Productivity growth and prices in Canada: What can we learn from the U. S. Experience?

Tiff Macklem and James Yetman
Research Department
Bank of Canada

November 2000
revised January 2001

Research Department, Bank of Canada
234 Wellington Street, Ottawa, Ontario, K1A 0G9, Canada
Phone: (613) 782-8473; (613) 782-7672
Fax: (613) 782-7163
Email: TMacklem@bank-banque-canada.ca;
JYetman@bank-banque-canada.ca

This paper was prepared for the B.I.S. conference on "Empirical Studies of Structural Change and Inflation". The views expressed here are the authors. No responsibility for them should be attributed to the Bank of Canada.

Acknowledgements

The authors thank Jennifer Glahs for providing the estimates to the Fillion and Léonard model, René Lalonde and Danielle Lecavalier for assistance with the U.S. data and estimates, Maral Kichian, David Longworth, Andrew Sharpe and participants at the B.I.S. conference on "Empirical Studies of Structural Change and Inflation" for many helpful comments, and Annie De Champlain and Geoff Wright for excellent research assistance.

Abstract

In recent years, there has been increasing discussion about the possible emergence of a new economy. In this paper we review recent developments in productivity growth and prices of final goods and services in the United States in an effort to identify early indicators of whether the Canadian economy is on a path to follow the United States to higher productivity growth. We put particular emphasis on the behaviour of prices, since monetary policy in Canada is directed towards maintaining low and stable inflation.

Although there is little evidence to date of a U.S.-style acceleration in productivity growth in Canada, we suggest that there are several reasons to be cautiously optimistic that Canada will follow the U.S. experience to some degree. We formalize one aspect of this hypothesis using estimated, expectations-augmented Phillips curves. We present evidence for the United States of changes in the relationship between prices and output that would be consistent with the emergence of the new economy, the effects of which have been largely concentrated in the provision of final goods. We then provide evidence of a similar break for Canada in 2000. However, with only two quarters of data for 2000, considerable uncertainty remains as to the timing, size, and the duration of any acceleration in productivity growth in Canada.

1. Introduction

In recent years, there has been increasing discussion about the possible emergence of a "new economy."[1] In its extreme form, proponents claim that existing economic paradigms no longer apply due to recent technological innovations, and economic growth may remain at historically high levels indefinitely without stimulating inflation. They argue that increased globalization has decreased or removed the potential for domestic firms to increase prices in the face of high demand. As a result, evidence of increased demand does not require a tightening in monetary policy.

While many economists reject this notion of the new economy, there are others who believe that recent technological innovation has substantially reduced the cost of doing business, either directly or by raising the productivity of workers, and this has had the effect of allowing higher trend growth in output without stimulating inflation.

One early source of evidence on the new economy came from the information technology sector itself: one need look no further than the market for personal computers to observe increasing demand being met with higher quality products at a decreasing price over time. If such price declines were contained within the IT sector alone, the new economy would have few implications for monetary policy, as relative price changes on computers and related goods would have relatively minor direct effects on the broader price indices that are the focus of monetary policy. In recent years, however, there is some evidence for the United States that the effects of the new economy have spread so that the behaviour of inflation for the economy as a whole is significantly

1. See Nakamura (1999), Sharpe (2000), Stiroh (1999) or Triplett (1999) and the references contained therein for discussions of the emergence of a "new economy."

affected. To date, however, other economies have not shared in this experience to an important degree.

In this paper we review developments in productivity growth and the prices of final goods and services in the United States in the 1990s in an effort to identify early indicators of whether the Canadian economy is on a path to follow the United States to higher productivity growth. We put particular emphasis on the behaviour of prices. This reflects both the view that prices are the dual to productivity growth in the behaviour of prices, and the recognition that monetary policy is directed towards maintaining low and stable inflation. Thus, for monetary policy, a key issue is how the new economy is affecting the behaviour of inflation.

The paper proceeds in two sections. The first of these, section 2, compares the behaviour of productivity and prices in the United States and Canada in the 1990s and considers alternative views of the new economy and their implications for Canada. In section 3 we attempt to formalize one aspect of the story that we develop in section 2, namely the evidence of a structural break in the behaviour of inflation. In particular, we consider the effects of the new economy on inflation in the United States, and examine the extent to which the recent behaviour of inflation in Canada shows a similar pattern to developments in the United States with a lag.

2. Productivity growth and prices in the United States and Canada

2.1 Some stylized facts

The performance of the US economy over the past several years has been remarkable. From 1995 to 1999, growth in real output in the United States has averaged about 4 per cent and inflation has remained low – indeed, until recently, it was declining. This has been accompanied by a marked pick-up in labour productivity growth that has restrained costs. Output per person-hour in the business sector grew at an average rate of about 2.5 per cent from 1995 to 1999, compared to about 1.4 per cent from 1973 to 1995. In other words, labour productivity growth is about one percentage point higher in the recent period.

Canada, however, has not experienced such an acceleration in productivity growth. Output growth per person-hour averaged just below 1 per cent growth from 1995 to 1999, which is slightly less than the average rate of growth from 1973 to 1995.

These very different experiences are highlighted in Figure 1 which compares output-per-person-hour in the United States and Canada since 1993. To smooth out high-frequency fluctuations, the data are annual; the dotted lines for 2000 are the average of the first two quarters of 2000 relative to the first two quarters of 1999.[2]As shown, labour productivity in the United States moved above its historical average in 1996, and has continued to accelerate, moving above 4 per cent in the first half of 2000. In contrast, labour productivity growth in Canada has fluctuated between about 0 and 2.5 per cent over the same period, with no obvious change in trend.

2. Canada-U.S. comparisons, as with any international comparison of productivity performance, are plagued by differences between the data definitions and the methodologies used by the different national statistical agencies. In particular, the treatment of software as investment in the United States but not in Canada increases measured U.S. productivity growth relative to Canada's. However, with the continued widening of the Canada-U.S. productivity gap, it has become clear that the gap cannot be dismissed as a figment of measurement.

Figure 2 points out that what is remarkable about the U.S. experience in the 1990s is not the rise in productivity growth, but its timing. The typical cyclical pattern is for productivity growth to rebound sharply early in a recovery (e.g., 1976, 1983, and 1992), and then to weaken as the expansion matures (e.g., 1977-80, 1987-1990). In the most recent U.S. expansion, productivity growth has increased late in the cycle and continued to accelerate.

With higher productivity growth, output growth also increased late in the expansion, but less than productivity growth. The result, until recently, has been falling inflation. As shown in Figure 3, underlying inflation of final goods and services in the United States (measured as the CPI excluding food, energy, and tobacco) began to drift down starting in about 1996—the same year productivity growth began to pick up.

The Figure also points out that the decline in underlying inflation is almost entirely due to final goods prices. While the rate of increase in the prices of services has remained relatively stable at about 3 per cent since 1996, the rate of change of final goods prices has fallen by more than 4 percentage points, from about 1.5 per cent at the start of 1996 to less than -2.5 per cent mid-1999. Historically, goods prices have increased less rapidly than services prices because of the higher trend productivity growth in the goods sector. There are also a variety of factors that affect relative goods and services prices. In particular, the appreciation of the U.S. dollar has had a larger effect on goods prices than on services prices. Nonetheless, the dramatic fall in the price of final goods relative to final services suggests that it is in the provision of final goods that the new economy is having its main impact.

There are a number of possible reasons why this might be the case. If the new economy is fundamentally about globalization, the lower level of competition in the provision of final services across national boundaries relative to final goods could explain the divergence in goods and serv-

ices prices. Alternatively it may be that recent innovations have been concentrated in areas that affect final goods prices. This includes the direct effects of price declines in new economy goods, like consumer electronics, as well as indirect effects of cost reductions in intermediate services that are important inputs into final goods (but not final services), such as wholesale and retail trade. Another possibility is that, independent of the form that the new economy takes, for many services it is difficult to separate changes in the quality and quantity of the services provided from changes in the price of those services. Therefore it is possible that evidence of the new economy would first appear in published data for the goods sector.

Turning to Canada, the picture is very different. As Figure 4 makes clear, productivity growth in the recent cycle looks much like in previous cycles. Following a marked cyclical rebound immediately following the 1991 recession, productivity growth since then has shown no trend increase. Underlying inflation has also shown no trend movement since the mid-1990s. As shown in Figure 5, the year-over-year rate of increase in the CPI excluding food, energy, tobacco and alcohol has remained relatively stable at about 1.5 per cent since 1996.[3] Perhaps more significantly, there is no obvious trend in final goods prices relative to final services prices in the 1990s. As in the U.S., the rate of increase of goods prices has been systematically below that of services prices, but in marked contrast to the U.S., goods and services prices have moved up and down together. The very recent period starting in mid-1999 is the exception—a point we will return to below.

3. The Bank of Canada's official measure of core inflation is the CPI excluding food, energy and the effects of indirect taxes. We use the alternative shown in Figure 5 because separate series for goods and services adjusted for the effects of indirect taxes are not available.

