Exact prediction of inflation and unemployment in Canada

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Abstract

Potential links between inflation and unemployment in Canada have been examined. No consistent Phillips curve has been found likely due to strong changes in monetary policy of the Bank of Canada. However, there were two distinct periods where linear links between inflation and unemployment could exist - before 1983 and after 1983.

A linear and lagged relationship between inflation, unemployment and labor force has been obtained for Canada. Similar relationships were reported previously for the USA, Japan, France and Austria. Changes in labor force level are simultaneously reflected in unemployment and lead inflation by two years. Therefore this generalized relationship provides a two-year ahead natural prediction of inflation based on current estimates of labor force level and unemployment rate. The goodness-of-fit for the relationship is of 0.7 for the period since 1965, i.e. including the periods of high inflation and disinflation.

Key words: inflation, unemployment, labor force, prediction, Canada
JEL Classification: E3, E6, J21

Introduction

Canada is a middle-size economy with real GDP of $815 billions in 2006, as reported by the Conference Board and Groningen Growth and Development Center (2007). This GDP level is about 9 times lower than that in the USA and 7 times larger than in Ireland – the best economic performer during the last twenty years. As a close neighbor of the USA, Canada is likely to be dependent on economic performance of the larger economy. Therefore, it is interesting and illustrative to model the evolution of inflation and unemployment in Canada using our general concept linking these two macroeconomic variables to the only driving force – the change in labor force level (Kitov, 2006ab; Kitov, 2007ab; Kitov, Dolinskaya, 2007a, Kitov, Kitov, Dolinskaya, 2007b).

Inflation in Canada is relatively well studied by the Bank of Canada and some independent researchers. In general, the Canadian inflation did not attract any specific attention related to any outstanding features. Hostland (1995) found some shifts in the Canadian inflation process with the period of low inflation from the mid-1950s to the early 1970s. He also concluded that reduced-form models are not always useful for inflation forecasts due to the presence of some important changes in the inflation process. Nelson (2005) compared the influence of monetary (and non-monetary) policy on inflation in Canada, Australia, and New Zealand. He found that similar approaches led to quit different inflation trajectories. Gosselin and Tkacz (2001) evaluated the forecasting performance of a variety of factor models for Canadian inflation. They found a possibility to construct some small-number factor models, which performed well compared to more elaborated inflation forecasting models. They also demonstrated that a model estimated using only U.S. data was helpful in predicting changes in the Canadian inflation rate. The latter observation indicates the presence of some strong links between inflation processes in Canada and the USA.

There are several papers devoted to inflation forecasting in Canada. Dib, Gammoudi, and Moran (2006) estimated out-of-sample forecasting accuracy of the New Keynesian model for Canada and found it useful for prediction at longer time horizons. Cheung and Demers (2007) evaluated the performance of static and dynamic factor models for forecasting Canadian core inflation on a quarterly basis. They found their models useful at time horizons of up to 8 quarters. Binette and Martel (2005) empirically studied the relationship between different aspects of inflation and relative price dispersion in Canada using a Markov regime-switching Phillips curve. They showed that expected inflation influences relative price dispersion.

A thorough comparative study of the Phillips curve in the USA and Canada was carried out by Fortin *et al.* (2002). They argued that the conventional Phillips curve that is vertical in the long run fails to describe simultaneous presence of low inflation and low unemployment in the USA with high unemployment and the absence of price deceleration in Canada. They recommended the Federal Reserve and the Bank of Canada "stand ready to explore the range of inflation rates between 2 and 3.5 percent in search of the lowest sustainable unemployment rate in each country".

Our approach links together inflation, unemployment and the change rate of labor force level and resolves severe empirical problems experienced by conventional economic concepts, including the New Keynesian Phillips Curve. The principal assumption underlying our concept and related model consists in the existence of some valid relationship between true values of measured parameters. These true values (of inflation, unemployment and labor force) can not be accurately defined and measured at the current level of overall understanding and availability of technical means. In sense, all hard sciences are based on the same assumption and suffer the same problems since measured values of variables are never the same as true values linked by fundamental laws. This unmeasured gap between the true and measured values allows any fundamental law to span only specific periods of time and to hold in some dynamic range of change. Such limited validity defines the principle of falsifiability.

In our framework, accurate projections of working age population and labor force participation rates allow accurate predictions of inflation and unemployment at any time horizon. Therefore, main efforts in economic study related to inflation and unemployment should be focused on accurate enumeration of labor force. This enumeration must be consistent through time representing the same portion of true labor force.

1. The Phillips curve

As in many developed countries, inflation in Canada has not been a big problem since the mid-1990s. Figure 1 summarized two different measures of inflation: GDP deflator and CPI inflation reported by the OECD. There is a general agreement between these two measures, except the former one covers the period after 1971 and the latter one starts in 1955. The GDP deflator time series includes the period of the highest inflation between 1970 and 1985. The largest value of the measured GDP deflator is 0.15 in 1974 and the lowest is -0.004 in 1998. This change from 0.15 to -0.004 provides a significant dynamic range which potentially allows reliable modeling. The CPI inflation varies in a slightly narrower range and has never been negative since the start of the reported measurements. It is interesting that the volatility of the Canadian GDP deflator is higher than that of the CPI, even during the most recent period of the Great Moderation. In the USA and many developed countries, CPI is characterized by a higher volatility.

The difference between the curves associated with the GDP deflator and CPI, which is as large as 4% in 1974 and 2.7% in 1991, provides some room for quantitative modeling – it is very likely that corresponding readings were obtained under varying definitions and methodologies and, thus, actually measured changing portions of true inflation values as related to CPI and GDP deflator. Therefore, one can allow for relatively large deviations between observed and predicted curves, at least in some segments of these time series. Due to the problems with the accurate definition and measurement of inflation in Canada (and other economies as well) any temporary discrepancy with predicted value may be explained by artificially induced uncertainty of corresponding measurements.

There are two different estimates of unemployment in Canada: one provided by national statistics and that obtained according the US definition of unemployment given by the Bureau of Labor Statistics – both series are available at the BLS (2007). They are very close in shape, but undergo some divergence after 1974. True unemployment, as related to some perfect (but not available) definition of unemployment might be between the curves and out of the curves as well. Both presented measures of unemployment are similar and it is very likely that the true unemployment repeat their shape. In this case, any of the measures can be used in quantitative modeling as representing the same portion of true unemployment. The same is valid for inflation measures. Therefore, actual problem is not the difference between measured and true variables but sudden jumps in the definitions of measured variables.

According to conventional economic theories, there likely exists a statistical link between inflation and unemployment. This link is called the Phillips curve. Since the first work of A.W. Phillips in 1958, economists have been searching for empirical evidences supporting validity of such a link. No unifying empirical relationship covering all developed countries and all periods has been found. One can say that there is no empirical proof in support of quantitative theories associated with the Phillips curve approach. Our concept explains why. The Phillips curves are different in developed countries. Only the same driving force behind inflation and unemployment unify them and build a Phillips-curve-type relation between them.

We have already obtained a number of linear and lagged links between inflation and unemployment in developed countries. Corresponding relationships actually demonstrate various and even opposite dependencies between the involved variables. In the USA, this dependence is characterized by a positive coefficient (Kitov, 2006a) and a three-year lag of unemployment behind inflation.

In Germany (Kitov, 2007b), the coefficient in the Phillips curve is negative, i.e. low inflation results in high unemployment. Also, there is only one-year lag between inflation and unemployment, with inflation leading unemployment. This also might be an artificial result of a half-year shift between actual timing of inflation (end of year) and unemployment (mid-year) estimates.

Figure 3 demonstrates that there is no conventional Phillips curve in Canada. This Figure displays two curves - the NAC unemployment and modified CPI inflation. Figure 4 presents the results of a linear regression analysis for the curves in Figure 3 without any time shift. There is no correlation between the curves as they are. Only an eleven-year forward shift of inflation allows to obtain a better correlation at a level of R^2=0.6. This is likely an artificial result. One can conclude that there is no long-term equilibrium relation between inflation and unemployment in Canada.

This does not deny the possibility that these two variables are driven by the same single force – the change in labor force level. The link is not simple, however. Some actions of the Bank of Canada could result in a change of the relation between inflation and unemployment, as we found in France (Kitov, 2007a; Kitov, Kitov, Dolinskaya, 2007a). As shown in this study, there is no opportunity to disturb the generalized relationship between labor force change, inflation and unemployment. Any change in the reaction of inflation to some change in labor force is completely compensated by reaction of unemployment to the same change in labor force. Kitov (2006b) described this generalized relationship in detail.

