gap.

Table 1
Phillips Curve Estimates: CPI exc GST with Unemployment and Output gaps

	Unemployment Gap			Output Gap		
	$\bar{\pi}^1$	$\bar{\pi}^2$	$\bar{\pi}^3$	$\bar{\pi}^1$	$\bar{\pi}^2$	$\bar{\pi}^3$
β	0.978*** (0.026)	0.993*** (0.035)	0.995*** (0.033)	0.995*** (0.028)	0.994*** (0.033)	1.0004*** (0.034)
θ	0.553*** (0.099)	0.766*** (0.097)	0.651*** (0.156)	0.639*** (0.109)	0.783*** (0.093)	0.658* (0.084)
κ	-0.175*** (0.056)	-0.040 (0.053)	-0.111** (0.051)	0.088*** (0.038)	0.045 (0.046)	0.106** (0.044)
γ	0.019*** (0.008)	0.000 (0.012)	0.015* (0.009)	0.021** (0.009)	0.01 (0.012)	0.020* (0.010)
R^2	0.761	0.684	0.720	0.730	0.679	0.72
se	0.43	0.471	0.472	0.460	0.502	0.47
First-Stage F's (gap measure)	190	183	186	121	112	118

Notes: The GMM estimates for the 1994:1 - 2015:1 sample period. Newey-West standard errors are in brackets. (*), (**) and (***) represent statistical significance at 10, 5 and 1 percent respectively. The final row reports the first-stage F statistic, testing the exclusion restrictions on the instruments in the regression of the unemployment gap or output gap on the instruments.

$$\pi_t = \beta(\theta_t \bar{\pi}_t + (1 - \theta_t) \pi_t^s) + \kappa_t y_t + \gamma_t \Delta p_{m,t} + \epsilon_t \quad (4)$$

$$\theta_t = \theta_{t-1} + \eta_{1,t} \quad (5)$$

$$\kappa_t = \kappa_{t-1} + \eta_{2,t} \quad (6)$$

$$\gamma_t = \gamma_{t-1} + \eta_{3,t} \quad (7)$$

where equation (4) is the measurement equation, and equations (5) - (7) are the state equations. The variance of the measurement equation is $\epsilon_t \sim N(0, \sigma_\epsilon^2)$, and the variances of the state equations are $\eta_{1,t} \sim N(0, \sigma_{\eta_1}^2)$, $\eta_{2,t} \sim N(0, \sigma_{\eta_2}^2)$ and $\eta_{3,t} \sim N(0, \sigma_{\eta_3}^2)$. We calibrate the ratios between the variances of measurement and state equations to achieve an appropriate degree of smoothness in the time-varying parameters. The intuition for this smoothness in the case of κ_t is that firms' price setting behaviour, which plays a role in the determination of the slope of the Phillips curve, does not change from quarter to quarter.⁸ The values we choose for these variance ratios are 0.078, 0.031 and 0.022 for θ_t , κ_t and γ_t respectively. These hyperparameters imply that the variances of these parameters are significantly (between 25-50 times) lower than the variance of inflation.

