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Canadian Regional NAIRU Estimates: A Structural Break Approach

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Abstract. This paper applies the Bai-Perron method to identify longer-run structural breaks in Canadian regional unemployment rate series in order to estimate natural rates of unemployment for Canada and its regions. The longest samples (Canada, Quebec, Ontario, British Columbia, the Maritimes, and the Prairie region) span the 1946-2011 period while the shortest samples, covering smaller provinces, are for 1966-2011. In all cases the technique reveals significant breaks. On the longer series a jump upward of 1.6%-3.2% is found in the mid-1950s. A second, and larger, increase occurs in the mid-1970s in all but the two western-most provinces and the Prairie region. Further increases are seen in the early 1980s in all provinces west of Ontario as well as in the Maritime region and Nova Scotia. Declines in natural rate estimates are found for several provinces and Canada as a whole in the mid-to-late 1990s.

1. Introduction

Canadian regional unemployment rates varied considerably over the period 1946-2011. Some of the variation, indeed the sharpest changes, are undoubtedly due to the business cycle. However, much of it may be accounted for by changes in the level of longer-run equilibrium unemployment rates around which the actual unemployment rate fluctuates; in other words, it is accounted for by changes in the natural rate of unemployment or NAIRU.[1] These long-run natural rates are of some interest as indicators of the efficiency of individual regional labor markets and as determinants of regional well-being. The complex interplay between these regional NAIRUs and interregional migration is also of much interest. The level of the long-run regional unemployment rate may help determine long-run interregional migration patterns or the business locations of firms. Conversely, these same long-run unemployment rates will in part be determined by interregional labour mobility and its long-run determinants.

This paper applies the Bai-Perron method to identify longer-run structural breaks in Canadian regional unemployment rate series in order to estimate natural rates of unemployment for Canada and its regions. The method is described after discussions of alternative approaches and data.

2. Measuring the natural rate: Alternative approaches

One branch of the empirical natural rate literature hearkens back to Friedman's (1968) view of a natural rate of unemployment determined by various labor market frictions or imperfections. This imperfections approach estimates unemployment rate equations with proxies for the imperfections and a cyclical measure as control variables. Nickell, Nunziata, and Ochel (2005) is a recent example that

[1] Of course, regional differences in labor market effects of business cycles and recessions are also of much interest. See, for example, Connaughton and Madsen (2010, 2012) for recent work on the response of U.S. regional labor markets to recessions.

generates estimates for Canada as a whole and other OECD countries. Canadian examples which use this approach to generate regional natural rate estimates include Riddell (1980), Miller (1987), Burns (1990), and Johnson and Kneebone (1991). Note that regional context factors that discourage interregional labor mobility will raise regional natural rates. See Cebula and Alexander (2006) for a recent study of the determinants of interregional mobility and Deller (2009) for an examination of regional equilibrium unemployment rates using a wage curve model.

An alternative approach infers the value of the natural rate or NAIRU from behavior of a Phillips curve relationship. Examples of this approach include Gordon (1997), Ball and Mankiw (2002), and Ball (2009). These studies use a Hodrick-Prescott filter to separate the effect of the Phillips curve error term from the NAIRU. Laubach (2001) adopts another common approach that starts with a Phillips Curve relationship and then uses a Kalman filter to infer behaviour of the unobserved NAIRU.[2] Both the imperfections approach and the Ball-Mankiw Phillips Curve method give natural rate estimates that show considerable variability over time. Indeed, they often resemble the actual rate series with the shorter-term fluctuations smoothed out. This degree of variability seems somewhat inconsistent with an interpretation of the NAIRU as a long-run equilibrium rate. By contrast, Phillips curve-based estimates using the Kalman filter often give quite stable NAIRU time profiles; however, the estimates imply implausibly lengthy periods when the NAIRU is persistently above or below the actual unemployment rate.[3]

A look at a typical unemployment rate series, such as that for Canada shown later in Figure 1A, suggests an alternative approach: the NAIRU can be treated as constant for specific intervals but subject to occasional structural breaks. For example, the data for Canada could be consistent with a low NAIRU early in the sample period followed by a rise to a new plateau sometime in the 1970s followed by a fall sometime in the late 1990s. A method of this type allows the actual unemployment rate to fluctuate around the natural rate estimate through the business cycle consistent with it being a long-run equilibrium rate. Long periods with actual rates consistently above or below the NAIRU estimate are avoided by allowing for occasional structural breaks. The time series procedure for determining multiple unknown structural breaks developed by Bai and Perron (1998, 2003a) can be used to determine the number, size, and timing of the shifts in the natural rate. Papell, Murray, and Ghiblawi (2000) is an early application of the Bai-Perron method to OECD unemployment rates for 1955-1997. Clemente, Lanaspa, and Montanes (2005) apply the method to US states and regions while Fallahi and Rodriguez (2011) apply a version of the method to quarterly Canadian provincial data for 1976-2005. The Bai-Perron approach is applied below to the Canadian regional unemployment rate data described in the next section.

3. Data

All of the unemployment series used are ultimately derived from the Labour Force Survey which began in 1946.[4] Statistics Canada's CANSIM database provided annual data on provincial unemployment rates for 1976-2011. Unemployment rate data for 1966-75 came from Statistics Canada's *Historical Labour Force Statistics* and was adjusted by Statistics Canada to enhance comparability with data from the revised post-1975 version of the survey. Riddell (1980) provides 1955-65 Newfoundland and Ontario unemployment rate data, which he reports adjusting to enhance comparability with later years. Comparability is an issue with earlier Labour Force Survey data due to various changes in survey design, frequency, and age group covered. Unemployment rate data for Quebec, British Columbia (BC), and the Prairie region for 1946-65 and Ontario for 1946-54 from Ostry (1968, Table 13) are grafted onto the later unemployment rate series by applying the year-to-year proportional changes in the older series to the newer data.[5] The 1946-65 data series for the

[2] Shannon (2012) applies these Phillips curve-based methods to the sample examined in this paper.

[3] For example, Laubach's NAIRU estimate for Canada exceeds the actual 1971-1981 rate and is below it through the 1990s. He finds similar long-lasting gaps for other countries. Estimates of this type from Shannon (2012) find that some Canadian regions had NAIRUs above or below actual rates for as long as 20 years.

