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Joseph W. Gruber

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Abstract: This study examines the impact of productivity growth on the relationship between inflation and unemployment in Canada. Recently it has been suggested that higher productivity growth is responsible for a shift in the U.S. Phillips curve that occurred in the late 1990s. This paper examines whether the Phillips curve in Canada shifted in a manner similar to that of the United States, and the degree to which higher productivity growth explains this shift.

Keywords: Inflation, Phillips Curve, Productivity

JEL Classifications: E31

* Contact address: The Board of Governors of the Federal Reserve System, Washington, DC, 20551, Tel: (202) 452-3931 (e-mail: Joseph.W.Gruber@frb.gov) I would like to thank Jane Ihrig, Steve Kamin, Jamie Marquez, Robert Tetlow, and Jon Faust for their helpful comments. The views in this paper are solely the responsibility of the author and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System.

1 Introduction

In the 1990s, the average rate of inflation in both Canada and the United States declined relative to the average rate in previous decades. The average rate of CPI inflation, measured as the Q4/Q4 change in the all-items CPI index, from 1978 to 1994 was 5.5 percent in Canada and 5.4 percent in the United States, whereas post-1994 average CPI inflation was 1.8 percent in Canada and 2.5 percent in the United States. Figure 1 plots inflation measured by the CPI index and the GDP deflator for Canada, while Figure 3 depicts the equilivent measures for the United States. The historical pattern of inflation is similar in both countries: relatively moderate inflation in the 1960s, followed by high inflation in the 1970s and 1980s, and then a return to moderate inflation in the 1990s.

In the United States, the low inflation of the late 1990s was associated with a low level of unemployment, a level previously thought to be consistent with accelerating inflation rather than the steady or declining rates of the period. Figure 4 depicts the rate of CPI inflation along with the unemployment rate and an OECD-derived measure of the output gap.[1] As inflation declined in the 1990s the output gap narrowed and the unemployment rate fell. The congruence of these events has led some commentators to suggest that the Phillips curve, i.e. the relationship between inflation and unemployment, shifted in the mid-1990s, altering the historical trade-off between these variables.

The apparent 1990s shift of the Phillips curve in the United States has been ascribed to the pick-up in the growth rate of productivity that occurred around the same time. A number of papers, including Brayton, Roberts, and Williams (1999), Staiger, Stock, and Watson (2001), and Ball and Moffitt (2001), have supported the hypothesis that faster productivity growth changed the relationship between inflation and unemployment in the United States.

Canada's similar experience with inflation in the 1990s and close integration with the United States raises the question as to whether a similar Phillips curve shift occurred in Canada. Has Canadian inflation been lower than expected since the mid-1990s, as it has been in the United States, signifying a possible shift in the Phillips curve, or rather is Canada's low inflation the product of high unemployment and favorable price shocks? If the Canadian Phillips curve shifted, is an increase in productivity responsible, as has been conjectured for the United States? This paper attempts to answer these questions.[2]

A cursory examination of the data, presented in Figure 2, reveals that Canadian inflation remained steady at a low rate as the unemployment rate fell and the output gap narrowed in the late 1990s, suggesting a similar Phillips curve shift as in the United

[1] OECD output gaps are reported in order to maintain comparability between the United States and Canada.

[2] The Bank of Canada's adoption of a policy of inflation targeting in 1991 has been cited as another possible explanation for a change in the behavior of Canadian inflation in the 1990s. Beaudry and Doyle (2000) associate inflation targeting with a change in the slope of the Canadian Phillips curve, defined in relation to output gaps rather than the unemployment gaps used in this paper. On the other hand, Honda (2000) finds that the adoption of inflation targeting had no empirical impact on Canadian inflation. This paper does not explicitly consider the impact of changes in monetary policy on the Phillips curve.

States. However, unlike unemployment in the United States, Canadian unemployment, though decreasing, remained high throughout the entire period.[3]

Whereas unemployment in the United States was thought to have dropped below the level associated with non-accelerating inflation, it is not clear that the same can be said about Canadian unemployment. Consistent with the high level of the unemployment rate, the OECD estimate of the Canadian output gap was substantially negative for most of the decade.

Not only is there less prima facie evidence that the Phillips curve shifted in Canada, but there is also less evidence of an upswing in productivity growth that might have caused such a shift. Canada's recent productivity growth has not matched that of the United States, as depicted in Figure 5. While productivity growth has increased in the 1990s, the HP-filtered trend suggests that Canadian productivity growth lags that of the United States. Thus, even if the Canadian Phillips curve did shift in the 1990s, productivity growth might not be as plausible an explanation as it is in the United States.

The remainder of this paper attempts to address in greater depth two questions regarding recent inflation dynamics in Canada. First, can a standard Phillips curve, ignoring the impact of productivity, predict Canada's low rate of inflation since the mid-1990s? Second, what role, if any, has productivity played in Canada's recent experience with inflation? The paper is structured as follows. The first section examines the role that productivity growth can play in altering the trade-off between inflation and unemployment, using the particular methodology developed by Ball and Moffitt (2001). The next section tests the predictive ability of a standard non-productivity Phillips curve in regard to Canada's recent low rate of inflation. Then a Phillips curve that allows productivity effects is estimated and examined for predictive content. The final section concludes.

2 Productivity Model

Ball and Moffitt (2001) examine the hypothesis that increased productivity growth in conjunction with sticky real wage aspirations on the part of workers can explain the recent dynamics of the trade-off between inflation and unemployment, i.e. the Phillips curve, in the United States. In this paper I carry out a similar exercise in regard to Canada.

The late 1990s witnessed lower inflation and lower unemployment in the United States than previously was thought to have been mutually compatible. The Phillips curve appears to have shifted, such that the nature of the historical trade-off between inflation and unemployment has changed. Ball and Moffitt, among other commentators, suggest that the pick-up in productivity growth that occurred around 1995 in the United States is responsible for the late 1990s shift in the Phillips curve.

[3] Sharpe (2001) is a useful reference regarding comparative labor market trends in Canada and the United States.

Ball and Moffitt start with a unit labor cost characterization of inflation,

$$\pi_t = \omega_t - \theta_t + \upsilon_t \tag{1}$$

such that inflation, π, is determined by the difference between nominal wage growth, ω, and the growth rate of productivity, θ, with the addition of an error term, υ. The equation assumes that markups are constant, so that any increase in wages above productivity must show up as an increase in prices. The equation also implies that the growth rate of the real wage is equal productivity growth, plus an error.

$$\omega_t - \pi_t = \theta_t + \upsilon_t \tag{2}$$

The second part of the model is a characterization of the wage-setting process. In this stylized model, workers set their wages. In the steady state, absent any rigidities, workers opt for nominal wage growth equal to the rate of inflation plus the rate of productivity growth. The key innovation of Ball and Moffitt, however, is to introduce stickiness into the real wage adjustment process. Workers look not only at contemporaneous inflation and productivity when setting their wages, but also at their past levels of real wage growth, captured in a "wage aspirations" term. Wage aspirations, A, are defined as:

$$A_t = \frac{1-\beta}{\beta} \sum_{i=1}^{\infty} \beta^i \left(\omega_{t-i} - \pi_{t-i}\right) \tag{3}$$

The discount factor, β, determines the weight placed on past levels of real wage growth. Combined with the definition of inflation, it is clear that A is the discounted sum of past levels of productivity growth.

