Modelling New Zealand inflation in a Phillips curve[1]

David Hargreaves, Hannah Kite and Bernard Hodgetts

This article presents some simple estimates of Phillips curves for New Zealand inflation and outlines a recent reorganisation of the inflation process in the Reserve Bank's Forecasting and Policy System (FPS). While modern economic theory suggests the traditional Phillips curve should be used only with care, empirical estimates for New Zealand suggest it continues to have some value. We find that estimates of the impact of resource pressure (the "output gap") on inflation are easiest to obtain from an equation on the non-tradables component of CPI inflation, and show that this relationship can be improved statistically by introducing a (fairly smooth) measure of inflation expectations on the right hand side. We present some evidence that the relationship between resource pressures and non-tradables inflation is stronger in New Zealand than some comparable countries, and further evidence that this could be related to the cyclicality of housing construction costs in New Zealand. In the latest version of the Reserve Bank's macro-model, FPS, the inflation process has been written with a tradables/non-tradables split and an explicit empirical measure of inflation expectations. This does not greatly change model properties but allows the model's congruence with the data to be assessed more directly.

1   Introduction

A central bank charged with controlling inflation needs to monitor and understand the inflation process within its economy. Building up a view of the determinants of inflation will typically involve a range of statistical techniques and economic theories.

While the Reserve Bank takes an eclectic approach to thinking about the possible causes of inflation, the Bank's core model of the economy (the Forecasting and Policy System or FPS) focuses on a fairly simple story of inflation determination, the so called "Phillips curve" which relates inflation to measures of resource strain in the economy.

A recent article in the *Bulletin* (Hodgetts, 2006) described some changes in New Zealand's inflation process over the past 20 years. This article builds on that discussion by providing more details on the Phillips curve structure in use within FPS, which has recently been altered significantly to allow better monitoring of the inflationary process. We begin by discussing the ideas and history behind the Phillips curve and some recent related theoretical developments in section 2. In section 3, we describe some representative Phillips curves estimated on New Zealand non-tradables and

tradables inflation data, showing a significant relationship between non-tradables inflation and resource pressure. We show that this relationship looks more reliable in New Zealand than in some other countries, and consider further why this might be the case. In section 4 we describe how this evidence has been calibrated into the most recent version of FPS.

2   Some history of the Phillips curve and recent developments

The simplest Phillips curve, which Bill Phillips, a New Zealand economist, sketched around 1958, showed an empirical inverse relationship between inflation and unemployment "in the previous 90 years or so of United Kingdom data" (Laidler, 2001). The curve has attracted a lot of fame and notoriety ever since.

The notoriety of the Phillips curve came about because of the risk that it might be interpreted as a potentially exploitable relationship for policy purposes. A possible interpretation of the curve was that lower unemployment could be permanently achieved at the cost of a higher (but stable) rate of inflation. However, as shown by Milton Friedman and others, this depended on the assumption that inflation expectations would remain stable as inflation rose. If inflation expectations instead responded gradually (adaptively) to

rising inflation, there would only be a temporary reduction in unemployment unless the central bank was prepared to tolerate steadily increasing rates of inflation.[2]

Friedman's critique of the exploitability of the Phillips curve was not the end of the controversy. The rational expectations revolution in economics in the 1970s introduced the idea that inflation expectations might respond instantly to the prospect of higher inflation, meaning that predictable monetary policy actions would essentially have no influence on economic activity. This was followed by work showing that providing there are "frictions" that slow down price adjustment, monetary policy could still exert an influence on the real economy, and demand cycles could still generate inflation, even if expectations were rational. These new generation models of inflation, known as "Dynamic Stochastic General Equilibrium" (DSGE) models, are now

being developed as policy and forecasting models in central banks and elsewhere.

As discussed in Box 1 (p. 28), several countries have found that the empirical relationship between traditional measures of excess demand in the economy and inflation has weakened considerably over the past decade or so. Nevertheless, the Phillips curve remains near the centre of policy analysis in most inflation-targeting central banks, but typically in a quite different form from Phillips' original empirical construct. Firstly, there is usually a measure of inflation expectations included in the relationship instead of a constant. This might be a survey-based measure of inflation expectations, a lag of inflation, or something more sophisticated. Secondly, Phillips curves now typically use something other than the unemployment rate as a measure of "inflationary pressure".

Figure 1
Measures of excess demand in New Zealand

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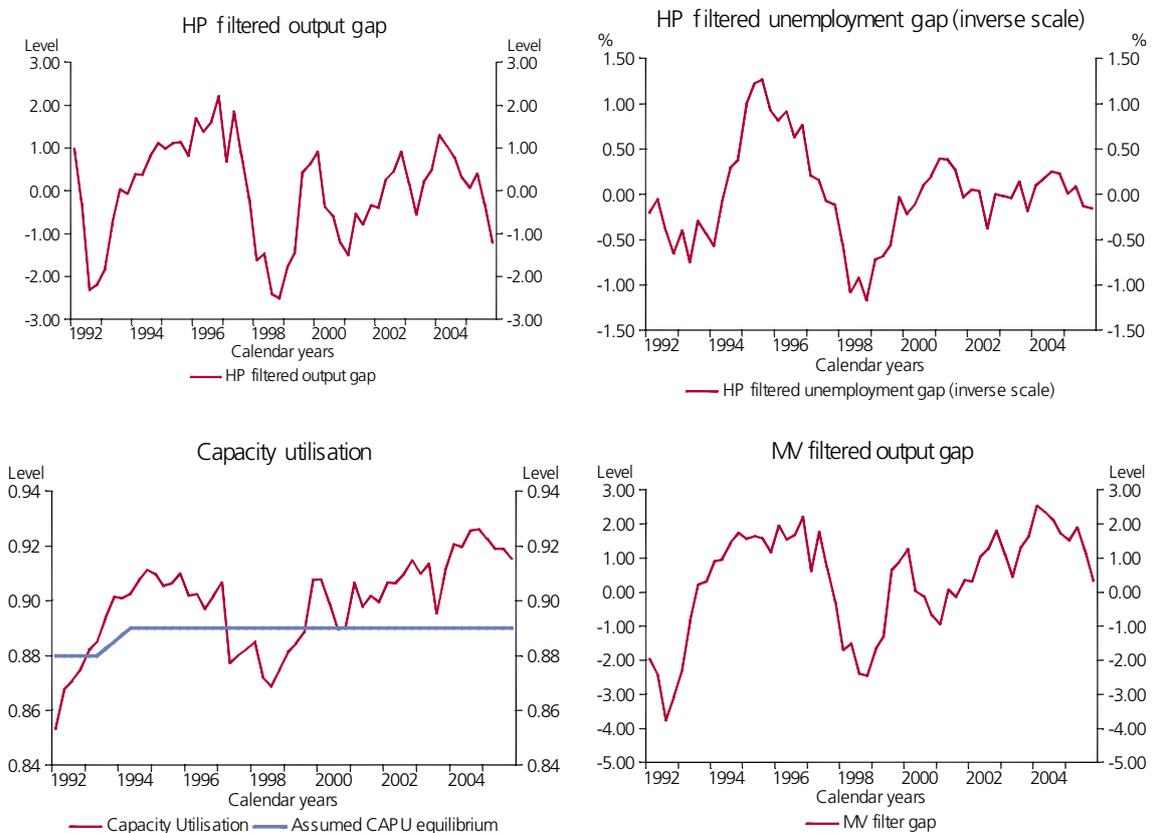
[2]   Laidler (2001) notes that Bill Phillips was entirely aware that all he was showing was demonstrating an empirical relationship, and documents substantial discussions between Friedman and Phillips that followed.