2.2 Is Canada following the United States to higher productivity growth?

To speculate intelligently on this question first requires a clear understanding of the resurgence in U.S. productivity growth. This has been a very active area of research, as well as debate, and we make no attempt to summarize it systematically. Rather we focus on a few issues that are particularly relevant to Canada.

The rise in productivity growth in the United States lagged an acceleration in business spending on machinery and equipment by about 4 years. Figure 6 plots investment in machinery and equipment as a share of GDP, and starting in 1992 there is a very obvious trend increase in this ratio that shows no signs of abating.

Two reasons are typically cited for the increase in business investment in machinery and equipment. First, investment has been spurred in the United States by high levels of economic activity. With firms pushing up against capacity limits and facing a tight labour market, there has been a strong incentive to invest to increase both capacity and labour productivity. By itself, however, this probably cannot account for the acceleration in labour productivity. As discussed above in the context of Figure 2, the typical cyclical pattern is for the growth of labour productivity to decline as the economy reaches high levels of economic activity late in the cycle. This points to a second factor, namely the acceleration in the rate of decline of computer prices since 1995 and the associated increase in investment in computers, or new information and communication technologies more generally.

While there is a considerable consensus that investment in computers has contributed to the acceleration in productivity growth, there is more debate about how it has done so. Gordon (2000) argues that the main source of higher trend productivity growth in the United States is improvements in the production of computers. He points out that much of the higher productivity

growth in the United States is concentrated in two sectors—electrical and electronic products, and industrial machinery—and argues that there is little evidence that the use of computers has raised productivity in other sectors. Other research, however, has found a significant role for the use of computers. Oliner and Sichel (2000), Whelan (2000), and Jorgenson and Stiroh (2000) all find that while the production of computers is an important factor, the use of computers is more important.

The nature of the role of computers in the U.S. productivity growth resurgence is important for Canada because the computer-producing sector in Canada is considerably smaller than in the United States. Thus if, as Gordon argues, most of the gains in the United States have come from the production of computers, the prospects for Canada to experience a U.S.-style acceleration in productivity growth are limited. If, on the other hand, it is the use of computers, Canada is well positioned to benefit from the diffusion of information and communication technologies across a broad range of industries.

Looking at the U.S. experience, there are several reasons to be optimistic that productivity growth will accelerate in Canada. First, starting in about 1996 business investment in machinery and equipment in Canada accelerated, leading to a rise in machinery and equipment as a share of GDP (Figure 6). In the United States, productivity growth increased about four years after investment in machinery and equipment began increasing as a share of GDP. If Canada were to experience a similar lag, this implies productivity growth should start to accelerate in 2000. Coincidentally, productivity growth has moved up in the first half of 2000, though it is clearly much too early to identify this movement as the start of a new trend.

Second, underlying inflation has been surprisingly weak. As shown in Figure 5, the year-over-year rate of increase of the CPI excluding good, energy, tobacco and alcohol has drifted

down slightly since mid-1999 against a background of particularly strong output growth.[4] More significantly perhaps, the rate of increase in final goods prices has decelerated sharply since mid-1999 relative to the rate of increase in final services prices. Goods prices in Canada, as in the United States, are now falling on a year-over-year basis. Notice also that the lags line up roughly with the U.S. experience, with surprises in final goods inflation in Canada following the acceleration in investment by about 4 years.

Third, the Canadian economy is now operating at a high level of activity with some signs that capacity pressures are emerging.

Fourth, in the 1990s Canadian firms went through a more intense period of restructuring (Kwan (2000)) as did the public sector. As markets tighten, the productivity gains from these changes may become more evident.

These signals all provide room for optimism. Needless-to-say, considerable uncertainty remains as to the timing, size, and the duration of any acceleration in productivity growth.

3. Structural change in the behaviour of inflation

In this section we put the focus squarely on prices and consider the evidence of structural change in the U.S. economy based on Phillips curves for underlying inflation and its goods and services components. We then turn to Canada and examine whether there is any evidence of similar structural changes in the behaviour of final prices in this country that lags the experience in the United States. Relative to the graphical analysis in Section 2, Phillips curves have the attraction that they control for a variety of factors that affect prices. Structural change– or

4. A similar pattern is present in the official measure of core inflation – the CPI excluding food, energy and the effects of indirect taxes.

evidence of the new economy– only emerges if these other factors cannot explain the observed behaviour. Estimated Phillips curves also have the attraction that they allow us to bring standard statistical techniques to bear on the issues, from which we can make probabilistic statements.

Our main tool is the expectations augmented Phillips curve. In its simplest form, it is given by

$$\pi_t = \pi_t^e + \beta \tilde{y}_{t-j} + \varepsilon_t, \tag{1}$$

where π_t is inflation, π_t^e is a measure of inflation expectations which will be proxied below by lagged inflation and $\tilde{y}_{t-j}$ is a measure of the output gap or labour gap, lagged j quarters. For each of the definitions of the new economy described in the introduction above, estimates of the Phillips curve relationship would be fundamentally changed. For example, if increased global competition reduced the ability of domestic companies to respond to excess demand by raising prices, inflation shocks (ε_t) would be persistently negative. Alternatively, if the new economy resulted in an increase in trend productivity growth, measures of potential output or the NAIRU based on extrapolating historical trends would understate the true value. Either way, it would appear that there was a change in the Phillips curve relationship. Here we will investigate evidence of such a break, first using a Phillips curve model of the U. S. economy, and then with a model of the Canadian economy.

We examine the relationship between output and inflation for the United States using a simple Phillips curve similar to that found in Gordon (1997), Brayton, Roberts, and Williams (1999), and Crary (2000). This takes the form

$$\pi_t = A(L)(\pi_{t-1}) + \beta \tilde{y}_t + B(L)(\pi_{t-1}^{rel}) + \delta \pi_t^{fe} + \varepsilon_t \tag{2}$$

where π_t is the growth rate in the all items CPI, $\tilde{y}_t$ is a measure of the labour gap, where for simplicity, the NAIRU is assumed to be constant and equal to 6.18 per cent,[5] π_{t-1}^{rel} is the rate of change in the relative price of imports to the total CPI, and π_t^{fe} is the rate of change in the relative price of food and energy to the total CPI. Twenty-four lags of inflation are included in $A(L)$, and parsimony is achieved through the use of successive four-quarter averages as in Gordon (1997), so that only six coefficients must be estimated. Further, the sum of these coefficients is constrained to equal one.[6] Four lags on the relative inflation rate of imports are included.

The model was estimated over the 1975:1-1995:4 period, commencing shortly after the Nixon-era price controls and ending before evidence started to emerge of an apparent new economy in the United States. Dynamic out-of-sample forecasts were then constructed to 2000:2. Estimated parameters are given in Table 1, while the forecasts, together with bootstrap-based confidence bands, are given in Figure 7.[7]

From the dynamic forecasts, we see that realised inflation is only a little below the dynamic forecast for most of the period, although it crosses the 75 per cent confidence level near the end of the sample. At this degree of aggregation, there is thus limited evidence of a change in the relationship between output and prices that is consistent with the new economy.

The estimation was then repeated, but with inflation for final goods (g) and final services (s) considered separately, as follows:

$$\pi_t^i = A^i(L)(\pi_{t-1}^i) + \beta^i \tilde{y}_t + B^i(L)(\pi_{t-1}^{reli}) + \delta^i \pi_t^{fei} + \varepsilon_t^i \qquad (3)$$

5. Crary (2000) estimates a Phillips curve using a wide variety of different assumptions about the NAIRU, including this one, and obtains qualitatively similar results for them all.

6. Crary (2000) and Brayton *et al* (1999) also impose this restriction.

7. Note that only the lagged inflation terms are simulated out-of-sample in the construction of these confidence bands. All other independent variables are assumed to be known.

for $i \in (g, s)$. Notice that the rate of change in the price of imports is now measured relative to the inflation rate of component i, as is the rate of change in the price of food and energy. Also the relative inflation rate of food and energy was not significant in the services equation so, in the results that follow, $\delta^s = 0$.

The equations for both sectors can be estimated using Seemingly Unrelated Regression Estimation, taking advantage of the fact that inflation shocks will be correlated across sectors. Again, estimation is conducted using data from 1975:1 to 1995:4. Estimates are given in Table 2. Fitted values, along with dynamic out-of-sample forecasts and bootstrapped confidence bands to 2000:2, are given in Figure 8 for goods and Figure 9 for services.

The out-of-sample forecasts reveal that realised inflation is very close to its dynamic forecast for the services sector, but well below its dynamic forecast in the goods sector. As shown, the realised rate of change of goods prices has been largely below the 90 per cent confidence band since mid-1999. This implies that, from a standard estimated Phillip's curve for the U.S. economy, evidence of a new economy is largely concentrated in the goods sector. Note that we also considered an estimated Phillips curve for the U.S. economy incorporating the output gap, based on the Congressional Budget Office's measure of potential output projected forward from 1995:4 using its historical trend. Evidence of the new economy obtained using this measure was qualitatively very similar to that presented here, although less statistically significant.

