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Estimating Potential Output: a semi-structural approach

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Abstract

As part of the new macroeconomic modelling project at the Reserve Bank of New Zealand, considerable effort has been directed towards constructing an historical estimate of the productive capacity of the New Zealand economy. The technique documented in this paper augments the stochastic-trend estimation approach of the Hodrick-Prescott (1997) filter with information from broad macroeconomic relationships. This strategy is designed to improve the accuracy with which the filter identifies supply (trend) and demand (cyclical) disturbances in New Zealand real output data. The evolution of inflation over the historical period is now more highly correlated with the estimated demand cycles. Further, the conditioning information improves the updating properties of the estimation technique, relative to the Hodrick-Prescott filter.

Summary

For the purpose of formulating monetary policy, potential output is the level of goods and services that an economy can supply without putting pressure on the rate of inflation. Based on this definition, the deviation of actual output from potential output provides a measure of inflationary pressure in the economy. Unfortunately, potential output cannot be directly observed. This paper describes one method of estimating potential output using information from observable macro-economic aggregates and presents results for the New Zealand economy.

To derive an estimate of potential output, actual output must be decomposed into two components. The first component represents the economy's level of potential output and the second component represents the fluctuations of demand for goods and services around potential output. The technique documented in this paper uses a range of macroeconomic information to extract a measure of the economy's level of potential output from actual output data. Because changes in potential output and changes in demand for goods and services have inherently different implications for the inflation process, past inflation in the economy is one source of information that is used to condition the estimate of potential output. An indicator of labour market conditions is also incorporated into the estimation technique, given that the labour market may contain valuable information about disequilibrium in the goods market. Finally, a survey measure of the economy's capacity utilisation rate is used as conditioning information, given that this is the only observable information conceptually close to the notion of potential output.

Common techniques for decomposing real output often assume that, on average, demand for goods and services will be equal to potential output. Consequently, potential output is estimated by applying some form of averaging technique to the real output series. The method presented in this paper uses a broader range of relevant macroeconomic information and should therefore yield a more accurate measure of potential output. As a consequence, the deviation of actual output from potential output should provide a more reliable gauge of inflationary pressure in the New Zealand economy. The new technique also displays improved updating properties in that the measure of potential output is less prone to revision as new data becomes available. This characteristic is important from a policy perspective, given that the view of inflationary pressure that will emerge over the near term is largely dependent on the current estimate of disequilibrium in the goods market.

1. Introduction

For the purposes of formulating monetary policy, potential output is the level of output consistent with a stable rate of inflation.[1] Based on this definition, the deviation of actual output from potential, or the output gap, provides a measure of inflationary pressure in the economy. If the output gap is positive through time, so that actual output is greater than potential output, then inflation will begin to move upwards in response to demand pressures in key markets. Within this framework, an accurate measure of the economy's level of potential output is required to explain the historical path of inflation and assess the extent of

[1] This applies only in a deterministic sense. In a stochastic steady-state with a non-linear inflation process output will be below potential output. For an informed discussion of this issue, see Laxton, Rose and Tetlow (1994) and Debelle and Laxton (1997).

current inflationary pressures. This paper describes a method for measuring potential output in the New Zealand economy and presents the resulting estimate.

Because potential output cannot be directly observed, economists have developed techniques that infer the level of potential output from information contained in observable macroeconomic data. Probably the most common class of techniques extract a trend measure from the actual output series. Trend output is then taken as a measure of the economy's level of potential output. These techniques decompose output into its supply (trend) and demand (cyclical) components based solely on the information contained in the actual output series.

More sophisticated approaches to the measurement of potential output incorporate aspects of economic structure into the estimation problem. However, considerable uncertainty exists as to the precise nature of structural relationships within the economy, suggesting that a pure structural approach will not be practicable. Accordingly, this paper employs a semi-structural estimation strategy in which additional information derived from broad macroeconomic relationships is incorporated into a time-series filter in a fairly general way. The resulting filter, called the multivariate (MV) filter, exploits information designed to more accurately identify supply (trend) and demand (cyclical) disturbances to output, relative to univariate techniques. As a consequence, the estimated output gap should provide a more reliable gauge of inflationary pressure in the New Zealand economy.

The remainder of the paper is structured as follows. Section 2 briefly discusses the limitations of time-series and structural approaches to the estimation of potential output. The characteristics of the Hodrick-Prescott (1997) filter are emphasised, given that the multivariate filter is developed within this framework. Techniques designed to overcome the limitations of the Hodrick-Prescott filter are discussed in Section 3 and shown to justify a semi-structural approach to the estimation of potential output. The multivariate filter is specified in Section 4. Calibration issues are discussed in Section 5 and the MV filter estimate of potential output is presented. Section 6 offers two metrics by which to evaluate the methodology and Section 7 contains a brief conclusion.

2. Previous approaches and their limitations

A comprehensive overview of the history of the estimation of potential output can be found in Laxton and Tetlow (1992). In brief, early approaches model potential output as a deterministic process. Common techniques include 'a-line-connecting-the-peaks' approach and the fitting of segmented linear or polynomial time trends to the actual output series. All of these techniques estimate potential output based solely on information contained in the actual output series. The supply side of the economy is assumed to evolve relatively smoothly through time, with shocks to aggregate demand providing the sole impetus to business cycle fluctuations.