One concept sometimes used in the Phillips curve is the so-called "output gap": the difference between actual output and a measure of "potential" output. Conceptually, potential output is intended to mean the level of output which does not generate upward or downward pressure on inflation. One traditional measure of the output gap can be obtained by running some sort of statistical smoother (or filter) through output, to obtain a rough measure of potential output. The implicit assumption is that the supply side of the economy evolves in a fairly slow and regular fashion, while deviations of output from that smooth trend are driven mostly by demand shocks that will tend to generate inflation. At the Reserve Bank, we use a measure of the output gap that augments this simple filter with other information. This "multivariate" (or MV) measure of potential output has been described in Conway and Hunt (1997), Citu and Twaddle (2003), and Graff (2004). Matheson (2006) is a recent statistical study of New Zealand inflation that shows the output gap is a useful statistical predictor of non-tradables inflation.

Figure 1 shows some of the inputs used to create the MV measure of the output gap, as well as showing the MV gap itself (on the bottom right). A simple statistical filter measure of the output gap (the top left) is combined with other inputs including a statistically detrended unemployment rate (top right) and the level of capacity utilisation (bottom left)[3]. These different measures of pressure on resources are all fairly correlated with each other, with simple correlation coefficients between 0.5 and 0.8.

The Reserve Bank's main macroeconomic model, FPS, includes a Phillips curve for the determination of inflation (see Black et al 1997). This is part of a set of calibrated dynamic relationships that are not generally derived from formal microfoundations, but are designed to be consistent with the Bank's view of how the economy works. For example, FPS implies that the peak effect of changes in export prices on export volumes takes around six quarters. This reflects the view, backed up by empirical evidence collected over the years, that New Zealand's commodity exports cannot be expanded quickly because of agricultural constraints. We have not gone further and explicitly modelled those agricultural constraints, as we would do if we were trying to incorporate them in a fully structural (eg DSGE) model. It may therefore be more appropriate to describe the FPS inflation system as "semi-structural" when comparing it to some of the DSGE models that are beginning to be implemented in other countries.

We have already discussed the importance of including a measure of inflationary expectations as a driver of inflation in a (structural or semi-structural) Phillips curve. In a fully structural model, this measure would be the "model consistent lead" or rational forecast of inflation; this basically means that in the absence of unforeseen events, the inflation expectations measure in the Phillips curve would be a correct forecast of next period's inflation rate. Such a model would have a very forward-looking inflation process where future events can greatly influence inflation today. Many economists postulate rational expectations but assume that some "intrinsic lags" or impediments to the adjustment of prices make inflation partly backward-looking, creating the so-called hybrid Phillips curve which is used in FPS. In a hybrid Phillips curve, inflation is a function of inflation last period as well as forecast inflation next period, with the weights on these two factors summing to one. It is also possible to motivate this type of inflation process by assuming that some people are forming expectations of inflation adaptively, with reference to past inflation.

It is also important to examine the theoretical foundations behind the use of an "output gap" derived using a 'smoother'. The case for this is informal rather than rigorously derived and has been criticised in some recent analysis (see for example Neiss and Nelson (2001) for a discussion). One line of criticism against a filtered output gap as an indicator of inflation is that there may be periods where sudden increases in GDP are caused by improvements on the supply side of the economy, rather than a sudden increase in demand. In this case, the sudden increase in output may be associated with a fall in inflation. A simple example would be an economy that only produced (and consumed) apples. During an excellent growing season, we would expect GDP (production of apples) to rise and the CPI (apple prices) to

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[3]   The MV gap also uses survey information about the level of skill shortages, and the inflation rate. The mean level of capacity utilisation is assumed to have shifted after the early 1990s recession, as shown in figure 1.

fall. If demand for apples was relatively stable, the quality of the growing season would be the key macroeconomic shock and the reduced form relationship between the output gap and inflation would be negative.

To explain why we think that the output gap may retain some validity in the New Zealand context, we can extend the analogy above to consider trade in commodities and non-tradable goods. Consider a small open economy which consumes a broad basket of goods, but imports almost all of them, and produces only apples and houses. Suppose again that the key macroeconomic shocks relate to the apple growing season. An excellent growing season will now produce an increase in GDP. But assuming the economy is a relatively small producer of apples internationally, apple prices will not fall significantly. Thus domestic farmers will receive higher incomes and be able to purchase or rent larger houses and import more imported goods. Assuming housing is a much more significant component of the domestic CPI than apples, we might expect the overall CPI to be rising. Thus the existence of supply shocks may not invalidate the output gap as an inflation predictor, if the main source of supply volatility is an export good. Since most of New Zealand's agricultural output is exported, agricultural supply shocks may create less difficulty for the output gap as an inflationary indicator than one might have thought.

Finally, other critics of the output gap note that it is subject to revisions as new information about the evolution of the economy becomes available. Thus as a "real time" measure of inflation pressures, the output gap could be seriously misleading, even if historical estimates track inflation well. This is definitely a potential source of difficulties when using the output gap to forecast inflation. However, Graff (2004) and Matheson (2006) find that real time output gap estimates have had some ability to predict inflation in New Zealand. Broadly, the Reserve Bank's approach has been to make use of frameworks where inflation is presumed to depend on pressure on resources (measured using tools like the output gap), but to complement those frameworks with a range of other statistical approaches to inflation forecasting, such as the so-called "factor models" discussed in Matheson (2005).