Other robustness checks included the choice of the relative price of imports measure. The results for the goods sector are very robust to to this choice. For example, if we exclude petroleum and computers from our measure of import prices as in Brayton et al (1999),[8] the out-of-sample

8. Brayton et al (1999) also exclude semiconductors using an unpublished series. Other measures of import prices examined here included import prices by sector (goods versus services).

forecasts that results are given in Figure 10, and are qualitatively similar to those presented previously, with similar levels of statistical significance.

In contrast, the results for the estimated Phillips curve of services inflation were less robust. Examining the same alternative measure as above, the out-of-sample forecasts are given in Figure 11. Now the forecasts increasingly diverge from realised inflation, and reach statistically significant levels by the end of the sample. One result that remains clear, however, is evidence of a structural break in the relationship between prices and output in the goods sector for the United States.

We now examine similar relationships using estimated Phillips curves for the Canadian economy. As was argued in the previous section, if the path of events leading up to the change in inflation behaviour were similar to that for the United States, we would expect a break in the Phillips curve to have occurred very recently. We start with the Phillips curve model based on that estimated in Fillion and Léonard (1997), which is used for monitoring and short-term forecasting of inflation at the Bank of Canada.

The estimated Phillips curve is of the following form:

$$\pi_t = dummies + A(L)\pi_{t-1} + \beta\tilde{y}_{t-1} + B(L)(\Delta\pi^{imp}_{t-1}) + C(L)(\Delta ind_t) + D(L)(\Delta\pi^{oil}_{t-1}) + err_t \quad (4)$$

where π_t is the growth rate in the all items CPI less food, energy, and indirect taxes. $dummies$ is a set of intercepts combined with dummy variables to capture different inflation regimes in Canada,[9] $\tilde{y}_{t-1}$ is a measure of the output gap,[10] and $\Delta\pi^{imp}_{t-1}$ is the change in imported inflation, where π^{imp}_{t-1} is measured as the growth rate of the value of the Canadian dollar (expressed as dol-

9. These dummies also interact with the lagged inflation terms in the initial version of the model considered here.

10. The measure of potential used here is the internal Bank of Canada measure: see Butler (1996) for details of its construction.

lars Canadian per U.S. dollar) plus the rate of growth in the all items CPI less food and energy in the United States, averaged over the previous three quarters. $\Delta\pi_{t-1}^{oil}$ is the first difference of the ratio of the growth rate of the price of crude oil to the United States G.D.P deflator, and Δind_t is the first difference in the rate of indirect taxes on goods excluding food and energy.

We estimate equation (4) over the period 1970:1 to 1995:4 and, as for the U.S. model above, construct out-of-sample dynamic forecasts to 2000:2. The forecasts and realised inflation are given in Figure 12. Over the early part of the forecasting period, forecast inflation is below realised inflation, while after the middle of 1998, realised inflation lies systematically below the inflation forecast.[11]

To further examine this relationship, the same analysis was repeated with the dependent variable being the inflation rate for final goods. Since there is no readily available measure of core inflation by sector in Canada, the measure used was final goods inflation excluding food, energy, tobacco and alcohol. These latter components remove a large portion of the indirect tax changes over the sample. A dummy variable is also added in the first quarter of 1991, to take account of the introduction of the Goods and Services tax.

Realised goods inflation lies systematically below the dynamic forecasts (given in Figure 13) starting in approximately 1998. In contrast, repeating the analysis on final services inflation (Figure 14) reveals no such systematic forecast bias. The model produces only small forecast errors all the way out to the end of the forecast period. These results suggest that negative aggregate surprises in Canadian inflation since 1998 can be largely explained by price changes in final goods.

11.In a future version of this paper, we will construct bootstrapped confidence intervals around this dynamic forecast.

This analysis of the Canadian economy has assumed the same independent variables affect inflation for each sector. We will now consider generalizing this model to allow for the propagation of inflation to differ across sectors. As for the U.S. model before, we will use Seemingly Unrelated Regression Estimation to estimate both Phillips curves jointly, making use of the fact that inflation shocks are correlated across sectors.

Following a series of specification tests on the variables and lag lengths in the above Fillion and Léonard (1997) model, we arrived at an estimated Phillips curve of the form

$$\pi_t^i = \alpha^i + \delta^i D_t + A^i(L)(\pi_{t-1}^i - \delta^i D_{t-1}) + B^i(L)(\pi_{t-1}^j - \delta^j D_{t-1}) + \beta^i \tilde{y}_{t-1} + C^i(L)(\Delta\pi_{t-1}^{imp}) + E^i(L)(\Delta\pi_{t-1}^{oil}) + err_t^i \quad (5)$$

for $i \in (g, s)$, $j \in (g, s)$, $i \neq j$. D_t is a dummy variable equal to 1 in 1991:1 and 0 elsewhere to take account of the impact of the introduction of the GST. The inclusion of this dummy in the lagged inflation terms is consistent with the idea that the introduction of the GST had only a one-time effect on inflation, and did not fuel increased inflation expectations. Lags on services inflation provide little explanatory power for goods inflation so $B^g(L) = 0$. The other variables included in this equation are as described earlier.

There are now two equations, one for final goods inflation and one for final services inflation, that can both be estimated jointly, incorporating the cross-equation restriction in δ^i. The equations are estimated over the 1970:1-1995:4 period with out of sample forecasting and bootstrapped confidence bands constructed out to 2000:2. The results are given in Table 3, while graphs of the fitted values and forecasts for goods are in Figure 15, and for services in Figure 16.

Realised inflation in final goods has been consistently lower than forecast for most of the forecast period, but until the end of 1999 it was largely within the 90 per cent confidence interval. In the first two quarters of 2000, however, realised goods inflation has fallen sharply, pushing it

below the 90 per cent confidence interval. Very similar results can also be obtained if one considers dynamic out-of-sample forecasts starting at a later date. In contrast, while realised inflation in the final services sector is slightly below its forecast on average since about 1998, the error is always within the 90 per cent confidence band and in 2000 the forecast error has virtually disappeared. As with the earlier Canadian model, this evidence is suggestive of a structural break in the relationship between output and prices that is concentrated in final goods.

4. Conclusions

The possible emergence of the "new economy" has important implications for the conduct of monetary policy, since it implies that economic growth above historically sustainable levels does not necessarily imply rising inflation, other things equal.

In this paper we have reviewed recent developments in productivity growth and prices in an effort to identify early indicators of whether the Canadian economy is following the United States to higher productivity growth. There are several reasons to be cautiously optimistic that Canada will follow the United States to higher productivity growth with a lag of approximately 4 years, although the acceleration may be less pronounced than in the United States. According to this view, we should now be starting to observe signs of the emergence of a new economy in terms of increased productivity growth and lower-than-expected inflation, as we have in 2000.

We then formalize one aspect of the story, namely the evidence of a structural break in the behaviour of inflation using estimated, expectations-augmented Phillips curves, first for the United States and then for Canada. We presented evidence that, in the United States, changes in the relationship between prices and output that would be consistent with the emergence of the new economy have been largely concentrated in final goods.

We also identify evidence of a similar break in the relationship between output and prices for final goods in the Canadian economy, but it is concentrated in the two most recent quarters. Clearly with only these two observations fitting the new economy hypothesis as outlined here, we are in need of further observations to determine whether these residuals reflect a new direction for the economy or simply a short-term aberration due to some unmodelled factor or random shock.

Our econometric evidence of the emergence of a “new economy” in the United States and Canada is based on the properties of residuals. In particular, we ascribe the persistent overprediction in recent years of the U.S. Phillips curve for final goods prices to the “new economy”. And we make a similar inference with respect to the much more recent overprediction of the Canadian Phillips curve for final goods prices. While there are good reasons for the “new economy” to be the leading suspect, there are other developments that may account for at least part of this overprediction. In the United States, the changes in the way the CPI is calculated may explain as much as 0.5 percentage points of the unexplained decline in the CPI inflation. There may also be factors independent of the “new economy” that have lowered NAIRU in the latter half of the 1990s - for example, reductions in the coverage of welfare. These other factors may explain part of the overprediction of the aggregate Phillips curve in the United States, but it is less clear that they could explain the large drop in goods prices relative to services prices. Exchange rate pass-through, in contrast, does have the potential to explain this relative price change. Our estimated Phillips curves control for changes in import prices, and we considered alternative measures of import prices as a robustness check to ensure that we have adequately captured the the full effects of exchange-rate pass-through. We found that the results for the U.S. Phillips curve for final goods prices are robust to alternative measures, while those for final services are less so.