[4] Gower (2001), using Denton (1983), provides a national unemployment rate series that goes back to 1921. Gower notes that the 1921-45 data is constructed by combining Census data with employment information from larger employers and unemployment data collected by trade unions. The early data is not used here due to the major differences in coverage and collection methods.

[5] Ostry (1968, p. 26) notes: "Rates for 1946 to 1952 have been adjusted for timing of the LFS which was conducted quarterly before November 1952." Denton (1983) describes other pre-1976 changes to the LFS. The 1976 revisions saw a new questionnaire and revised operational definitions as well as a change in the covered age group from 14+ to 15+.

Maritimes is constructed from Denton (1983) and grafted to the earlier data in the same way.[6]

The resulting data set contains unemployment rates for 1946-2011 for Canada, Quebec, Ontario, British Columbia, the Prairie region (Manitoba, Saskatchewan, and Alberta) and the Maritime region (Nova Scotia, New Brunswick, and Prince Edward Island). Data for Newfoundland spans 1955-2011[7] while individual provincial data for Nova Scotia, New Brunswick, Manitoba, Saskatchewan, and Alberta cover 1966-2011. Prince Edward Island is not analyzed due to a lack of pre-1976 data.

4. Unit root tests and structural change

Examination of the unemployment rates used in the present study reveals that the rates have been highly volatile and countercyclical. In other words, they trend upward during recessions and downwards during recoveries, which is consistent with stationarity.[8] Before attempting to measure the natural rates, we need to examine the univariate properties of the underlying series used in this study. The main question investigated in this section is whether shocks have transitory or permanent effects on the unemployment rates. If the impacts of shocks are found to be transitory in nature, then one can argue that the unemployment rates fluctuate around a stable mean value consistent with the natural rate hypothesis.

In examining the univariate properties of the unemployment series, we have paid special attention to the changing trend behavior of the unemployment rates. Given the relatively low power of the standard unit root tests, we subjected the rates to a series of tests. First, we used the augmented Dickey-Fuller (ADF) tests which included a constant (c), a constant and a time trend (ct), or a constant, time trend and trend squared (ctt) and lags of first differences as regressors as suggested by Dickey and Fuller (1979, 1981) and Said and Dickey (1984). The p-values for the Dickey-Fuller tests are based on MacKinnon (1996). The optimum lag length is determined by the procedure suggested by Ng and Perron (1995).

The power of the above unit root tests is seriously compromised in cases where the series under examination has undergone a structural change.[9] Perron (1989) proposed various unit root tests allowing for a one-time exogenous change in the level of the series.[10] In this study, we utilize the sequential method of Banerjee, Lumsdaine and Stock (1992) that allows for a single shift or break in a deterministic trend at an unknown date. The model considered is:

$$Y_t = \mu + \beta_1 T + \beta_2 DT(k) + \alpha Y_{t-1} + B(L)\Delta Y_{t-1} + e_t \quad (1)$$

where T is a time trend, $B(L)$ is a lag polynomial of known order p, k refers to the time of break (i.e., the period at which the change in the parameters of the trend function occurs), and $DT(k) = T-k$ if $T>k$ and 0 otherwise. The deterministic regressor $DT(k)$ captures the possibility of a shift in trend at time k which is consistent with the behavior of many of the unemployment rates used in this study. Perron (1989) showed that as β_2 diverges from zero, the power of the standard ADF tests declines dramatically.[11] To test for a unit root in a series characterized by a changing trend, one estimates model (1) sequentially using all T observations for $k = k_0, k_0+1, \ldots, T-k_0$, where k_0 allows for trimming the initial and final parts of the sample.[12] The OLS estimate of model (1) is used to test the null hypothesis H_0: $\alpha = 1$. The break date is chosen to minimize the pseudo t-ratio on α (t_α). We use the critical values reported by

[6] Denton's Atlantic region series for 1946-49 excludes Newfoundland. For 1950-65, Newfoundland labor force and employment estimates are subtracted from his Atlantic region figures to obtain their Maritime equivalents, which are then used to calculate the Maritime unemployment rate.

[7] Newfoundland became part of Canada in 1949. Denton (1983) provides labor force and employment data for Newfoundland for as far back as 1950 (separate unemployment figures were suppressed due to small numbers). Unemployment rates constructed from Denton's pre-1955 data seem suspiciously variable. It was therefore decided to start the Newfoundland series in 1955 using Riddell's figures.

[8] Earlier examinations of Canadian unemployment rate behavior have tended to find a lack of persistence consistent with stationarity. See, for example, Jones (1995). The bounded range of the Canadian unemployment rate series is also suggestive of stationarity.

[9] A structural break can be modelled in different ways. For example, Perron and Vogelsang (1992) consider testing for a unit root in a time series characterized by a structural break in its mean. On the other hand, Clemente et al. consider testing for a unit root in a time series characterized by two structural changes in its mean.

[10] Perron and Vogelsang (1992) also proposed tests that allow for a one-time break in the mean while endogenizing the breakpoint selection.

[11] As β_2 diverges from zero, the cumulative density function of the estimated coefficient of the lagged Y_t used in standard ADF tests gets closer to unity and thus the power of the unit root test declines dramatically.

[12] $k_0 = T\delta_0$. The choice of δ_0 entails a trade-off between needing enough observations in the shortest regressions to support the Gaussian approximation while allowing for possible breaks early and late in the sample.

Banerjee, Lumsdaine, and Stock (1992) to assess the significance of the unit root statistic.

5. Testing for unit roots

Table 1 reports the results of various tests of the null hypothesis of unit root in the unemployment rate series for each of the Canadian provinces, the Atlantic, Prairie, and Maritime regions, and the overall Canadian economy. The p-values are in parentheses. Table 1 shows that the ADF test rejects the presence of a unit root for Ontario, British Columbia, Newfoundland, Nova Scotia, New Brunswick, Manitoba, Saskatchewan, and Alberta at the 10 percent level of significance or lower. The presence of a unit root could not be rejected for Canada, Quebec, and the Atlantic, Prairie, and Maritime regions. As mentioned above, the standard unit root tests have very low power when the series are characterized by a changing trend. Therefore, to ensure that our results are valid, we tested all series while allowing for a change in the trend function as specified in model (1). Results are reported in the last column of Table 1.