In the short run, workers attempt to achieve a target level of real wage growth

$$(\omega_t - E\pi_t) = \alpha - \gamma U_t + \delta\theta_t + (1-\delta)\,A_t + \eta_t \tag{4}$$

where E is an expectations operator and U is the rate of unemployment. Workers' real wage aspirations depend on a weighted average of current productivity growth, θ, and wage aspirations, A, (of course, since A reflects past productivity growth, their target real wage ultimately depends upon both current and past productivity growth.) Unemployment, U, appears in the equation as workers revise down their expectations of real wage growth when there are many competing job seekers.

Substituting the wage-setting equation (4) into the inflation equation (1) results in the following productivity-augmented Phillips curve.

$$\pi_t = \alpha + E\pi_t - \gamma U_t - (1-\delta)\left(\theta_t - A_t\right) + \epsilon_t \tag{5}$$

Assuming adaptive expectations, such that $E\pi_t = \pi_{t-1}$ and allowing supply shocks, S, the curve becomes:

$$\pi_t = \alpha + \pi_{t-1} - \gamma U_t - (1-\delta)\left(\theta_t - A_t\right) + \lambda S_t + \epsilon_t \tag{6}$$

Equation (6) indicates that inflation is negatively associated with the excess of productivity growth over past real wage growth. In the steady state $\theta = A$, since A ultimately reflects past productivity growth. When productivity growth rises, however, the increase in θ is not matched by an increase in A, leading to downward pressure on inflation. Ball and Moffitt (2001) argue that this is what caused inflation to fall in the United States.[4]

3 Empirical Results

3.1 Forecasts from Standard Phillips Curves

An important starting point is to assess the accuracy of inflation forecasts derived from standard non-productivity augmented Phillips curves. If the standard model succeeds in forecasting inflation reasonably well, it diminishes the need to consider additions to the model. A non-productivity Phillips curve is estimated through 1994 and then out-of-sample forecasts are constructed through 2001 for both Canada and the United States. The standard curve has the following representation:

$$\pi_t = a_1 + b(L)\pi_{t-1} + c_1 U_t + d_1 FE_t + f_1 IMP_{t-1} + \epsilon_t \tag{7}$$

All data are at an annual frequency. Two measures of inflation, π, were considered in both the United States and Canada, the Q4/Q4 change in both the all-items CPI index and the GDP deflator. Inflation is allowed to enter with up to six lags, with the actual number of lags determined by the Akaike Information Criterion. The coefficients on lagged inflation are constrained to add to one, thereby ensuring the existence of a steady state inflation rate. The unemployment rate, U, is the BLS measure for the United States and the OECD measure for Canada. Food and energy price shocks are captured via FE. For the Canadian regressions, FE is constructed as the difference between the change in the food and energy index and the change in the all-items CPI index. For the United States, FE is the change in the all-items index less the change in the all-items excluding food and energy index.[5] The Canadian regressions include an additional import price shock variable, IMP, which is represented as the percent change in the Canadian dollar price of a U.S. dollar plus the lagged U.S. rate of inflation less the lagged Canadian rate of inflation.[6] Both shock series were taken as deviations from their means, so that in the steady state they do not impact the rate of inflation.

[4] The Ball and Moffitt methodology differs slightly from the Gordon (1998) and Staiger, Stock, and Watson (2001) method of incorporating productivity into the Phillips curve. Productivity in these papers enters as the deviation of the current level from its HP-filtered trend; whereas Ball and Moffitt use the one-sided filter represented by A. Thus, only lagged values of productivity impact inflation in Ball and Moffitt, consistent with a story of sticky expectations on the part of workers.

[5] This is similar to the manner in which Gordon (1998) incorporates food and energy price shocks, though with the CPI index rather than the PCE deflator.

[6] This is similar to the import shock measure used in Macklem and Yetman (2000) in their study of the Phillips curve in Canada.

The number of observations in the regressions varies according to availability of the data series.

Equation (7) was estimated through 1994 for Canada and the United States. Then I conduct out-of-sample forecasts for 1995 - 2001. The choice of 1994 as the break date is in line with previous studies of the Phillips curve shifts conducted in reference to the United States. Ball and Moffit estimate through 1995 on the hypothesis that new economy productivity growth started in 1996. In Canada, if a break in the Phillips curve occurred, it is possible that the break occurred at an earlier or, more likely, later date. A later break date would be apparent through large errors in the out-of-sample forecasts.

The results of the standard Phillips curve regressions are presented in Table 1. For each inflation series, CPI or GDP deflator, in addition to an equation that allows food and energy and import price shocks, a simplified Phillips curve that does not include these shocks was estimated. In the Canadian regressions, the coefficient on the unemployment rate is significant and negative in all cases, while the coefficient on the food and energy shock is significant and positive in the case of CPI inflation but insignificant for the GDP deflator measure. The import shock coefficients were not significant. For the U.S. regressions, the coefficient on unemployment is consistently significant and negative and the food and energy shock coefficient is significant and positive.

The constant NAIRU implied by each regression is reported in the last row of the table for each country. The constant NAIRU is calculated as

$$NAIRU = \frac{-a_1}{c_1}$$

Across Canadian regression specifications, the constant NAIRU term is roughly 7.6 percent. The U.S. regressions imply a considerably lower constant NAIRU, at around 6.2 percent.

Next, I use the estimated regression coefficients to forecast inflation out-of-sample from 1995 to 2001. The forecasts are static in that the lagged dependent variables are represented by their actual values rather than previous forecasts. Thus, forecast errors are not allowed to compound. The Canadian static forecasts are shown in Figure 6. A 95 percent confidence interval is constructed around each forecast. For the most part, the actual rate of inflation lies within the forecast error bands, suggesting that the non-productivity-augmented Phillips curve does a fairly good job of forecasting Canadian inflation. With respect to CPI inflation, errors are weighted towards underprediction as opposed to overprediction. Mean forecast errors are presented in Table 3. The mean error confirms that the standard Phillips curve underpredicts CPI inflation in Canada, and slightly overpredicts inflation as measured by the GDP deflator. None of the Canadian forecast errors are significantly different from zero.

Figure 7 presents the U.S. static forecasts. The U.S. forecasts are consistently above the actual inflation rates. The mean error for the U.S. CPI forecast is approximately 1.2 percentage points, suggesting substantial overprediction. The mean forecast errors are significantly different from zero in the United States. The consistency of the errors is supportive of the hypothesis that the U.S. Phillips curve shifted to allow lower rates of unemployment to be compatible with lower rates of inflation than previous historical experience would have suggested. The same does not appear to be true in the case of Canada, the historical relationship between unemployment and inflation seems to have held in the 1990s.