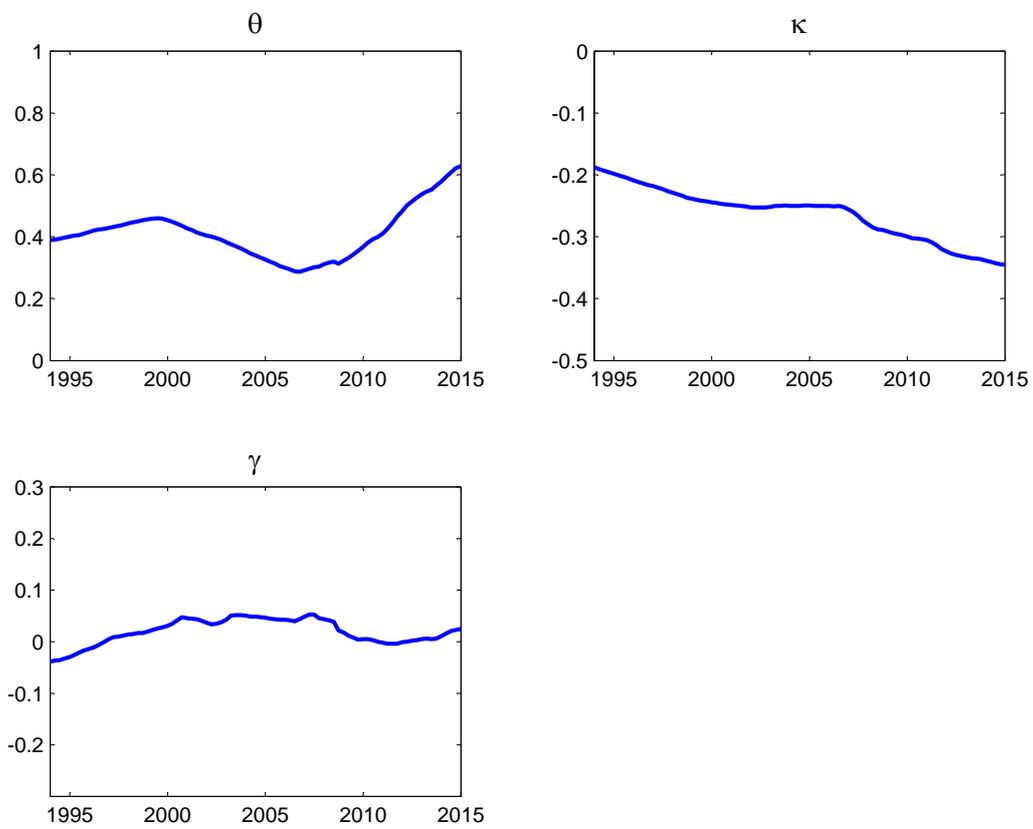
Estimated time-varying parameters are shown in figure 3. They indicate that there is some variation in parameters over time. The most striking time-variation is observed in θ_t , which measures the weight on the backward-looking component in the expectations term. This coefficient was falling throughout 1990s and 2000s, perhaps reflecting more firmly anchoring of expectations. However, starting from 2008-2009, this coefficient has been increasing from the low of 0.28 to 0.63 at the end of the sample.

The time-varying κ_t coefficient is found to be increasing, albeit slightly, over the sample and is estimated to be around -0.34 at the end of the sample.⁹

⁸ Similar arguments can be made for other parameters.

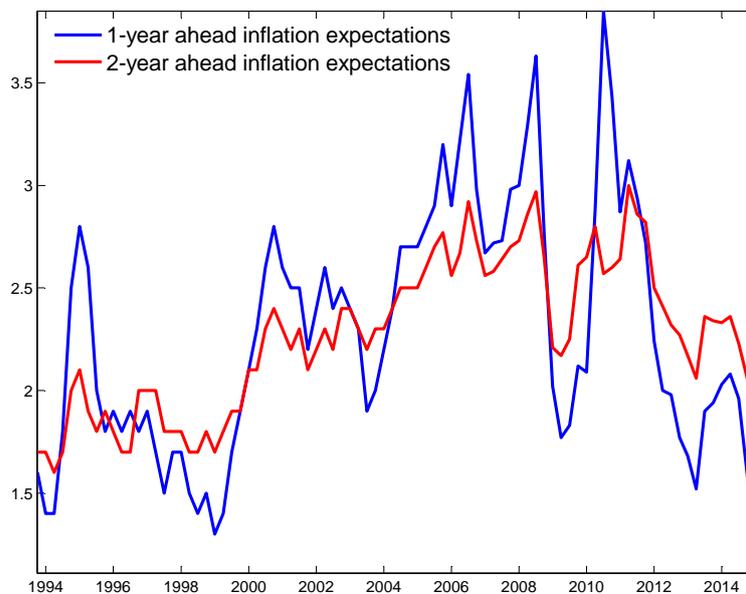
⁹ When we estimate the same model using the output gap rather than the unemployment gap we find similar results.

Figure 3
Time-varying parameter for inflation



Notes: Time-varying coefficients estimated with maximum likelihood with the Kalman filter. β is fixed at 0.99. θ is the weight on the past inflation, κ is the slope of the Phillips curve and γ is the relative price parameter.

