Is Estimating the NAIRU like Searching for a Will o' the Wisp? The Canadian Case

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ABSTRACT

In 1992, Setterfield, Gordon, and Osberg published a seminal article in the European Economic Review, argued that varying measurement approaches significantly impact Non-Accelerating Inflation Rate of Unemployment (NAIRU) estimates. He likens the search for NAIRU to chasing a will o' the wisp. This study replicates Setterfield's methodology, utilizing a steady-state wage equation and a markup price equation to estimate NAIRU. While adhering closely to Setterfield's approach, this study differs by using data from 1997 to 2023, incorporating cost-push factors from imported intermediate inputs, and testing for stationarity, alongside rigorous diagnostic tests. Many regression variants were rejected due to failing these tests, but those that passed showed remarkably consistent NAIRU estimates. This raises the question of whether Setterfield's conclusion—that finding NAIRU is elusive—was influenced by using equations that would not pass diagnostic scrutiny. The tentative conclusion here is that the NAIRU is relatively well-defined and not a will o' the wisp at all.

DEDICATION

This research paper, undertaken as part of my MA in Economics, is dedicated to God, whose infinite wisdom, guidance, and grace have been my steadfast source of strength and inspiration throughout this academic endeavor.

To my family, whose constant love, support, and understanding have sustained me through every challenge and success. Your unwavering belief in me has been the driving force behind this achievement.

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CHAPTER 1: INTRODUCTION

1.1 Background and Statement of the Problem

Estimating the Non-Accelerating Inflation Rate of Unemployment (NAIRU) involves decisions about what model to use, what variables to include, how the variables are defined and how they are measured. Setterfield, Gordon and Osberg (1992) (hereafter denoted as "Setterfield") demonstrate that different, though entirely reasonable, decisions about these matters have great consequence for the resulting NAIRU estimates. In fact, the difference in estimates was as high as 5.5 percentage points. Their point was that searching for the NAIRU is like searching for a will o' the wisp. If it exists at all, we have very little knowledge of what it is.

This research paper follows the Setterfield procedure. There are 36 model variants depending on decisions about how expected inflation is measured, how union density is measured, how EI generosity is measured and how cost push is incorporated. The aim is to determine whether the Setterfield conclusion can be replicated using more recent data. Do seemingly innocuous decisions about how variables are measured have a big influence on NAIRU estimates?

CHAPTER 2: LITERATURE REVIEW

The literature dealing with the Phillips curve and the NAIRU is so large it might be called gargantuan without any hyperbole. Consequently, the following reviews of theory and literature are brief and selective.

2.1 Brief Theoretical Review

A.W. Phillips (1960), a New Zealand economist, published a paper in 1958 on the relationship between the unemployment rate and wage inflation in the United Kingdom based on observations from 1861 to 1957. The paper found an inverse relationship between wage growth and the unemployment rate. This relationship became known as the Phillips curve. Initially, it was an empirical relationship without theoretical basis. Richard G. Lipsey (1960) was the first to provide one.

Lipsey based his explanation on simple market clearing assumptions. When there is excess demand for an item, we expect the price to go up, and to increase at a faster rate, the greater is the excess demand. Similarly, when there is excess supply for an item, we expect the price to fall, and to fall at a faster rate the greater is the excess supply. Lipsey suggested that these principles should apply to the labor market and noted that the price of labor is not the nominal wage (W), but the real wage. Further, when wage bargains are struck, parties need to expect future prices. So, the effective price of labor is the nominal wage divided by the expected price level. Denoting N as employment, and N^f as full employment (or the market clearing level of employment), we can write:

$$The\ rate\ of\ change\ of\ \left(\frac{W}{P^e}\right) = \beta\ (N - N^f),\ \text{where}\ \ \beta > 0$$

Or

$$\dot{w} - \pi^e = \beta\ (N - N^f)$$

where $\dot{w}$ denotes wage inflation and π^e denotes the expected rate of change of prices (expected inflation). Since employment and output are positively related through the production function, we can replace the $(N - N^f)$ term with a term measuring the output gap, $(Y - Y^f)$. Finally, we invoke Okun's Law to replace the output gap with the unemployment gap, yielding:

$$\dot{w} = \pi^e + \phi\ (UR - UR^f),\ where\ \phi < 0 \qquad \textit{Wage inflation Phillips curve}$$

In this way, simple market clearing assumptions give rise to a Phillips curve where expected inflation enters with a unity coefficient. We can modify this equation in one respect: we could allow for the fact that in practice unions will often try to gear wage increases to productivity increases. Incorporating this element leads to the following equation:

$$\dot{w} = \pi^e + \phi\ (UR - UR^f) + a\ q \qquad \textit{Modified Wage Inflation Phillips curve}$$

In the above equation, q denotes the rate of growth of productivity and 'a' is the extent to which workers, through the bargaining process, can capture productivity growth as wage increases.

We move from the wage-inflation version of the Phillips curve to a price-inflation version by linking wages and prices through a simple mark-up equation of the form:

PY = k W N

This says the value of output, PY, is marked up by a factor "k", over labor costs, WN. Dividing through by output (Y) we have:

$$P = \frac{kW}{(Y/N)}$$

Note that Y/N is average productivity. Re-expressing the mark-up equation as rates of change, and assuming that the mark-up, k, is constant, we get:

$$\pi = \dot{w} - q$$

where q has already been defined as the growth of average productivity. Using the above equation to replace $\dot{w}$ from the wage-inflation Phillips curve, we get:

$$\pi = \pi^e + \phi\,(UR - UR^f) - (1 - a)\,q, \;\; where\; \phi < 0$$

The above equation is interesting because the non-accelerating inflation rate of unemployment (NAIRU) is defined as the unemployment rate that exists when actual equals expected inflation. Setting $\pi = \pi^e$, and $UR = NAIRU$, the above equation implies:

$$NAIRU = UR^f + \left\{\frac{(1-a)}{\phi}\right\} q$$

As Myatt (2008) points out, the idea of a distinction between the NAIRU and the full employment level of unemployment, UR^f, cannot be found in the literature. The only way to avoid the distinction is to assume that 'a' equals one, meaning that all productivity gains are captured by workers as wage increases. Setting 'a' = 1 we get NAIRU = UR^f, but whether 'a' actually equals unity is an empirical matter.

2.2 Brief Review of the Literature

Alternative micro underpinnings have been provided by other authors, including for example Edmund Phelps (1968). In his paper "Money-Wage Dynamics and Labor Market Equilibrium," he employed search theory to generate an expectations-augmented Phillips Curve. Again, expected inflation enters with a unity coefficient.