2. Modeling inflation and unemployment in Canada

Now we start to analyze CPI and GDP deflator in Canada following the approach linking inflation and unemployment in developed countries to the change rate of labor force level. As mentioned above, consumer price index can be defined in multiple ways, sometimes in incompatible ones. In such a situation and considering complex revisions of definitions and methodology introduced in corresponding time series since their start, it is reasonable to limit the modeling of inflation as a function of labor force in Canada to the last 40 years, i.e. to the period after 1968. One can try to extend the period to the entire range where data are available, bearing in mind probable large difference between the earlier and recent periods.

As in previous papers, our prediction is made on the basis of labor force measurements. There are two time series provided by the US BLS: one - according to its own definition and another one is reported by national statistics. Both curves are displayed in Figure 5. In general, they are identical, except 1966 and 1976, when significant revisions to national definitions were introduced.

The best-fit prediction of the CPI inflation is obtained using trail-and-error method as applied to the relationship:

$$CPI(t)=A+B*dLF(t-t_0)/LF(t-t_0) \qquad (1)$$

where A and B are empirically estimated constants and t_0 is the time lag, which can be zero or some positive value. One has to vary corresponding constants in order to obtain the best fit between the observed CPI and the one predicted according to (1). Figure 6 depicts the best case with A=-0.0043, B=2.58, and t_0=2 years. Because of the wide dynamic range of the CPI changes, the estimate of coefficient B is relatively reliable: *stdev*=0.32 and *p-value*=6.0E-09. Coefficient A is characterized by *stdev*=0.007 and provides an overall upward or downward shift of the predicted curve and also defines the level of inflation in the absence of any labor force change. Therefore, in the case of Canada, one can assume that coefficient A is effectively equal to zero. Also, a constant labor force level provides zero inflation. Increasing labor force results in positive inflation in Canada.

Figure 7 compares the observed CPI curve to that obtained from the change rate of labor force with the coefficients and time lag from Figure 6. The two-year time lag provides a good synchronization of the observed and predicted curves during the period between 1972 and 1998. The most prominent features are the abrupt changes near 1971, 1981, and 1991. Conventional approaches based on autoregressive properties of inflation, such as various versions of the Phillips curve using "inflation expectations", definitely fail to provide an adequate description for these unexpected changes and are forced to introduce artificial "structural breaks".

Our model does not need any artificial structural breaks but is affected by changes in definitions and such actions of central banks as constrained monetary supply. Therefore, the discrepancies between the measured and predicted curves in Figure 7 before 1972 and after 1998 are likely related to these effects. The case of France demonstrates (Kitov, 2007a), however, that these deviations are compensated by the reaction of unemployment and the generalized relationship between labor force, inflation and unemployment holds.

The predicted curve is characterized by a slightly higher volatility. As in other developed countries, this effect is induced by measurement uncertainty. As a rule, labor force is measured using small sample surveys, and then it is projected to the whole population with some "population controls". The latter are also characterized by relatively low accuracy as estimated from up-to-date information on births, deaths and net migration. So, one can not expect accurate annual estimates of labor force level, but there are some benchmark years then all previous estimates are revised in order to match this to more accurately measured (benchmark) level of labor force. It is likely that the accuracy of the net change in labor force level increases with increasing time baseline. In other words, the net change in the labor force during 10-year interval has to be measured much more accurate than that defined as a sum of 10 annual estimates of labor force change. The longer is the baseline, the more accurate is the net change measured.

If two macroeconomic variables are linked by a long-term equilibrium relation and are presented as levels or cumulative values, as labor force and consumer price index, and the levels are measured with a constant accuracy then one can expect a diminishing relative discrepancy between the variables with time. Hence, if these variables are actually linked by a robust mathematically exact relationship then the absolute difference between these cumulative values is constant, i.e. it depends only on the accuracy of corresponding measurements, and the relative difference is inversely proportional to the attained level.

The next step obviously consists in modeling of unemployment as a function of labor force change. There is no expectation of a good fit between these two variables. If there exist a generalized relation between the three studied variables, the relative failure to model inflation via labor force should result in associated relative failure to model unemployment. Figure 8 presents the results of a trail-and-error process. Since this manual procedure is based on visual fit only, no statistical estimates were made. Resulting relationship between unemployment and labor force in Canada is as follows:

$$UE(t) = -2.1*dLF(t)/LF(t)+0.12 \qquad (2)$$

The observed and predicted curves demonstrate similar shapes and there are two peaks, which are relatively well synchronized in time and amplitude. There are periods of large discrepancy between the curves, however. The most important finding is that unemployment in Canada decreases with increasing rate of labor force growth. So, the remedy against high unemployment is Canada consist in intensive population growth. Here we assume that labor force participation rate is hardly controllable by socioeconomic means.

The ultimate part of the modeling gathers all individual relationships in one generalized relation. So, we are trying to find the best-fit coefficients for the generalized (reduced-form) equation:

$$CPI(t) = A*dLF(t-2)/LF(t-2) + B*UE(t-2)+C \qquad (3)$$

There are several opportunities to estimate coefficient in (3). Standard way is to regress the CPI against shifted readings of the *UE(t-2)* and *dLF(t-2)/LF(t-2).* As explained in (Kitov, Kitov, Dolinskaya, 2007ab), this is not the most reliable way in the case of variables measured as levels or cumulative values. The best technique is to find the coefficients, which retain the lowermost RMS deviation between cumulative curves. This method is applied to the time series of CPI inflation, unemployment (BLS and NAC), and labor force. Figure 9 depicts two cases associated with the two available definitions of labor force. The difference is observed only in free term *C* in (3) and is associated with the difference in labor force level in 2002: 16367000, as reported by the BLS, and 16579000, as estimated by national statistics. Otherwise, the cumulative curves are different only in 1966 and 1976, when severe revisions to the level of labor force were carried out by the Canadian national statistical agency.

Both panels in Figure 9 demonstrate a very close evolution of the cumulative curves of the observed and predicted CPI inflation. Moreover, the curves reveal three periods of different behavior, which are usually explained by structural breaks in the literature devoted to inflation modeling. The cumulative curves prove that there was no change in the long-term equilibrium relation between these three studied variables. In Canada and other developed countries, the existence of such different periods is predetermined by the behavior of labor force only.

The difference between the cumulative curves is very small compared to the net change between 1969 and 2004. Moreover, this difference decreases with time as Figure 10 shows. One can easily find that the coefficients obtained by linear regression of the *CPI* on the *LF* and *UE* do not provide such a closeness between cumulative curves as those coefficients, which are estimated by visual fit between the cumulative curves: $A = 3.8$, $B = 0.79$, and $C = -0.096$ for the labor force series obtained according to the US definition; and $A = 3.8$; $B = 0.79$, and $C = -0.098$ for the labor force readings obtained by the Canadian national statistics. The latter estimates are also characterized by some spike-like deviations associated with labor force revisions.

Figure 11 demonstrates the advantages of moving average technique applied to the annual measurements of labor force, unemployment, and CPI inflation in Canada. As discussed above, these measurements are characterized by random errors, which are weighted through years in accordance with benchmark measurements. It means that average measurement error approaches zero for the increasing length of time series. Therefore, a five-year moving average, MA(5), should significantly suppress random (as associated with measurements) errors and provide close cumulative curves, as one can observe in Figure 11.

Finally, Figure 12 displays the originally measured CPI inflation and the predicted inflation obtained from the NAC labor force estimates. This case is the worst case scenario since the LF time series contains several step-like revisions. Nevertheless, the general fit between the curves is relatively high, as Figure 13 demonstrates. One can consider the curve in Figure 13 as a modified Phillips curve. Really, relationship (3) involves unemployment, as the authentic Phillips curve contained, and also the change rate of labor force instead of "inflation expectations". Our approach has two advantages: the two-year lead of the predicted inflation, and that the prediction is based on actually measured variables – unemployment rate and labor force level.

3. Conclusion

There exists no conventional Phillips curve for Canada, i.e. there is no unique link between inflation and unemployment. The absence of such a link might be related to the changes in monetary policy of the Bank of Canada during the studied period. Some reported changes in definitions of unemployment and associated incompatibility of values measured in different periods can add to the destroying the link between inflation and unemployment.