Figure 4
1 and 2 year ahead expectations



5.2 The expectations spread

We have highlighted that there is a significant role for both past inflation and survey expectations in fitting a Phillips curve in New Zealand context. However, the survey measure we use (2-year ahead) strongly reflects the ‘anchoring’ of inflation expectations. To the extent the shorter-term inflation expectations diverge from this ‘anchor’, the speed at which the inflation converges to the anchor may also be relevant in determining inflation outcomes.¹⁰

To expand on this idea, suppose that the central bank’s inflation target is credible and price-setters expect inflation to converge back to the target in the medium term. The ‘spread’ between the short-term inflation and the medium-term anchor gives an indication about price setters’ belief about

¹⁰ Similar arguments are put forward by Fuhrer (2015) where he allows for the possibility of short-term expectations adjusting gradually towards the long-run expectations.

Table 2
Phillips Curve Estimates with spread variable

	Unemployment Gap	Output Gap
β	0.970*** (0.022)	0.989*** (0.023)
θ	0.482*** (0.079)	0.541*** (0.106)
κ	-0.158*** (0.053)	0.057 (0.034)
γ	0.018** (0.008)	0.019** (0.008)
δ	-0.470** (0.236)	-0.564** (0.273)
R^2	0.792	0.776
se	0.411	0.422

Notes: GMM estimates for the 1994:1 - 2015:1 sample period. Newey - West standard errors are in brackets. (*), (**) and (***) represent statistical significance at 10, 5 and 1 percent respectively.

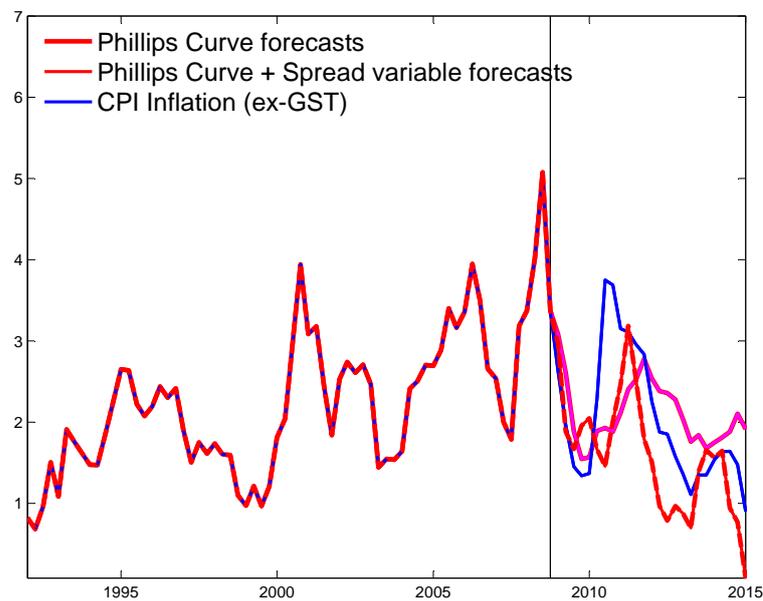
the speed of adjustment to the target. As the spread gets larger, prices are set with an inflation rate that differs from the inflation target to which the inflation is believed to converge at some time in the future. In this environment, it may become ‘optimal’ for price setters to set prices that reflect both near-term inflation and the short-term inflation expectations.

We test this proposition by augmenting the NKPC specification with this spread variable. The spread variable is defined as the gap between the 2-year ahead inflation expectations and the 1-year ahead expectations. Figure 4 shows that since around 2009 the 2-year ahead measure has mostly remained above the 1-year ahead measure.

Table 2 reports the GMM estimates of the spread-augmented NKPC. Estimated β and θ coefficients are similar to the results we obtained in table 1. The coefficient κ which links economic slack to inflation is insignificant in the specification that uses the output gap. The new parameter δ measures

the effect of the ‘spread’ variable, and is estimated to be around -0.5.¹¹ It implies that as the 1-year ahead measure falls 1 percent below the 2-year ahead measure inflation would be around 0.5 percent lower. The role that the spread variable plays also shows that inflation is influenced by more near-term expectations rather than expectations far into the future.

Figure 5
Dynamic Forecasts with Spread variable



Notes: The red dashed line is the headline CPI inflation excluding 2010 GST. The blue line is the Phillips curve forecasts from 2009Q1 onwards, while the purple line is the inflation forecasts from the spread-augmented Phillips curve.