The above results suggest that economic shocks such as the recessions of the 1980s or 1990s do not appear to have had permanent effects on the unemployment rates. Their impacts for all regions appear to have been transitory in nature once a break point is allowed for.

Table 1. Univariate properties of the unemployment rate series.

Region	Sample Size	ADF	Break Point	t_α
Canada	1946 to 2011	-3.41^{ct} (0.14)	1991	-4.32 (0.10)
Ontario	1946 to 2011	-4.03^{ctt} (0.03)	1991	-4.52 (0.05)
Quebec	1946 to 2011	-2.27^{ct} (0.18)	1991	-4.24 (0.10)
British Columbia	1946 to 2011	-2.59^{c} (0.09)	1986	-4.29 (0.10)
Newfoundland	1955 to 2011	-2.59^{c} (0.10)	1992	-4.27 (0.10)
Nova Scotia	1966 to 2011	-3.75^{c} (0.01)	1982	-4.48 (0.05)
New Brunswick	1966 to 2011	-3.93^{c} (0.00)	1982	-5.37 (0.01)
Manitoba	1966 to 2011	-3.28^{c} (0.02)	1988	-4.23 (0.10)
Saskatchewan	1966 to 2011	-2.98^{c} (0.04)	1989	-4.34 (0.10)
Alberta	1966 to 2011	-2.62^{c} (0.09)	1986	-4.20 (0.10)
Prairies	1946 to 2011	-2.36^{c} (0.15)	1990	-4.29 (0.10)
Maritimes	1946 to 2011	-1.91^{c} (0.32)	1991	-4.33 (0.10)

Notes: ^{c} denotes ADF with a constant, ^{ct} adds a time trend, and ^{ctt} adds trend squared.

6. Bai-Perron method

Bai and Perron (1998) provide a procedure for determining multiple structural breaks whose timing is unknown. They also develop tests and calculate critical values for determining the optimal number of breaks. The method begins by specifying the minimum allowable time span between breaks. The best single break is found by using OLS to estimate the sum of squared residuals (SSR) for each possible break on the full sample.[13] The best single break is the one which gives the lowest SSR. For two breaks the best outcome is arrived by first identifying each possible combination of two breaks satisfying the minimum span requirements. Next, OLS is used to estimate each two-break specification, and then the specification with the minimum SSR is chosen as the

[13] Given a minimum span of *M* the first possible break occurs after observation *M*, and the latest possible break on a sample size of *N* is after observation *N-M*.

optimal two-break case.[14] This procedure is repeated for three or more breaks up to some plausible maximum (five was always sufficient for the series examined here). The method can be computationally intensive on longer samples with higher numbers of breaks. Bai and Perron (2003a) provide an efficient dynamic programming algorithm for determining the optimal breaks. This paper uses a STATA program written by M. Kerkeres (see Kerkeres, 2011) to implement the algorithm.

Bai and Perron (1998) equation (10) provides a test of the null hypothesis of L breaks vs. the alternative of $L+1$ breaks.[15] Starting with L=0 and then repeatedly applying the test for higher L until the null is not rejected gives the optimal number of breaks. Versions of the test and critical values are offered for different values of the "trimming parameter" (minimum span length divided by sample size) and alternative variance-covariance structure assumptions. The estimates reported here set the minimum span length to six years. The exercise was also done assuming minimum span lengths of five and seven years. For most series, the number and timing of the breaks was unaffected by this change. In a few cases reducing span length raised the number of breaks found but raised concerns that too short a span length made it more likely that a cyclical rise in unemployment would be identified as a change in the natural rate.

7. Bai-Perron natural rate estimates

The main set of natural rate estimates are reported in Table 2 and plotted along with the actual unemployment rates in Figures 1A through 1L. For the 1946-2011 samples three breaks were found for Canada, Quebec, and the Prairie region while Ontario had two. British Columbia and the Maritimes had the largest number of breaks during 1946-2011 at four. Newfoundland was something of an outlier with only a single break on its 1955-2011 sample.[16] On the shortest samples (1966-2011) Nova Scotia, Manitoba, and Saskatchewan each had three breaks while New Brunswick and Alberta had two. Most series follow a similar pattern. On the longer samples the natural rate ratchets up in the mid-to-late 1950s and is stable through the 1960s. Sometime in the mid-1970s it rises once again in Canada as a whole, Newfoundland, the Maritime provinces, central Canada, Manitoba, and Saskatchewan. A further rise occurs in the early 1980s in provinces other than New Brunswick, Quebec, and Ontario. The rate declines in BC in the late 1980s. Canada as a whole, the Prairie and Maritime regions, and provinces other than Ontario, Newfoundland, and BC see declines in the mid-to-late 1990s. BC sees a fall in 2003-04. In all cases, the natural rate estimate is higher in 2011 than at the start of the sample period, and the lowest rate is always at the start of the sample regardless of whether the sample begins in 1946, 1955 or 1966. The lowest natural rate estimates found are for 1946-57 in Ontario (2.5%) and the Prairies (2.4%). Estimates for Canada 1946-56, Quebec 1946-53, and Saskatchewan 1966-75 are also exceptionally low (3.0%-3.1%). The highest natural rate estimates are for Newfoundland 1974-2011 at 16.3%, and the Maritimes 1982-98 (12.7%). BC reaches 13.4% in 1982-87, though, as noted below, this high value is likely capturing the effects of a downturn rather than changes in the natural rate. The smallest ranges between lowest and highest estimates were for Ontario (5.0%), Alberta (4.9%), Manitoba (4.0%), and Saskatchewan (4.4%). The ranges were largest for BC (9.4%), the Maritimes (8.6%), Quebec (8.3%), and Newfoundland (7.2%). For Canada as a whole the range between highest and lowest estimate was 6.3% for 1946-2011. This 6.3% range is large, suggesting substantial swings in the efficiency of the Canadian labor market over time.

Allowing the minimum span length to rise to seven or fall to five years had little effect for most series. In one case, Manitoba 1966-2011, the timing of the first break in 1975-76 changes to 1970-71 when the minimum span is reduced to five years. In Nova Scotia and Canada as a whole, lowering the minimum span resulted in an additional break (1970-71 in Nova Scotia and 1981-82 for Canada).