Milton Friedman (1968) made a key contribution to the Phillips curve hypothesis with his presidential address to the American Economic Association, titled "The Role of Monetary Policy." Friedman argued that the economy is inherently stable and has a natural tendency to return to a natural rate of unemployment, regardless of the inflation rate. Furthermore, any attempt to keep unemployment below the natural rate by expansionary monetary policy would result in accelerated inflation. As Friedman pointed out, the natural rate of unemployment depends on structural forces in the labor market, such as minimum wages, EI generosity, and the amount of structural turbulence in the economy. These influences have been extensively studied, and their empirical importance established.

For example, Johnson and Layard (1986) examined the effect of EI generosity using panel data from OECD nations covering the years 1970 to 1983. Generosity of EI was measured using replacement rates and benefit length. The study used a fixed effects model to separate the impacts of unemployment insurance and adjust for features unique to each country. According to their research, more generous EI programs often result in longer periods of unemployment, which raises NAIRU estimates. The effects differed between the countries, while some observed more moderate effects, others saw considerable rises in NAIRU because of greater benefit levels. This variation emphasized the distinctions across OECD nations and the important impact that unemployment insurance policies have in affecting the natural rate of unemployment.

Another study that focused on the effects of EI generosity is Abbott and Beach (1997). They employed Ordinary Least Squares (OLS) regression to explore the impact of different Employment Insurance (EI) program designs on the NAIRU using data from 1980 to 1994. Their analysis examined how various features of EI programs, such as the generosity and duration of benefits, influenced NAIRU. The study integrated variables related to EI system characteristics with other macroeconomic indicators in their models. By incorporating data on unemployment rates, EI program features, productivity levels, and labor market conditions, they assessed how the design of EI programs affects unemployment duration and incidence. OLS regression was used to estimate these relationships, and diagnostic tests were conducted to ensure model accuracy and control for potential biases. The findings revealed that the design of EI programs significantly impacts NAIRU estimates. Specifically, well-designed EI systems with appropriately calibrated benefits and durations mitigate adverse labor market outcomes and lead to lower NAIRU values. Differences in EI program characteristics across regions resulted in variations in NAIRU estimates. This study provided valuable insights into how well-structured EI systems can influence labor market dynamics and NAIRU stability.

Many studies have focused on the effects of minimum wages. For example, Tulip (2004) used data from 1980 to 2000 to explore the relationship between minimum wage legislation and the NAIRU in the US and Canada. He found that reductions in relative minimum wages were associated with lower NAIRU. However, the effect of minimum wages on unemployment is controversial. In the early 1990s, articles by Card, Katz, & Krueger et al. (1994), showed that minimum wage increases often have a zero or positive impact on employment. These results have been the subject of a 'lively' debate, discussed in Card and Krueger's 1995 book '*Myth and Measurement*'.

The effects of unions were studied by Layard et al. (2005). They used data from 1980 to 1990 across several OECD countries. Their study utilized Pooled Ordinary Least Squares incorporating fixed effects. The analysis revealed that higher unionization rates were associated with increased structural unemployment and higher NAIRU estimates. This was attributed to the increased bargaining power of unions, which led to higher wage demands and subsequently elevated unemployment rates as firms adjusted to increased labor costs. The findings indicated that in countries with higher unionization rate, NAIRU estimates were significantly higher, reflecting the challenges posed by union policies on long-term employment outcomes. The study highlighted the need for policy measures aimed at enhancing labor market flexibility and investment in human capital to address the structural issues associated with high unionization rates. Layard et al. suggested that improving labor market flexibility and mitigating the adverse effects of unionization on wages reduces the NAIRU and improves employment outcomes in the long term.

Supply-side shocks were emphasized by Robert J. Gordon (1997). He explored the dynamics of the inflation-unemployment trade-off in the United States, using data from the early 1960 to 1995, and accounted for factors such as fluctuations in oil prices and technological advancements.

For about a decade, the theory of the Phillips curve was well accepted and relatively uncontroversial. But in the 1980s, Europe experienced extended periods of high unemployment that did not seem related to structural factors mentioned so far (such as increases in the minimum wage or increases in EI generosity). Rather the high unemployment was linked to the lingering effects of the 1970s economic crisis. Termed hysteresis, Blanchard and Summers (1986) emphasized the "outsider" view of wage negotiation, where employed workers raise their wages when others become unemployed, preventing the unemployed from regaining their positions. They argued that the temporary increase in the unemployment rate generated by European economic downturns led to long-term rises in the NAIRU, with the impact persisting in the labor market even after the underlying causes were resolved. Their findings revealed that hysteresis affects more than just sticky unemployment rates, it also affects participation rates and hours worked, both of which display similar persistence.

Besides the insider/outsider theory, there are many other possible causes of hysteresis. For example, temporary rises in the unemployment rate could lead to skill erosion among the unemployed, shifts in worker and firm behavior, changes in wage-setting procedures, employer stigma towards the long-term unemployed, and diminished bargaining power among workers, leading to lower pay and less aggregate demand, and exacerbating high unemployment. This dynamic leads to a higher natural rate of unemployment, emphasizing the possibility that short-term increases in unemployment can have long-term negative impacts on the economy.

2.3 Critiques of the Phillips curve and the NAIRU

Using Canadian data, Setterfield, Gordon and Osberg (1992) explored the robustness of estimates of the NAIRU to seemingly innocuous decisions about how variables are measured. They concluded that different choices led to very big differences in the estimates of the NAIRU. The difference between the lowest estimate and highest was as big as 5½ percentage points. There was no good basis for deciding between very different estimates.

Staiger, Stock and Watson (1997) came to similar conclusions using US data. While arguing that a NAIRU was present in the data, they conceded that it could not be pinned down with any precision. Moreover, knowledge of the NAIRU did not much matter from the perspective of forecasting inflation (which is essentially the same point). Further, there were much better indicators than the unemployment rate (or the gap between the unemployment rate and the NAIRU) for forecasting inflation.

These papers suggest that if NAIRU exists, we do not know its value with any certainty. It could be practically anything. Myatt (2023) points out that we can see this in the data ourselves. The basic point of the accelerationist hypothesis – which requires a long-run vertical Phillips curve – is that when the unemployment rate is less than the NAIRU, inflation should increase, when unemployment is greater than the NAIRU, inflation should decrease, and when unemployment equals the natural rate, the change in inflation should be zero. Figure 1 plots the *change* in the inflation rate on the vertical axis, against the unemployment rate on the horizontal, for Canada.