A natural question is whether including the spread variable in our Phillips curve would have improved the forecasts of inflation over recent years. To examine this, we estimate Phillips curves with and without spread variables

¹¹ Granger-causality tests indicate that the spread variable does Granger-cause inflation. The null of no-Granger causality is rejected at 5 percent significance with associated p-value of 0.0398, with 5 lags in the test. The likelihood ratio test and AIC test both indicate 5 lags.

up to 2008 and then forecast inflation. Figure 5 shows the dynamic forecasts from the Phillips curves with and without the spread variables. The addition of the spread variable confirms our proposition that the dynamic forecasts from 2008:4 onwards improve dramatically. These results also suggest price-setters are less forward-looking in a low inflation environment.

5.3 Estimated expectations

We have found that the Phillips curve fits the data better when expectations incorporate some information from past inflation or near-term expectations. What do these estimated inflation expectations look like? In figure 6 we compare the fitted inflation expectations series from the time-varying parameter model, to the 2-year ahead survey expectations. Figure 6 also includes a ‘trend inflation’ estimate *a la* Stock and Watson (2007), which is an alternative measure of inflation expectations.¹²

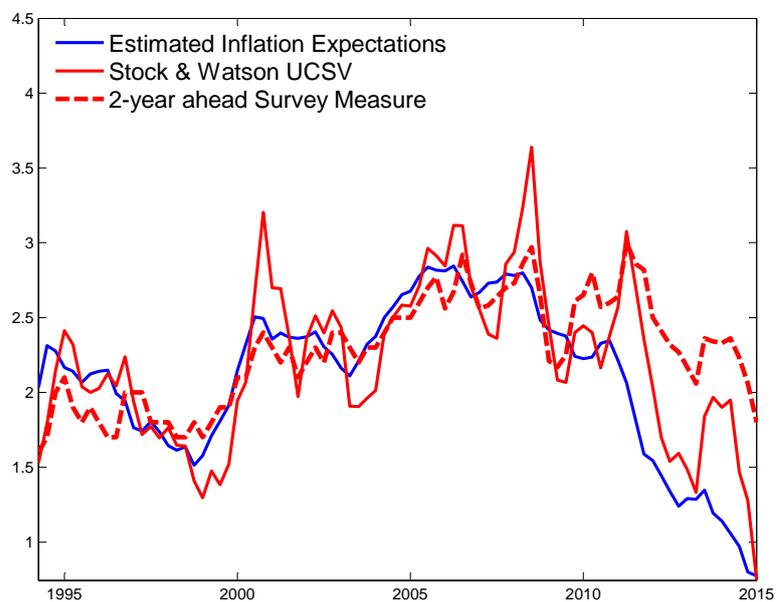
The 2-year ahead measure and the trend inflation estimate follow each other closely until 2012 and then diverge. Moreover, this empirical estimate supports the ‘fitted inflation expectations’ series that is backed-out of the time-varying parameter model. These estimates suggest that the unobserved inflation expectations have been lower than what survey measure suggests.

6 Conclusion

The unusually low inflation in the face of a robust output growth has been a key puzzle in the New Zealand economy. We find that the expectations channel explains a significant proportion of the unusually low inflation in New Zealand. More specifically, we find that in a New Keynesian Phillips curve the inflation expectations process has become more backward-looking or at the very least less forward-looking. The relationship between the size of underutilised resources in the economy, and the influences of the imported inflation have not changed in recent years and so cannot account for the forecasting errors in inflation.

¹² The Stock and Watson model is an unobserved components model with stochastic volatility. Trend inflation captures the level of inflation in the presence of shocks to the trend component only. Clark (2014) argues that this as an *empirical measure of inflation expectations*, as it measures the level of inflation once the temporary shocks are all dissipated.

Figure 6
Estimated inflation expectations



Notes: The blue line is the estimated expectations from the time-varying model, the red line is the ‘trend inflation’ measure from the Stock and Watson (2007) unobserved-components model, and the red-dashed line is the 2 year-ahead inflation expectations from the Reserve Bank of New Zealand’s Survey of Expectations.