During the late 1970s the assumption of a deterministic supply side became less palatable. A new literature emerged in which the level of potential output was treated as a stochastic phenomenon, implying that shocks to demand *and* to supply can exert important influences on variations in output. Accordingly, techniques for measuring potential output must assess the components of output growth attributable to supply and demand side disturbances. Variations of the filter outlined in Hodrick and Prescott (1997), hereafter the HP filter, have been widely used to decompose output under the stochastic-process approach. The HP filter calculates a trend output series that minimises the expression:

$$\Lambda = \sum_{t=1}^{T} (y_t - \tau_{y,t})^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{y,t+1} - \tau_{y,t}) - (\tau_{y,t} - \tau_{y,t-1})]^2 \qquad (1)$$

where y_t is the log of actual output and $\tau_{y,t}$ is its trend. The parameter λ is a smoothness constraint that determines how closely trend output follows the actual output series. For quarterly output data λ is usually set equal to 1600. The value of λ reflects, at least implicitly, a view about the relative importance of supply and demand shocks in the output series.

The extensive use of the HP filter in decomposing time series into their trend and cyclical components has motivated a body of research examining the accuracy of such decompositions.[2] As an illustration, consider the following data generating process, which is a reasonable representation of the conventional wisdom regarding the process underlying the evolution of real output.

$$Y_t = U_t + C_t \qquad (2)$$

Where:

Y_t represents real output,
U_t is its trend component and
C_t is its cyclical component.

The trend component in output is characterised as a random walk.

$$U_t = U_{t-1} + \varepsilon_t \qquad (3)$$

with $\varepsilon_t \sim NID(0, \sigma_\varepsilon^2)$

The cyclical component in output is characterised as an AR(2) process.

$$C_t = \phi_1 C_{t-1} + \phi_2 C_{t-2} + \varsigma_t \qquad (4)$$

with $\varsigma_t \sim NID(0, \sigma_\varsigma^2)$

Monte Carlo evidence in Guay and St-Amant (1996) suggests that the HP filter, with the smoothness parameter (λ) set equal to 1600, will accurately decompose Y into its trend and cyclical components when:

1) The ratio $\sigma_\varepsilon/\sigma_\varsigma$ is less than 1.[3] As far as measuring potential output is concerned, this condition effectively constrains the relative importance of supply and demand disturbances. For example, if 20 percent of the innovations in real output arise as the

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2 Some recent examples of this research include: Harvey and Jaeger (1993), Cogely and Nason (1995) and Guay and St-Amant (1996).

3 In Harvey and Jaeger (1993) this point is cast in terms of the relative importance of the I(1) and I(2) components of the series determining the extent to which the standard HP filter induces spurious correlations in the de-trended series at business cycle frequencies.

result of aggregate supply shocks, and 80 percent as the result of aggregate demand shocks, then $\sigma_\varepsilon/\sigma_\varsigma$ will equal 0.5.[4] However, if the relative importance of shocks is reversed, with 80 percent and 20 percent of real output variability attributable to supply and demand side disturbances respectively, then $\sigma_\varepsilon/\sigma_\varsigma$ will equal 2 and the condition will be violated.

2) For ϕ_1 in the neighbourhood of 1.2, ϕ_2 must be less than -0.4. This restriction relates to the persistence in the cyclical component of real output. A high degree of persistence implies that a large portion of the variance in the cyclical component is a function of long lived cycles (beyond 32 quarters).

Evidence suggests that both of these constraints are unlikely to be satisfied in practice.[5] Real output time series typically have *either* a trend component that is important relative to their cyclical component (violating condition 1 above) *or* a cyclical component whose variance is largely a function of long-lived cycles (violating condition 2 above). There is therefore no guarantee that the HP filter will accurately decompose output into its trend and cyclical component.

Another problem associated with using the HP filter to measure an economy's level of potential output is the instability of estimates near the end of the sample period. The HP filter is unable to accurately disentangle the relative incidence of permanent and temporary shocks at the end of the sample period, given that the persistence characteristics of recent shocks to output cannot be readily determined. This property of the HP filter results in substantial revision to the end-of-sample measure of potential output in light of subsequent observations of the actual output series. However, it is estimates of the current level of potential output that generally underpin forecasts of the evolution of inflation over a significant portion of the relevant policy horizon.

All of these considerations suggest that the mechanical application of the HP filter to actual output is unlikely to result in an accurate estimate of potential output.

As an alternative to univariate techniques, the 'structural-production-function' approach relates the evolution of potential output to trends in total factor productivity and the quantity of labour and capital used in the production process. However, without an accurate representation of the true structural determinants of the supply side of the economy, this approach to the estimation of potential output will generally not be practicable. Often researchers attempting to apply this technique use *ad hoc* time trends in the production function to explain productivity.[6] As a consequence, the estimate of potential output is largely conditioned by exogenous time trends.

Furthermore, the imposition of rigid structural assumptions is particularly difficult to justify in the context of the New Zealand economy, given the degree of structural change that has occurred over the last decade or more and the high degree of uncertainty associated with measures of the capital stock. Given these considerations, a pure structural approach to the estimation of potential output in the New Zealand economy does not appear to be a feasible option.