To summarise this section, while there have been a range of

theoretical challenges to the Phillips curve, we think that a Phillips curve that is augmented to include expectations and lags of inflation and a "multivariate" measure of resource pressure may remain useful in the New Zealand context. In the next section, we look at whether this view matches the data.

3 Modelling New Zealand inflation

The inflation process in New Zealand has obviously seen significant structural change: inflation was relatively low in general until the 1970s, then rose dramatically until the mid-1980s, fell during the disinflationary process after 1989, and has been relatively low and stable since approximately 1992. Given that we do not expect our approach to be robust to large structural changes, it seems prudent to do most of our estimation work over the period during which inflation has been low and stable, and we therefore restrict our statistical analysis to the period post 1992.

Another important issue to consider is the impact of the exchange rate on the behaviour of traded goods prices. When the exchange rate rises, there tends to be fairly quick pass-through into the price of traded goods in the New Zealand CPI. Because the exchange rate may change significantly from quarter to quarter, it is likely to be a key driver of traded goods inflation, which in turn may be quite volatile.

Consequently, it is important to include the change in the exchange rate in any reduced form Phillips curve for New Zealand CPI inflation, or account for it in some other way.[4] As in Matheson (2006), our approach is to disaggregate inflation into traded and non-traded goods, on the assumption that the traded component of the CPI incorporates the direct exchange rate effects. This approach enables us to separately track traded and non-traded inflation within our macroeconomic model. The idea that

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[4] Some tests of the reduced form Phillips curve in New Zealand such as Razzak (2002) were constructed without an exchange rate term. This will reduce the power of the model and may lead to the output gap appearing to be insignificant when a model including exchange rate changes may conclude the opposite.

statistical models of the Phillips curve should focus on non-traded inflation (or alternatively a measure of core inflation) is common internationally.

The traded and non-traded components of CPI inflation in New Zealand since 1990, as well as aggregate CPI inflation, are shown in figure 2. The figure shows the fall in inflation during New Zealand's disinflationary period and the more stable rates of inflation that have prevailed since 1992. It is also interesting to note that, over the period since 1992, non-tradables inflation and tradables inflation have tended to be negatively correlated. Tradables inflation has a lower mean than non-tradables inflation over the period, and has also been a bit more volatile.

Figure 2

## Annual CPI inflation and the tradable and non-tradable components
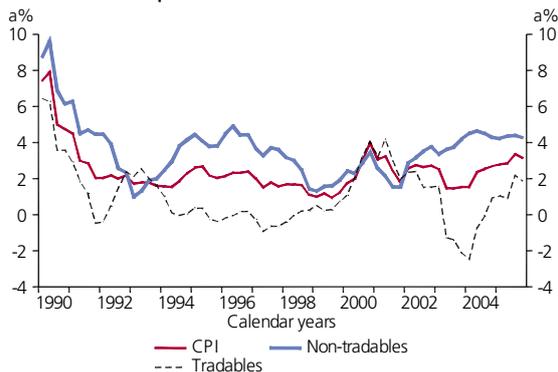
(i) Modelling non-tradables inflation

Figure 3 shows the relationship between annual non-tradables inflation (defined as how much non-traded prices in a given quarter have changed compared to a year earlier) and the output gap lagged three quarters; the simple correlation coefficients between these variables is around 0.8. Figure 3 suggests that a 1 per cent increase in the output gap, all else equal, will lead to a roughly 0.6 per cent increase in annual non-tradables inflation. This relationship between excess demand and inflation in New Zealand is generally more robust than that found in other countries (see box 1, overleaf).

The quarterly non-tradables inflation series (defined as non-traded prices in one quarter compared to prices in the previous quarter) displays considerably more variability or "noise" than the annual inflation series. This increased

Figure 3

Output gap and annual non-tradables inflation
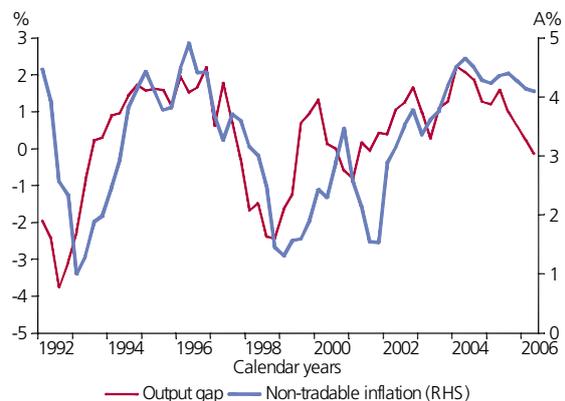
variability means that the correlation between quarterly non-tradables inflation and the output gap is lower (around 0.6). However, for the purposes of FPS, we need equations for the quarterly inflation rate in tradables and non-tradables, so our calibrations have been based on some fairly simple quarterly regressions.[5]

In table 1 on p. 29, we present a range of estimated equations modelling quarterly non-tradables inflation. The first equation (specification 1) models non-tradables inflation simply as a function of its own lag. The second equation (specification 2) introduces the lagged output gap. The output gap is highly significant and its introduction drives the estimated value of the lagged inflation term to near zero, suggesting that as a purely empirical matter it is reasonable to model non-tradables inflation as being driven by the output gap and a constant.

However, in the introduction we discussed reasons why an equation relating inflation to the output gap and a constant cannot be seen as a structural relationship. There are a number of economic interpretations of the fact that a Phillips curve with a fairly constant term as a proxy for inflation expectations fits reasonably well in this context. Most obviously, actual inflation has not varied greatly over the sample period over which the equations have been estimated, suggesting that expectations may not have shifted markedly. More generally, if expectations are fully rational, but inflation is quite difficult to forecast, the rational one period ahead forecast of inflation may be roughly constant.

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[5] We hope to produce further technical details on the model recalibration in a future discussion paper.

Box 1

Inflation and excess demand and supply in other countries

In New Zealand, the relationship between various measures of excess demand (such as the capacity utilisation reported by firms and the output gap) and the non-tradable component of CPI inflation appears to have endured over the past decade; the relationships between these excess demand measures have also been relatively stable over time.

However, in a number of countries the relationship between excess demand and inflation has weakened since the mid-1980s and, in some cases, has become very difficult to detect. Melick and Gelati (2006) report findings for a range of countries of a breakdown in the statistical relationship between the output gap and inflation over the past decade or so. A number of other studies have also found that the relationship between measures of capacity utilisation and inflation has deteriorated, with the most convincing evidence coming from Canada, the US, and a range of European countries.[6]

A number of possible explanations have been posed (and debated) for the deterioration of the excess demand-inflation relationship, including:

- the increased openness of national economies.