3.2 Adding Productivity

The question now is whether adding some measure of productivity to the Phillips curve improves its forecasting ability, especially in the later half of the 1990s. In adding productivity growth to the model, I follow the aspiration wage methodology of Ball and Moffit. First, the wage aspiration term, equation (3) is constructed. Replicating equation (3):

$$A_t = \frac{1-\beta}{\beta} \sum_{i=1}^{\infty} \beta^i \left(\omega_{t-i} - \pi_{t-i}\right)$$

Real wage growth is subtracted from its mean and then the mean producitivity growth rate is added to the series. Thus, the mean of real wage growth is made equal to that of productivity growth, ensuring that $\theta - A = 0$ in the long-run.[7] For the aspiration term, the initial value of A is set equal to the 1947 value of the HP-filtered real wage growth series. Subsequent As are then dynamically constructed such that

$$A_t = \beta A_{t-1} + (1-\beta)\left(\omega_{t-1} - \pi_{t-1}\right)$$

The discount parameter is set to equal .95, as it was for much of the analysis in Ball and Moffitt (2001). The difference between θ and A is graphed, along with its HP-filtered values, in Figure 10 for Canada and Figure 11 for the United States. For both countries the measure has been trending up since the 1980s, with the trend crossing into positive territory in 1996 in the United States and 2000 in Canada. A positive value implies that productivity growth exceeds aspirations of real wage growth, with a consequent negative impact on inflation.

I now estimate a new Phillips curve equation including a productivity minus real wage aspirations term.

$$\pi_t = a_1 + b(L)\pi_{t-1} + c_1 U_t + d_1 FE_t + f_1 IMP_{t-1} + g_1\left(\theta_t - A_t\right) + \epsilon_t$$

The estimation results are presented in Table 2. In Canada, the productivity term coefficient is significant and negative in the CPI regressions but is insignificant in the GDP deflator regressions. Figure 8 plots the actual rate of Canadian inflation along

[7]Equation (2) requires that real wage growth equal productivity growth plus an error term. Thus, the wage aspiration term can be interpreted as being the long-run average of lagged productivity growth. The imposition of equation (2) requires that θ and A be cointegrated with a cointegrating vector of $[1 - 1]$. This hypothesis is not rejected for either Canada or the United States

with the static forecast and a 95 percent confidence band. The figure reveals that the addition of the productivity term does not significantly improve the predictive ability of the Phillips curve in Canada. Productivity actually increases the underprediction error in regard to Canadian CPI inflation.

In the United States the productivity term coefficient is significant and negative in all four regressions. The static forecasts derived from the U.S. regressions are presented in Figure 9. While overprediction is still the norm, the productivity-enhanced forecasts perform much better than their non-productivity counterparts. The mean forecast error is roughly halved once productivity is included in the model, and the errors are no longer significantly different from zero. Thus, faster productivity growth since the mid-1990s appears to have significantly altered the inflation - unemployment trade-off in the United States.

One way to assess the importance of productivity growth on the Phillips curve is to calculate a model-derived NAIRU that moves over time and then compare how it moves with and without the consideration of productivity growth. Figure 12 presents residual based time-varying NAIRUs for both Canada and the United States, calculated using the CPI inflation regressions including the shock variables. The reported NAIRUs are calculated such that the entire Phillips curve error is assigned to variation in the NAIRU. That is:

$$NAIRU_t = \frac{-(a_1 + \epsilon_t)}{c_1}$$

In each year the time-varying NAIRU is that value of the NAIRU that would set the predicted value of inflation equal to the actual value of inflation. The NAIRU's are constructed from a Phillips curve estimated over the entire sample, i.e. through 2001. If the time-varying NAIRU is relatively constant, the implication is that the Phillip's curve errors are small or offsetting. If the NAIRU trends down, the Phillip's curve must be producing consistently positive errors, such that inflation is being overpredicted. An upward movement in the NAIRU suggests consistent underprediction. The resulting series are then smoothed through a HP-filter.

In the United States, the NAIRU calculated from the CPI regression including food and energy shocks but not a productivity term has been trending down for some time, after increasing in the 1970s, suggesting that the standard Phillips curve underpredicted inflation in the 1970s and overpredicted inflation in the 1990s. Once the productivity aspiration term is added to the equation, the estimated NAIRU flattens out considerably, implying that productivity is responsible for much of the standard curve's prediction errors in the United States.

For Canada, the addition of productivity does not seem to flatten the time-varying NAIRU to any significant degree. The addition of productivity does not appear to explain Canadian Phillips curve prediction errors. Additionally, the time-varying NAIRU reveals that through 1998, Canadian unemployment remained above the rate associated with accelerating inflation. Thus, Canada's low inflation in the 1990s is consistent with Canada's high rate of unemployment at the time.

4 Conclusion

A standard Phillips curve does a fair job of forecasting Canada's inflation rate since the mid-1990s. Canada's relatively low rate of inflation through the 1990s was largely the product of its high unemployment rate, rather than a rapid increase in productivity. Forecasts suggest that, if anything, the mystery is why Canadian inflation was so high in the 1990s given Canada's relatively high unemployment rate during that period. The productivity aspiration term enters significantly in the Canadian CPI regressions but not in the GDP deflator regressions, giving mixed support to the relevance of the productivity model in Canada. However, while productivity growth can potentially affect the rate of Canadian inflation, low realized productivity growth over the 1990s prevents this from being a significant part of Canada's low inflation story. This contrasts with the experience in the United States, where a pick-up in productivity growth is important to explaining why inflation was so low in the later 1990s.

References

Ball, L., and R. Moffitt (2001): "Productivity Growth and the Phillips Curve," *NBER Working Paper No. 8421.*

Beaudry, P., and M. Doyle (2000): "What Happened to the Phillips Curve in the 1990s in Canada?," *Proceedings of the Bank of Canada Conference on Price Stability and the Long-Run Target for Monetary Policy.*

Brayton, F., J. M. Roberts, and J. C. Williams (1999): "What's Happend to the Phillips Curve?," *Fed Working Paper.*

Gordon, R. J. (1998): "Foundations of the Goldilocks Economy: Supply Shocks and the Time-Varying NAIRU," *Brookings Papers on Economic Activity.*

Honda, Y. (2000): "Some Tests on the Effects of Inflation Targeting in New Zealand, Canada, and the UK," *Economics Letters*, 66.

Macklem, T., and J. Yetman (2000): "Productivity Growth and Prices in Canada: What can we learn from the U.S. Experience?," *BIS Papers.*

Sharpe, A. (2001): "A Comparison of Canadian and U.S. Labour Market Performance, 1989 - 2000," *Centre for the Study of Living Standards Working Paper.*

Staiger, D., J. H. Stock, and M. W. Watson (2001): "Prices, Wages, and the U.S. NAIRU in the 1990s," *NBER Working Paper No. 8320.*

Table 1: Non-Productivity Phillips Curve Model through 1994

Canada

	CPI		GDP Deflator	
Regression #	1	2	1	2
# Inflation Lags	1	1-4	1	1-3
# of Observations	34	33	32	30
Constant	2.65**	3.38**	2.14**	1.96*
	(.99)	(.781)	(.958)	(1.06)
Unemployment	-.357**	-.445**	-.281**	-.259*
	(.119)	(.111)	(.114)	(.146)
Food & Energy		.375**		.288
		(.120)		(.205)
IMP[a]		.020		-092
		(.083)		(.132)
Adjusted R-Squared	.74	.83	.72	.79
Serial Independence[b]	.40	.82	.03	.74
Homoskedasticity[c]	.13	.36	.99	.13
Normality[d]	.78	.79	.16	.23
Implied NAIRU%	7.4	7.6	7.6	7.6

United States

	CPI		GDP Deflator	
Regression #	1	2	1	2
# Inflation Lags	1	1-4	1	1-5
# of Observations	34	34	34	34
Constant	5.30**	4.23**	3.63**	3.02**
	(1.67)	(.89)	(1.00)	(1.51)
Unemployment	-.851**	-.675**	-.584**	-.486**
	(.240)	(.133)	(.143)	(.080)
Food & Energy		1.173**		.570**
		(.226)		(.096)
Adjusted R-Squared	.66	.86	.82	.91
Serial Independence[b]	.20	.76	.10	.11
Homoskedasticity[c]	.43	.31	.04	.59
Normality[d]	.50	.63	.03	.00
Implied NAIRU %	6.2	6.3	6.2	6.2

** Statistical significance at the 5% level
* Statistical significance at the 10% level
a: The Change in the CAD price of USD plus lagged US CPI inflation minus lagged Canadian CPI inflation
b: p-value to reject the hypothesis of serial independence of the regression residuals as determined by a Breusch-Godfrey LM test with 2 lags
c: p-value to reject the hypothesis of homoskedasticity as determined by a ARCH LM test with a single lag
d: P-value to reject the hypothesis of normality.