[14] Bai and Perron (1998) also offer a sequential method for determining the optimal breaks. If in the sequential case you wish to calculate the best "L" breaks you start with the best "L-1" breaks from the previous step and then find the best (minimum SSR) additional break. Notice that the sequential method requires that all L-1 breaks from the previous step be included in the L breaks at the next stage. The global estimate of the best L breaks used here does not require that it include the best L-1 breaks from the previous step.

[15] Critical values are obtained from the unpublished tables in Bai and Perron (2003b). When applying the test the restricted model with L breaks is the global minimum-SSR estimate while the unrestricted model with L+1 breaks is obtained using the sequential method mentioned in footnote 11. It is necessary to use the sequential L+1 break version rather than the global L+1 estimates so that the restricted model is nested in the unrestricted.

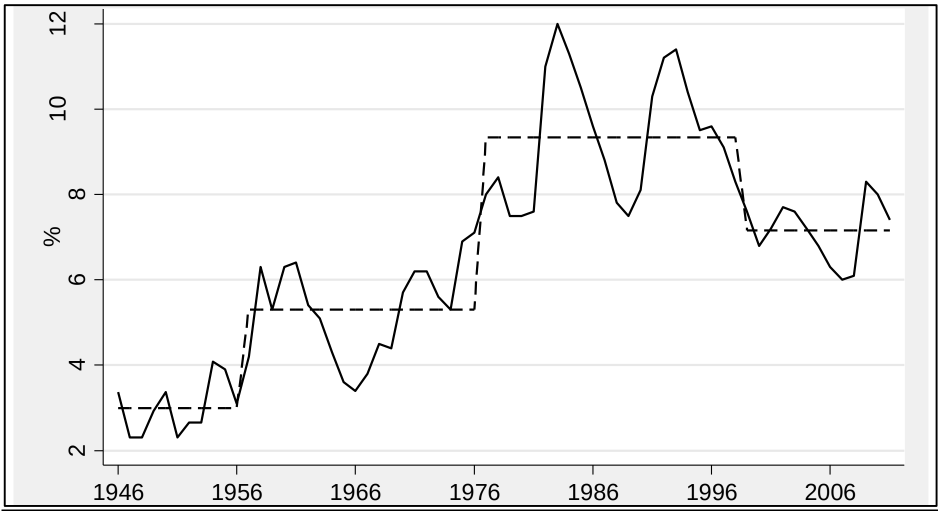
[16] Estimates for the Atlantic region (Newfoundland plus Maritimes) were also generated on the 1955-2011 sample but are not reported in the table. Three breaks were found (1975, 1982, and 1999).

Table 2. Breaks and NAIRU Estimates Based on the Bai and Perron Method

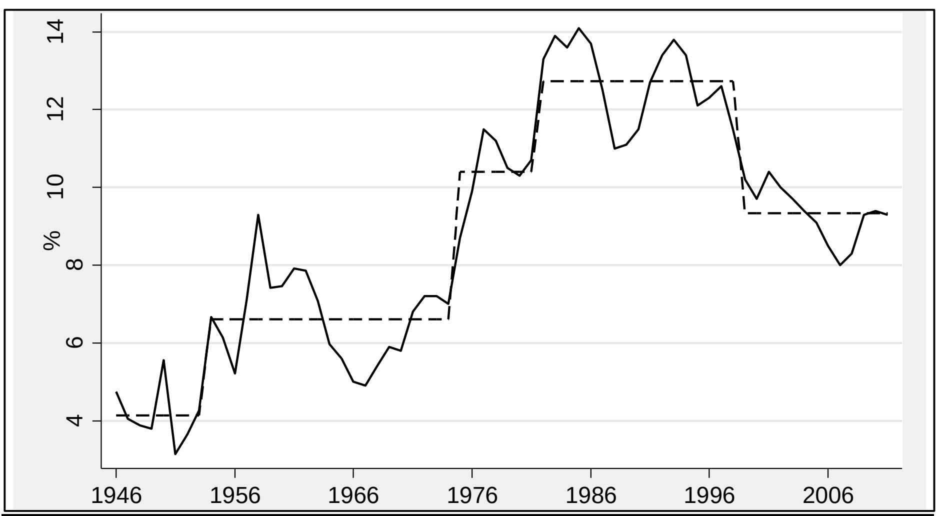
1946-2011 sample:						
Canada	3 breaks	1946-56	1957-76	1977-98	1999-11	
	NAIRU	3.0	5.3	9.3	7.2	
Quebec	3 breaks	1946-53	1954-76	1977-98	1999-11	
	NAIRU	3.1	6.4	11.4	8.3	
Ontario	2 breaks	1946-57	1958-74	1975-11		
	NAIRU	2.5	4.1	7.5		
British Columbia	4 breaks	1946-57	1958-81	1982-87	1988-03	2004-11
	NAIRU	4.0	6.9	13.4	8.8	6.2
Prairies	3 breaks	1946-57	1958-81	1982-96	1997-11	
	NAIRU	2.4	4.1	8.4	5.1	
Maritimes	4 breaks	1946-53	1954-74	1975-81	1982-98	1999-2011
	NAIRU	4.1	6.6	10.4	12.7	9.3
1955-2011 sample:						
Newfoundland	1 break	1955-73	1974-2011			
	NAIRU	9.1	16.3			
1966-2011 sample:						
Nova Scotia	3 breaks	1966-75	1976-81	1982-97	1998-11	
	NAIRU	6.0	10.0	12.4	9.0	
New Brunswick	2 breaks	1966-74	1975-98	1999-11		
	NAIRU	6.4	12.5	9.5		
Manitoba	3 breaks	1966-75	1976-81	1982-96	1997-11	
	NAIRU	4.2	5.7	8.2	5.1	
Saskatchewan	3 breaks	1966-75	1976-81	1982-96	1997-11	
	NAIRU	3.0	4.3	7.4	5.2	
Alberta	2 breaks	1966-81	1982-95	1996-11		
	NAIRU	4.1	9.0	5.1		

Notes: Estimates assume a minimum span of 6 years. The optimal number of breaks is determined using Bai and Perron's (1998) test of L vs. L+1 breaks (see their equation 10) assuming no heteroskedasticity or autocorrelation.