- technological developments;

- the increasing size of the services sectors within national economies; and

- the improved conduct of monetary and fiscal policy.

Increased openness has two possible effects that may reduce inflationary pressures in times of high capacity utilisation. First, a high level of external trade increases competition, leading to downward pressure on prices of domestically produced goods, even in times of high domestic capacity utilisation. Second, in an open economy cheaper goods may be more easily sourced from foreign producers at times of high domestic capacity utilisation, thereby muting the inflationary effect. In support of this explanation,

Borio and Filardo (2005) find that the importance of global factors has increased relative to domestic factors in explaining inflation for a sample of 16 countries.

Technological change is another explanation put forward for a breakdown in the capacity-inflation relationship in the literature. New technologies may enable less skilled workers to perform tasks that previously required skilled workers, decreasing the marginal costs faced by firms under 'high' rates of capacity utilisation and thus reducing any inflationary pressures.

Another argument made in the literature is that the relative importance of the manufacturing and industrial sectors continues to decline as the services sector becomes bigger. This may render some traditional metrics of the economic cycle, such as capacity utilisation, a poor indicator of inflation.

Some researchers have also suggested that the improved conduct of fiscal and monetary policies over the past 15 years may have reduced the volatility of inflation and output (and the output gap) to an extent that the drivers of inflation are simply harder to detect statistically.

The findings and arguments in the literature pose a puzzle for New Zealand. If the explanations are valid, why has the excess demand-inflation relationship broken down in some other countries, but not in New Zealand? New Zealand is an open economy facing international competition and largely has access to the same production technologies as foreign producers. New Zealand's services sector has also been getting bigger over time. Likewise the amplitude of cycles in inflation and output in New Zealand has reduced in recent years.

The very dominant role the housing sector seems to play in shaping the New Zealand inflation cycle may account for some of the discrepancy. The housing component has dominated movements in non-tradables inflation over the past 10 years and is also closely correlated with measures of the economic cycle. When housing is removed from non-tradable inflation, the strong relationship between capacity utilisation and inflation deteriorates quite markedly, although a relationship can still be detected. The role of housing in the relationship between inflation and the economic cycle in New Zealand is discussed in more detail in box 2.

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6   These studies tend to look at the relationship between capacity usage and aggregate CPI inflation (and not narrower inflation measures, such as non-tradables). However, when we have looked internally at the international data using services CPI (a proxy for non-tradables) we find similar conclusions.

Table 1

Equations modelling quarterly non-tradables CPI inflation

(Sample period is 1992q1 to 2005q4, 56 observations)[7]

Equation variables	(1)	(2)	(3)	(4)	(5)
Constant	0.52 (.11)	0.73 (.11)	0.74 (.20)	0.33 (.32)	.24 (.04)
Inflation expectations or lagged inflation[8]	0.36 (.13)	0.04 (.14)	0.02 (.36)	0.82 (.62)	1.0 (restricted)
Output Gap (first lag)		0.14 (.04)	0.15 (.03)	0.14 (.03)	.14 (.03)
Diagnostics					
Adj R-squared	.11	.30	.30	.32	.34
Durbin Watson	na	na	1.81	1.83	1.82
Akaike I.C.	.87	.64	.64	.61	.58

Another possibility is that the output gap is a useful proxy for the component of inflation that is able to be forecast, so that the coefficient on the output gap in the equation is partly driven by the influence of the output gap on inflation expectations.

We look at this further in specifications 3 to 5 by incorporating two alternative measures of inflation expectations derived from a Reserve Bank survey. We look at expected inflation in the next quarter in specification 3. Simple microfounded models suggest that this is the appropriate measure to use in the regression. However, the measure has a coefficient very near zero and is statistically insignificant from zero, leading us to also investigate longer horizon measures of inflation expectations. These measures turn out to improve the fit of the regression and have significantly larger coefficients. We searched over a range of surveys and lags, but ultimately settled on the surveyed expectation of annual inflation two years ahead, entering the regression with a two quarter lag. In specification 4, this gets a coefficient of .82, close to the value predicted by theory, which is 1. In specification 5 we restrict the coefficient on that measure of expectation to equal 1.

We have used the first lag of the output gap in the equations above. However, the output gap is serially correlated, making it hard to identify the precise lags with which it influences quarterly non-tradables inflation. The strongest simple correlations are between inflation and either the contemporaneous output gap or the first lag. In table 2 we investigate the consequences of using a contemporaneous term, and we also look at empirical estimates of the asymmetric Phillips curve, where positive output gaps are able to influence inflation more than negative output gaps.

Our results suggest that the contemporaneous and first lag of the output gap fit approximately equally well (comparing specifications 5 and 6), and in the final model specification

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[7] Technical note: the number in brackets after each regression coefficient is the standard error of the coefficient. To interpret this, note that we can be fairly confident the true coefficient is not more than 2 standard errors from the estimated value in the table. The Adjusted R-squared and Akaike Information Criteria (AIC) are measures of how well the equation summarises the data. A higher R-squared and lower AIC suggest better fit. The Durbin-Watson is a test for serial correlation in the equation's errors. It should not be conducted if there is a lagged dependent variable, and is omitted from the reporting of those regressions. The other non-tradable regressions do not appear to exhibit serially correlated errors.

[8] Specification 3 uses the Reserve Bank survey of expected quarterly inflation next quarter. Specifications 4 and 5 use the second lag of the Reserve Bank survey of expected annual inflation in two years time. In specifications 1 and 2, lagged quarterly non-tradable inflation is used rather than surveyed inflation expectations.

Table 2

Non-tradables inflation with an expectations term and different output gap lags[9]

(sample period is 1992q1 to 2005q4, 56 observations)

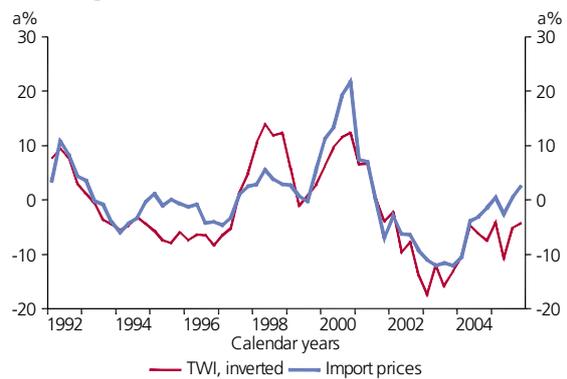| Equation variables	(5)	(6)	(7)	(8)
Constant	.24	.23	.16	.20
	(.04)	(.04)	(.07)	(.09)
Output gap		.15		.08
		(.03)		(.08)
Output gap (first lag)	.14		.10	.06
	(.03)		(.04)	(.06)
Output gap (positive values only)			.12	.05
			(.09)	(.11)
Diagnostics				
Adj R-squared	.34	.36	.35	.35
Durbin Watson	1.82	1.76	1.85	1.81
Akaike I.C.	.58	.54	.57	.59

we include both.[10] We find only weak evidence of an asymmetry in the Phillips curve (with the coefficient on the positive values of the output gap positive, but not statistically significant), but choose to retain it. Asymmetry in the model makes the risk of inflation spiralling upward slightly greater than the risk of a deflationary spiral. The underlying idea behind the asymmetric Phillips curve is discussed further in Black et al (1997).