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4 For example, if σ_ε^2 = .4 and σ_ς^2 = 1.6 then the total variance output would be 2 and supply shocks would represent 20 percent of that variance and $\sigma_\varepsilon/\sigma_\varsigma$ = 0.6324/1.2649 = 0.5.

5 The spectrums of real output series tend to have typical "Granger" shapes.

6 For example, Perloff and Wachter (1979).

3. Solutions

A priori it is reasonable to assume that the supply side of the economy evolves subject to random disturbances, suggesting that the stochastic-process approach is the preferred methodology for estimating potential output. Three general strategies have been followed to improve the identification properties of the HP filter under the stochastic-process approach:

i. Laxton and Tetlow (1992) condition HP filter estimates of potential output using additional information suggested by the economic paradigm within which the estimate of potential is used. On the basis of a Monte Carlo experiment, Laxton and Tetlow find that conditioning information from a Phillips curve relationship and an Okun's Law relationship improves the accuracy of the HP filter estimate of potential output. The improvement occurs even though the true persistence in the cyclical component is higher than that associated with time series for which the HP filter is optimal (ie, $\phi_2 > -0.4$). However, the degree to which the additional conditioning information improves the point estimate of potential output declines as the ratio $\sigma_\varepsilon/\sigma_\varsigma$ increases. In other words, additional conditioning information of the type employed in Laxton and Tetlow (1992) improves the HP filter estimate of potential output when the cyclical component is highly persistent but not when supply disturbances are the dominant factor in the evolution of real output.

ii. Additional constraints, often determined judgementally, have been used to condition the filter's estimate of trend output. These constraints tend to become binding at the end of the sample period to help overcome the end-point problem associated with two-sided filters. To this end, Butler (1996) conditions filter estimates of potential output at the end of the sample period using a long-run growth restriction on potential output.

iii. In Razzak and Dennis (1995), the smoothness constraint (λ) in the HP filter is adjusted to more accurately reflect the relative importance of supply and demand shocks on the evolution of real output in New Zealand. This strategy trades on the fact that significant structural change in an economy can be expected to have somewhat predictable supply side consequences. The extent of the structural change that has occurred in New Zealand over the last decade suggests that such supply-side consequences may have played a predominant role in the evolution of real output. Razzak and Dennis (1995) estimate Phillips curves using various estimates of potential output obtained by reducing the smoothness parameter (λ) during periods in which their evidence suggests supply side shocks were predominant. The out-of-sample forecasting performance of the Phillips curves improves as the smoothness parameter is reduced.

To mitigate the pitfalls inherent in the HP filter, the multivariate (MV) filter allows all three of the above strategies to influence the estimate of potential output. Following Laxton and Tetlow (1992), information derived from broad macroeconomic relationships consistent with the economic paradigm implicit in the Reserve Bank's *Forecasting and Policy System* (FPS)[7] is used to condition the estimate of potential output. A survey measure of capacity utilisation is also used as conditioning information. All of this information is incorporated into the estimation problem in a fairly general way, reflecting the fact that significant uncertainty exists about the explicit nature of these macroeconomic relationships. The estimate of potential output is tied to a constant growth rate towards the end of the sample period to

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[7] For a discussion of the core model in the FPS see Black, Cassino, Drew, Hansen, Hunt, Rose and Scott (1997).

alleviate some of the end-point problem inherent in two-sided filters. The specification of the MV filter is detailed in the following section.

Consistent with the evidence presented in Razzak and Dennis (1995), we examine the impact of adjusting the value of the smoothing parameter (λ) over relevant sub-sample periods to reflect a higher incidence of aggregate supply shocks. This issue is dealt with in Section 5.

4. The specification of the multivariate filter

As noted above, the multivariate filter uses information contained in broad macroeconomic relationships to better isolate the components of real output attributable to aggregate supply and demand disturbances. Specifically, the Hodrick-Prescott filter is augmented with information from a Phillips curve relationship, an Okun's Law relationship and a survey measure of capacity utilisation. There are cogent reasons for incorporating each of these relationships into the estimation process.

The Phillips curve is central to the natural rate paradigm underlying the evolution of inflation in the FPS modelling framework. Within this paradigm, constraints implied by the productive capacity of the economy fundamentally drive the inflation process. As a consequence, supply and demand shocks have inherently different implications for inflation. It is therefore reasonable to assume that a Phillips curve relationship contains information relevant to the estimation of potential output. Accordingly, the Phillips curve depicted in equation (5) provides information that conditions the estimate of potential output.[8]

$$\pi_t = \pi_t^e + A(L)\left(y_t - \tau_{y,t}\right) + \varepsilon_{\pi,t} \tag{5}$$

The variables π, π^e, y and τ_y represent inflation, inflation expectations, actual output and potential output respectively. Residual error is represented by ε. Inflation expectations are measured as a weighted average of a survey measure of future expected inflation and the recent history of actual inflation outcomes. The natural rate hypothesis is imposed by constraining the sum of the coefficients on the inflation expectations terms to equal one.[9]

The inclusion of an Okun's Law relationship recognises that conditions in the labour market may contain valuable information about disequilibrium in the goods market. This aspect of the multivariate filter follows from numerous theoretical and empirical papers in which the gap between actual and potential output is linked with the gap between the actual and trend rate of unemployment.[10] *Ceteris paribus*, a movement of actual unemployment below its trend rate is interpreted as indicative of a positive shock to aggregate demand. Equation (6) illustrates the Okun's Law relationship used to condition the estimate of potential output:

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8 Using information from the inflation process to condition estimates of potential output within an HP filtering framework has also been done by Haltmaier (1996) and Gibbs (1995). In Kuttner (1994), an unobservable components approach is used to simultaneously estimate potential output and the inflation process.