Table 2: Productivity-Augmented Phillips Curve Estimation Through 1994

Canada

	CPI		GDP Deflator	
Regression #	1	2	1	2
# Inflation Lags	1	1-4	1	1-3
# of Observations	34	33	32	30
Constant	2.25**	3.30**	1.96*	2.05*
	(.92)	(.80)	(1.00)	(1.04)
Unemployment	-.353**	-.498**	-.278**	-.249
	(.113)	(.118)	(.114)	(.157)
Food & Energy		.348**		.290
		(.146)		(.200)
IMP[a]		.010		-.092
		(.084)		(.129)
Prod - Aspirations	-.255**	-.330**	-.108	.106
	(.095)	(.132)	(.161)	(.209)
Adjusted R-Squared	.75	.85	.71	.78
Serial Independence[b]	.15	.48	.12	.36
Homoskedasticity[c]	.14	.24	.82	.16
Normality[d]	.95	.63	.05	.18
Implied NAIRU %	6.4	6.6	7.1	8.2

United States

	CPI		GDP Deflator	
Regression #	1	2	1	2
# Inflation Lags	1	1-4	1	1-5
# of Observations	34	34	34	34
Constant	3.91**	3.57**	2.59**	2.51**
	(1.38)	(.81)	(.81)	(.50)
Unemployment	-.693**	-.626**	-.466**	-.439**
	(.216)	(.123)	(.126)	(.079)
Food & Energy		1.025**		.439**
		(.233)		(.110)
Prod. – Aspirations	-.430*	-.380*	-.324**	-.238*
	(.232)	(.196)	(.156)	(.126)
Adjusted R-Squared	.70	.88	.87	.93
Serial Independence[b]	.39	.56	.17	.12
Homoskedasticity[c]	.56	.17	.50	.57
Normality[d]	.51	.99	.87	.17
Implied NAIRU %	5.6	5.7	5.6	5.7

** Statistical significance at the 5% level
* Statistical significance at the 10% level
a: The Change in the CAD price of USD plus lagged US CPI inflation minus lagged Canadian CPI inflation
b: p-value to reject the hypothesis of serial independence of the regression residuals as determined by a Breusch-Godfrey LM test with 2 lags
c: p-value to reject the hypothesis of homoskedasticity as determined by a ARCH LM test with a single lag
d: P-value to reject the hypothesis of normality.

Table 3
Static Forecast Errors: Predicted minus Actual Inflation

Canada

Non-Productivity Phillips Curve Forecasts

	Regression #	Mean Error
CPI Inflation	1	-.48
	p-value	.31
	2	-.40
	p-value	.30
GDP Deflator	1	.20
	p-value	.38
	2	-.07
	p-value	.40

Productivity-Augmented Phillips Curve Forecasts

	Regression #	Mean Error
CPI Inflation	1	-.80
	p-value	.19
	2	-.94
	p-value	.06
GDP Deflator	1	.06
	p-value	.40
	2	.10
	p-value	.39

United States

Non-Productivity Phillips Curve Forecasts

	Regression #	Mean Error
CPI Inflation	1	1.34
	p-value	.07
	2	1.16
	p-value	.02
GDP Deflator	1	.85
	p-value	.04
	2	.75
	p-value	.01

Productivity-Augmented Phillips Curve Forecasts

	Regression #	Mean Error
CPI Inflation	1	.54
	p-value	.29
	2	.58
	p-value	.15
GDP Deflator	1	.25
	p-value	.31
	2	.37
	p-value	.13

p-values are the significance level at which the hypothesis that the mean forecast error is equal to zero can be rejected.

Figure 1: Canadian Inflation (Q4/Q4)