Figure 1: The Change in inflation, Canada, 1962-2019

Source: Myatt, T. (2023). The Macroeconomics Anti-Textbook: A Critical Thinker's Guide (p. 16).

There does appear to be an overall negative slope to the scatter of points in Figure 1. As expected, really big recessions bring down the inflation rate, as occurred in 1983 and

1992. But if zero change in inflation occurs at the NAIRU, then the NAIRU apparently fluctuated from less than 4 percent in 1967 to over 10 percent in 1996. Further, we can find pairs of years with nearly identical unemployment rates that have very different changes in their inflation rates. Compare 1992 and 1993 for example. In both cases the unemployment rate was just over 11 percent. But in 1992 inflation fell by over 4 percentage points (due to missing deflation puzzle), while in 1993 inflation increased slightly. Since these were adjacent years, one could hardly claim that the NAIRU had changed significantly.

Fortin (2003) generalizes this point by calculating the deflation that should have occurred during the 1990s using consensus estimates of the NAIRU and the slope of the SRPC. He determines that inflation should have declined by 9.7 percentage points from 1992 to 2000. But the annual level of inflation in the year 2000 (1.5 percent) was unchanged from its 1992 value. Given this *missing deflation puzzle* he suggests that the long run Phillips curve is non-vertical implying that the NAIRU does not exist.

Naturally, this critique has not gone unanswered. Scarth (2020) argues that the data is readily explained once we incorporate imported intermediate goods. When we moved from the wage-inflation Phillips curve to the price-inflation version we assumed that labor was the only variable factor of production and that prices were marked up over wages. This allowed the replacement of the rate of change of wages, $\dot{w}$, with the rate of inflation, π. But Scarth (2020) notes that in an open economy, with both labor and imported intermediate inputs as variable factors in the short run, markup pricing involves:

$$\pi = \dot{w} + \gamma\, \dot{m}$$

where m denotes the price of imported intermediate inputs and γ stands for their relative importance in the production of final goods. Substituting the Phillips curve into the markup equation yields:

$$\pi = \pi^e - \lambda\,(UR - UR^f) + \gamma\, \dot{m}$$

Now if we set $\pi = \pi^e$ (when expectations are fully realized), this relationship does not imply that the actual unemployment rate equals the natural rate. Instead, the steady state inflation rate of unemployment (when $\pi = \pi^e$) is given by:

$$UR = NAIRU = UR^f + (\gamma/\lambda)\, \dot{m}$$

Since the domestic price of imported intermediate inputs rises whenever the real exchange rate falls, and since Canada's real exchange rate was falling significantly through the 1990s, the last term in the equation above was positive throughout this period. Scarth concludes that this explains the missing deflation puzzle. An unemployment rate greater than the NAIRU is consistent with a constant inflation rate whenever the real exchange rate is falling.

This discussion has emphasized the importance of incorporating both productivity growth and imported intermediate imports into estimates of the Phillips curve.

CHAPTER 3: METHODOLOGY, MEASUREMENT AND OBJECTIVES

3.1 Methodology

This study follows in the footsteps of Setterfield, combining a steady state wage equation with a markup price equation. Using both wage and price equations allows the incorporation of potentially important determinants of the equilibrium unemployment rate into the estimation process. They label this approach "a consensus technology for calculating the NAIRU".

Consider the following rate of change in wage equation:

$$\dot{w}_t = \alpha_0 + \alpha_1 \dot{w}_{t-1} + \alpha_2 \pi^e_{t-1} - \alpha_3 UR + \alpha_4 q_t + \alpha_5 EI_t + \alpha_6 MINIW_t + \alpha_7 UNION_t \qquad (1)$$

where "t" subscripts indicate the period, $\dot{w}$ is the rate of change in aggregate wages, π^e_t is the expected rate of inflation of the consumer price index, UR is the unemployment rate, q is the productivity growth rate, EI is a measure of employment insurance generosity, MINW is the ratio of the minimum wage to average hourly wages, and UNION is a measure of union density. All the α-coefficients are expected to be positive.

The lagged change in wage term is included by Setterfield to capture system inertia; expected inflation is included since the wage bargain should be in real terms and since both workers and firms are forward looking. Productivity growth can be used by workers to bargain for higher wages. EI is included since it insulates workers from some of the negative income impacts of unemployment, and thus makes unemployed workers more choosey when it comes to accepting or rejecting job offers. In this way, EI counters the downward pressures on wages in a high unemployment economy. Minimum wages are included since they may cause structural unemployment. If structural unemployment were to increase, the downward pressure on wages for any given level of total unemployment would be reduced.

Many would expect union density to work in the same way as minimum wages. However, as Setterfield notes (1991, page 124) there is not a consensus on the theoretical effect of unions on unemployment. The segmented labor market hypothesis suggests that unions have no quantity effects on the labor market, while others, such as McDonald and Solow (1985), argue that unions might even increase employment.

The wage-inflation equation is combined with the following price-inflation equation:

$$\pi_t = \beta_0 + \beta_1 \dot{w}_t + \beta_2 p_{it} - \beta_3 UR_t - \beta_4 q_t + \beta_5 \dot{m}_t \qquad (2)$$

There are two new variables in equation (2). The first is p_{it} which is defined in Setterfield as "the rate of change of non-wage input costs". It is not exactly clear what this variable captures. Is it non-labor costs? Or, is it *non-wage* labor costs? This study defines p_{it} as non-wage labour costs in order to capture changes in payroll taxes such as employer contributions to pension plans, EI benefits and other taxes. Clearly, higher payroll taxes increase the cost to the employer of hiring labor. Therefore, in the short run, increases in payroll taxes decrease employment growth and increase unemployment.

The second term (which is omitted in Setterfield) is $\dot{m}$, which denotes the rate of change of imported intermediate inputs. The importance of this variable is emphasized by Scarth (2020). It could be regarded as capturing “cost-push” factors, such as changes in world oil prices or changes in the real exchange rate, and according to Scarth is critical in explaining the “missing deflation problem” of the 1990s.

All the β-coefficients are expected to be positive. Of note, is the negative sign in front of the β_3 and β_4 coefficient. The negative β_4 reflects the fact that with mark-up pricing, increases in productivity would lower prices, ceteris paribus.