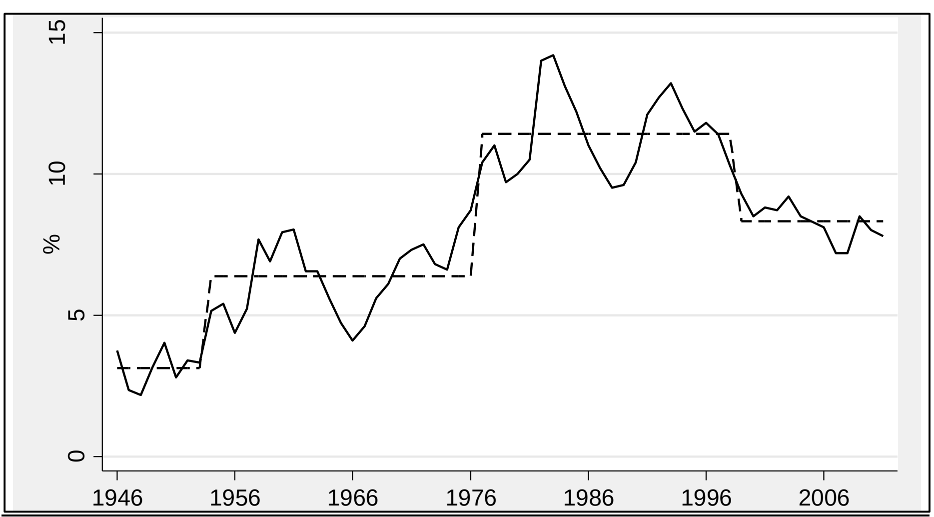
Figure 1. Unemployment rates (solid line) and NAIRU estimates (dashed).



A) Canada 1946-2011, ms = 6,7.

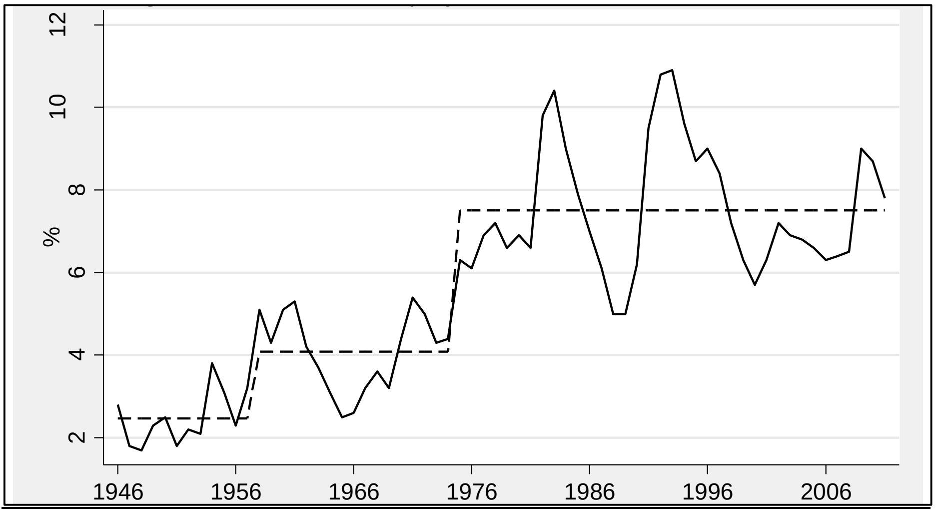


B) Maritimes 1946-2011, ms = 5,6,7.

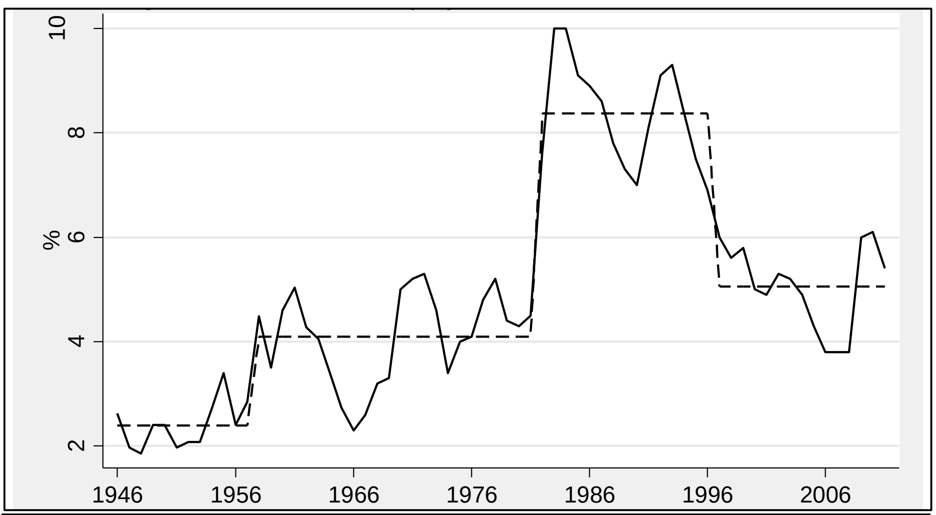


C) Quebec 1946-2011, ms = 5,6,7.

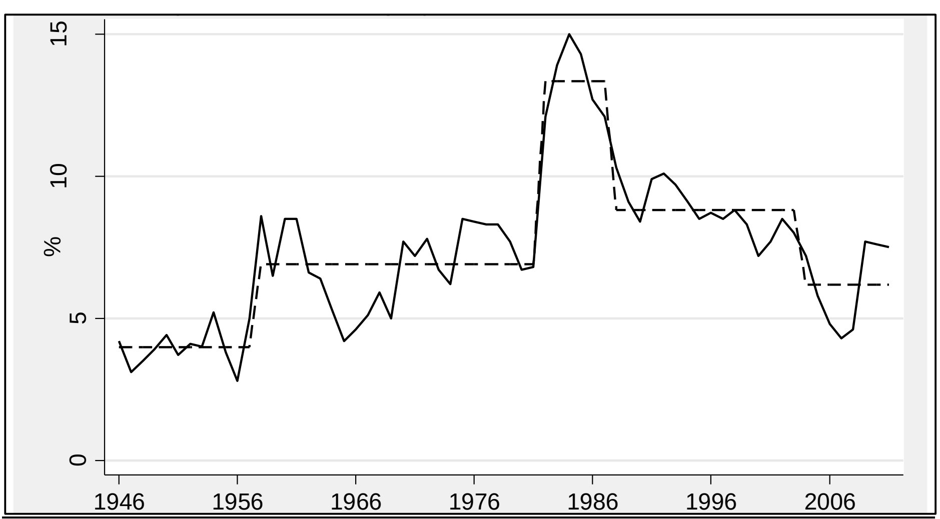
Figure 1 (continued). Unemployment rates (solid line) and NAIRU estimates (dashed).