More broadly, our analysis points towards a number of paths for future research. It would be interesting to apply our research to other countries, such as the United Kingdom, that have experienced strong investment in machinery and equipment together with declining final goods prices, but little acceleration to date in labour productivity growth. Another priority is to better understand why evidence of structural change is concentrated in the behaviour of final goods prices. Does this largely reflect difficulties in the measurement of quality improvements of services, productivity improvements in the production of final goods, or productivity improvements in intermediate services that are inputs into final goods production? There is some evidence to support all three hypotheses, but further work is required before we can draw any conclusions.

References

1. Brayton, Flint, John M. Roberts, and John C. Williams (1999) *What's Happened to the Phillip's Curve?* Federal Reserve Board of Governors, Manuscript.

2. Butler, Leo (1996) *A Semi-Structural Method to Estimate Potential Output: Combining Economic Theory with a Time-Series Filter.* Bank of Canada Technical Report #77.

3. Crary, David B. (2000) *Labor Quality, Natural Unemployment, and U.S. Inflation.* The Quarterly Review of Economics and Finance, #40: 325-336.

4. Fillion, Jean-François and André Léonard (1997) *La coube Phillips au Canada: un examen de quelques hypothèses.* Bank of Canada Working Paper #97-3.

5. Gordon, Robert J. (2000) *Does the "New Economy" measure up to the great inventions of the past?* NBER Working Paper #7833.

6. Gordon, Robert J. (1997) *The Time-Varying NAIRU and its Implications for Economic Policy.* Journal of Economic Perspectives, #11(1): 11-32.

7. Jorgenson, Dale and K.J. Stiroh (2000) *Raising the Speed Limit: U.S. Economic Growth in the Information Age.* Brookings Papers on Economic Activity, #1: 125-211.

8. Kwan, Carolyn C. (2000) *Restructuring in the Canadian Economy: A Survey of Firms.* Bank of Canada Review, Summer: 15-26.

9. Nakamura, Leonard (1999) *Intangibles: What put the New in the New Economy?* Federal Reserve Bank of Philadelphia Business Review, July/August: 3-16.

10. Oliner, Stephen D. and Daniel E. Sichel (2000) *The Resurgence of Growth in the late 1990s: Is Information Technology the Story?* Forthcoming, Journal of Economic Perspectives and Federal Reserve Board of Governors, Finance and Economics Discussion Series #2000-20.

11. Sharpe, Andrew (2000) *Trend Productivity and the New Economy.* Centre for the Study of Living Standards, Ottawa.

12. Stiroh, Kevin (1999) *Is there a New Economy?* Challenge, #42(4): 82-101.

13. Triplett, Jack E. (1999) *Economic Statistics, the New Economy, and the Productivity Slow-down.* Business Economics, #34(2): 13-17.

14. Whelan, Karl (2000) *Computers, Obsolescence, and Productivity.* Federal Reserve Board of Governors, Finance and Economics Discussion Series #2000-6.

TABLE 1. U.S. Phillips curve[a]

Dependent Variable: π_t

Estimation: 1975:1-1995:4

Regressor	Coefficient	p -value
$\bar{\pi}_{t-1,\,t-4}$	0.39	0.049*
$\bar{\pi}_{t-5,\,t-8}$	0.27	0.168
$\bar{\pi}_{t-9,\,t-12}$	0.13	0.425
$\bar{\pi}_{t-13,\,t-16}$	-0.030	0.849
$\bar{\pi}_{t-17,\,t-20}$	0.22	0.154
$\bar{\pi}_{t-21,\,t-24}$	0.011	0.910
$\tilde{y}_t$	0.65	0.004**
π^{rel}_{t-1}	0.083	0.026*
π^{rel}_{t-2}	0.055	0.134
π^{rel}_{t-3}	-0.021	0.569
π^{rel}_{t-4}	0.011	0.748
π^{fe}_t	0.32	0.000**
$\bar{R}^2$	0.71	
S.E.E.	3.44	
S.S.R.	237.0	
D.W.	1.86	

a. * and ** indicate significance at the 5% and 1% level respectively.

TABLE 2. U.S. Phillips curve by Sector

Dependent Variable: π_t^g Dependent Variable: π_t^s

Estimation: 1975:1-1995:4 Estimation: 1975:1-1995:4

Regressor	Coefficient	*p* -value	Regressor	Coefficient	*p* -value
$\bar{\pi}^g_{t-1,\,t-4}$	0.28	0.097	$\bar{\pi}^s_{t-1,\,t-4}$	0.40	0.014*
$\bar{\pi}^g_{t-5,\,t-8}$	0.22	0.168	$\bar{\pi}^s_{t-5,\,t-8}$	0.43	0.013*
$\bar{\pi}^g_{t-9,\,t-12}$	0.16	0.284	$\bar{\pi}^s_{t-9,\,t-12}$	-0.053	0.746
$\bar{\pi}^g_{t-13,\,t-16}$	0.17	0.227	$\bar{\pi}^s_{t-13,\,t-16}$	0.042	0.775
$\bar{\pi}^g_{t-17,\,t-20}$	0.14	0.331	$\bar{\pi}^s_{t-17,\,t-20}$	0.25	0.054
$\bar{\pi}^g_{t-21,\,t-24}$	0.030	0.780	$\bar{\pi}^s_{t-21,\,t-24}$	-0.071	0.538
$\tilde{y}_t$	1.10	0.000**	$\tilde{y}_t$	0.66	0.014*
π^{relg}_{t-1}	-0.002	0.974	π^{rels}_{t-1}	0.15	0.000**
π^{relg}_{t-2}	0.080	0.088	π^{rels}_{t-2}	0.041	0.312
π^{relg}_{t-3}	-0.095	0.048*	π^{rels}_{t-3}	0.018	0.653
π^{relg}_{t-4}	0.093	0.034*	π^{rels}_{t-4}	-0.021	0.596
π^{feg}_t	0.82	0.000**	S.S.R.	494.6	
S.S.R.	441.2		D.W.	1.94	
D.W.	1.84				

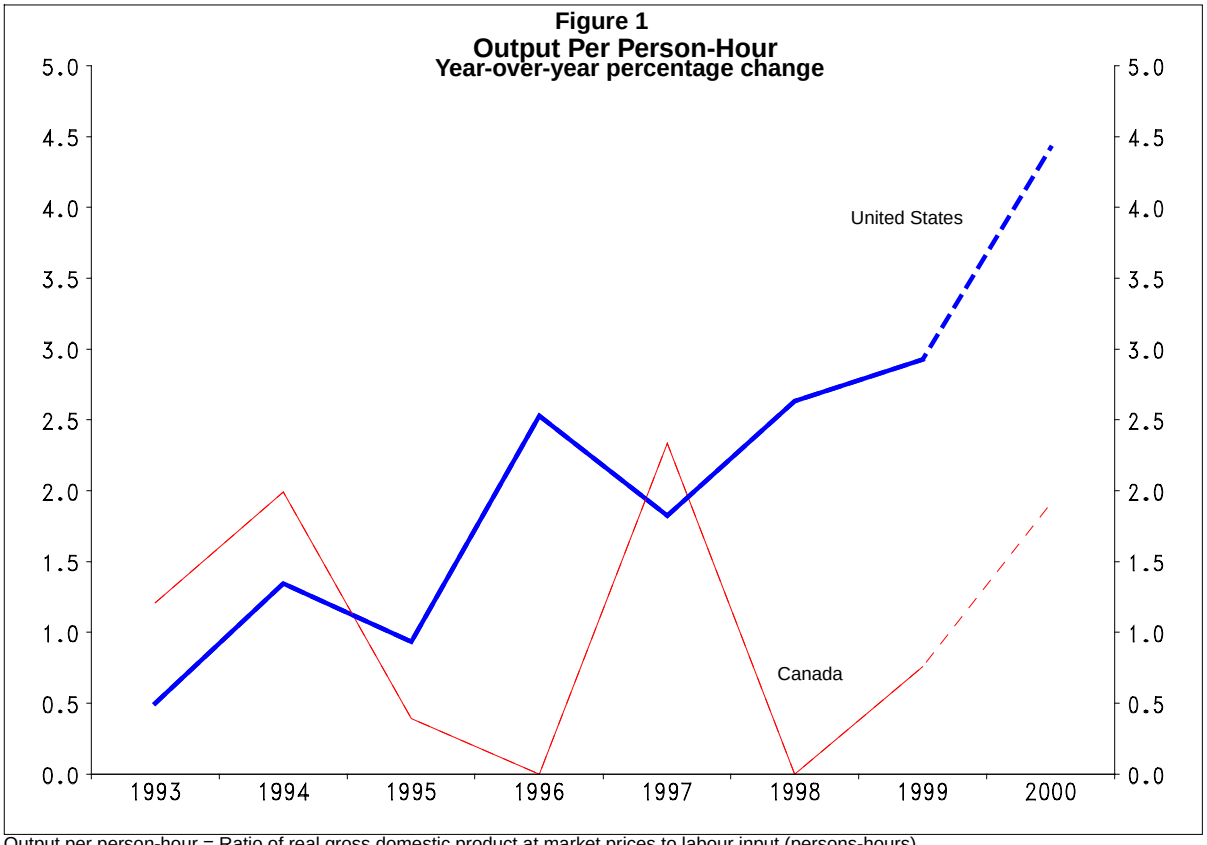
TABLE 3. Canadian Phillips curve by Sector