(ii) Modelling tradables inflation

We now repeat a selection of the equations estimated above on non-tradables inflation to model tradables inflation. The key difference is that in every tradables regression we also include the change in domestically denominated import prices (as measured by Statistics New Zealand's Overseas Trade Indices). Figure 4 below shows that this series is substantially explained by the change in the value of the

New Zealand dollar (measured using the trade weighted index). In the results reported below we use the annual change in import prices to model quarterly inflation.[11]

Figure 4

Annual percent changes in import prices and the Exchange rate

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[9] Specifications 5 through 9 include the second lag of the Reserve Bank survey of expected annual inflation in two years time, with a coefficient restricted to equal 1.

[10] With a contemporaneous output gap, there are endogeneity issues – it is in principle possible that inflation is causing the output gap rather than the other way around. This is a reason for caution regarding the precise estimates obtained using the contemporaneous gap.

[11] A search over unreported specifications showed that using the contemporaneous annual change in import prices produced the best fit. Since taking annual changes induces a lag, this specification implies that the average lag between import price changes and the impact on the CPI is around 1.5 quarters. To see this, note that the annual change is the sum of the current quarterly change and the three previous quarterly changes. Implicitly we are restricting these four quarterly changes to have the same coefficient, a restriction which is not rejected by a joint F test (p value = .24).

Box 2

Housing and non-tradables inflation

The finding of a stable relationship between non-tradables inflation and the output gap in New Zealand has prompted the Bank to look closely at which components of non-tradables inflation drive the relationship. This work has revealed that the cycle in non-tradables inflation is basically made up of two sub-cycles: the cycle in housing inflation and the cycle in non-housing non-tradables inflation. In each case, the relationship to the output gap is different.

Figure 5

Housing and non-housing components of non-tradables inflation
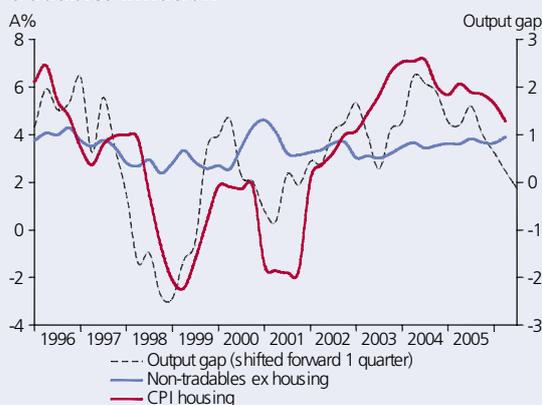
As shown in figure 5 the housing component of non-tradables moves closely with the economic cycle (as measured by the output gap). On a more detailed level, it can be seen that the correlation is driven by the construction costs component (approximately 50 per cent of the housing component by weight), and to a lesser extent the rental price component (about 30 per cent). These components tend to exhibit a much larger cycle than other components of the CPI, and are also closely correlated with the economic cycle. The inclusion of a measure of construction costs in the New Zealand CPI is relatively unique; aside from Australia, we are the only country to include such a measure.[12] In addition, the rental component in New Zealand has been considerably more cyclical in the past compared to the relatively subdued rental series in other countries such as Australia. The

reason rentals have closely followed construction costs is because prior to 2001 the survey they were based on focused on new rents; since this time a matched sample has been used and the cycle in rentals has been considerably less pronounced.[13] Nonetheless, because of their large weight in the CPI, and strongly cyclical behaviour, construction costs tend to have a dominating effect on non-tradables inflation; and it is this component that drives the relationship between non-tradable inflation and the economic cycle in New Zealand.

But what about the non-housing components of non-tradables inflation? The Bank has found that there is a statistical relationship between the non-housing components of non-tradables and the economic cycle; however, this relationship is more muted and occurs with a relatively long time lag.[14] Most of the non-housing components are services (such as childcare and haircuts) and tend to be quite highly labour-intensive. Thus, the delayed effect of the economic cycle on the non-housing components could be the result of a wage effect, wages (and the inflation expectations that drive them) being slower to respond to the economic cycle than the housing market. On closer analysis we find that wages do lead changes in non-housing non-tradables inflation, and in turn wages are closely related to measures of capacity pressures (such as skill shortages) with a long time lag – this finding explains the more delayed link between the economic cycle and non-housing components.

One implication of this analysis is that following periods of high resource utilisation or capacity pressures, we may observe housing inflation falling relatively rapidly as capacity pressures ease, but non-housing inflation showing greater persistence. The recalibrated FPS exhibits similar dynamics, because non-tradables inflation has an immediate response to the output gap, then a secondary response which is caused by an increase in the model's measure of inflation expectations.

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[12] Most other countries use a rental equivalence approach to measuring housing in the CPI. To date there is no international consensus regarding the best way to measure housing in the CPI.

[13] Over time this may result in a less pronounced inflation cycle within the housing group.

[14] The best relationship is achieved when capacity utilisation (or the output gap) is lagged by around six quarters.

Table 3

Tradables inflation specifications

(Sample period is 1992q1 to 2005q4, 56 observations)

Equation variables	(1)	(2)	(3)	(4)	(5)
Constant	.25	.23	-.51	-.31	-.31
	(.07)	(.07)	(.30)	(.06)	(.05)
Inflation expectations or lagged inflation[15]	-.11	-.10	1.39	1.0	1.0
	(.12)	(.12)	(.91)	(restricted)	(restricted)
Import prices (annual % change)	.053	.057	.055	.055	.056
	(.01)	(.01)	(.009)	(.009)	(.009)
Output gap		.042	.048	.047	.13
		(.05)	(.04)	(.04)	(.09)
Output gap (first lag)					-.08
					(.08)
Diagnostics					
Adj R-squared	.33	.32	.34	.35	.35
Durbin Watson[16]	na	na	2.46	2.44	2.48
Akaike I.C.	1.42	1.44	1.41	1.38	1.40

The coefficients of around 0.05 on the annual change in import prices imply that a 1 per cent change in import prices pushes up tradables inflation by around 0.2 per cent and CPI inflation by around 0.1 per cent. This is a much lower effect than one would expect based on the share of imported goods in consumption, which is closer to 25 per cent than 10 per cent. The lower coefficient suggests some firms delay passing on rises in the costs of imports. Hampton (2001) finds a larger elasticity than in our study, but we are estimating a response to cyclical changes in import prices, whereas Hampton is estimating the long-run impact of changes in import prices. One would expect a cyclical elasticity to be lower if firms tend to delay price increases until they are sure that the rise in import prices will endure.