D) Ontario 1946-2011, ms = 5,6,7.

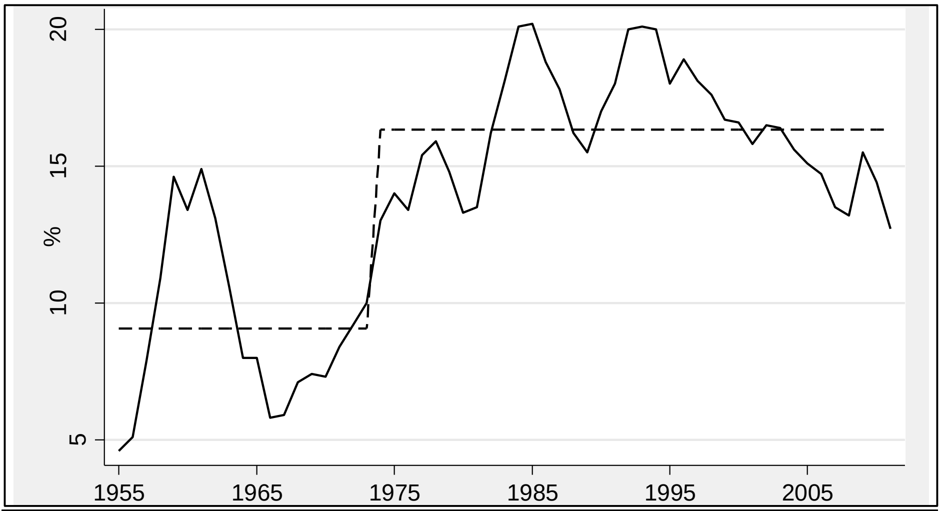


E) Prairies 1946-2011, ms = 5,6,7.

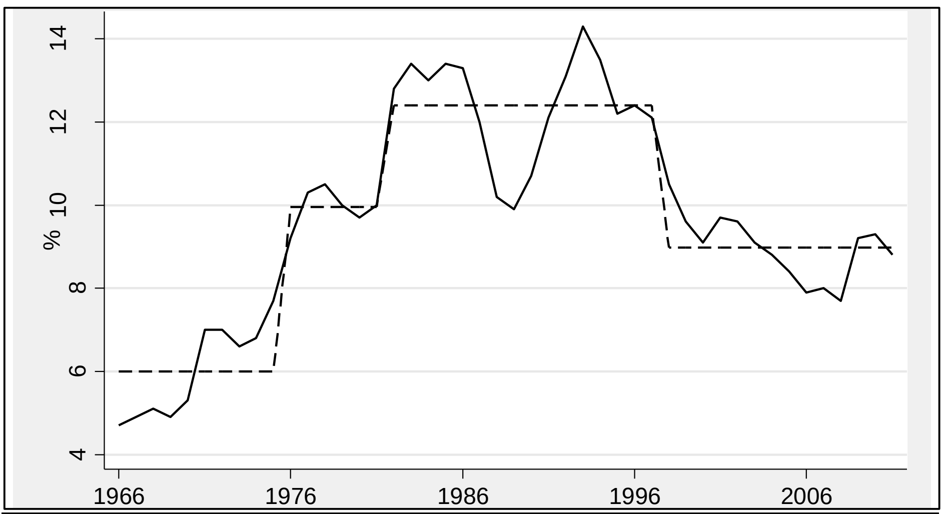


F) British Columbia 1946-2011, ms = 5.

Figure 1 (continued). Unemployment rates (solid line) and NAIRU estimates (dashed).



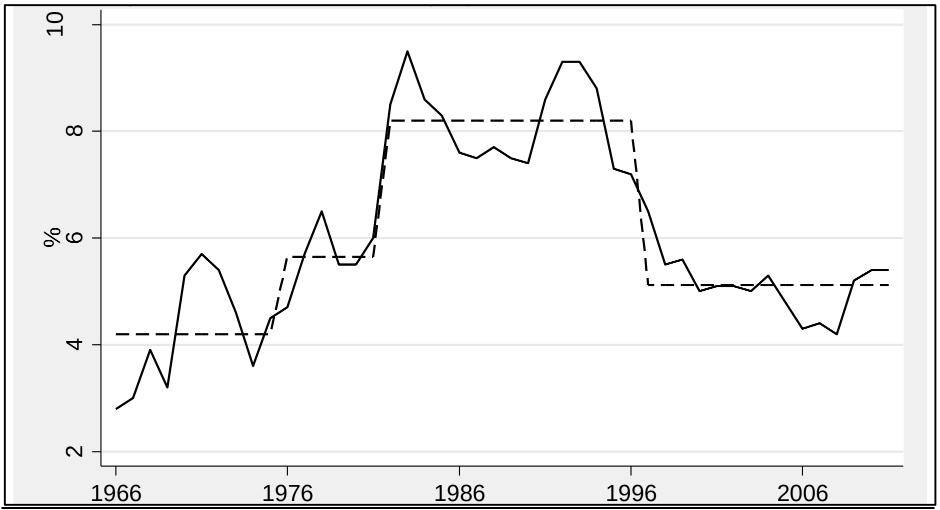
G) Newfoundland 1955-2011, ms = 5,6,7.



H) Nova Scotia 1966-2011, ms = 6.