9 Initially, first and second differences of the nominal exchange rate (contemporaneous and lagged) were also included as explanatory variables in the Phillips curve. Some of both the first and second differences were found to be significant. However, this specification of the Phillips curve did not substantially change the estimate of potential output. Exchange rate effects were therefore removed from equation (5).

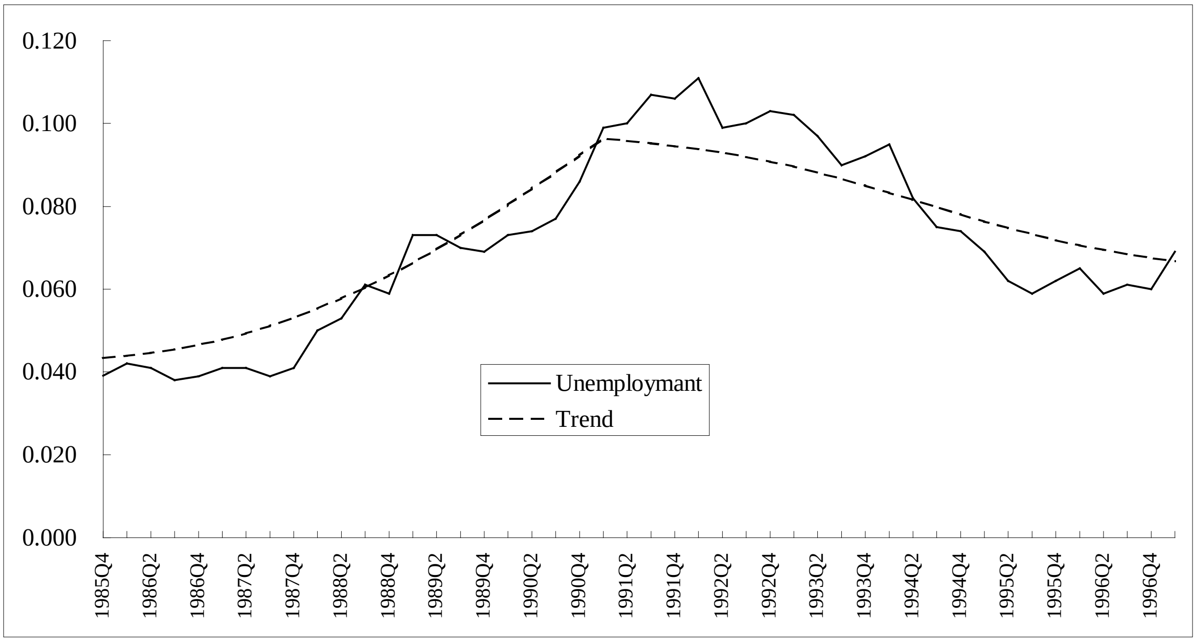
10 The seminal paper of this literature is Okun (1962).

$$U_{t-4} - \tau_{U,t-4} = b\left(y_t - \tau_{y,t}\right) + \varepsilon_{U,t} \qquad (6)$$

U is the unemployment rate and τ_U is the trend rate of unemployment. Deviations of actual unemployment from trend are assumed to influence conditions in the goods market after a lag of four quarters. The coefficient, b, is imposed at 0.333, implying an Okun's Law coefficient of 3. This is consistent with the value of b obtained by estimating equation (6), in conjunction with the other components of the MV filter, over the 1990s. It is also close to the estimate obtained by Gibbs (1995) of 0.35 for the New Zealand economy and the original estimate of Okun (1962) of 0.35 to 0.40.[11]

The trend rate of unemployment is estimated using a standard HP filter on the actual unemployment series.[12] The value of the smoothness parameter (λ) is set equal to 1600 in all periods except 1991q2, in which it equals zero. This allows for a break in the trend rate of unemployment, coinciding with the inception of the Employment Contracts Act (1991). The unemployment series is extended beyond its last historical observation using forecast data. The HP filter is then applied to the extended series to alleviate the end-point problem. Figure 1 displays the estimate of the trend rate of unemployment, along with the actual unemployment series.

Figure 1: Unemployment: actual and trend



The multivariate filter also uses information about the level of capacity utilisation in the economy to condition the estimate of potential output. Although capacity utilisation is a survey measure from only two sectors of the economy, it has a very attractive feature in that is the only observable information that is conceptually close to the notion of potential output.

[11] Sensitivity analysis reveals that the MV filter estimate of potential output does not change a great deal given other reasonable values of b.