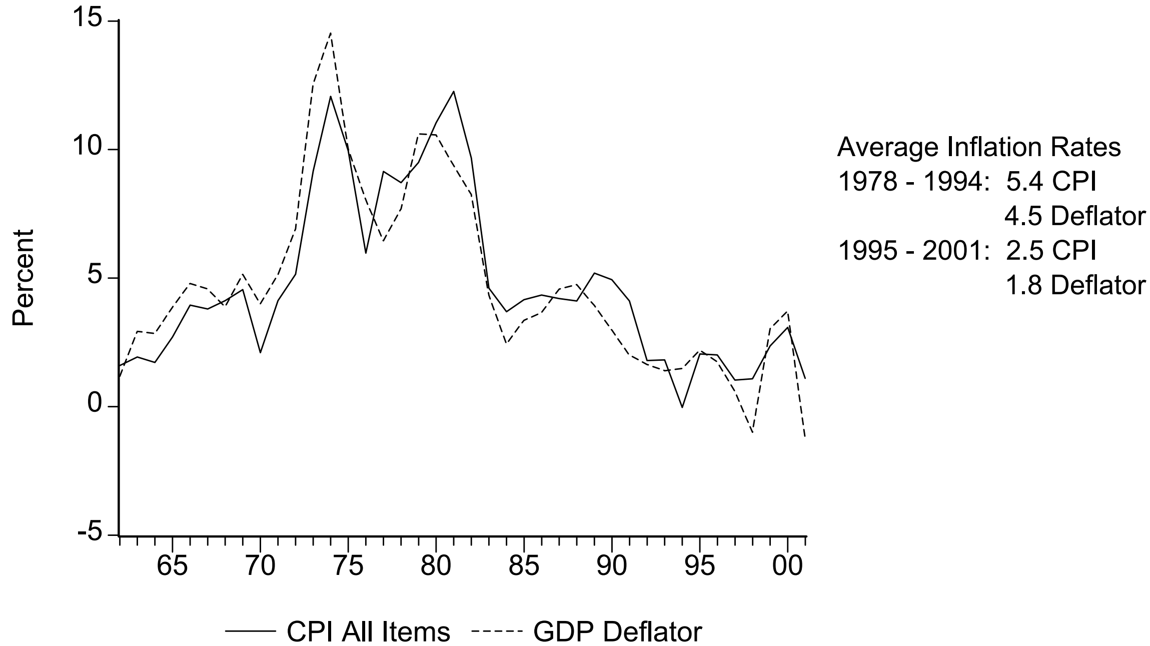


Figure 2: Canadian Unemployment Rate and Output Gap

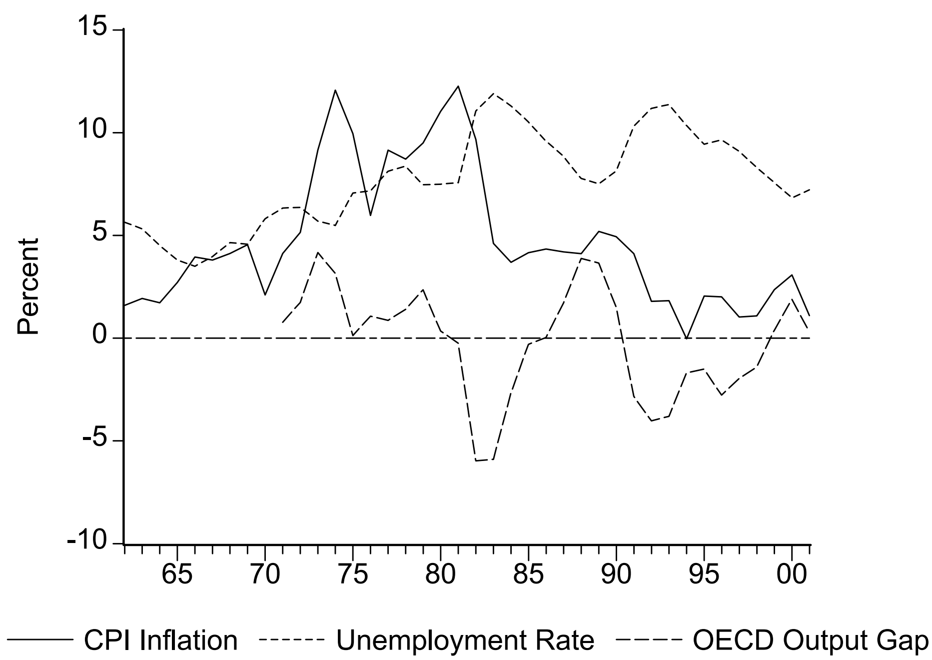
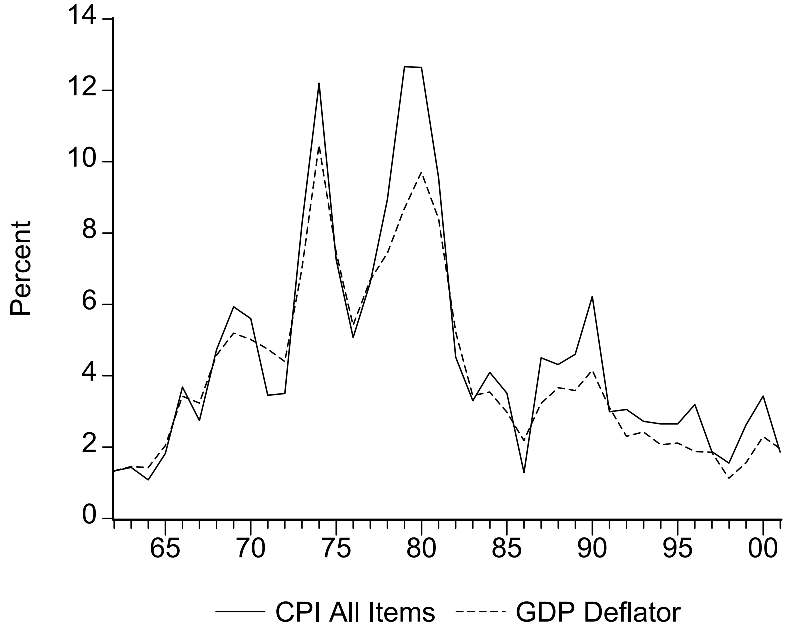


Figure 3: United States Inflation (Q4/Q4)



Average Inflation Rates
1978 - 1994: 5.4 CPI
4.5 Deflator
1995 - 2001: 2.5 CPI
1.8 Deflator

Figure 4: United States Unemployment Rate and Output Gap

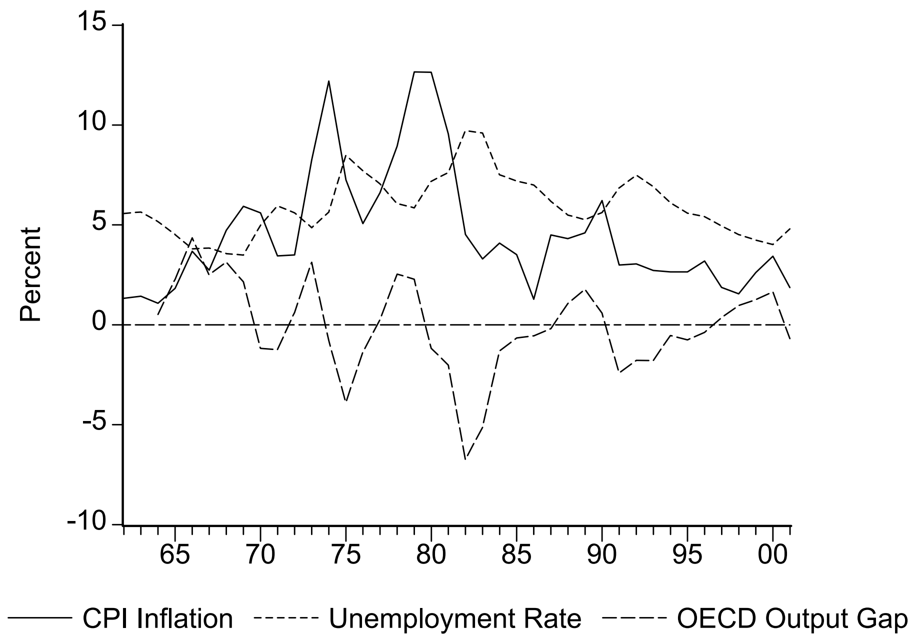
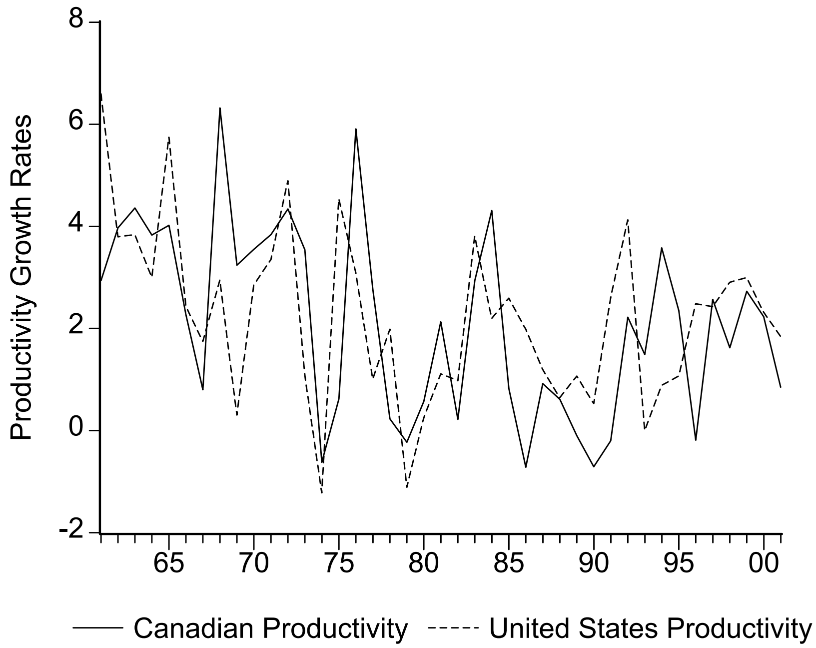