Denoting the steady state value of a variable with a “bar” superscript, we can solve equation (1) for the steady state wage-inflation equation by setting $\dot{w}_t = \dot{w}_{t-1} = \overline{w}$. This yields:

$$\overline{w} = \left[\frac{1}{1-\alpha_1}\right]\{\alpha_0 + \alpha_2\pi_t^e - \alpha_3 UR_t + \alpha_4 q_t + \alpha_5 EI_t + \alpha_6 MINIW_t + \alpha_7 UNION_t\} \quad (3)$$

Substituting (3) into (2) yields

$$\pi_t = \beta_0 + \beta_1\left[\frac{1}{1-\alpha_1}\right]\{\alpha_0 + \alpha_2\pi_t^e - \alpha_3 UR_t + \alpha_4 q_t + \alpha_5 EI_t + \alpha_6 MINIW_t + \alpha_7 UNION_t\} + \beta_2 p_{it} - \beta_3 UR_t - \beta_4 q_t + \beta_5\dot{m}$$

Collecting terms, we can write

$$\boldsymbol{\pi_t = \gamma_0 + \gamma_1\pi_t^e - \gamma_2 UR_t + \gamma_3 q_t + \gamma_4 EI_t + \gamma_5 MINIW_t + \gamma_6 UNION_t + \beta_2 p_{it} + \beta_5\dot{m}} \quad \textbf{(4)}$$

All γ coefficients are positive except for γ_2 coefficients of unemployment.

where:

$\gamma_0 = \beta_0 + \alpha_0\beta_1/(1-\alpha_1)$	$\gamma_1 = \frac{\beta_1\alpha_2}{1-\alpha_1}$	$\gamma_2 = \frac{\beta_1\alpha_3}{1-\alpha_1} + \beta_3$
$\gamma_3 = \frac{\beta_1\alpha_4}{1-\alpha_1} - \beta_4$	$\gamma_4 = \frac{\beta_1\alpha_5}{1-\alpha_1}$	$\gamma_5 = \frac{\beta_1\alpha_6}{1-\alpha_1}$
$\gamma_6 = \frac{\beta_1\alpha_7}{1-\alpha_1}$		

The steady state equilibrium condition is $\pi_t = \pi_t^e = \bar{\pi}$. Substituting into (4) we obtain

$$\bar{\pi} = \gamma_0 + \gamma_1\bar{\pi} - \gamma_2 UR_t + \gamma_3 q_t + \gamma_4 EI_t + \gamma_5 MINIW_t + \gamma_6 UNION_t + \beta_2 p_{it} + \beta_5\dot{m}$$

Collecting like terms, and using the definition of γ_1 this becomes

$$0 = \gamma_0 + \left\{\left[\frac{\beta_1\alpha_2}{1-\alpha_1}\right] - 1\right\}\bar{\pi} - \gamma_2 UR_t + \gamma_3 q_t + \gamma_4 EI_t + \gamma_5 MINIW_t + \gamma_6 UNION_t + \beta_5\dot{m}$$

(5)

The existence of a NAIRU requires a vertical long run Phillips curve. In this context, this requires that $\alpha_1 + \alpha_2 = \beta_1 = 1$. When this is the case, the term in front of $\bar{\pi}$ in equation (5) becomes zero. This is easily shown. Replacing $1-\alpha_1$ with α_2, the $\bar{\pi}$ coefficient becomes

$$\{[\frac{\beta_1\alpha_2}{\alpha_2}] - 1\} = \beta_1 - 1 = 0$$

It should be noted that when $\alpha_1 + \alpha_2 = \beta_1 = 1$ that the term γ_1 in equation 4 is unity. This gives us an easy way to test the existence of a NAIRU.

The vertical Phillips curve means that, in equilibrium, workers and employers establish wages and prices that align with the existing stable rate of price inflation. Therefore, labor and product markets are primarily influenced by changes in relative prices. The NAIRU is both unique (equilibrium behavior is unaffected by price inflation) and stable. To challenge this assumption, we test the hypothesis that $\alpha_1 + \alpha_2 = \beta_1 = 1$. If the condition holds, we may solve for NAIRU from equation (5):

$$NAIRU = (1/\gamma_2)\{\gamma_0 + \gamma_3\bar{q}\} + (1/\gamma_2)\{\gamma_4 EI + \gamma_5 MINIW_t + \gamma_6 UNION_t + \beta_5 \dot{m}\} \quad (6)$$

Note that the existence of a steady state rate of productivity growth, $\bar{q}$, follows from growth theory. But it doesn't make sense to assume the existence of a steady state level of either EI nor minimum wages since they are both policy-determined and can be changed by the government at any time. Nor does it make sense to assume a steady state level of union density. Literally, equation (6) solves for a time series of NAIRU. We could, however, use the average values of these variables to compute the average value of NAIRU over any given period. This would be "in the spirit of" Setterfield and allow the results from this study to be more easily compared to theirs.

We now shift our focus to the question of measurement.

3.2 Measurement of variables

For some variables, theory gives a clear indication of how they should be measured. For example, productivity should be measured by total factor productivity growth and not by GDP per worker since the latter would be expected to vary over the business cycle. Also, non-wage input cost is measure as ration of supplementary income to total wage income. On the other hand, many variables involve arbitrary choices. This is the case for expected inflation, union density, EI generosity and imported intermediate inputs.

3.2.1. Expected inflation

Since expected inflation cannot be observed, it needs to be proxied. We use three proxies, the first two of which were used in Setterfield. The first is to assume regressive expectations, where expected inflation equals last period's actual inflation $\pi^e = \pi_{t-1}$. This method has been used by Fortin (1989). The second method is to use an eight-quarter moving average of past inflation rates. This was used in the Bank of Canada's 1988 RDXF model. We will denote this as π^e_{ma}. The third is to assume rational expectations where the expected rate of inflation is the predicted value of inflation regressed on all the lagged independent variables. We will denote this as π^e_{re}.

3.2.2. Union density

Setterfield measures union density in three different ways, depending on what they use to deflate the number of unions members. The three denominators were: total labour force denoted as “udl”, non-agricultural paid workers denoted as “ude”, and all employees denoted as “uda”. However, deflating by non-agricultural paid workers seems odd, given that some union members may themselves be agricultural workers. This leaves two reasonable measures of union density as well as the possibility of omitting the variable entirely.

3.2.3. EI generosity

Two measures of EI generosity are used. First, following Fortin (1984), an index number denoted as “fei” is constructed. It is the product of coverage (the proportion of the labor force insured), replacement rate (the ratio of net after-tax unemployment benefits to a net after-tax wage equal to 80 percent of the average weekly wage) and duration ratio (the ratio of the maximum duration of benefits to the minimum number of weeks). Second, EI payments per EI recipient measured in real terms denoted as “cei”.