References

- Adam, K and M Padula (2011), Inflation dynamics and subjective expectations in the United States, *Economic Inquiry* 49(1), 13-25.
- Ball, L and S Mazumder (2011), Inflation Dynamics and the Great Recession, *Brookings Papers on Economic Activity*, 337-381.
- Cogley, T and A Sbordone (2008), Trend Inflation, Indexation, and Inflation Persistence in the New Keynesian Phillips Curve, *American Economic Review* vol. 98, no. 5, pp. 2101-26.
- Constancino, V (2015), Understanding Inflation Dynamics and Monetary Policy, presented at 2015 Jackson Hole Conference, Federal Reserve Bank of Kansas City.
- Coibion, O and Y Gorodnichenko (2015), Is the Phillips curve alive and well after all? Inflation Expectations and the missing disinflation, *American Economic Journal: Macroeconomics*, 7, 197-232.
- Clark, T (2014), The Importance of Trend Inflation in the Search for Missing Disinflation, Federal Reserve Bank of Cleveland, Economic Commentary, 2014-16.
- Del Negro, M and S Eusepi (2010), Fitting Observed Inflation Expectations, Federal Reserve Bank of New York Staff Report, No 476.
- Ehrmann, M (2015), Targeting Inflation from Below - How Do Inflation Expectations Behave?, *International Journal of Central Banking*, Vol 11, S1, pp 213-249.
- Haldane, A (2015), Drag and Drop, Bank of England, Speech given at the BizClub lunch, Rutland.
- Fuhrer, J (2011), The Role of Expectations in Inflation Dynamics, *International Journal of Central Banking*, Vol 8, No S1, pp. 137-165.
- Fuhrer, J (2015), Expectations as a Source of Macroeconomic Persistence: Evidence from Survey Expectations in Dynamic Macro Models, Federal Reserve Bank of Boston, Working Paper No 12-19.
- Fuster, A, Laibson, D and B Mendel (2010), Natural Expectations and Macroeconomic Fluctuations, *Journal of Economic Perspectives* 24(4), pp.67-84.
- Fuster, A, Laibson, D and B Mendel (2012), Natural Expectations and

Macroeconomic Dynamics and Asset Pricing, in NBER Macroeconomics Annual 26, (eds) Acemoglu, D and M Woodford, 1-48. Chicago, University of Chicago Press.

Galí, J (2015), Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications, Princeton University Press, 2nd edition.

Galí, J and T Monacelli (2005), Monetary Policy and Exchange Rate Volatility in a Small Open Economy, *Review of Economic Studies* 72, pp 707-734.

Gordon, R J (1975), Alternative Responses of Policy to External Supply Shocks, *Brookings Papers on Economic Activity* 3(2), pp 183-206.

Kergozou, N and S Ranchhod (2013), Why has inflation in New Zealand been low? Reserve Bank of New Zealand Bulletin, September, pp. 3-11.

Lienert A and Gilmore D (2015), The Reserve Bank's method of estimating potential output, Reserve Bank of New Zealand Analytical Note 2015/01.

Mavroeidis, Plagborg-Møller and Stock (2014), Empirical Evidence on Inflation Expectations in the New Keynesian Phillips Curve, *Journal of Economic Literature* 52(1), pp 124-188.

Monetary Policy Statement (2013), Reserve Bank of New Zealand, December, Box B.

Phillips, P C B, and S Jin (2015), Business Cycles, Trend Elimination, and the HP Filter, Cowles Foundation Discussion Paper No. 2005

Roberts, J M (1995), New Keynesian Economics and the Phillips Curve, *Journal of Money Credit and Banking* 27(4), 975-984

Stock, J and M Watson (2007), Why Has U.S. Inflation Become Harder to Forecast?, *Journal of Money Credit and Banking*, 39(1), pp. 3-33.

Table 3
Descriptions of Series

Series	Mnemonic	Description
CPI inflation excluding GST	π_t	Headline CPI inflation adjusted for the GST changes in 2010
Survey Inflation expectations	π_t^s	Reserve Bank of New Zealand Survey of Expectations 1 and 2 year ahead CPI expectations
Unemployment rate gap	u_t	Hodrick-Prescott filtered unemployment rate ($\lambda=500000$)
Output gap	y_t	RBNZ estimates June 2015 MPS
Relative import price inflation	$\Delta p_{m,t}$	Annual changes in the ratio of import price deflator and the GDP deflator

Appendix: Data descriptions

The CPI inflation data we use excludes the increase in the GST in New Zealand that occurred in 2010. We use an ex-GST CPI inflation series where we lower the inflation by the size of the increase in the GST in 2010:3. For the measure of slack in the economy we use an unemployment gap measure with a very slow moving NAIRU.¹³

¹³ We check the robustness of these results to different measures of NAIRU, with different lag specifications. We find similar results. Results are available upon request.