Figure 5: Productivity

Business Sector Output per Hour



Trend Business Sector Output per Hour

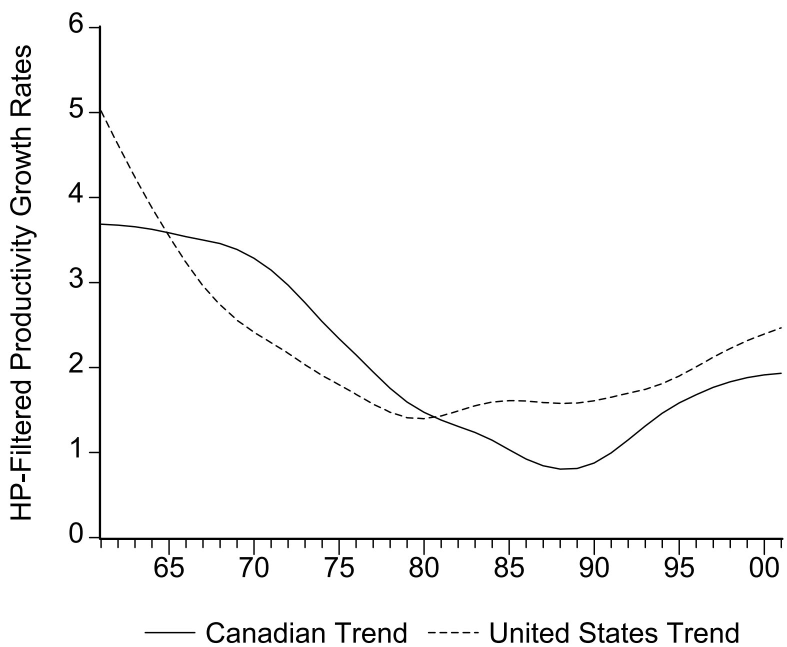


Figure 6: Canadian Non-Productivity Phillips Curve Forecasts

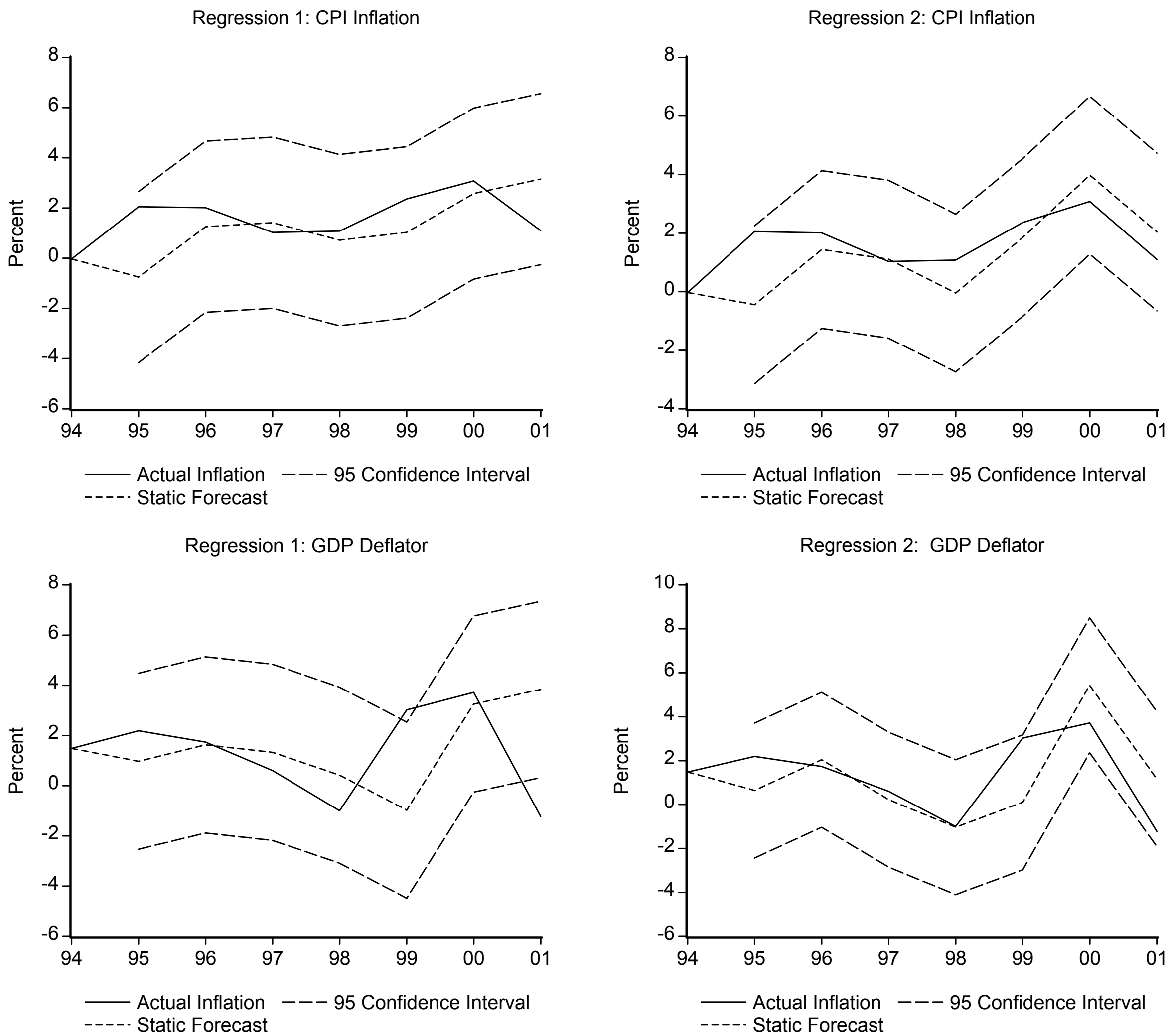