The output gap appears to have a mild influence on measured tradables inflation (although it is not statistically significant). The idea that the output gap can influence tradables inflation is plausible given that a lot of non-tradable resources are involved in distributing and retailing tradable goods within New Zealand. For example, a t-shirt is a tradable good, but when it is purchased in a New Zealand retail store, a lot of fixed New Zealand resources (such as warehouses, and the retail premises) have been used to get it to the final consumer. This suggests that pressure on New Zealand resources can influence the domestic price of imported goods sold here. For this reason we retain the contemporaneous output gap in our model even though the statistical significance is weak.

We find that the first lag of tradables inflation is statistically insignificant, suggesting that it does not systematically contribute to inflation expectations and the setting of tradable prices. Instead, we find that including a longer horizon measure of inflation expectations (the same one used in the non-tradables equation) improves the

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[15] Specifications 3, 4 and 5 use the second lag of the Reserve Bank survey of expected annual inflation in two years time. In specifications 1 and 2, lagged quarterly tradable inflation is used rather than surveyed inflation expectations.

[16] Specifications 3, 4 and 5 use Newey-West standard errors to correct for apparent negative autocorrelation.

Figure 6

New inflation nexus in FPS
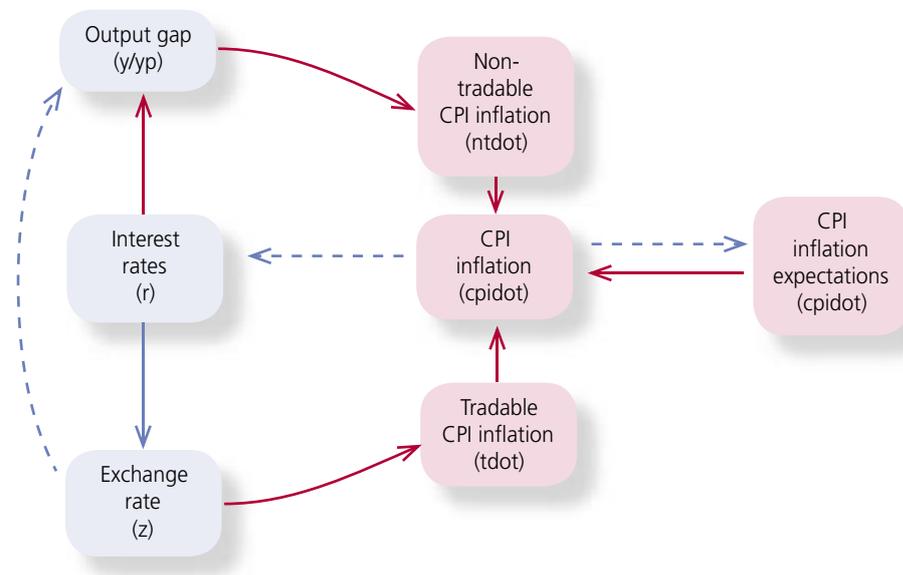
regression fit. The coefficient on this expectations term is statistically insignificant from 1 and we restrict it to equal 1 in specifications 4 and 5. There is a negative constant in the regression after including the two-year ahead inflation expectations with a coefficient of 1, reflecting the fact that traded inflation has on average been significantly lower than overall CPI inflation.

The fact that the exchange rate seems to be important in the determination of tradables inflation may be one reason why tradables and non-tradables inflation have tended to be negatively correlated. When the economy is strong and recording positive output gaps and high non-tradables inflation, the currency has tended to be rising (pushing down tradables inflation).

4 Building our empirical results into FPS

In the final section of this paper we describe the equations we have recently calibrated into FPS for tradables and non-tradables inflation, and inflation expectations. We then do a model simulation to show how the new inflation process works.

The original CPI inflation structure in FPS (described in Black et al, 1997) was fundamentally based on a Phillips curve

with a series of leads and lags of inflation and a measure of the output gap, much as in the new structure. However, the old system was not able to be compared to the data in as much detail as it can be after the recalibration.[17] By including tradable and non-tradable inflation and inflation expectations as observed data, we are able to evaluate quarterly outturns for those variables and decide how to treat any surprises.

A diagrammatic description of the new model is shown in figure 6. Note that dotted lines denote relationships that are very gradual and/or forward-looking, while solid lines represent relatively direct and immediate influences.[18]

The tradables and non-tradables inflation equations (see Appendix 1) are based on the estimated equations reported in the previous section. The dynamic parameters used in the tradable and non-tradable system are not exactly identical

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[17] There was a FPS variable measuring domestic inflation (PDOT), but over history this was effectively obtained by treating a Phillips curve as an identity, and there was no directly observable counterpart to PDOT. The ultimate empirical test of the old inflation system was in the way the model tracked the behaviour of CPI inflation.

[18] The old inflation system also included a number of other influences on inflation such as tax rates and labour costs. However, these were calibrated to have a relatively minor impact. While these could certainly be significant in inflation determination in the future, we have eliminated those terms from the current version of the model pending deeper analysis of how these issues should be handled in the new system.

to the regression results, because they have been calibrated with the overall properties of FPS in mind, but they are fairly close.

To close the model, we needed to decide how to design a model counterpart for the two year ahead inflation expectations survey. Inflation expectations are often modelled as a function of leads and lags of actual inflation. The "leads" of inflation can be thought of as rational forecasts in the sense discussed in section 2. So using a mixture of leads and lags to represent inflation expectations effectively implies that some people are forming expectations with a well-informed view of the future, while others are using rules of thumb based on recent inflation history. A smooth series of lags and leads was found to be an effective proxy for the two year ahead survey, but the data was not very informative as to the extent to which expectations should be forward-looking relative to backward-looking, and this is crucial for the overall properties of the model. The parameterisation we adopted is shown in the Appendix. Essentially, it says that inflation expectations are determined by current inflation and inflation over the last 5 quarters (with a weight of around 70 per cent), and also determined by the medium term future inflation outlook (with a weight of around 30 per cent). This gave model properties that were not too different to the old inflation system.