Dependent Variable: π_t^g Dependent Variable: π_t^s

Estimation: 1975:1-1995:4 Estimation: 1975:1-1995:4

Regressor	Coefficient	p -value	Regressor	Coefficient	p -value
Constant	0.82	0.032*	Constant	0.75	0.003**
$\pi_{t-1}^g - \delta^g D_{t-1}$	0.47	0.000**	$\pi_{t-1}^s - \delta^s D_{t-1}$	0.74	0.000**
$\pi_{t-2}^g - \delta^g D_{t-2}$	-0.029	0.778	$\pi_{t-2}^s - \delta^s D_{t-2}$	-0.18	0.090
$\pi_{t-3}^g - \delta^g D_{t-3}$	0.26	0.015*	$\pi_{t-3}^s - \delta^s D_{t-3}$	0.40	0.000**
$\pi_{t-4}^g - \delta^g D_{t-4}$	0.14	0.161	$\pi_{t-4}^s - \delta^s D_{t-4}$	-0.24	0.012*
$\pi_{t-5}^g - \delta^g D_{t-5}$	-0.091	0.374	$\pi_{t-5}^s - \delta^s D_{t-5}$	0.062	0.530
$\pi_{t-6}^g - \delta^g D_{t-6}$	0.11	0.225	$\pi_{t-6}^s - \delta^s D_{t-6}$	-0.13	0.088
$\tilde{y}_{t-1}$	0.21	0.014*	$\pi_{t-1}^g - \delta^g D_{t-1}$	-0.051	0.344
$\Delta\pi_{t-1}^{imp}$	0.18	0.080	$\pi_{t-2}^g - \delta^g D_{t-2}$	0.082	0.174
$\Delta\pi_{t-2}^{imp}$	0.16	0.141	$\pi_{t-3}^g - \delta^g D_{t-3}$	0.016	0.798
$\Delta\pi_{t-3}^{imp}$	0.17	0.120	$\pi_{t-4}^g - \delta^g D_{t-4}$	0.034	0.575
$\Delta\pi_{t-4}^{imp}$	0.14	0.214	$\pi_{t-5}^g - \delta^g D_{t-5}$	0.19	0.002**
$\Delta\pi_{t-5}^{imp}$	0.03	0.753	$\pi_{t-6}^g - \delta^g D_{t-6}$	0.054	0.337
$\Delta\pi_{t-6}^{imp}$	0.24	0.013*	$\tilde{y}_{t-1}$	0.19	0.001**
$\Delta\pi_{t-1}^{oil}$	0.000	0.795	$\Delta\pi_{t-1}^{imp}$	0.21	0.001**
$\Delta\pi_{t-2}^{oil}$	0.004	0.004**	$\Delta\pi_{t-2}^{imp}$	-0.094	0.148
$\Delta\pi_{t-3}^{oil}$	0.004	0.000**	$\Delta\pi_{t-3}^{imp}$	0.060	0.372
$\Delta\pi_{t-4}^{oil}$	0.004	0.001**	$\Delta\pi_{t-4}^{imp}$	0.022	0.736
D_t	9.54	0.000**	$\Delta\pi_{t-5}^{imp}$	0.19	0.001**
S.S.R.	251.3		$\Delta\pi_{t-6}^{imp}$	-0.185	0.003**
D.W.	2.05		$\Delta\pi_{t-1}^{oil}$	0.001	0.061
			$\Delta\pi_{t-2}^{oil}$	0.002	0.008**
			$\Delta\pi_{t-3}^{oil}$	-0.001	0.355
			$\Delta\pi_{t-4}^{oil}$	0.001	0.418
			D_t	8.10	0.000**
			S.S.R.	81.5	
			D.W.	2.07	

Figure 1
Output Per Person-Hour
Year-over-year percentage change



Output per person-hour = Ratio of real gross domestic product at market prices to labour input (persons-hours)
Sources: U.S. Department of Labor, Bureau of Labor Statistics, and U.S. Department of Commerce, Bureau of Economic Analysis
Statistics Canada, Aggregate Productivity Measures, and Income and Expenditure Accounts Division

Figure 2
Output Per Person-Hour and Real GDP Growth - United States
Year-over-year percentage change

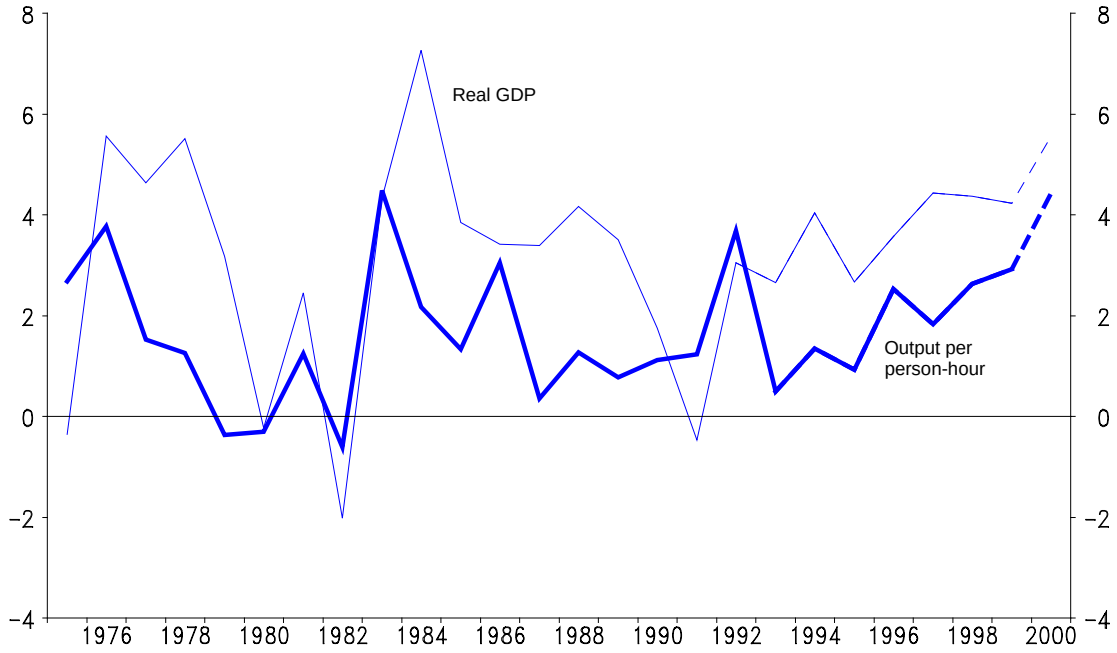
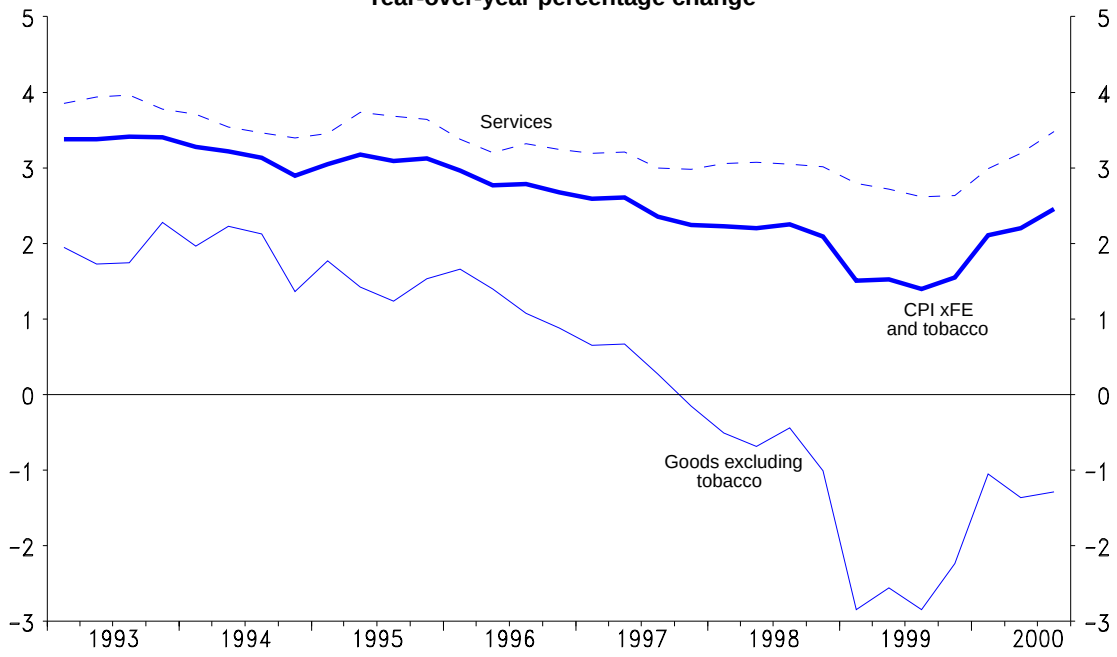