As in many other developed countries, the change rate of labor force has been found to be the driving force behind unemployment and inflation. This finding confirms the existence of the generalized linear and lagged relationship between labor force, unemployment and inflation in developed countries. The same relationship holds in the USA, France, Japan, Austria, the UK and Germany

The change in labor force in Canada leads inflation by 2 years and occurs simultaneously with the change in unemployment rate. In such circumstances, one can easily predict inflation at two-year horizon using only current estimates of labor force and unemployment, or even only the former variable. In the long run, labor force projections can accurately predict the evolution of inflation. The sign of the (tangent) coefficient in the linear relationship between inflation and labor force, i.e. in the modified Phillips curve, is positive, as also observed in the USA.

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Figures

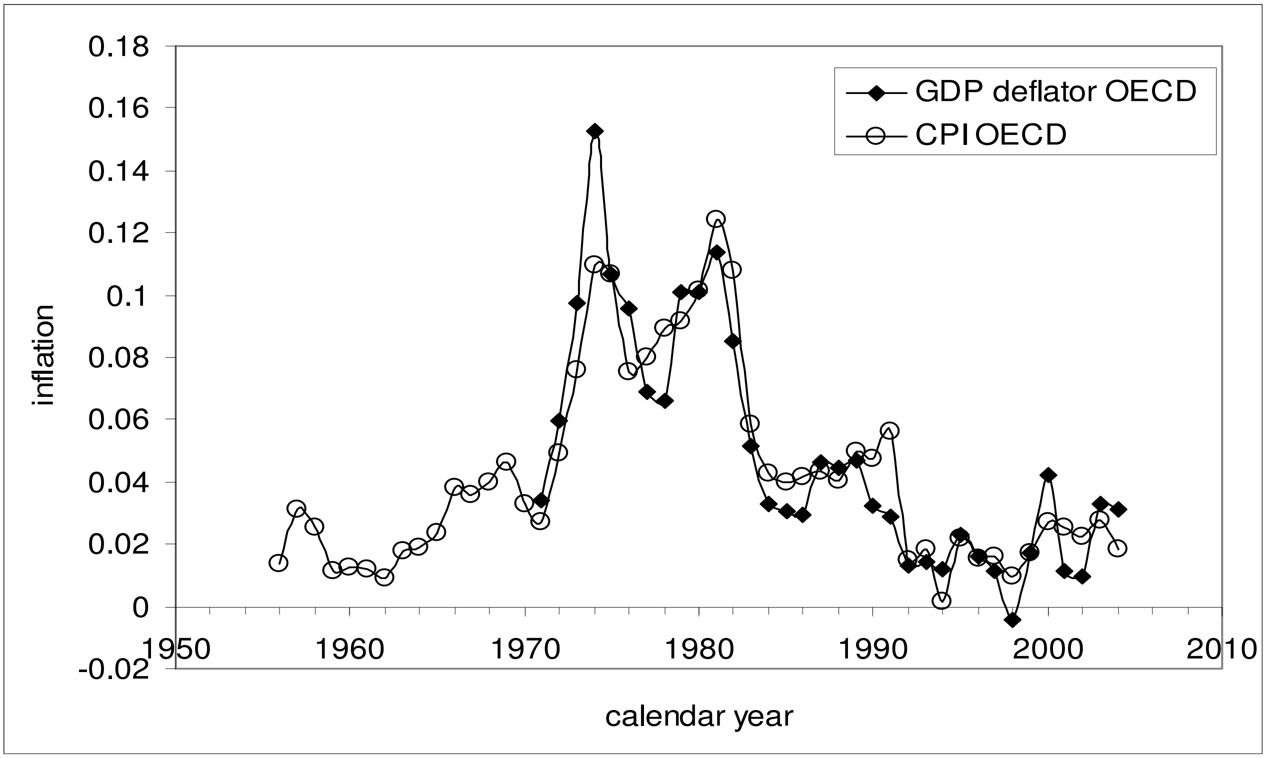


Figure 1. Two measures of inflation in Canada: GDP deflator and CPI reported by the OECD. The GDP deflator is available since 1971 and is characterized by higher volatility.

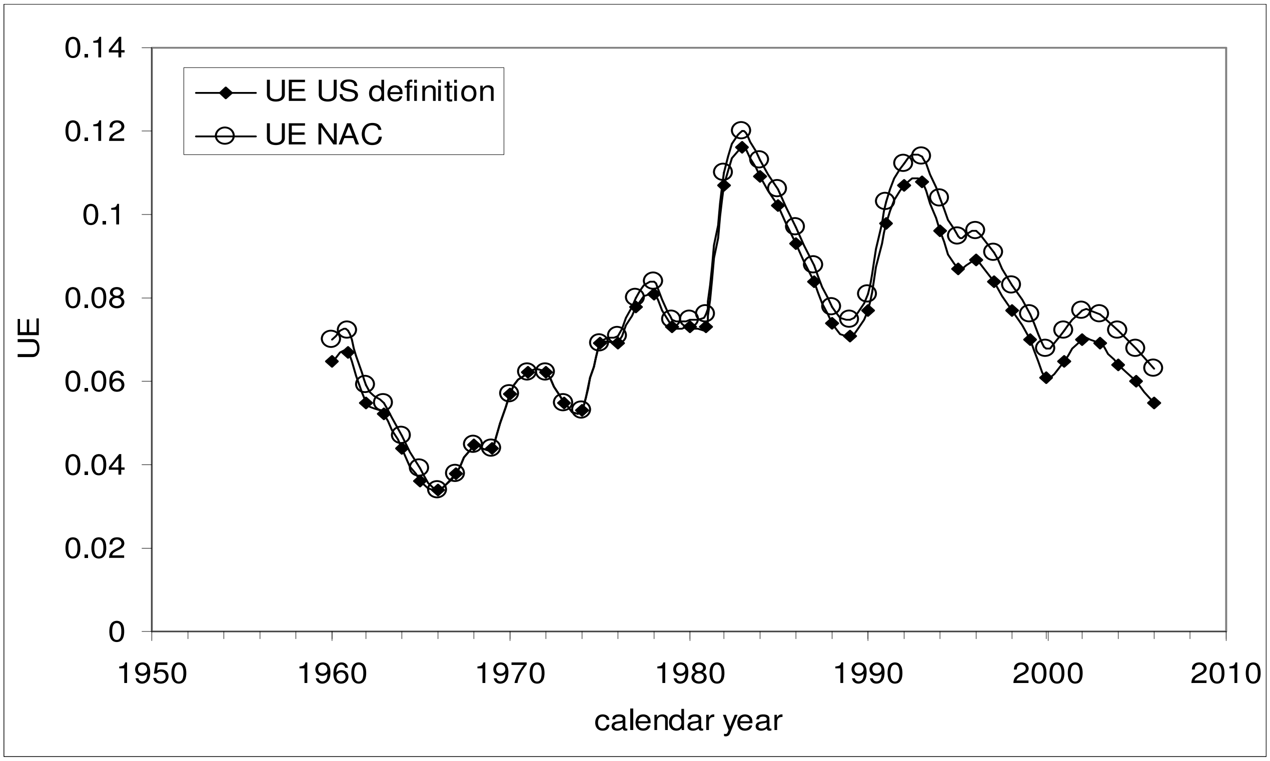


Figure 2. Comparison of two measures of unemployment provided by national statistics (NAC) and according to the US definition. Some differences are visible before 1967 and after 1974. These two curves clearly diverge with time.