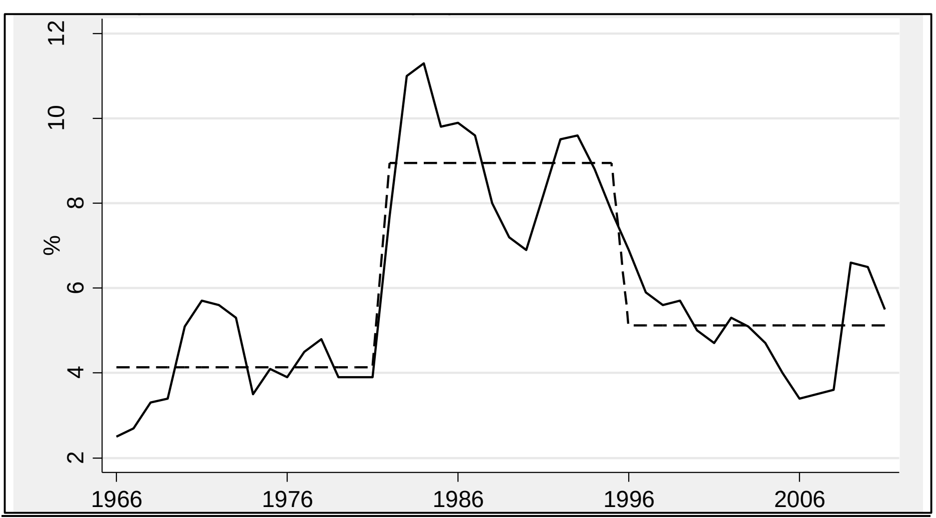
I) New Brunswick 1966-2011, ms = 5,6,7.

Figure 1 (continued). Unemployment rates (solid line) and NAIRU estimates (dashed).



J) Manitoba 1966-2011, ms = 6.

K) Saskatchewan 1966-2011, ms = 5,6.



L) Alberta 1966-2011, ms = 5,6,7.

What can explain the swings in the natural rates estimates found above? Are the estimates plausible or could they be mixing in business-cycle effects? The large theoretical and empirical literature on long-run unemployment rates identifies a number of potentially important determinants. One set of variables focuses on policies and institutions that might enhance or impede wage rigidity in the face of unemployment. These include minimum wages and the nature of wage-setting institutions including the degree of unionization and the level and degree of centralization in collective bargaining.[17] Results in the Canadian literature on the importance of such factors are mixed, reflecting the difficulties involved in isolating the effect of these factors.

A second set of variables considers the effects of the generosity, coverage, and design of the unemployment insurance (UI) system. These have received much attention, partly due to the significant changes to the Canadian UI program across time. UI may be of particular interest in explaining Canadian regional NAIRUs both because it may affect interregional labour mobility and because the generosity of the Canadian UI system is linked to regional unemployment rates. Indeed provisions dealing with fishermen and seasonal workers seem likely candidates for the persistently much higher unemployment rates found in Canada's eastern provinces, something for which there is no close U.S. counterpart. Benjamin, Gunderson, Lemieux, and Riddell (2012) provide a recent overview of the Canadian UI literature. Riddell (1980) and Card and Riddell's (1993) study of Canada-U.S. unemployment rate differences are specific examples that suggest that UI has important effects.

The degree of employment protection is a common focus in European studies but appears unlikely to have much power in explaining Canadian trends, a point made by Kuhn (2000). Some studies consider labor taxes as a possible contributing factor, with results in Nickell, Nunziata, and Ochel (2005) suggesting that this is a key factor in Canada, as shown in an earlier study by Côté and Hostland (1996).

Aside from policies and institutions, changing demographic composition is a possible contributor to NAIRU levels. A rise in the population share of a high unemployment rate group like young workers could push the natural rate up. Changes in information technology or other factors affecting the efficiency of the labor market matching process could also affect the natural rate. Others point to the interaction between rigidities and turbulence as a determinant. Hysteresis stories, by contrast, suggest dependence of equilibrium rates on past rates – something which has not received much support in the Canadian literature, see Jones (1995). In short the literature identifies many possible suspects. Can these factors lend plausibility to the pattern of breaks identified above?

The first set of breaks identified in Table 2 occurs in the mid-1950s. Interestingly, Denton and Ostry's (1964) decomposition of the Canadian unemployment rate for 1946-63 finds that the "residual" component rises after 1956 by some 2%-3%. This finding is consistent with results here; however, Denton and Ostry do not identify a cause.[18] Unemployment insurance program changes are a possible contributing factor. Statistics Canada (1995) indicates expanding program coverage (notably extension to some seasonal workers and fishermen), increased benefit rates, and extended benefit durations through the 1950s. Kuhn and Riddell (2010) find a jump in New Brunswick unemployment rates relative to those in neighboring Maine in the 1950s. Their analysis suggests that changes in the Canadian unemployment insurance system, especially the provisions extending benefits to seasonal workers, may have been important. The mid-1950s breaks in Table 2 are also close to the start of a mid-to-late 1950s downturn.[19] The timing is suggestive of some persistence or possible interaction with the newly enhanced UI system. Another possibility is that the detected break is partly capturing cyclical effects.

The mid-1970s breaks found in Newfoundland, the Maritime provinces, Quebec, Ontario, two of the Prairie provinces, and Canada as a whole may also be partly attributable to changes to the unemployment insurance system. Changes in 1971 extended coverage and made the program significantly more generous, especially for those with few weeks of insurable employment. Kuhn and Riddell identify these changes as key to the further increase in the New Brunswick-Maine unemployment rate gap that occurred in the mid-late 1970s. Riddell (1980) suggests that the 1971 changes were important for the rise in his natural rate estimates, especially that for

[17] See the Canadian papers using the "imperfections approach" cited earlier and, for a recent example, Nickell, Nunziata, and Ochel (2005).

[18] They break the national unemployment rate into a "short-cycle" component, minimum possible levels of frictional and seasonal unemployment, and a residual component.

[19] See Cross and Bergevin (2012) on the timing of Canadian recessions.

Newfoundland. Benjamin, Gunderson, Lemieux, and Riddell (2012) cite studies which cover this period and suggest that UI changes raised labor force participation among those with low labor force attachment.