[12] Ideally, the trend rate of unemployment would also be estimated using a multivariate filtering technique. A structural estimate of the trend, as well as other information, could be used to augment the HP filter. We leave this for future work.

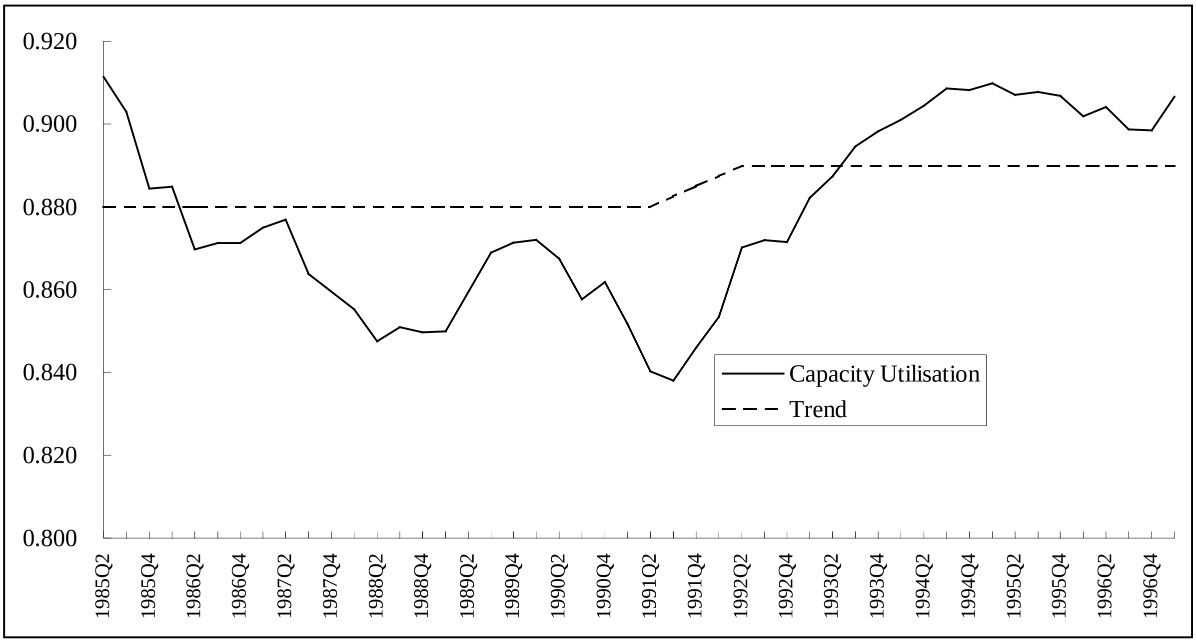
Using the same economic intuition that underpins the Okun's Law relationship, a movement of capacity utilisation above its long run or sustainable rate is interpreted as indicative of a positive shock to aggregate demand. Equation (7) depicts the relationship between the level of capacity utilisation relative to trend and the gap between actual and potential output.

$$CU_t - \tau_{CU,t} = c\left(y_t - \tau_{y,t}\right) + \varepsilon_{CU,t} \tag{7}$$

CU is capacity utilisation and τ_{CU} is its trend.[13] The parameter *c* is set equal to 1, implying that deviations of capacity utilisation from trend map directly into output gap space. This value of *c* is not rejected by the data when equation (7) is estimated in conjunction with the other components of the MV filter.

Because the level of capacity utilisation is measured in percentage terms, it is reasonable to assume that it evolves subject to a deterministic trend. Accordingly, τ_{CU} is set at a constant 88 percent from the beginning of the sample period until 1991q2. This is the mean level of capacity utilisation from the beginning of the series in 1970q1, until 1991q2. After 1991q2, the trend level of capacity utilisation is assumed to increase by one percent over a four quarter period. This upward shift in trend is made to reflect additional flexibility in the input of labour to the production process that arose as a result of the Employment Contracts Act. The level of capacity utilisation and its trend are displayed in Figure 2.

Figure 2: Capacity utilisation, actual and trend



Finally, the multivariate filter conditions on an assumed equilibrium growth rate of potential output of 2.75 percent per annum over the last eight quarters of history. This constraint helps to offset the two-sided filter's tendency to allocate movements at the end of the sample period

13 A description of the data used in equations (5) to (7) is contained in the data appendix.

to the trend component.[14] To keep exposition simple, this conditioning relationship is excluded from subsequent discussion.

The multivariate filter does not treat equations (5) to (7) as structural in a strict sense. Instead, information contained in the above macroeconomic relationships is used in a relatively flexible fashion to aid in the identification of supply and demand shocks over the course of New Zealand's recent economic history. The generalised problem is to choose τ_y to minimise:

$$\Lambda = \sum_{t=1}^{T}\left(y_t - \tau_{y,t}\right)^2 + \lambda \sum_{t=2}^{T-1}\left[\left(\tau_{y,t+1} - \tau_{y,t}\right) - \left(\tau_{y,t} - \tau_{y,t-1}\right)\right]^2 + \sum_{t=1}^{T}\theta_t \varepsilon_{\pi,t}^2 + \sum_{t=1}^{T}\mu_t \varepsilon_{U,t}^2 + \sum_{t=1}^{T}\rho_t \varepsilon_{CU,t}^2 \tag{8}$$