3.2.4 Imported intermediate inputs

Two measures were used as proxies here. First, the real exchange rate denoted as “exr”. Second, real oil prices denoted as “m”. Oil price is measured as a rate of change of oil price in dollar per barrel while exchange rate is measure relative to USD.

3.3 The Variants Matrix

By combining all these arbitrary choices, there are 3 x 3 x 2 x 2 = 36 different regressions that are possible.

Table 1: The Different Variants
<u>Expected Inflation</u> a. Regressive ($\pi^e = \pi_{t-1}$) b. 8-quarter moving average ($\pi^e = \pi^e_{ma}$) c. Rational expectations ($\pi^e = \pi^e_{re}$)
<u>Union Density</u> 1. Deflating union membership by total labour force (udl) 2. Deflating union membership by all employees (uda) 3. Union density not included
<u>EI generosity</u> A. Using the Fortin index (fei) B. Using real payments per recipient (cei)
<u>Imported Intermediate Imports</u> i. Using the real exchange rate (exr) ii. Using real cost of a barrel of oil (m)

3.4 Estimation Methods and Diagnostic Tests

Estimating the NAIRU in Canada involves several steps to ensure reliable estimates. The process begins by determining the appropriate lag length for the variables in the model using lagged order selection criteria such as the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). This step is crucial for accurately capturing the dynamic relationship between variables. Next, the stationarity of the data series is checked to ensure their mean and variance do not change over time. To check for sensitivity to a particular test, this study uses both the Augmented Dickey-Fuller test and the Phillips-Perron test. Sensitivity to the test is confirmed in this data set. In particular, all the variables were stationary using the Augmented Dickey-Fuller test, but the Phillips-Perron test suggests that productivity growth, real oil price, and the real exchange rate are non-stationary. Despite this mixed evidence we continue with the use of Ordinary Least Squares (OLS) for two reasons. First, it is supported by the Augmented Dickey-Fuller test, and second, it is the approach that Setterfield employed, and we wish to see if we can replicate his results. Once the equations are estimated, we apply diagnostic tests.

CHAPTER 4: EMPIRICAL RESULTS AND DISCUSSION

4.1 Lag selection order

Lag selection order refers to choosing the appropriate number of lagged terms to include in a model in order capture the relevant patterns and relationships in the data without overfitting or underfitting. The test was conducted for thirty-six combinations of variables, but we are reporting one as a representative sample of our model specifications. The reported variant is b, ii, A,1. This includes eight quarter moving averages of expected inflation (b), real oil price as a measure of cost push inflation (ii), Fortin index of EI generosity (A) and union density as a percentage of labor force (1).

Table 2: Lag selection order								
Lag	LL	LR	Df	p	FPE	AIC	HQIC	SBIC
0	64.0593				1.10E-12	-4.87472	-4.77539	-4.47977
1	596.281	1064.4*	64	0	3.10E-30	-45.5896*	-44.6957*	-42.035*
2			64		-1.9e-32*			

Table 2 presents the optimal lag lengths determined by indicators such as log-likelihood (LL), Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC), and Schwarz-Bayesian Information Criterion (SBIC). The asterisks (*) next to the values in the Lag 2 row suggest that this is the best model according to these criteria. For our empirical estimation, the model with 1 lags is the preferred choice, as it minimizes the prediction error (FPE) and information criteria (AIC, HQIC, SBIC), indicating a better fit and forecasting ability. Consequently, it provides more reliable results in the subsequent Phillips-Perron (PP) and Augmented Dickey Fuller test for stationarity.

4.2 Checking for Stationarity

The Phillips-Perron (PP) test was conducted on the data to check for unit root and their stationarity,

Table 3A: Phillips-Perron (PP) test				
Variable		Z(rho) Statistic	Z(t) Statistic	p-value (Z(t))
pinf	Price inflation	-14.212	-2.976	0.0372
ur	unemployment rate	-13.728	-2.969	0.0379
q	Productivity growth	-6.952	-2.019	0.2784
m	Real oil price	-5.458	-1.846	0.3578
exr	Real exchange rate	-3.78	-1.381	0.5915
MINIW	Minimum wages	-4.52	-3.27	0.0163
fei	Fortin index of unemployment rate	-16.846	-3.483	0.0084
udl (trend)	Union density as a percentage of labor force	-21.117	-3.916	0.0115
uda (trend)	Union density as a percentage of all employees	-19.91	-3.705	0.022
cei (trend)	EI payment per recipient	-28.218	-6.353	0

Table 3A presents the Phillips-Perron (PP) test for unit root. The tests reveal that the inflation rate, unemployment rate, minimum wage, EI payment per recipient, Fortin index of EI, union density as a percentage of labor force and union density as a percentage of all employees are stationary, indicating that these variables are mean-reverting and do not follow a unit root process. In contrast, productivity growth, real oil price, exchange rate are non-stationary, suggesting the presence of unit roots.

The Augmented Dickey–Fuller (ADF) test is the most common method for testing unit roots in time series data. We conducted the test with the term drift to ensure that our data is stationary. This test is a prerequisite for subsequent econometric methods. We use the term drift in inflation, unemployment rate, productivity growth, real oil price, real exchange rate and minimum wages. However, we use the term trend in EI recipient per person, Fortin measure of EI, Union density as a percentage of labor force and as a percentage of all employees.

Table 3B: Augmented Dickey Fuller Test					
Variable		Lags	Test Type	Z(t) Statistic	p-value
pinf	Price inflation	1	Drift	-3.42	0.0013
ur	unemployment rate	1	Drift	-4.057	0.0003
q	Productivity growth	1	Drift	-2.387	0.013
m	Real oil price	1	Drift	-2.063	0.0256
exr	Real exchange rate	1	Drift	-1.953	0.0318
MINIw	Minimum wages	1	Drift	-2.802	0.0052
fei	Fortin index of unemployment rate	1	Trend	-4.879	0.0003
udl	Union density as a percentage of labor force	1	Trend	-3.358	0.0572
uda	Union density as a percentage of all employees	1	Trend	-2.987	0.1357
cei	EI payment per recipient	1	Trend	-4.842	0.0004

Table 3B shows that all variables are stationary at integrated order of I(0). For that reason, we can now use OLS as our estimation method.