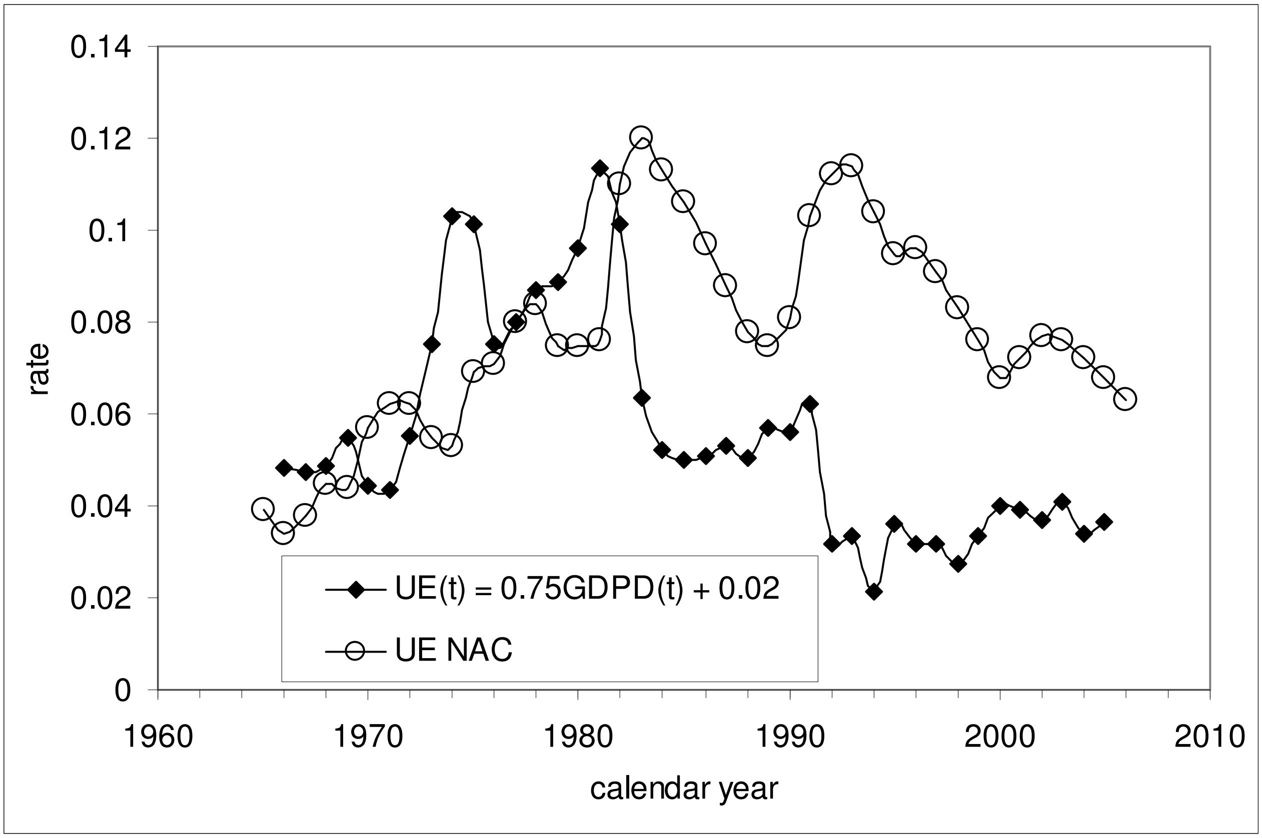


Figure 3. Unemployment (NAC) and GDP deflator (OECD) in Canada between 1965 and 2004.

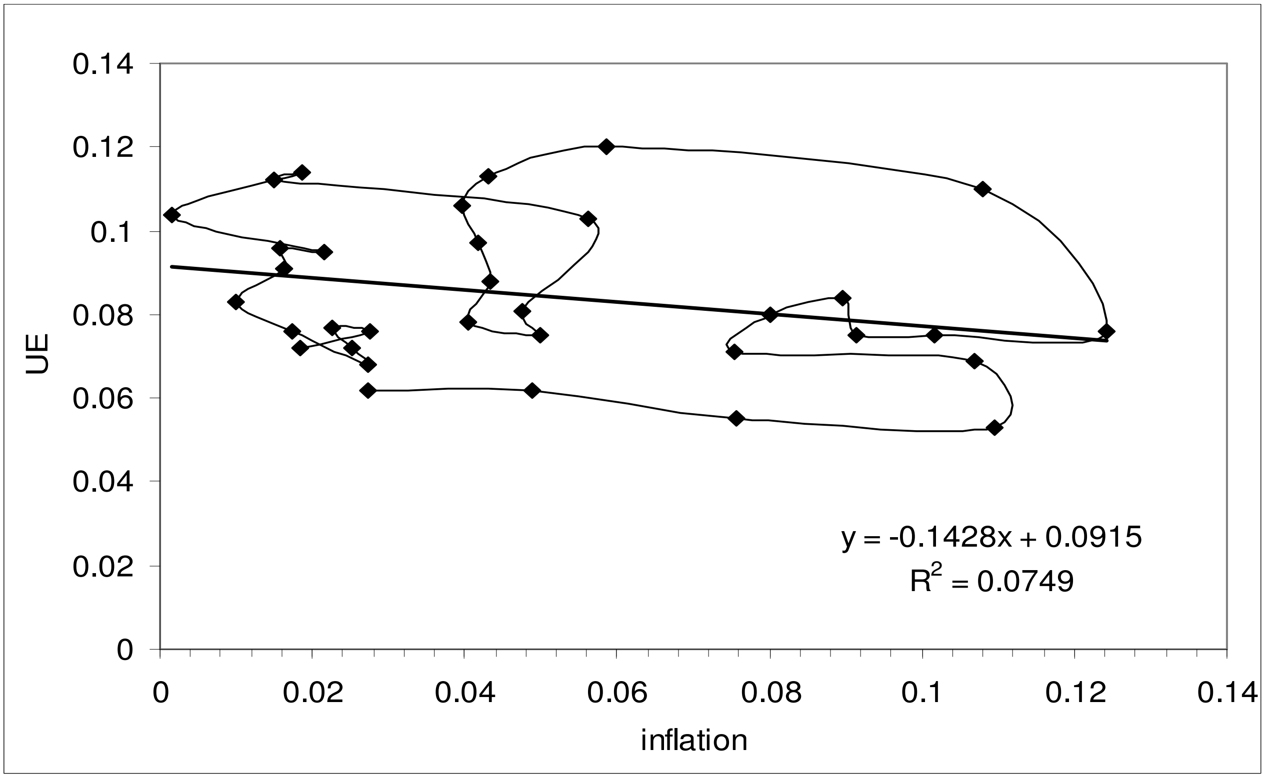


Figure 4. Illustration of the absence of the Phillips curve for Canada. Linear regression analysis of the readings between 1971 and 2004 demonstrates correlation at almost zero level.

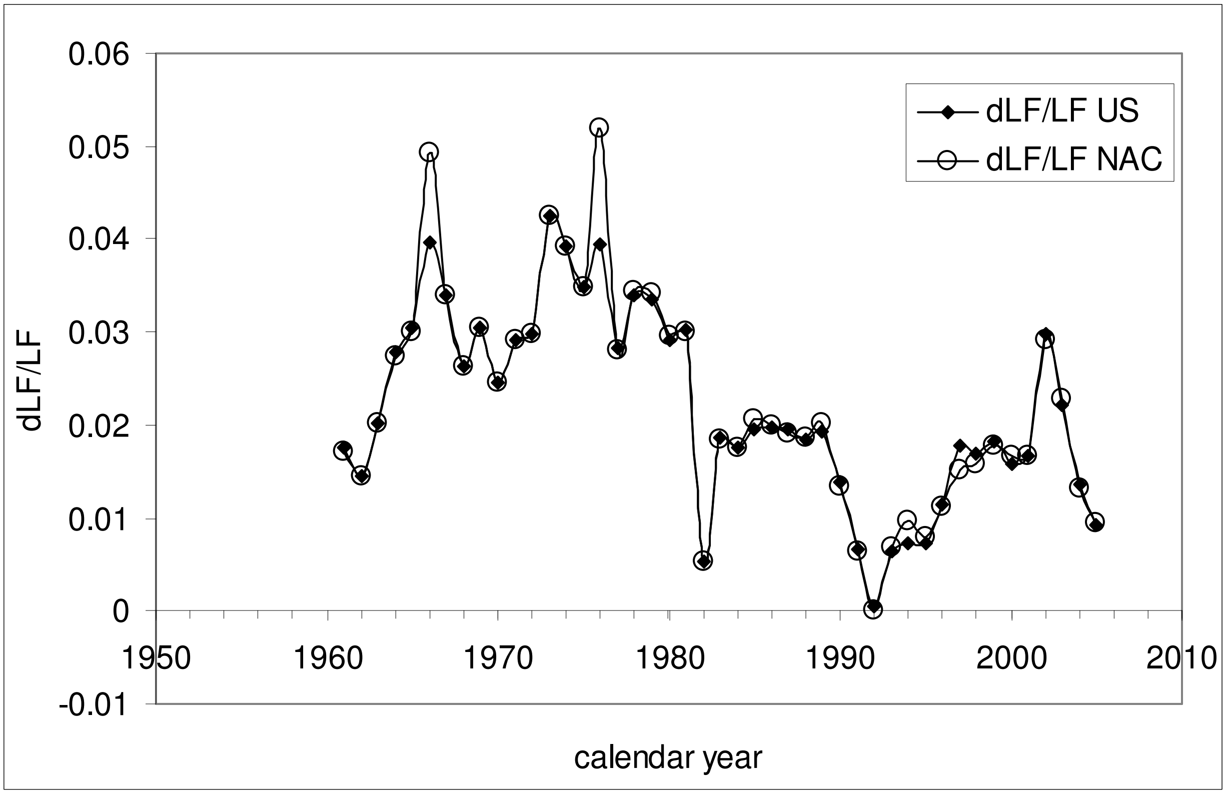


Figure 5. Comparison of the change rate of labor force level measured by national statistics and according the definition of the US BLS.