Beyond UI, Johnson and Kneebone suggest that minimum wages may have played a role in the NAIRU increases in the mid-1970s, and indeed real minimum wages in most provinces do reach a peak at this time. However, the small number of workers paid the minimum wage and small, sometimes ambiguous, recent estimates of minimum wage employment effects suggest that they are unlikely to be too important. Nickell, Nunziata, and Ochel (2005, Table 3) indicate rising collective bargaining coverage as a possible contributor to the rise in the Canadian natural rate in this period; however, the coverage increase after the late 1960s reflects a rise in public sector unionization. Demographics may be a more promising factor for explaining NAIRU increases in this period. The high-unemployment youth population saw its share of the population rise through the 1960s and reach a peak in the early-to-mid 1970s. This likely raised the natural rate. In short, there are plausible explanations for the 1970s NAIRU increases found in this paper.

In most provinces, actual unemployment rates rose sharply with the recession of the early 1980s, recovered later in the decade, then rose and recovered as a result of the early 1990s recession. Nova Scotia, the Maritimes, and provinces west of Ontario see their natural rates jump upward 1981-82 and, with the exception of British Columbia, remain high until the late 1990s.[20] This is consistent with Milbourne, Purvis, and Scoones (1991), who argue that post-1977 features of the Canadian UI system that linked benefit duration to regional unemployment rates increased unemployment persistence, making the rise in the natural rate obvious only with the onset of the 1980s recession. Another possible interpretation of these trends is that the 1990s recession arrived before labor market recovery from the 1980s recession was complete, resulting in actual unemployment rates well above long-run levels from the early 1980s through to the mid-1990s. If correct, this interpretation suggests that the early-1980s rise in the estimated NAIRU may be confusing cyclically high unemployment with a high natural rate.

Fortin (1996) argues that demand factors, in particular monetary policy, account for the severity and length of the 1990s recession. However, he also reviews a range of possible supply-side factors that could have contributed to high unemployment by pushing up the natural rate. He notes in particular that rising real minimum wages and rising payroll taxes could have contributed but estimates their effects to be quite small. He also mentions the possibility that structural factors such as technological change or free trade and deregulation may have pushed up non-cyclical unemployment. Fortin is skeptical of the importance of these factors; however, Freeman and Macklem (1998), in their critique of Fortin, disagree. If Freeman and Macklem are correct, the high 1980s and 1990s NAIRUs may be rooted in adjustments to the Canada-U.S. Free Trade Agreement, NAFTA, and increasing globalization as well as labor market adjustments to changing technologies. Fortin further suggests that tightening of the UI system and social policy changes in the 1990s would, if anything, have tended to push the natural rate down, especially in eastern provinces where UI is more important. A falling youth population share might also push the natural rate down in the early to mid-1990s, counter to the estimates in Table 2.

Table 2 shows several declines in natural rates in the late 1990s: 1995-97 in the Prairie provinces and Nova Scotia, and 1998-99 for the Maritimes, Quebec, and Canada as a whole. In part this fall may reflect the effect of the earlier favorable changes in demographics and policy that were masked by the 1980s and 1990s recessions. Further changes to the unemployment insurance system in the 1990s may also have contributed.[21] To the degree that structural adjustment to international trade and technological changes resulted in high 1990s rates, lower rates after 2000 may mean that these adjustments have finally been sorted out.

Some provinces are outliers in the sense that they lack some of the most common breaks just mentioned or have uniquely timed breaks. Notable examples are Newfoundland, which has a single break in the mid-1970s, and Ontario with mid-1950s and mid-1970s breaks. Also, the timing of British Columbia's breaks differs from many provinces, notably the declines in 1987-88 and 2003-04. BC and Alberta are also unusual in the absence of a mid-1970s rise in their natural rate estimates.

[20] There is also an early-1980s rise for Canada as a whole if the minimum span is five years rather than six or seven.

[21] Several changes were made during the 1990s, including lower benefit rates, strengthened quit penalties, some restrictions on benefit duration, and increased weeks needed to qualify for UI for some workers.

Good candidate explanations for these unusual cases include end-of-sample problems and region-specific demand shocks. For example, region specific booms likely explain why Alberta and BC lack a mid-1970s rise in their natural rates and why British Columbia's NAIRU falls 1987-88. The unusual stability of the Newfoundland and Ontario NAIRUs after the mid-1970s partly reflects the sample endpoint. Extending the sample to 2014 would likely produce an additional break somewhere in the late 1990s or early 2000s.

8. Conclusion

The paper adopted the Bai-Perron approach to estimate long-run equilibrium or natural rates of unemployment for Canada and its regions using annual data. The results show that natural rates rose early in the sample period with initial increases in the 1950s followed by further rises typically in the mid-1970s and/or the early 1980s. Declines occurred in most cases later in the sample (1996-99). The movements in the natural rate estimates over the sample periods were often substantial.

For the most part, the patterns found are plausible. They are also intuitively appealing in that the actual unemployment rates fluctuate around the long-run equilibrium rate with few persistent positive or negative gaps. Changes in unemployment insurance likely contributed to the natural rate increases in the 1950s and 1970s and may have played a role in the 1990s declines. Other factors, such as large shocks, may have contributed to high estimates for the 1980s and 1990s. There are some concerns that these latter estimates may be mixing the effect of cyclical movements in the unemployment rate with changes in natural rates. This is likely to be most severe if the minimum span length is short or if two recessions closely follow one another. Problems of confusing cyclical and natural rate movements may be especially severe at sample endpoints. The approach is also restrictive in that is assumes that natural rate changes occur exclusively as discrete jumps. This may be natural for changes caused by policy or some sudden change in circumstance, but not if the underlying cause is itself changing gradually.

The method used to estimate the NAIRUs is driven solely by patterns in observed actual unemployment rates and as such cannot directly identify why jumps occur. Older approaches included measures of imperfections as control variables when estimating natural rates and, provided that problems in measuring imperfections and of multicollinearity could be overcome (a tall order in practice), could potentially identify reasons for changes in NAIRUs. An interesting avenue for further work would be to develop a theoretical model of regional NAIRUs allowing for interdependence created by migration flows. Such a model, rooted in either a search and matching approach or a wage curve approach like that of Deller, may give additional insights into the reasons behind variation in regional NAIRUs. A second interesting extension is suggested by Kuhn and Riddell's (2010) paper, which uses differences between Maine and New Brunswick to infer the effect of country-specific policies. Replicating the current exercise on the same sample period for U.S. states or regions and pairing economically similar Canadian and U.S. regions may provide additional insights into the reasons and timing of changes in regional NAIRUs.

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