Figure 7: United States Non-Productivity Phillips Curve Forecasts

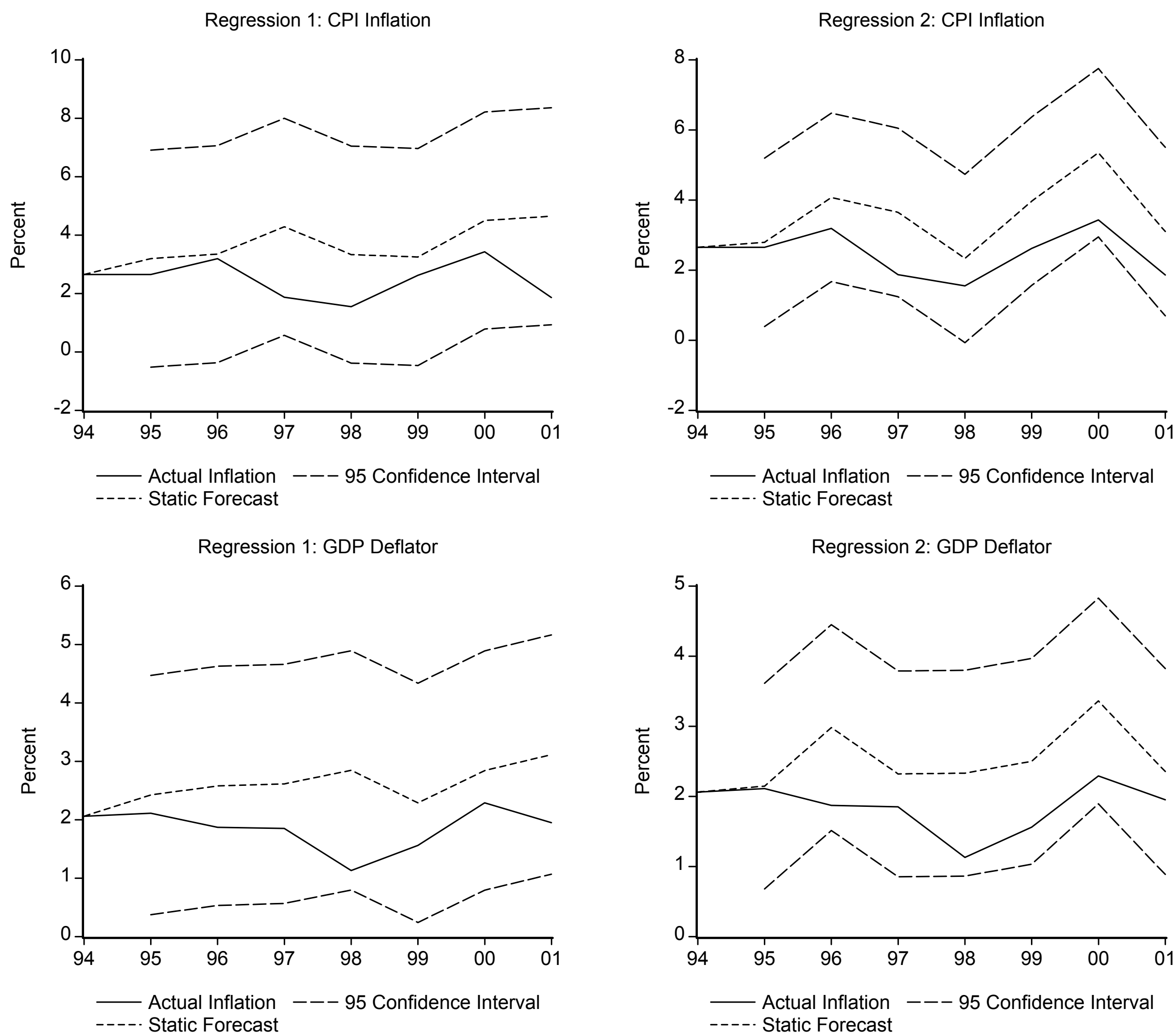


Figure 8:Canadian Productivity Phillips Curve Forecasts

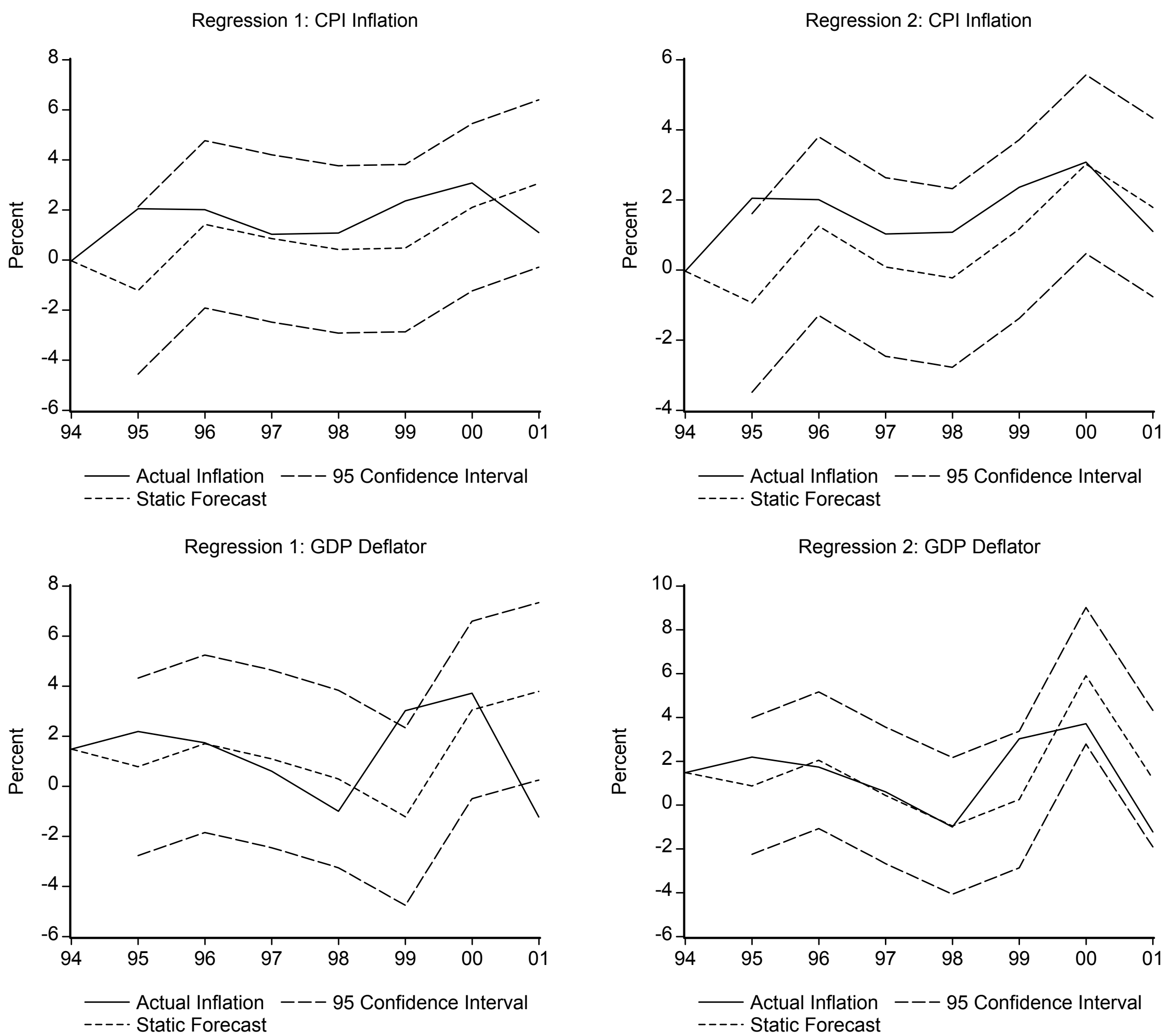


Figure 9: United States Productivity-Augmented Phillips Curve Forecasts