4.3 Regression Results and Diagnostic Tests

After running our 36 variants, all the equations were subject to diagnostic tests. To test for autocorrelation, we used the Durbin Watson statistic and the Breusch-Godfrey LM statistic. The Breusch-Pagan / Cook-Weisberg was used to test for heteroskedasticity. Of the thirty-six variants, six passed all the diagnostic tests and had a value for γ_1 insignificantly different from unity. Recall, if γ_1 is not equal to unity the long run Phillips curve is not vertical and NAIRU is not defined. We call these six variants our "preferred equations". Another 6 variants pass the autocorrelation tests but fail the heteroskedasticity test. These variants also have a value for γ_1 insignificantly different from unity and therefore yield estimates of NAIRU. We call this group of six equations the "less preferred equations". The remaining 24 equations fail all the diagnostic tests. We call this group the "rejected equations". Interestingly, none of the equations in this group have a value for γ_1 close to unity. Therefore, they do not yield estimates of the NAIRU. However, it is important to note that the equations were not rejected *because* γ_1 was significantly different to unity. Indeed, it would have been an interesting and novel result to conclude that the long run Phillips curve is non-vertical.

4.3.1 The Preferred Equations

Table 4 below shows the model variants of the preferred equations along with the diagnostic test results.

Table 4: Diagnostic Test of Estimates in the Preferred Equations

Variants	b,i,A,1	b, i,B,1	b,i,A,3	b, i,A,2	b,i,B,3	b, i, B,2
Coefficient of expected inflation γ_1	0.972	1	1.05	1.03	1.01	1.03
R square	0.88	0.87	0.87	0.87	0.87	0.88
Mean VIF	2.73	3.62	2.31	2.84	2.62	3.11
D Watson	1.93	2.27	1.72	1.79	2.27	2.24
Breusch-Godfrey LM Test	0.74	0.11	0.54	0.74	0.12	0.19
Breusch-Pagan / Cook-Weisberg Test	0.046	0.05	0.0445	0.051	0.124	0.054

Note: refer to variant matrix in table 1

b,i,A,1: Eighth quarter moving average (b), exchange rate (i), Fortin index of EI generosity (A), and union density as a percentage of labor force (1)

b, i,B,1: Eighth quarter moving average (b), exchange rate (i), payment per recipient of EI generosity (B), and union density as a percentage of labor force (1)

b,i,A,3: Eighth quarter moving average (b), exchange rate (i), Fortin index of EI generosity (A), and union density excluded (3)

b, i,A,2: Eighth quarter moving average (b), exchange rate (i), Fortin index of EI generosity (A), and union density as a percentage of all employees (2).

b,i,B,3: Eighth quarter moving average (b), exchange rate (i), Payment per recipient EI generosity (B), and union density excluded (3)

b, i, B,2: Eighth quarter moving average (b), exchange rate (i), Payment per recipient of EI generosity (B), and union density as a percentage of labor force (1)

It should be noted that all the preferred equations were of the “b” variant category, which used the eight-quarter moving average of past inflation rates to proxy for expected inflation. This was the approach used in the Bank of Canada’s 1988 RDXF model.

Considering the cells in Table 4, the model explains a significant portion of inflation variance, with R-squared values averaging 0.88. Also, the variance inflation factor (VIF) values suggest that multicollinearity is not a major concern in these models, and the estimates of the coefficients are likely reliable.

The Durbin-Watson statistic and Breusch-Godfrey LM test suggest no significant autocorrelation, confirming the reliability of the OLS estimates. Further, the Breusch-Pagan/Cook-Weisberg test suggests that heteroskedasticity is not a significant issue.

Next, let us consider the coefficient estimates in the preferred variants. These are contained in Table 5.

Table 5: Coefficients from the Preferred Equations											
Variants		π^e_{ma}	Ur	q	exr	MINIW	fei	cei	udl	uda	Const
b,i,A,1	Coeff	0.97	1	17	0.4	-1.7	-1.3		11.4		-24.8
	Std Err	0.2	0	9.7	1.3	6.9	1.1		12.9		12.1
	P-Value	0	0	0.1	0.8	0.8	0.3		0.39		0.1
b,i,B,1	Coeff	1	1	16	-0.1	0.1		0.0	1.9		-21.0
	Std Err	0.2	0	10	1.3	7.0		0.0	20.6		14.0
	P-Value	0	0	0.1	0.9	1.0		0.5	0.9		0.2
b,i,A,3	Coeff	1.1	1	16	0.7	-5.2	-1.4				-17.9
	Std Err	0.1	1	16	0.7	5.6	1.1				9.2
	P-Value	0	0	0.1	0.6	0.4	0.3				0.1
b,i,A,2	Coeff	1	1	16	0.6	-3.7	-1.4			4.46	-20.4
	Std Err	0.2	0	9.8	1.3	7.7	1.2			14.7	12.5
	P-Value	0	0	0.1	0.7	0.6	0.3			0.77	-20.4
b,i,B,3	Coeff	1	1	16	-0.1	-0.1		0.0			-20.0
	Std Err	0.1	0	9.4	1.2	6.6		0.0			9.3
	P-Value	0	0	0.1	0.9	1.0		0.2			-20.0
b,i,B,2	Coeff	1	1	15	0.1	-2.6		0.0		-12	-14.3
	Std Err	0.2	0	9.6	1.3	7.6		0.0		17.2	12.7
	P-Value	0	0	0.1	1.0	0.7		0.2		0.5	0.3