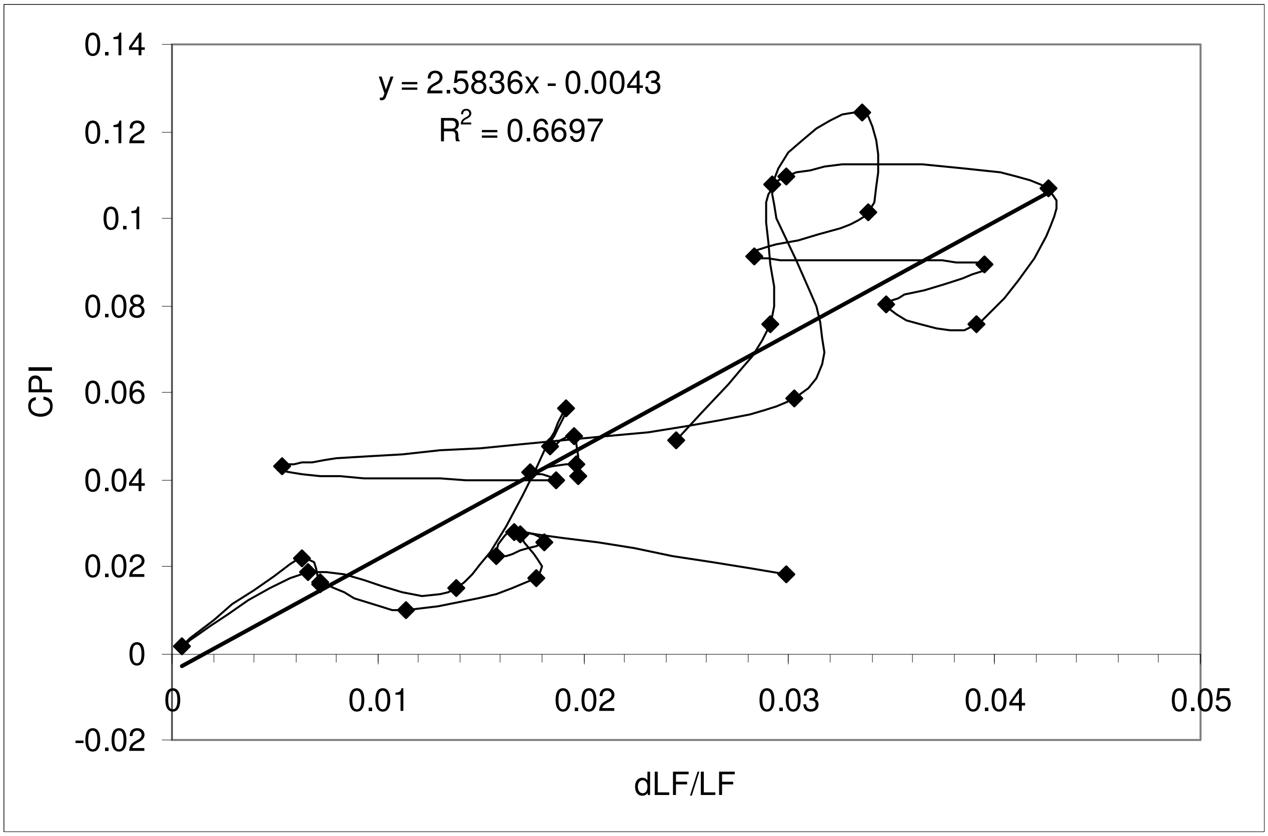


Figure 6. Linear regression of the CPI inflation on the change rate of labor force level, dLF/LF, for the period between 1972 and 2004. Coefficients: tangent *B*= 2.58, free term *A*= -0.0043, and the lag t_0=2 years provide the bets fit between these time series with R^2=0.67. This relation might be considered as a substitute or prototype of the Phillips curve.

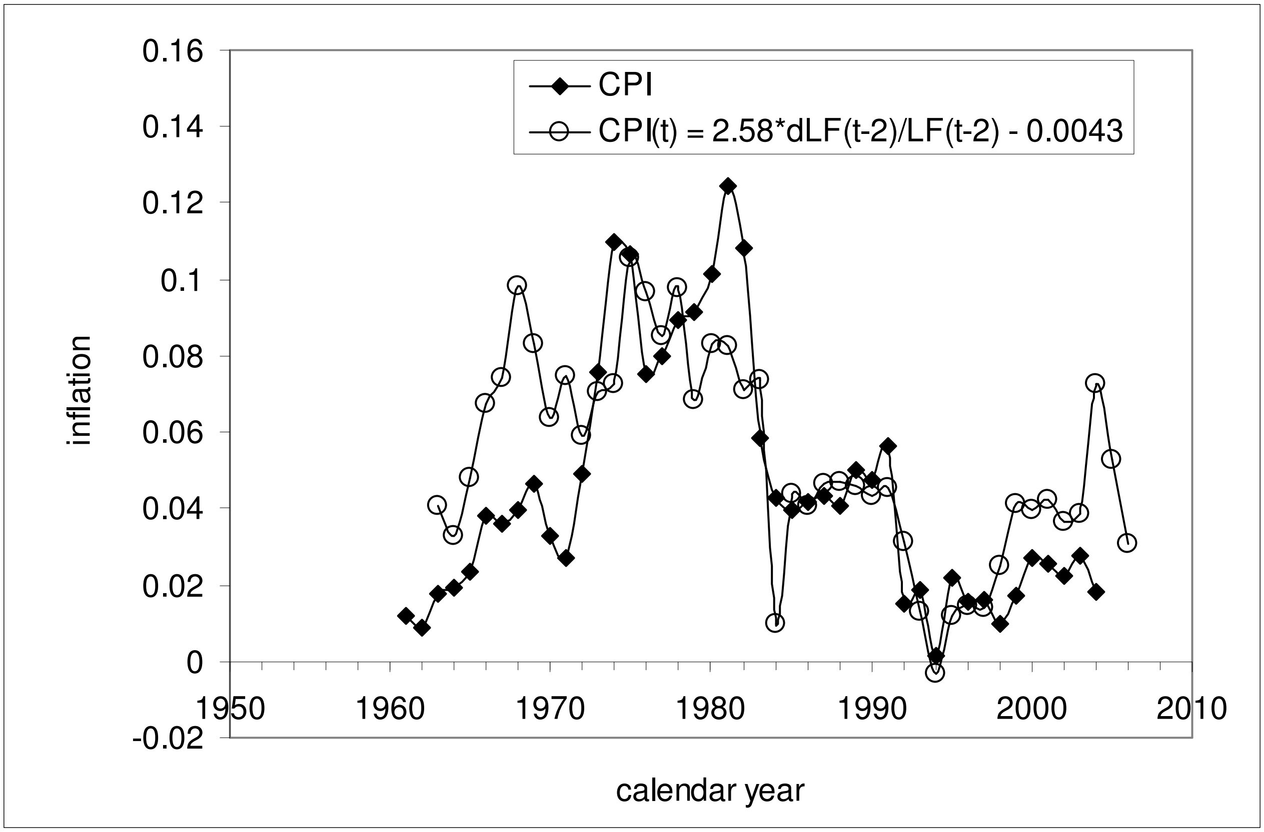


Figure 7. Comparison of the observed CPI inflation in Canada and that predicted using the change rate of labor force level as measured by the US BLS. Corresponding coefficients are obtained by linear regression as shown in Figure 6.