subject to equations (5) to (7). The first two terms on the right hand side of equation (8) are the straight HP filter. The last three terms are the residuals from equations (5) to (7) respectively. The time series $\{\theta, \mu, \rho\}$ allow weights to be attached to the various pieces of conditioning information that can vary through time. By assigning positive values to $\{\theta, \mu, \rho\}$, information from equations (5) to (7) is included in the minimisation problem. Accordingly, the resultant estimate of potential output will minimise the size of the residual errors (ε_j) by improving the fit of equations (5) to (7). The extent to which the estimate of potential output is conditioned by each of the residual error terms is determined by the relative magnitude of the associated weighting time series. The parameter (λ) is also specified as a time series so that the smoothing characteristics of the filter can be altered through time. This allows the evidence in Razzak and Dennis (1995) to be incorporated into the minimisation problem.

The coefficients of the Phillips curve relationship depicted in equation (5) are estimated on the basis of a given measure of potential output. As a consequence, the estimate of potential output derived using equation (8) will alter the form of equation (5) and the information content of ε_π. This circularity necessitates an iterative approach to the estimation technique. Initially, equation (5) is estimated using the HP trend of actual output as a measure of potential output. The minimisation problem of equation (8) is then solved, yielding an updated estimate of potential. The Phillips curve is then re-estimated given the revised measure of potential output. This iterative process is repeated until the changes from one iteration to the next in the coefficients of the Phillips curve satisfy some convergence criteria.

5. Calibration and the MV filter estimate of potential output

Determining the relative weight ascribed to each piece of conditioning information is essentially a subjective task. Butler (1996) advocates weighting conditioning information using the inverse of the residual error variance from the associated economic relationship.

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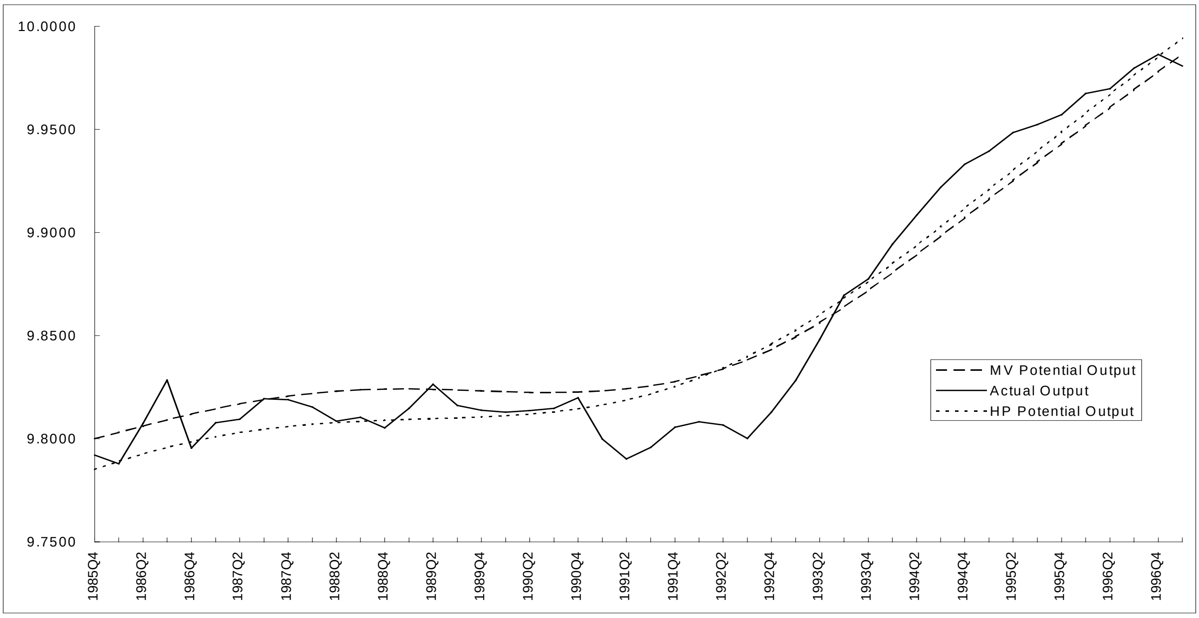
[14] The magnitude of the assumed equilibrium growth rate is set judgementally. During times of significant structural change, such as during New Zealand's reform period, it would be reasonable to assume that the growth rate of potential output is somewhat lower than 2.75 percent.