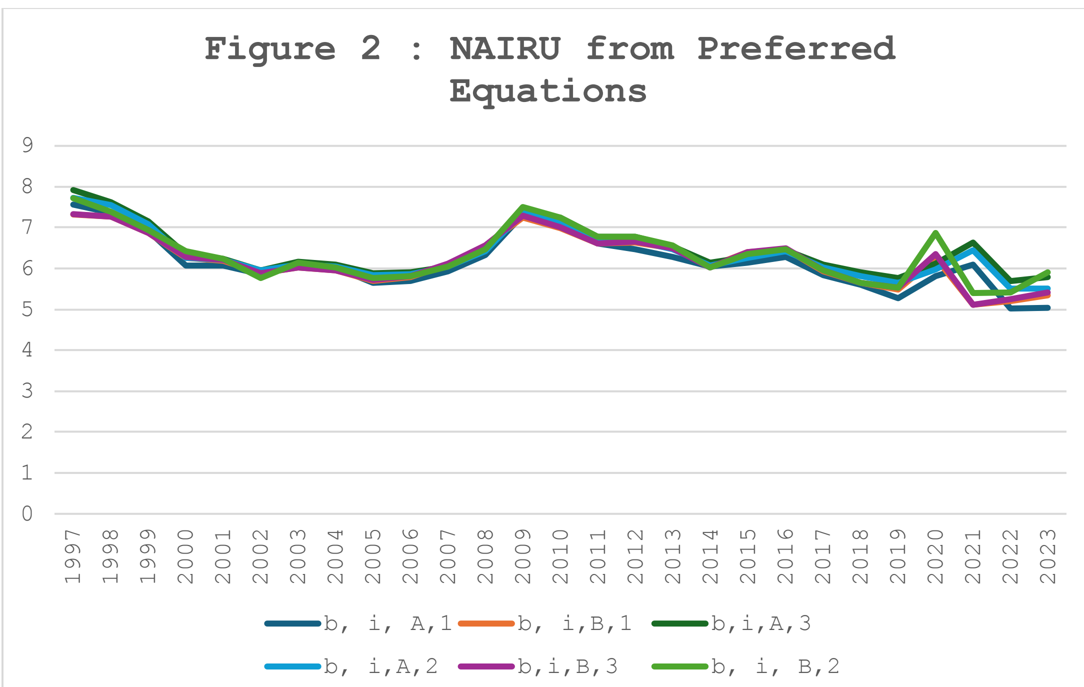
Table 5 shows that all the preferred variants have close to unity coefficient in front of expected inflation (γ_1 =1) so a NAIRU is defined in these cases. Of the remaining variables, unemployment, productivity growth, oil prices, union density (as a percentage of labor force) and real EI payments per recipient all have a positive sign in alignment with our a-priori expectations. The minimum wage, exchange rate, and union density (as a percentage of all employees) and the Fortin index of EI had negative (though insignificant) coefficients in few numbers of the preferred equations. The unemployment rate, and expected inflation are always significant at the 5% level. They appear to be the key drivers of changes in the inflation rate as simple Phillips curve would suggest. None of the remaining variables are statistically significant.

Next, we report the estimates of NAIRU derived from the preferred model variants. These are shown in Table 7 below. The first row shows the average NAIRU over the entire period. The remaining rows show the NAIRU for various sub-periods.

Table 6: The NAIRU estimates from the preferred equations									
Variants	b,i,A,1	b,i,B,1	b,i,A,3	b,i,A,2	b,i,B,3	b,i,B,2	Max	Min	Diff
1997-2023	6.17	6.22	6.42	6.34	6.23	6.34	6.42	6.17	0.26
1997-2000	6.98	6.93	7.27	7.15	6.94	7.12	7.27	6.93	0.34
2001-2010	6.10	6.17	6.25	6.21	6.19	6.22	6.25	6.10	0.15
2011-2020	6.16	6.27	6.40	6.33	6.28	6.34	6.40	6.16	0.24
2021-2023	5.50	5.48	6.06	5.86	5.53	5.90	6.06	5.48	0.57

The highest NAIRU in the entire research period is observed in variant {b, i, A, 3}. This is referring to the specification which has eight quarter moving average of expected inflation (b), cost push measured by the real exchange rate (exr) (i), EI generosity using Fortin index(A), and union density excluded (3). Contrarily, the lowest NAIRU in the entire research period is observed in variant {b, i, A, 2}. This is referring to the specification which has eight quarter moving average of expected inflation (b), cost push measured by the real exchange rate (i), EI generosity using Fortin index (A), and union density as a percentage of labor force (1).

The key issue is whether the NAIRU estimates are robust to seemingly innocuous decisions about how variables are measured. Recall that Setterfield reported that different choices led to very big differences in the estimates of the NAIRU. The difference between their lowest estimate and highest was as big as 5½ percentage points. Meanwhile, table 5 shows that our estimates vary much less than that. Over the entire period, the difference between the highest and the lowest NAIRU is only 0.26 percentage points. In contrast to Setterfield, these estimates are remarkably consistent. Chart 2 below plots the estimated NAIRU's for each year from 1997 to 2023 to check whether they exhibit much volatility over time.



The line graph of the NAIRU fluctuates like an elongated "W". Beginning in 1997 with a NAIRU around 7½%, the estimates fall to around 6% in 2006, before climbing to a peak at a little over 7% in 2009. Then they begin a downward drift towards 5%, a drift that is interrupted by some volatility late in the period (2019-2023) that could be related to the COVID pandemic.

4.3.2 The Less Preferred Equations

We now turn our attention to the variants from less preferred equations, beginning with the diagnostic test results shown in Table 7.

Table 7: Diagnostic test of NAIRU estimates in the less preferred equations

Variants	b,ii,A,1	b, ii,B,1	b,ii,A,2	b,ii,B,3	b, ii,A,2	b,ii,A,3
γ_1	0.88	0.88	0.92	0.90	0.92	0.96
R square	0.89	0.88	0.88	0.88	0.89	0.88
Mean VIF	2.61	3.46	2.7	2.4	2.92	2.46
D Watson	1.97	2.19	1.82	2.19	2.19	1.72
Breusch-Godfrey LM Test	0.59	0.18	0.90	0.18	0.22	0.57
Breusch-Pagan / Cook-Weisberg Test	0.00	0.00	0.00	0.00	0.00	0.00

It can be observed that the R-squared values of are quite high, averaging 0.88. The variance inflation factor is within a reasonable value. The Durbin-Watson statistic along with Breusch-Godfrey LM test p-values indicate no significant autocorrelation in the residuals. However, the Breusch-Pagan/Cook-Weisberg test results implies that heteroskedasticity is really a concern. We observed that outliers in oil price could disproportionately affect the variance of the residuals, leading to heteroskedasticity. Outliers could cause the error variance to increase or become non-uniform. Finally, since the $\gamma 1$ coefficients are all insignificantly different from unity, all these variants imply a vertical long run Phillips curve, meaning that a value for the NAIRU can be calculated. Table 8, below, shows the coefficients for the variables in these equations.

Table 8: The Coefficient Estimates in the Less Preferred Equations											
Variants		π_{ma}^{e}	Ur	q	m	MINIW	Fei	Cei	Udl	Uda	Const
b,ii,A,1	Coeff	0.9	0.6	22.7	0.0	3.8	-0.7		12.2		-32.4
	P-Value	0.0	0.0	0.0	0.3	0.5	0.5		0.3		0.0
b, ii,B,1	Coeff	0.9	0.5	21.5	0.0	4.3		0.0	4.3		-29.1
	P-Value	0.0	0.0	0.0	0.2	0.5		0.6	0.8		0.1
b,ii,A,2	Coeff	1.0	0.6	22.1	0.0	1.4	-0.7				-26.4
	P-Value	0.0	0.0	0.0	0.3	0.8	0.5				0.0
b,ii,B,3	Coeff	0.9	0.6	22.1	0.0	3.0	-0.9			6.4	-29.4
	P-Value	0.0	0.0	0.0	0.3	0.7	0.5			0.7	0.0
b, ii,A,2	Coeff	0.9	0.5	20.9	0.0	4.0		0.0			-27.0
	P-Value	0.0	0.0	0.0	0.2	0.5		0.3			0.0
b,ii,A,3	Coeff	0.9	0.5	20.4	0.0	2.4		0.0		-7.8	-23.0
	P-Value	0.0	0.0	0.1	0.3	0.7		0.3		0.6	0.1

Table 8 reveals that all the shift variables in the less preferred equations (except for Fortin index of EI) have a positive coefficient estimate, in alignment with our a-priori expectation. Also, eight-quarter moving averages of expected inflation, unemployment, productivity growth and oil prices are statistically significance at 5% level suggesting they are key drivers of changes in the inflation rate. However, the minimum wage, both measures of the generosity of EI, and both measures of union density are not statistically significant at 5% level.