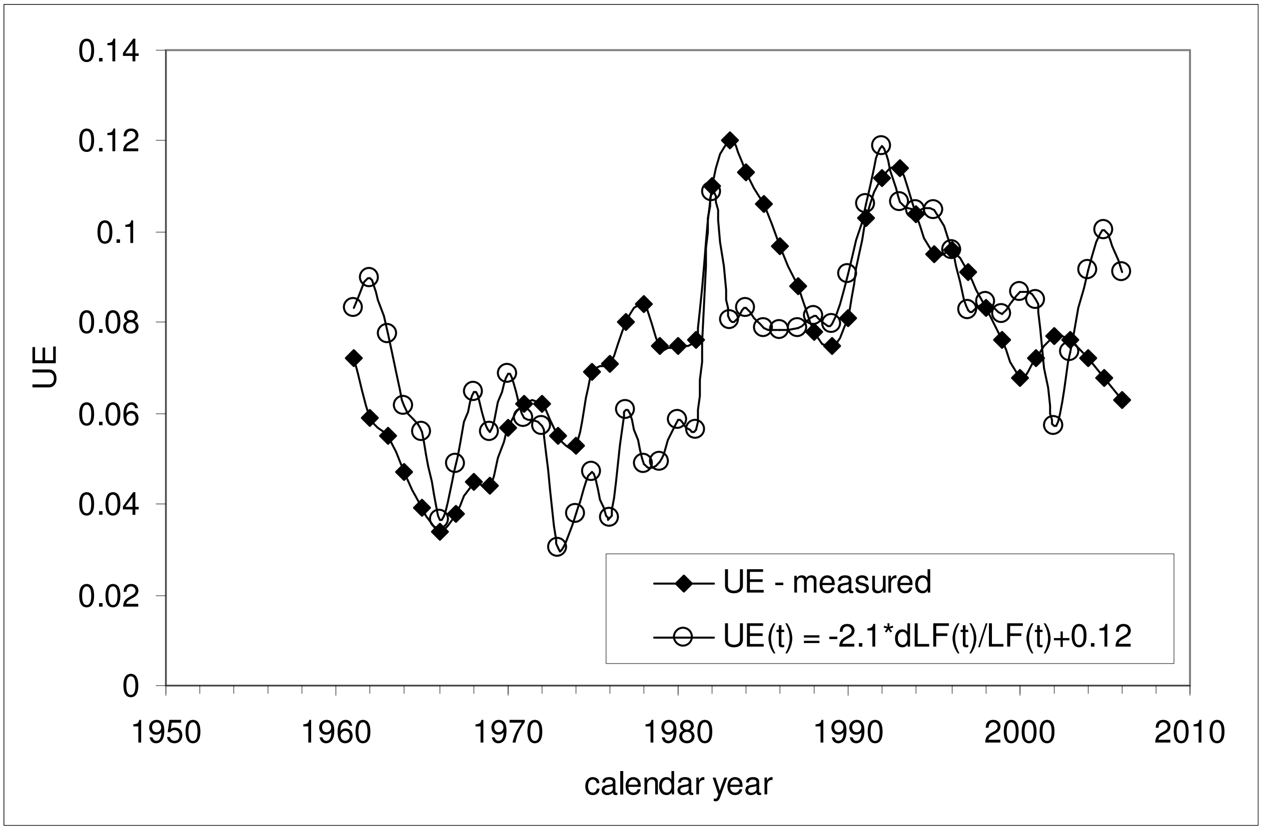
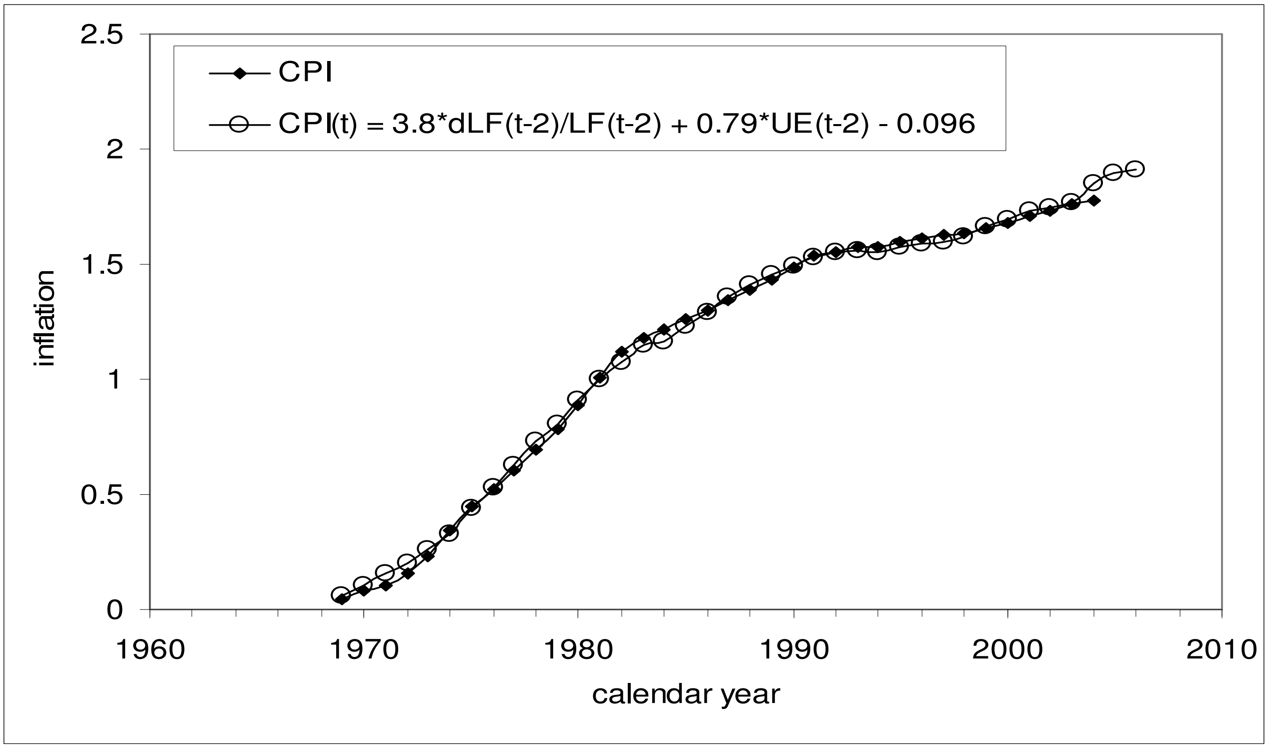


Figure 8. Comparison of the measured unemployment and that predicted from the change rate of labor force level. Only visual similarity between the curves has been sought.

a)



b)