In figure 7, we compare this model assumption to the behaviour of the survey over history. The chart suggests that the moving average of actual and future inflation does explain movements in expectations. When the blue line (the

Figure 7
Inflation expectations compared to the model proxy

2 year ahead expectations, RBNZ survey
Fitted using forecasts or actuals in place of leads

moving average of inflation) is above the red line (surveyed expectations), the red line tends to be rising, as our model predicts.[19]

While the direct empirical counterpart to the measure of inflation expectations in the system is a two quarter lag of the two-year RBNZ inflation expectation series, we do not plan to treat the quarterly movements in this series as our only relevant measure of inflation expectations. If it diverges from a broader view of inflation expectations (incorporating other survey measures, wage settlements and the like) we will probably put related judgement into the model forecasts.

Assessing the new model

We have analysed the response of the model to a range of shocks, comparing the old inflation structure to the new system. In general, the key business cycle dynamics of the model were not greatly changed by the redesigned system. The most interesting change is the fact that the model now makes specific predictions for the evolution of tradable inflation, non-tradable inflation and two-year ahead inflation expectations.

As an example, figure 8 shows the consequences of a temporary 3 per cent fall in the New Zealand dollar caused by a reduction in the willingness of foreign investors to invest here. The depreciation causes a rapid increase in tradables inflation. However, this increase is temporary, as tradables inflation quickly falls below its average level as a result of the currency appreciating back towards equilibrium. At the same time, the lower than normal currency stimulates net exports, which creates a positive output gap and a small but sustained increase in non-tradables inflation. Inflation expectations also rise gradually, as a result both of a higher non-tradables inflation outlook and a lagged consequence of the immediate rise in the CPI. While these channels were implicit in the old FPS framework, the new framework allows much more effective assessment against incoming data.
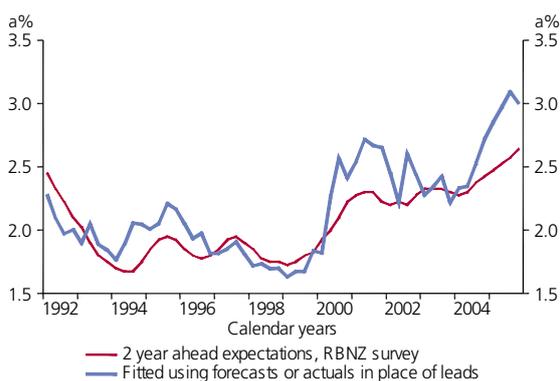
19 A difficulty with historical testing (and estimation) of expectations behaviour is the treatment of lead variables. Here we are using actual data (if available) and Reserve Bank June 2006 forecasts (where the data is not available) as the "rational forecasts". This makes fitted expectations look high at the end of the sample, because the fitted values assume that the rise in petrol prices over late 2005 and early 2006 was wholly predictable.
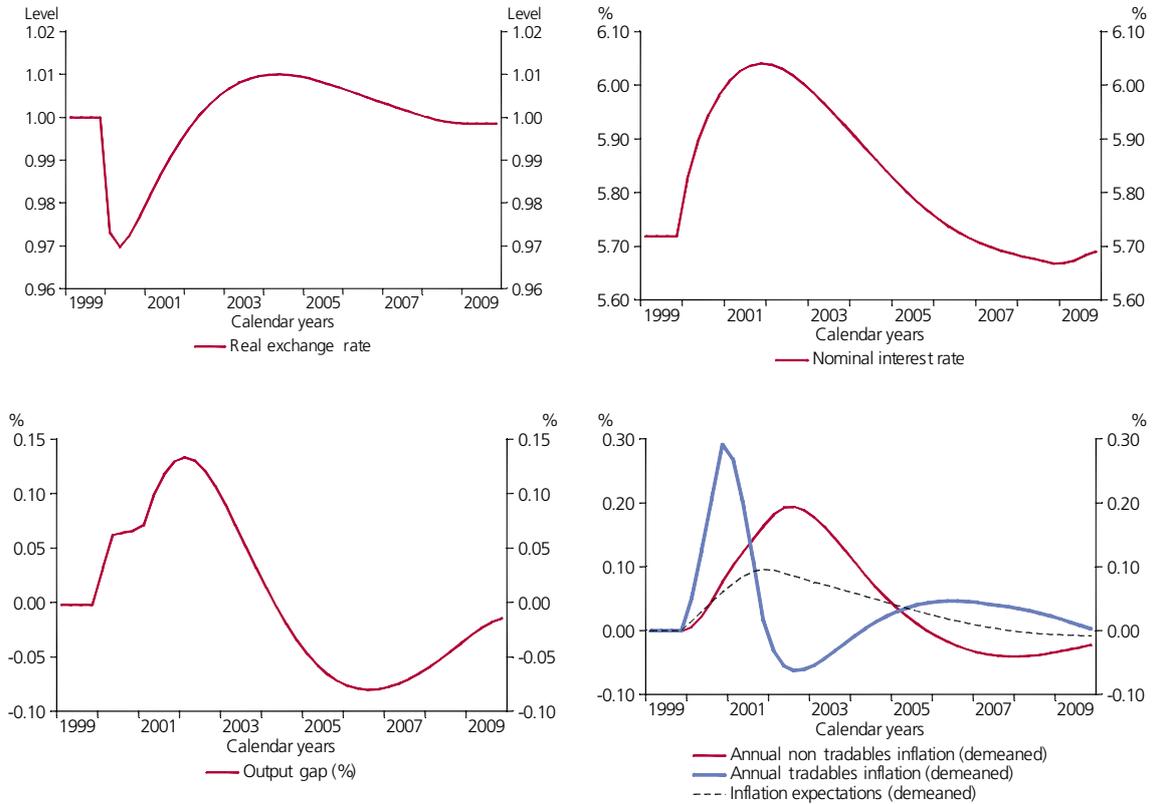
Figure 8

A 3% exchange rate depreciation

Real exchange rate

Nominal interest rate

Output gap (%)

Annual non tradables inflation (demeaned)
Annual tradables inflation (demeaned)
Inflation expectations (demeaned)

Figure 9

The impact of a temporary shock to aggregate demand

Real exchange rate

Nominal interest rate

Output gap (%)