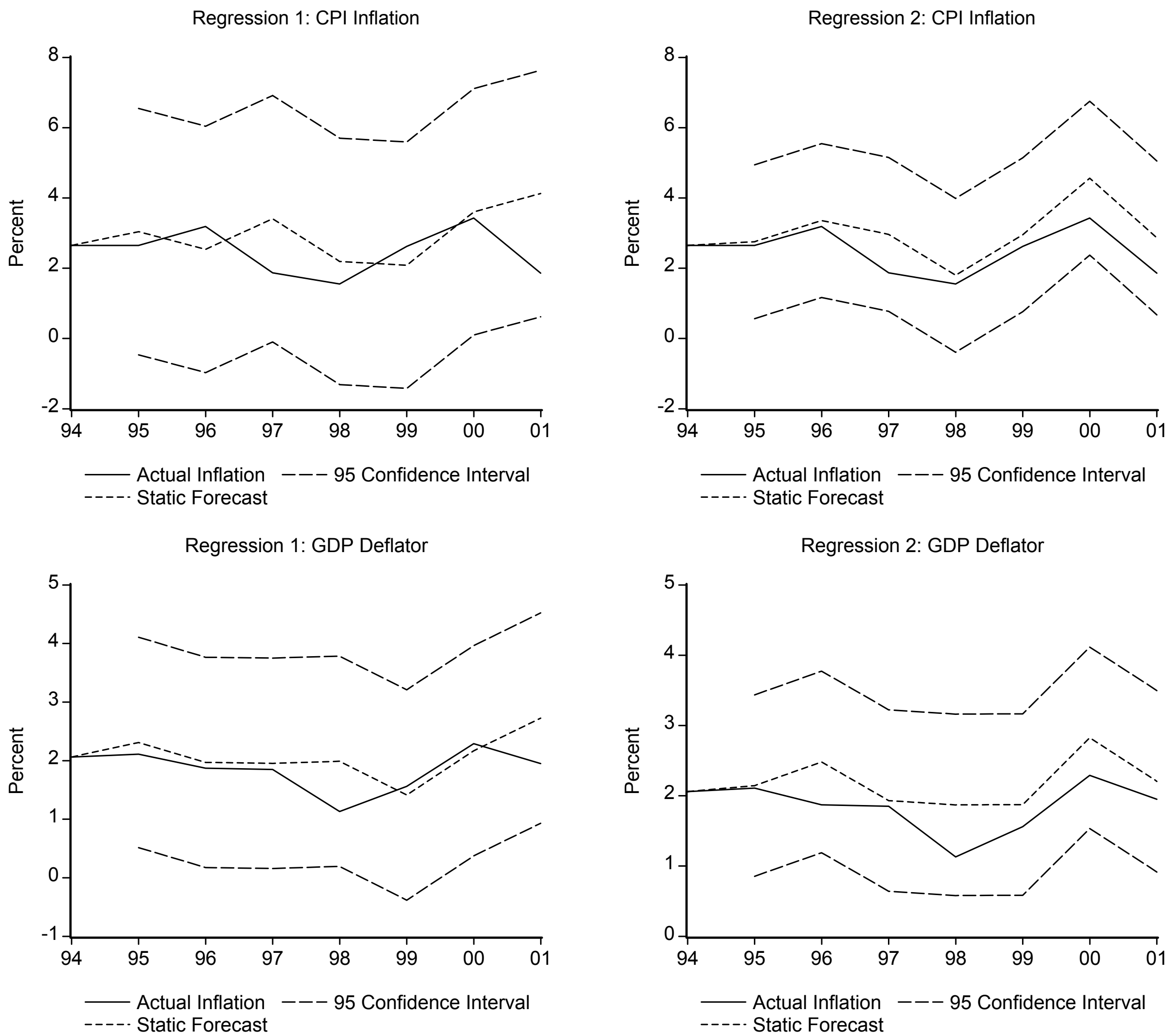


Figure 10: Canadian Productivity minus Wage Aspirations

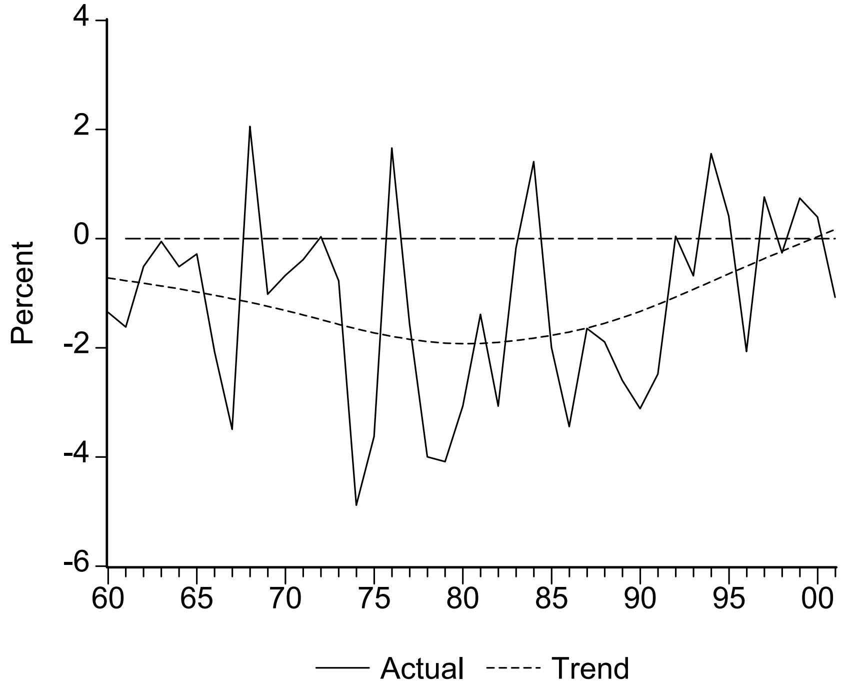


Figure 11: United States Productivity minus Wage Aspirations

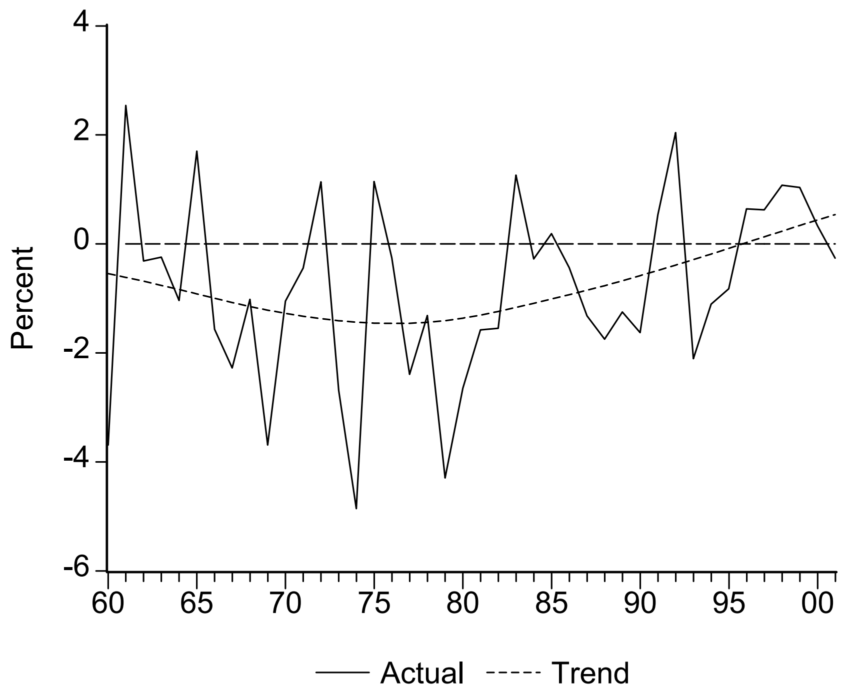


Figure 12: Time-Varying NAIRUs