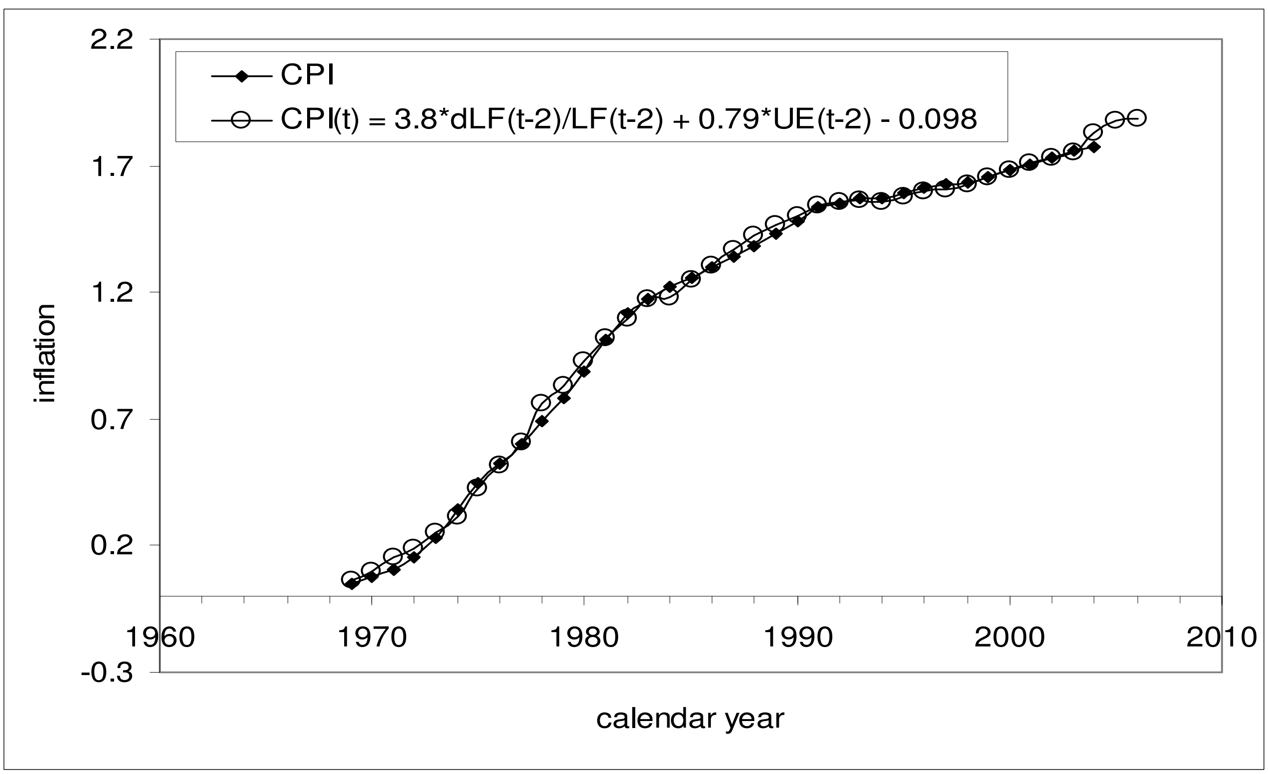


Figure 9. Comparison of cumulative curve for the measured CPI and that predicted according to relationship (3) using the BLS definition of labor force - a); and the national definition -b). The difference in definitions is explained by the change in free term *A* from -0.096 to -0.098.

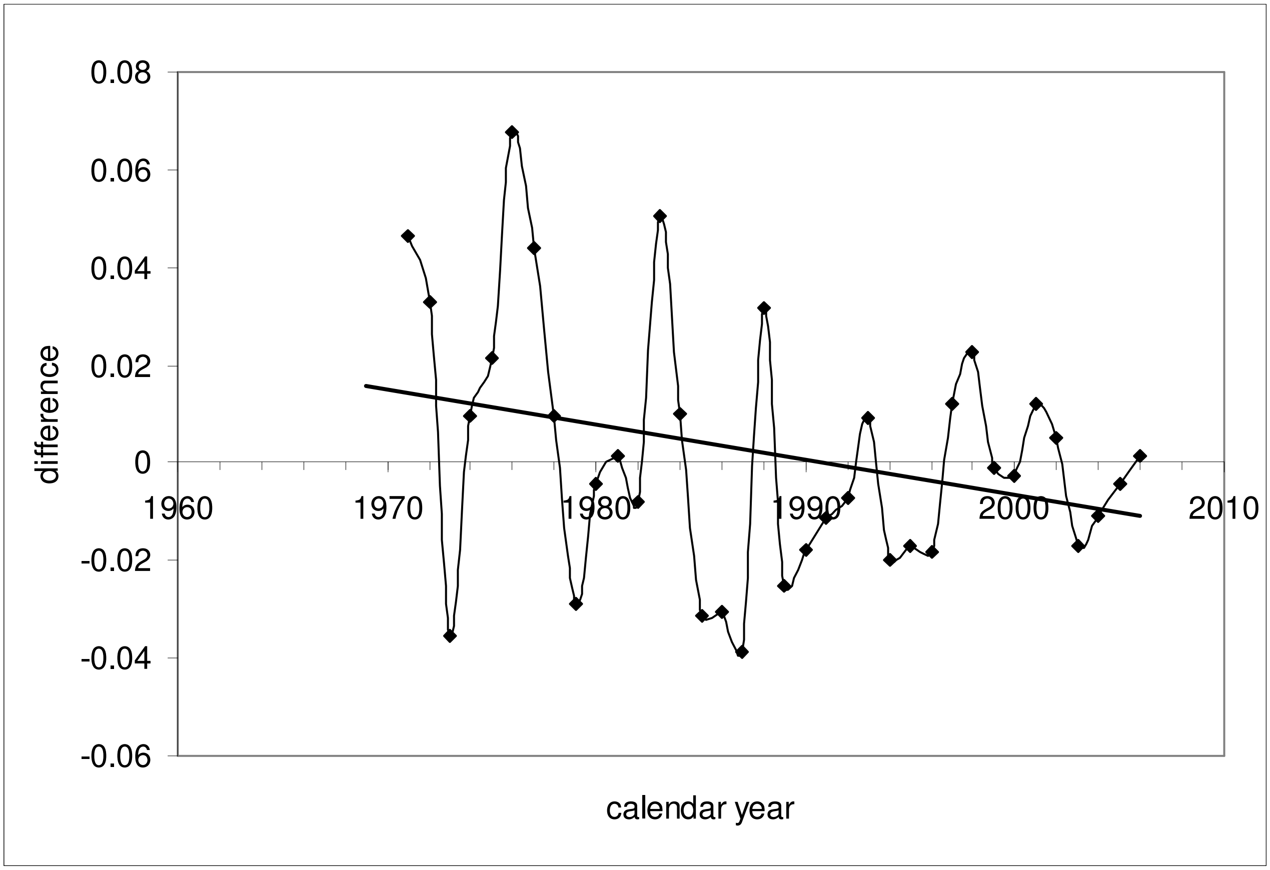


Figure 10. The difference between the cumulative curves in Figure 9a. The influence of the large step in the LF time series in 1976 is obvious. Amplitude of the difference decreases with time.

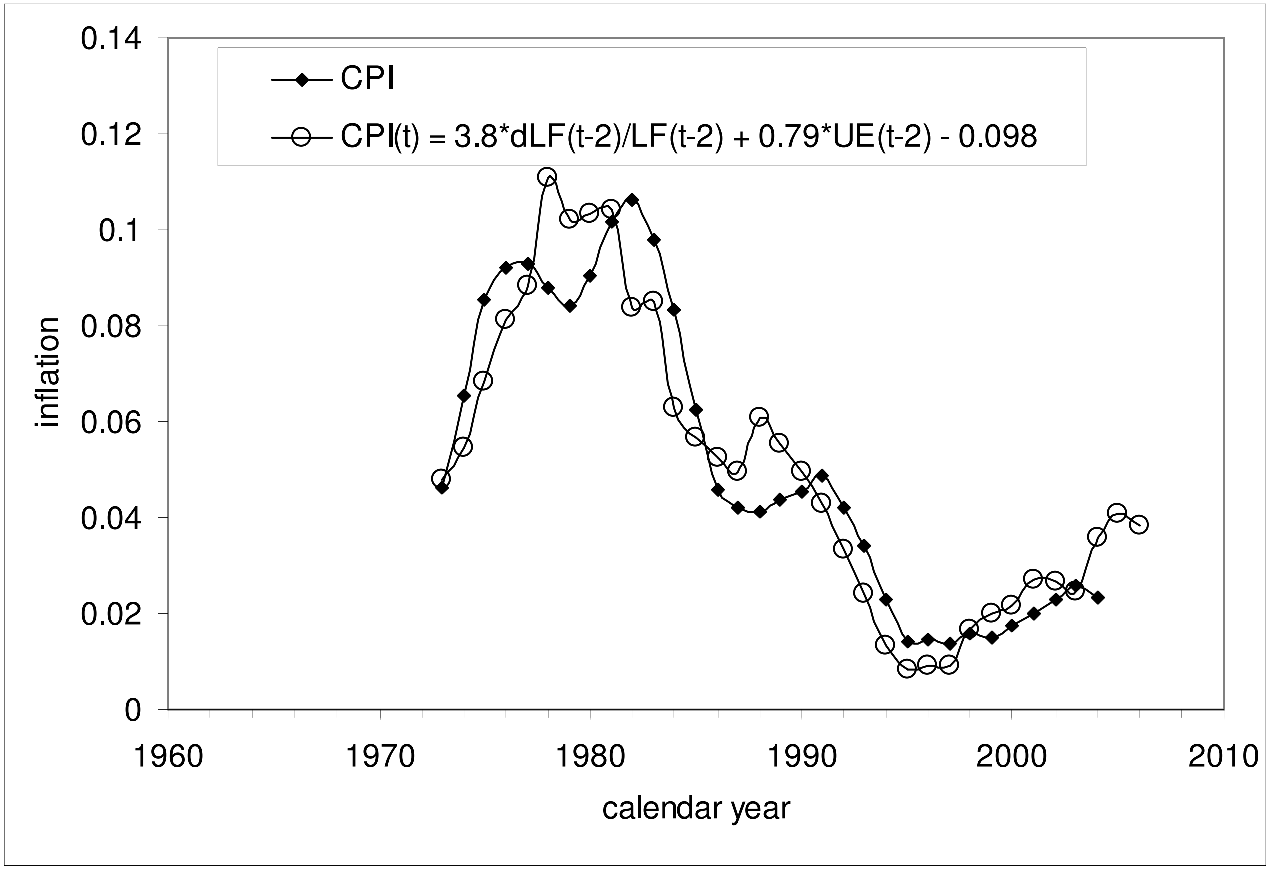


Figure 11. Comparison of MA(5) curve for the measured CPI and that predicted according to relationship (3).