Figure 3
Rate of increase in CPI excluding food, energy and tobacco and goods and services components - United States
Year-over-year percentage change



Output per person-hour = Ratio of real gross domestic product at market prices to labour input (persons-hours)
Sources: U.S. Department of Labor, Bureau of Labor Statistics, and U.S. Department of Commerce, Bureau of Economic Analysis

Figure 4
Output Per Person-Hour Real GDP Growth - Canada
Year-over-year percentage change

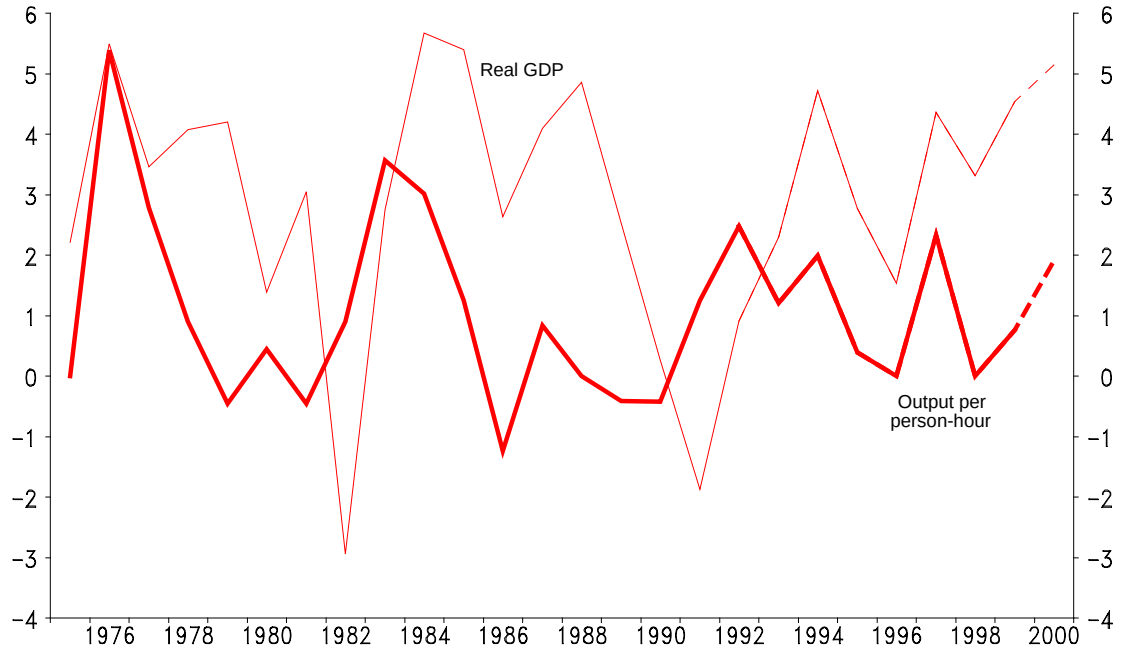
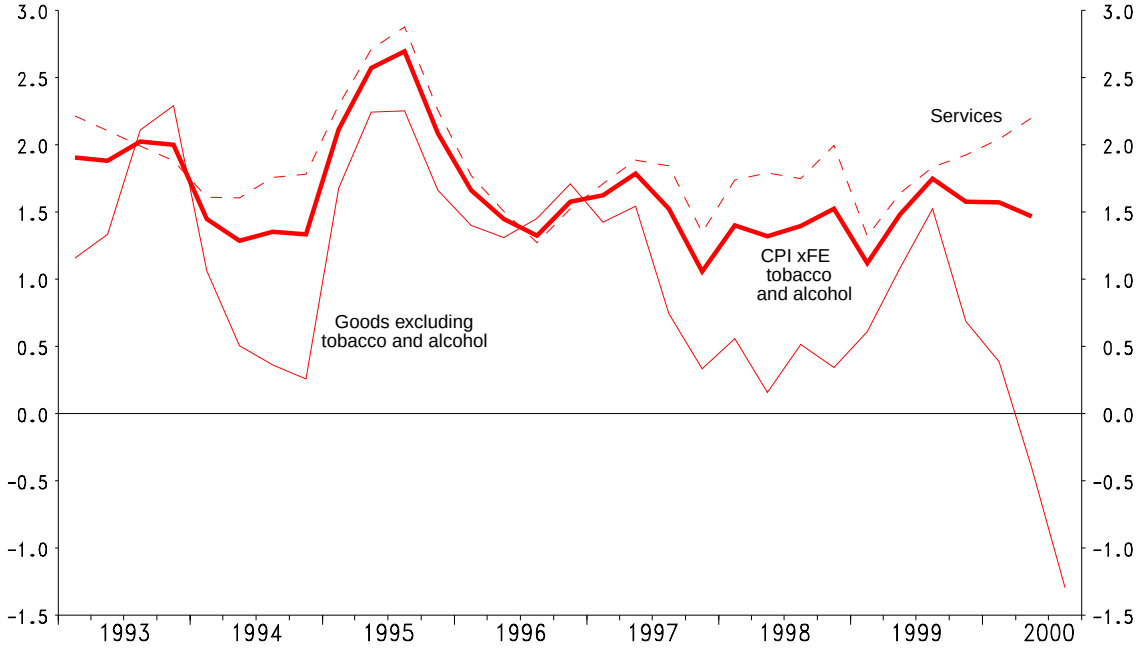
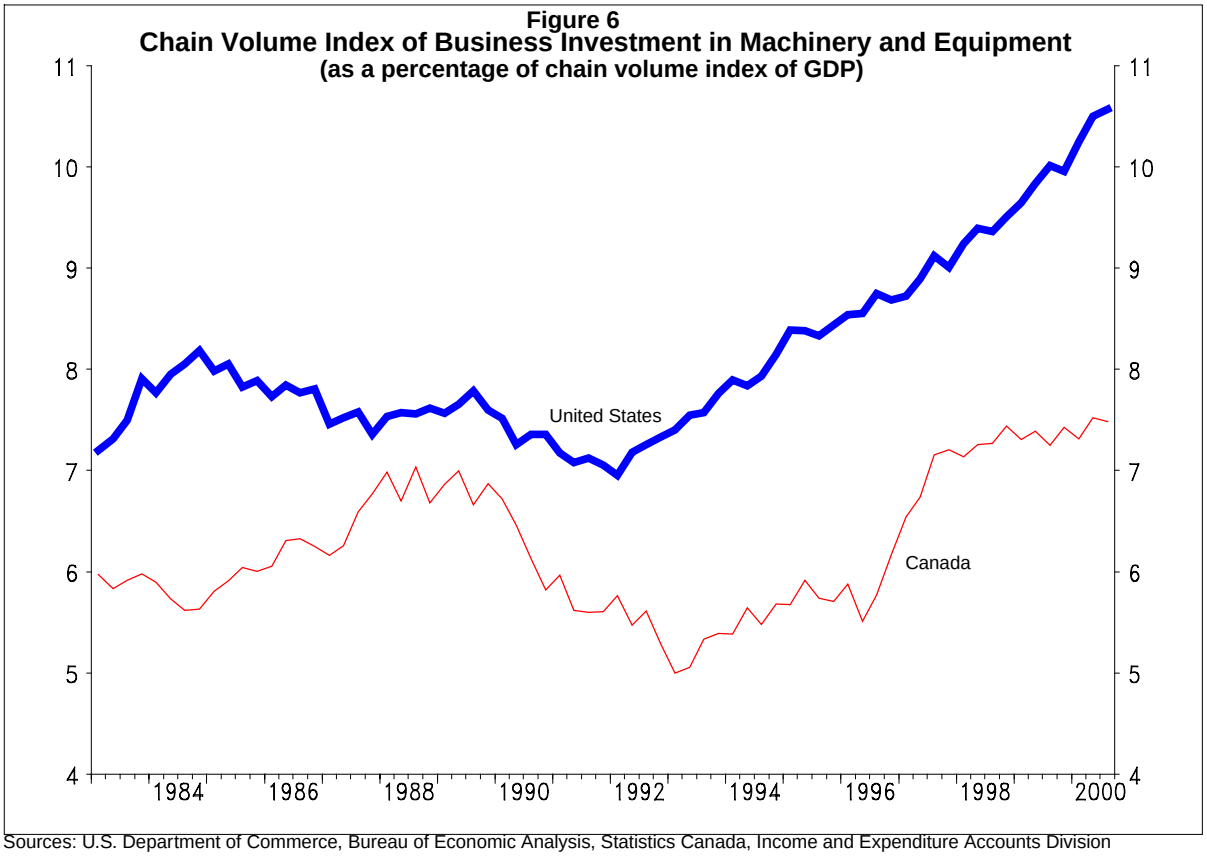