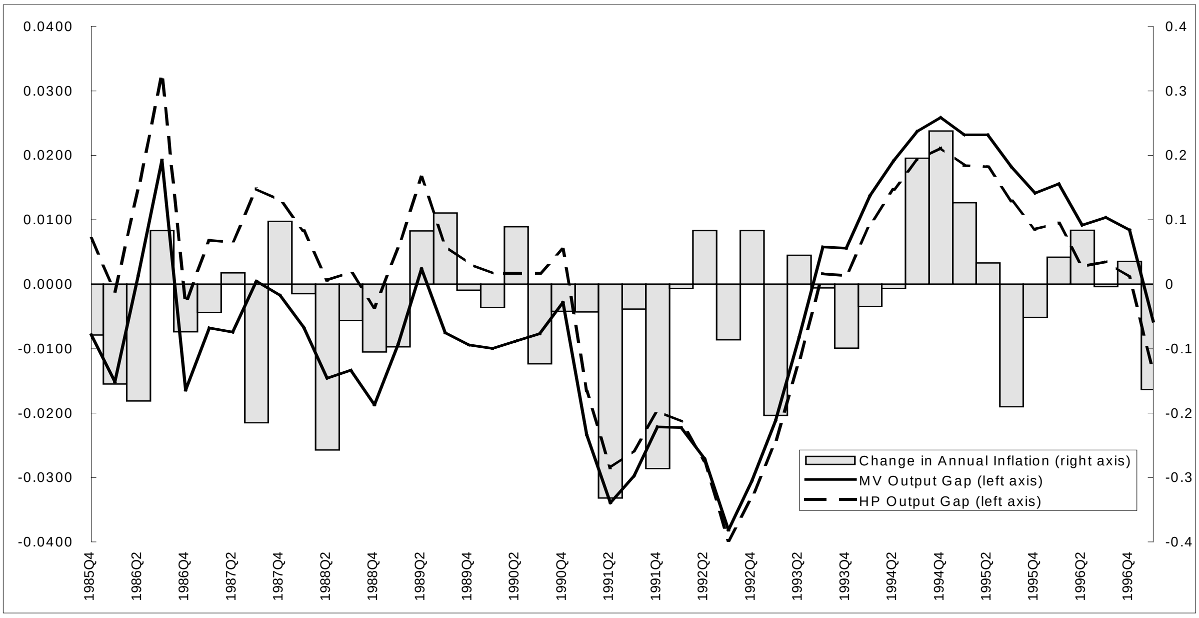
However, this approach is not applicable in the current context, given that the iterative nature of the estimation procedure makes the error variances a function of the weighting parameters. In any case, Butler (1996) finds that this approach does not substantially alter the measure of potential output, relative to a simple equal weighting of conditioning information. Laxton and Tetlow (1992) also estimate potential output using equal weights on each piece of conditioning information.

Given that no empirical method of specifying the weighting parameters contained in equation (8) can be considered infallible, it is reasonable to estimate a benchmark measure of potential output with equal weights on each piece of conditioning information. The magnitude of the weighting parameters reflects the relative bearing of the information content of equations (5) to (7) and actual output on the measure of potential output. To determine the most appropriate weight setting we experimented with a range of reasonable values. The upper panel of Figure 3 presents a measure of potential output derived using the MV filter with (θ, μ, ρ, λ) = (2, 2, 2, 1600). This setting ensures that judicious use is made of the information contained in equations (5) to (7) and the actual real output time series.

For comparative purposes, Figure 3 also displays the pure HP filter estimate of potential output. The output gaps associated with both filters are presented in the lower panel of Figure 3. Although both measures of the output gap tend to move together, the size of the output gap can be quite different over certain periods. For example, relative to the HP filter, the MV filter estimate of the output gap suggests significantly more excess supply in the goods market over the period of much of New Zealand's disinflationary experience in the mid 1980s.

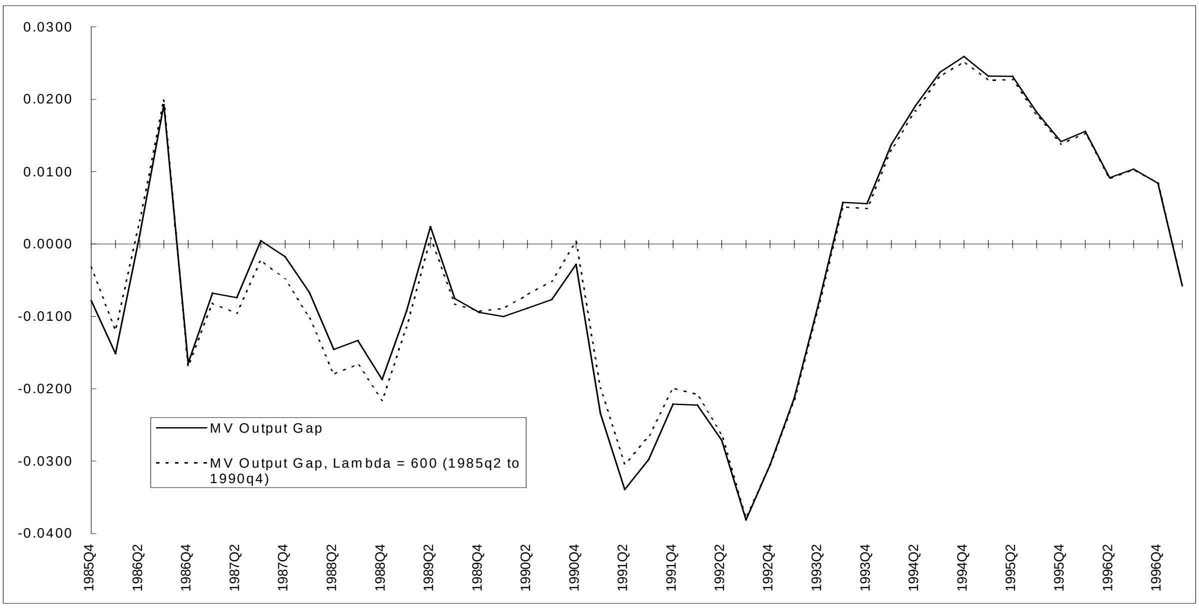
Figure 3: Estimates of potential output using the MV and HP filters