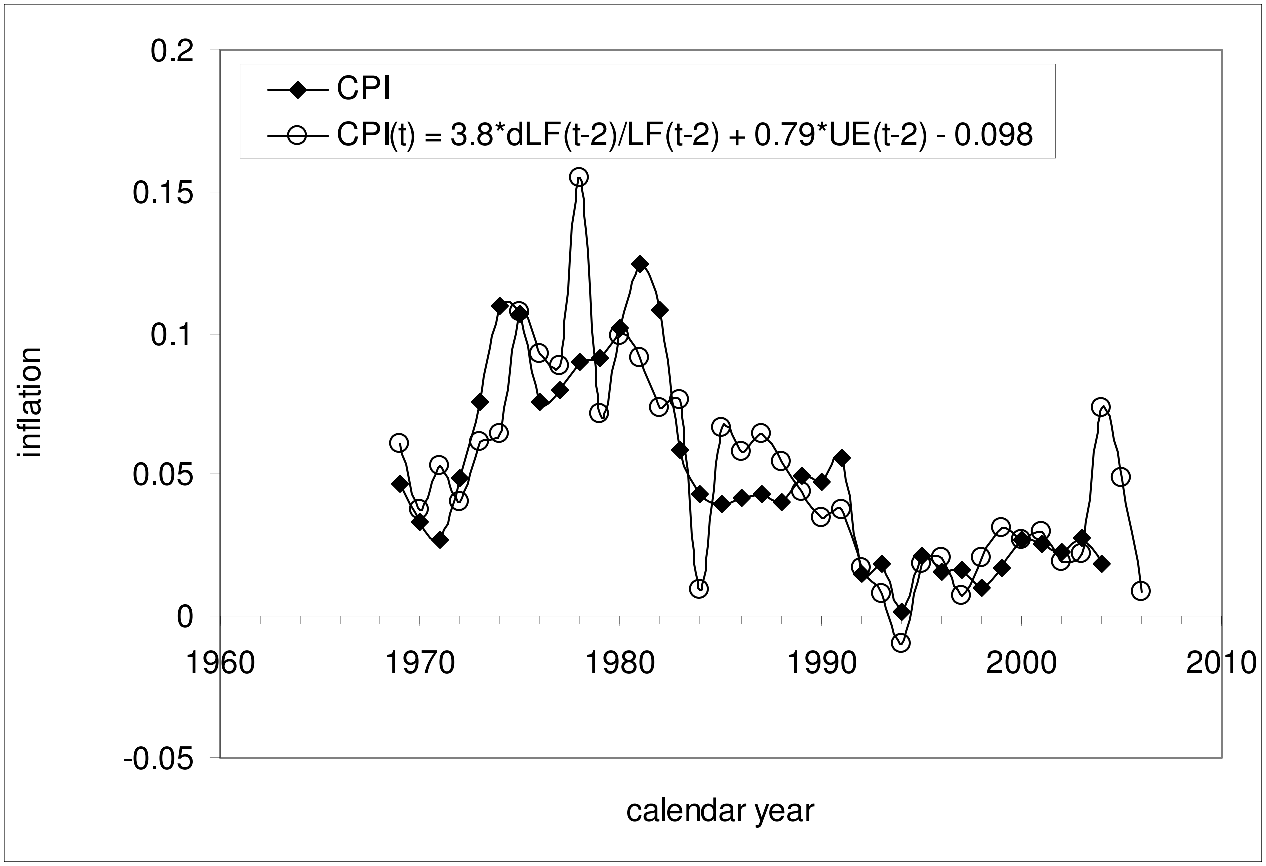


Figure 12. Comparison of the original measured CPI curve and that predicted according to relationship (3).

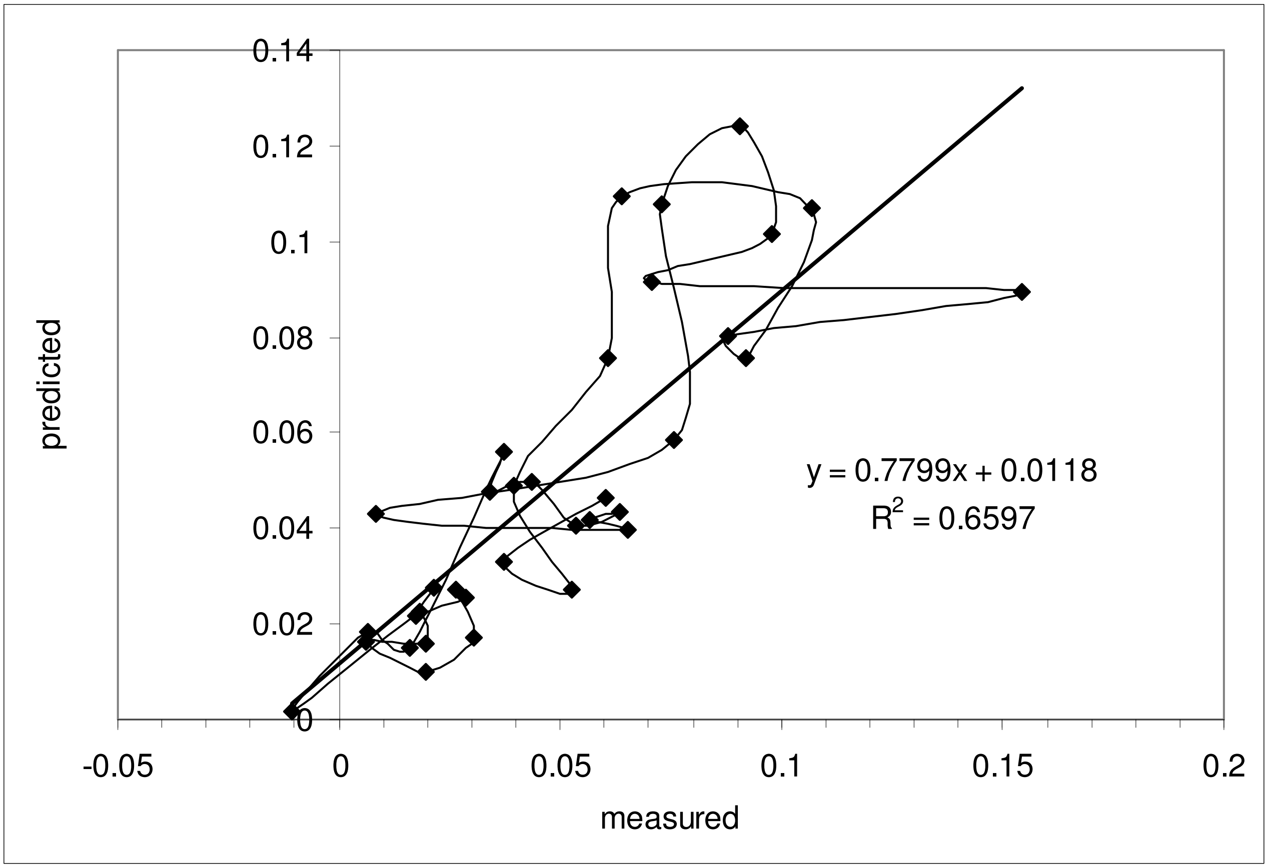


Figure 13. Linear regression of the observed CPI inflation against the predicted one for the period between 1969 and 2004.