Annual non tradables inflation (demeaned)
Annual tradables inflation (demeaned)
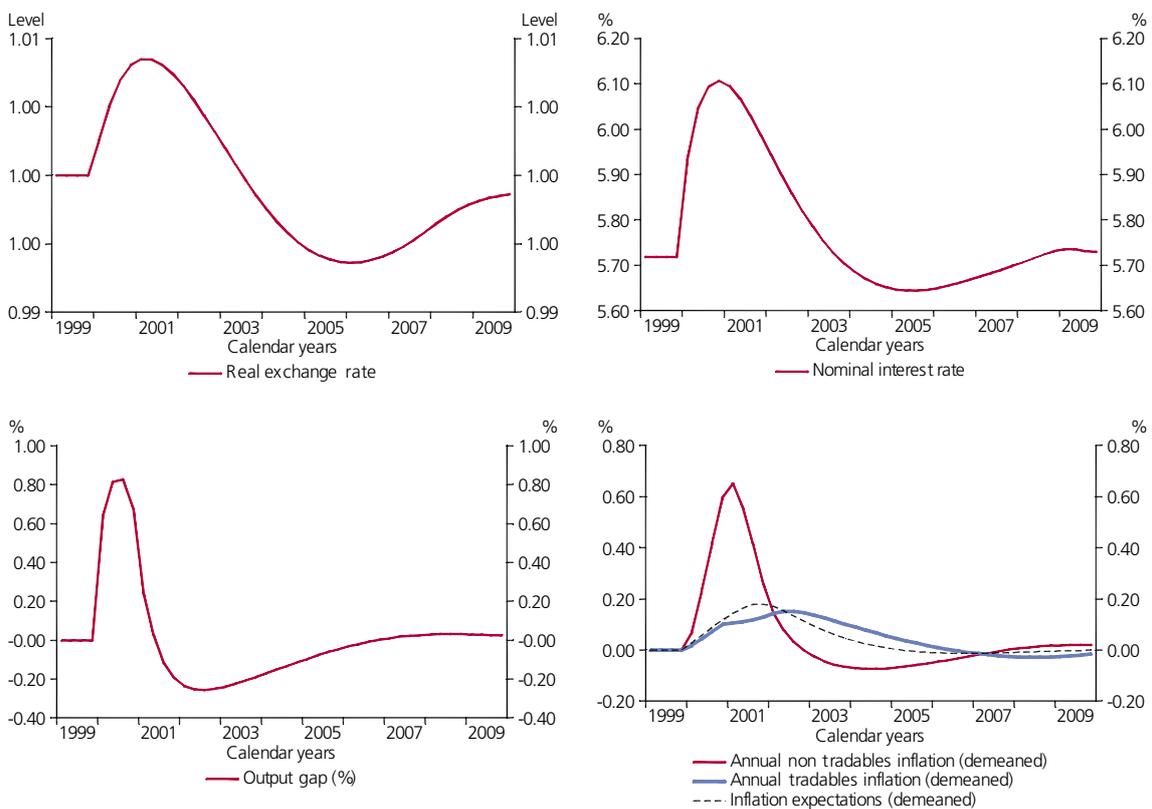Inflation expectations (demeaned)

Figure 9 shows a New Zealand demand shock (for example an increase in the demand for housing), which causes a rise in the output gap and an increase in non-tradables inflation. There is a resulting tightening in monetary policy and a mild appreciation of the exchange rate. Tradables inflation is much more contained in this shock, reflecting the rising currency and the ability to largely meet any rising demand for tradable goods through imports.

In Figures 8 and 9, we have removed the average values from the non-tradables and tradables inflation series and inflation expectations to make them easier to compare. But in the model there is assumed to be a systematic difference between the mean values of tradeables and non-tradables, with non-tradables inflation expected to average 0.8 per cent per annum faster than CPI inflation, and tradables inflation about 1.0 per cent lower than CPI inflation. This is consistent with the average difference over recent history. The tendency for non-tradables prices to rise faster than tradables prices is sometimes described by economists as the Balassa-Samuelson effect.

5   Conclusions

This article has shown that a Phillips curve has fit New Zealand data for non-tradables inflation reasonably well since the disinflation period: non-tradables inflation has been fairly well correlated with measures of the output gap. We have drawn links between this empirical Phillips curve and a redesigned inflation system in FPS. This system disaggregates the CPI into tradables and non-tradables inflation, and a survey measure of inflation expectations. The new system makes increased use of actual data, and so is much easier to validate, and more useful in analysing the latest information on inflation and inflation expectations.

A distinction is sometimes drawn between purely statistical models of inflation and "structural" models which take economic theory very seriously. We increasingly interpret FPS as a semi-structural model which incorporates significant economic dynamics that we believe to be relevant and important, but hard to incorporate in fully structural models. Examples of the semi-structural nature of the FPS inflation process include the use of a filtered measure of potential

output and a smoothly evolving (non-rational) measure of inflation expectations. In our quarterly forecasting process, we supplement FPS with inflation forecasts from fully statistical models like those described in Matheson (2005). In the future we hope to make use of more fully structural stories of inflation determination, based on DSGE models, as well.

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Appendix
Actual model equations

Non-tradables inflation (ntdot)

$$ntdot_t = cpidote_t + ntdot\_cc + (.05*gap_t) + (.1*gap_{t-1}) + (.05*\max(gap_t,0))$$

Where:

Cpidote denotes inflation expectations.

Ntdot_cc is a calibration constant that ensures non-tradables inflation averages higher than tradables (the weighted average of ntdot_cc and tdot_cc is zero).

Gap is the output gap. The third gap term is an asymmetry term that makes disinflation slightly harder than 'reinflation'.

Tradables inflation (tdot)

$$tdot = cpidote + tdot\_cc + .18 * \frac{\sum_{j=-3}^{1} pcmch(+j)}{4} + 0.03 * gap$$

Pcmch is the quarterly growth in import prices.[20] A passthrough of .18 into tdot represents passthrough of about .09 (or 9%) into the overall CPI - that is, a 10 per cent change in import prices would raise the tradables CPI by about 1.8% per cent and the overall CPI by about 0.9 per cent.

CPI Inflation (CPIDOT)

$cpidot = .556ntdot + .444tdot$ - a simple weighted average identity.

Inflation expectations (cpidote)

$$cpidote = .75(cpidote(-1)) + .175 \frac{\sum_{j=-5}^{1} cpidot(+j)}{6} + .075 \frac{\sum_{j=2}^{12} cpidot(+j)}{11} + \varepsilon_t$$

The driving force in our expectations specification is a fairly long series of leads and lags of inflation.

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[20] Technically, within FPS it is actually the first difference of detrended PCM (the relative price of consumption imports). PCM is a model variable built from trade data – it has very similar properties to the Overseas Trade Index Import price series.