As outlined in Section 3, Razzak and Dennis (1995) find that lowering the value of the smoothing parameter (λ) over the period of significant structural reform improves the ability of the standard HP filter to differentiate supply and demand shocks in New Zealand real output data. However, as is apparent from Figure 4, setting λ equal to 600 over the period 1985q2 to 1991q4 results in a minimal difference for the estimate of the output gap produced by the MV filter. It appears that the conditioning information of equations (5) to (7) is allowing the MV filter to distinguish effectively between supply and demand influences over this period.[15] For this reason, the value of the smoothness parameter (λ) is set at 1600 over all of the estimation period.

Figure 4: MV potential output, various lambda values



15 Given the evidence in Laxton and Tetlow (1992), it is probably the conditioning information from capacity utilisation that generates this result.

6. Evaluation

The output gap obtained using the MV filter estimate of potential output provides a better measure of inflationary pressure in the New Zealand economy, relative to an output gap estimated using the HP filter. For example, over a one year window, the correlation between the change in annual inflation and the MV filter output gap is, on average, 40 percent better than that obtained using the HP filter output gap. However, evaluating the MV filter on the basis of how well the estimated demand cycles explain inflation is not strictly justifiable, given that by construction the MV filter will out-perform the HP filter in this regard.

Two other methods are used to evaluate the multivariate filter. The updating stability of the MV filter estimate of potential output is assessed and the statistical properties of the residuals from the conditioning equations are analysed.

Because future data always contains information relevant to the current decomposition of supply and demand shocks, the most recent estimates of potential output will invariably change as the persistence characteristics of past shocks become more apparent. Measuring the extent of revisions in the estimate of potential output and the associated output gap, given subsequent data, is one way of evaluating the updating properties of the MV filter. This aspect of the MV filter is very important from a policy perspective. The view of inflationary pressures that will emerge over the near term is largely dependent on the current estimate of disequilibrium in the goods market. The more stable is the estimate of potential output through time, the more confidence we can have in the end-of-sample estimate of goods market disequilibrium.

To this end Figures 5 and 6 present rolling estimates of the output gap derived using the MV and HP filters respectively. The rolling estimates are obtained by running the filters recursively through time and saving the 'current' estimate of the output gap in each period. 'Current' estimates are then compared with the estimate that is obtained by running the filter over the full sample period.

Figure 5: Rolling MV filter estimate of potential output

Figure 6: Rolling HP estimation of potential output

From the graphs it is apparent that revisions to the MV filter estimate of the current output gap in response to new data are much smaller than those of the straight HP filter. In fact, the average absolute difference between the actual and rolling estimates of the output gap obtained using the MV filter is approximately 50 percent less than that of the HP filter. This implies that in comparison with the HP filter, the MV filter substantially reduces the uncertainty associated with the current estimate of potential output.

Turning to the statistical properties of the conditioning equations, the residuals of the Phillips curve are uncorrelated. However, the residuals from the Okun's Law and capacity utilisation relationships are significantly correlated, having an autocorrelation coefficient at lag one of 0.688 and 0.683 respectively. Even if these relationships are estimated rather than imposed the residuals remain significantly correlated. It would clearly be preferable if this were not the case.[16] Additional work may be able to improve this aspect of the MV filter.

7. Conclusion

The limitations of univariate time series methods and the impracticalities of pure structural approaches suggest that neither method will provide an adequate measure of potential output in the New Zealand economy. Accordingly, this paper develops a semi-structural approach in which aspects of economic structure are incorporated into a time series filter in a fairly general way. Specifically, the HP filter is augmented with information from a Phillips curve, an Okun's Law relationship and survey data on capacity utilisation to help identify supply and demand disturbances in real output. A long-run growth rate restriction is also included to alleviate the end-point problem associated with all two-sided filtering techniques. These relationships do not exhaust the list of possible sources of conditioning information. Future work will undoubtedly suggest that other conditioning information should be added to this set.

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[16] Note that Butler (1996) reports similar results from economic relationships used to condition an estimate of potential output in the Canadian economy.

The resulting estimate of potential output is more consistent with the natural rate paradigm embedded in the core model of the FPS. The estimate of the output gap is also more consistent with the historical evolution of inflation in the New Zealand economy, relative to that obtained using the standard HP filter. Furthermore, the MV filter is found to exhibit improved updating properties in comparison to the HP filter.

Data Appendix

π_t	Inflation	CPI inflation ex interest rates and GST.
π_t^e	Inflation Expectations	Weighted average of lagged π_t and a survey measure of expected inflation.
y_t	Real GDP	Production based real GDP, seasonally adjusted.
U_t	Unemployment Rate	HLFS official unemployment rate.
CU_t	Capacity Utilisation	QSBO capacity utilisation, builders and manufacturing.

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