Figure 5
Rate of increase in CPI excluding food, energy, tobacco and alcohol and goods and services components - Canada
Year-over-year percentage change



Output per person-hour = Ratio of real gross domestic product at market prices to labour input (persons-hours)
Sources: Statistics Canada, Aggregate Productivity Measures, and Income and Expenditure Accounts Division

Figure 6
Chain Volume Index of Business Investment in Machinery and Equipment
(as a percentage of chain volume index of GDP)



Sources: U.S. Department of Commerce, Bureau of Economic Analysis, Statistics Canada, Income and Expenditure Accounts Division

Figure 7
Rate of Increase in CPI - United States
Quarter-over-quarter percentage change
Fitted, actual and dynamic forecast

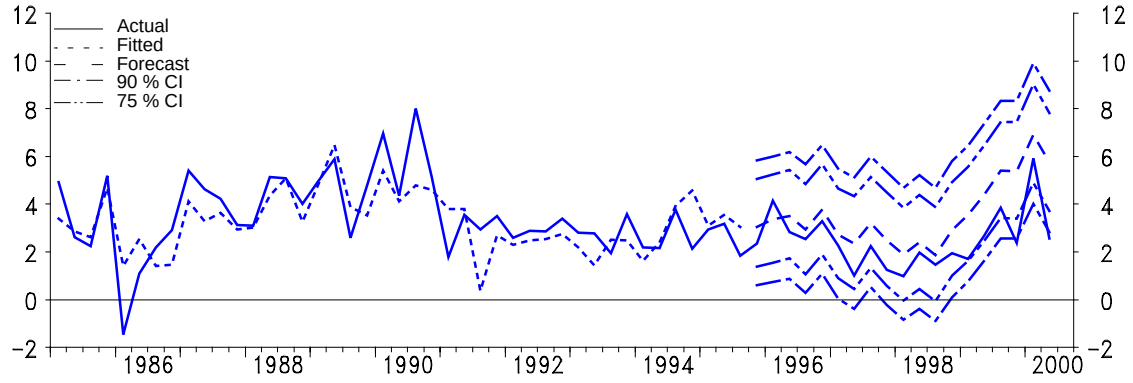


Figure 8
Rate of Increase in CPI goods components - United States
Quarter-over-quarter percentage change
Fitted, actual and dynamic forecast

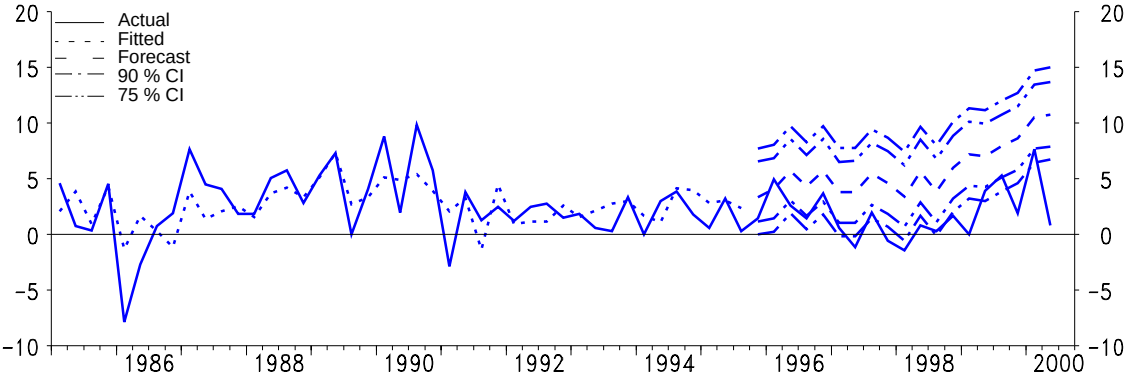


Figure 9
Rate of Increase in CPI services components - United States
Quarter-over-quarter percentage change
Fitted, actual and dynamic forecast

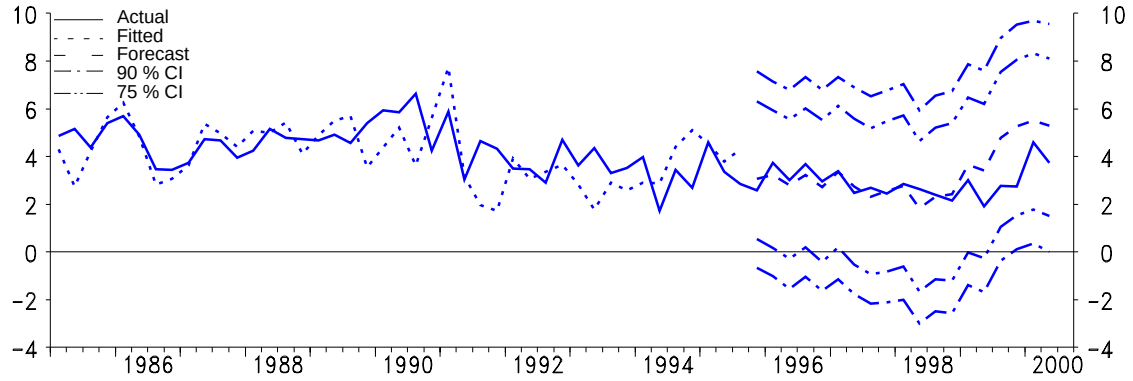


Figure 10
Rate of Increase in CPI Good Components - United States
Quarter-over-quarter percentage change
Alternative measure of imported inflation

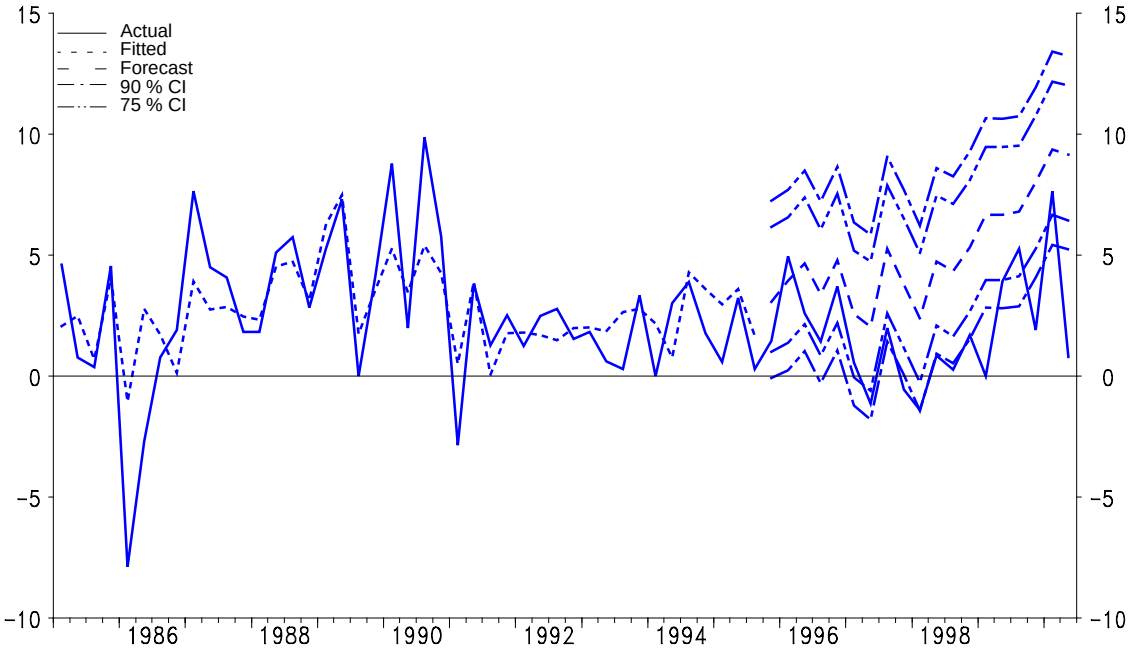


Figure 11
Rate of Increase in CPI services components - United States
Quarter-over-quarter percentage change
Alternative measures of imported inflation

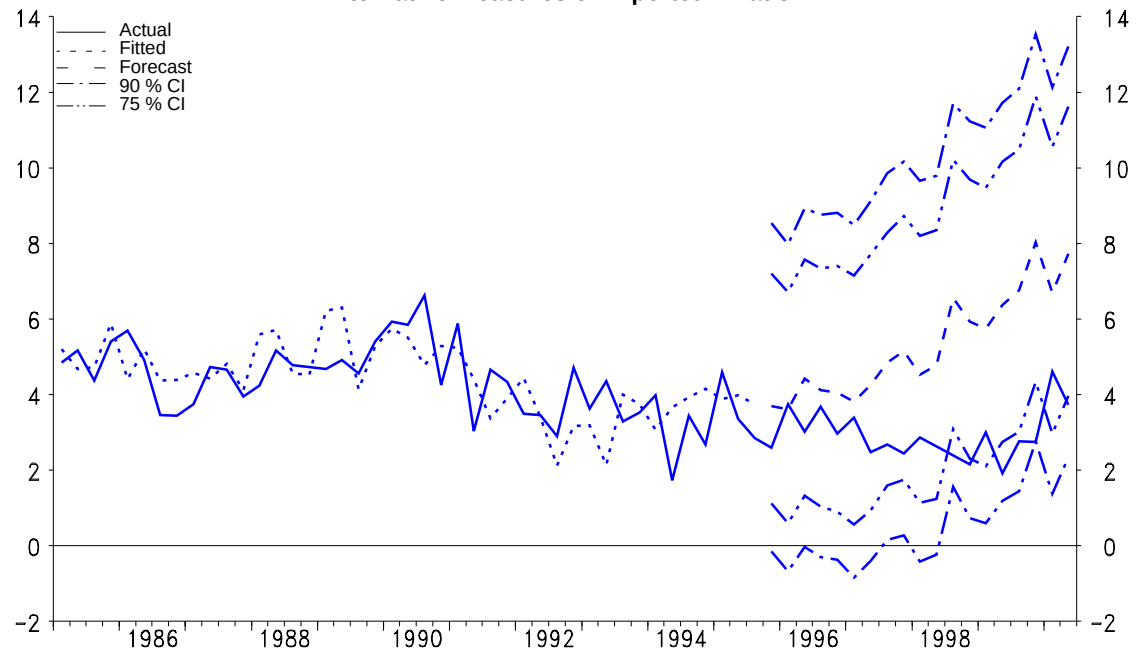


Figure 12
Rate of Increase in CPI excluding food, energy and indirect taxes - Canada
Quarter-over-quarter percentage change
Actual and dynamic forecast

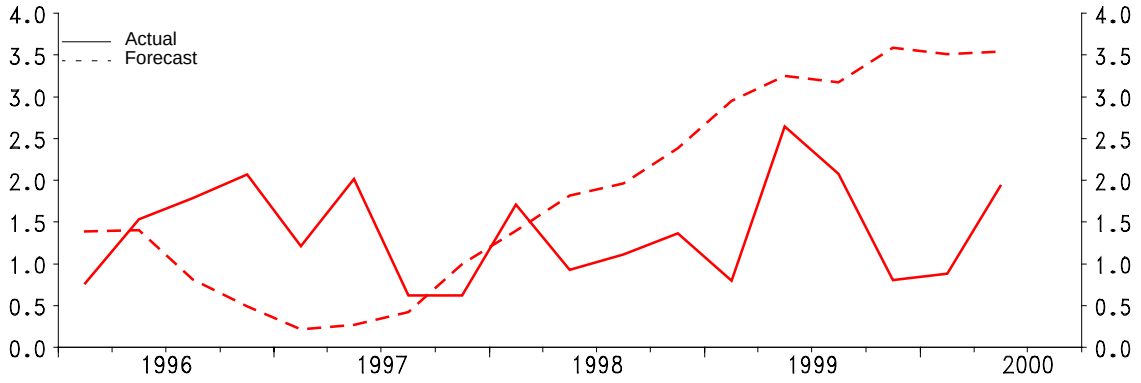


Figure 13
Rate of Increase in CPI good components excluding food, energy, alcohol and tobacco - Canada
Quarter-over-quarter percentage change
Actual and dynamic forecast

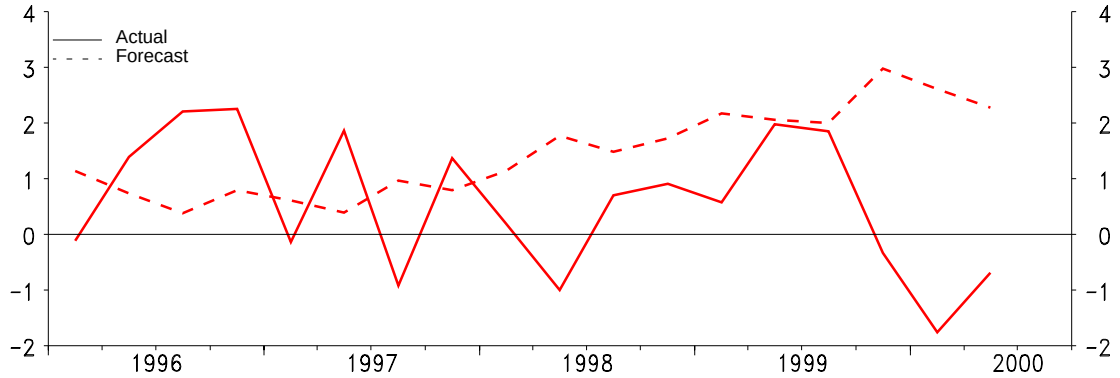


Figure 14
Rate of Increase in CPI services component - Canada
Quarter-over-quarter percentage change
Actual and dynamic forecast

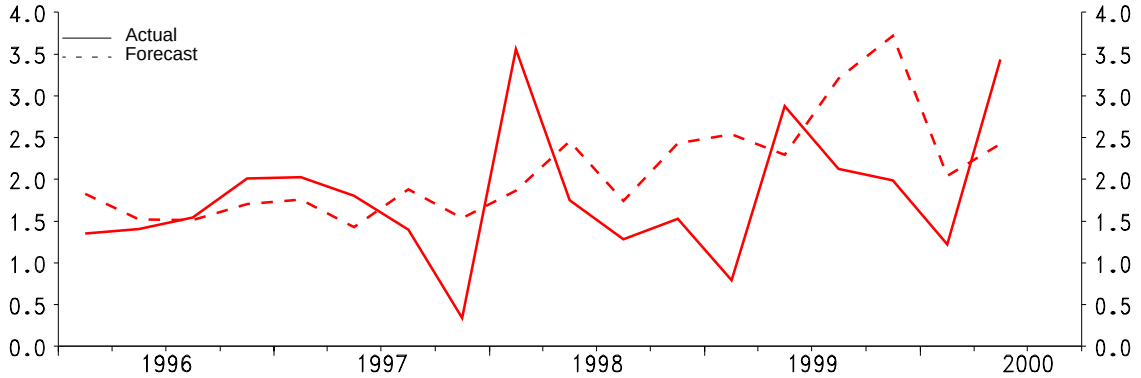


Figure 15
Rate of Increase in CPI good components excluding food, energy, alcohol and tobacco - Canada
Quarter-over-quarter percentage change
Fitted, actual and dynamic forecast

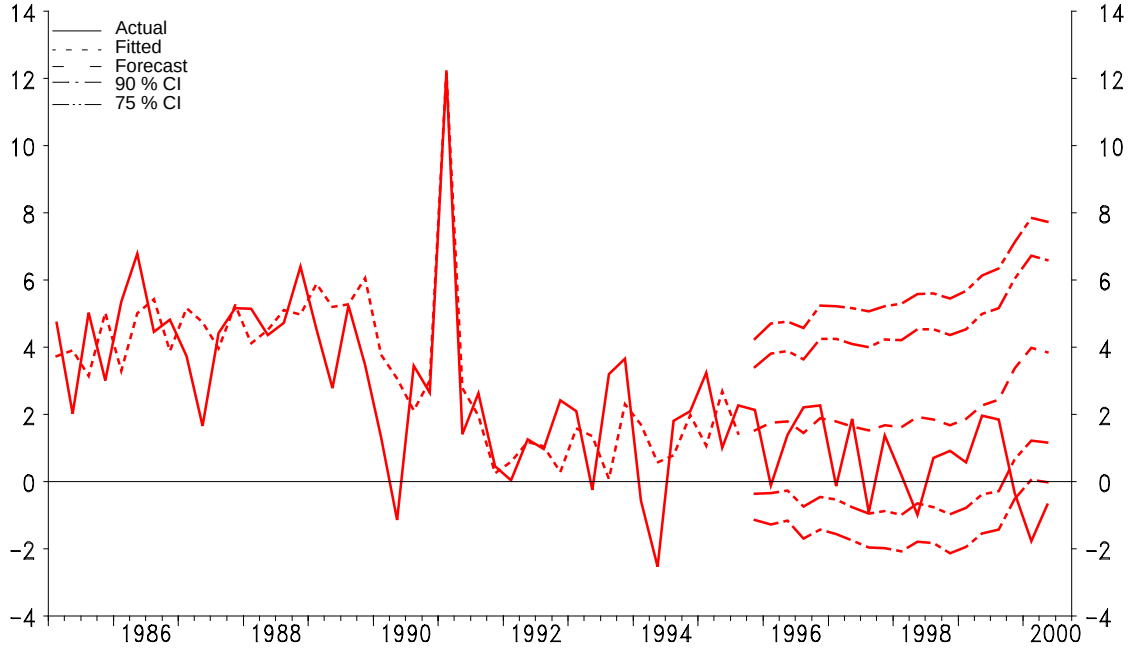


Figure 16
Rate of Increase in CPI services components - Canada
Quarter-over-quarter percentage change
Fitted, actual and dynamic forecast