Next, we consider the implied values of NAIRU from these equations, beginning in Table 9 with period averages.

Table 9: NAIRU Estimate from Less Preferred Equations									
Yr	b,ii,A,1	b,ii,B,1	b,ii,A,2	b,ii,B,3	b,ii,A,2	b,ii,A,3	Max	Min	Diff
1997-2023	5.80	5.75	5.95	5.78	5.86	6.08	6.08	5.75	0.34
1997-2000	6.56	6.47	6.68	6.48	6.60	6.84	6.84	6.47	0.37
2001-2010	5.86	5.82	5.94	5.84	5.88	5.99	5.99	5.82	0.17
2011-2020	5.80	5.83	5.97	5.87	5.94	6.11	6.11	5.80	0.30
2021-2023	4.56	4.26	4.95	4.33	4.57	5.29	5.29	4.26	1.03

Throughout the entire study period, the difference between the highest and lowest NAIRU estimates was 0.34 percentage points – practically identical to the difference using the preferred equations. The highest NAIRU was recorded in variant {b, ii, A, 3}, which includes eight quarter moving average of inflation expectations (b), cost push measured by oil price(ii), Fortin index measure of EI (A), and union density excluded (3). Conversely, the lowest NAIRU was found in variant {b, ii, B, 1}, characterized by eight quarter moving average of inflation expectations (b), cost push measured by oil price(ii), EI payment per recipient (B), and union density as percentage by total labor force (1). This variant {b, ii, B, 1} also has the lowest NAIRU across the sub-periods.

The variability of the NAIRU estimate in less preferred equations is primarily influenced by the inclusion or exclusion of union density. The highest NAIRU was observed when union density was excluded in the model, while the lowest NAIRU was recorded when union density was included as a percentage of labor force. However, the impact is not statistically significant. Chart 3 below plots the estimated NAIRU's for each year from 1997 to 2023 to check whether they exhibit much volatility over time.

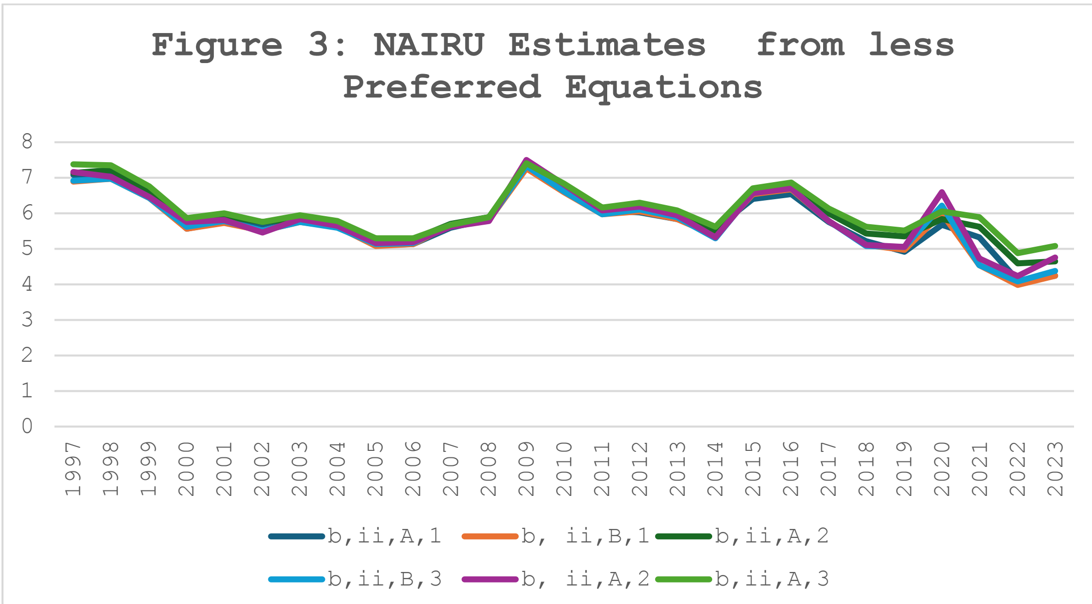


Chart 3 shows a very similar pattern to that of Chart 2. We again see an elongated "W" and some volatility late in the period (2019-2023) that could be related to the COVID pandemic.

To conclude this section, the NAIRU estimate from both preferred equations and less preferred equations are very similar. The variability of NAIRU is slightly higher in the less preferred equations but still much less than that of Setterfield. This could be because the preferred equations are more robust in that they pass all of the diagnostic tests.

4.3.3 The Rejected Equations

Table 10 below shows diagnostic tests for the rejected equations. None of the models proxying expected inflation using the regressive expectation assumption, nor those models using the rational expectations assumption passed the diagnostic tests. (The rationally expected value of inflation was obtained by regressing inflation on the lagged value of all the explanatory variables and using the predicted value.)

Table 10: The diagnostic Tests for the Rejected Equations					
Variants	R squre	D Watson	Breusch-Godfrey LM Test	Breusch-Pagan / Cook-Weisberg Test	γ_1
a,ii,A,1	0.74	1.94	0.91	0.01	0.28
a,ii,B,1	0.74	2.13	0.48	0.00	0.28
a,ii,A,3	0.68	1.58	0.14	0.00	0.39
a,ii,A,2	0.71	1.83	0.57	0.01	0.30
a,ii,B,3	0.72	2.20	0.34	0.00	0.32
a,ii,B,2	0.72	2.20	0.34	0.00	0.32
a,i, A,1	0.67	1.89	0.65	0.03	0.40
a,i,B,1	0.65	2.36	0.05	0.00	0.41
a,i,A,3	0.57	1.46	0.02	0.00	0.60
a,i,A,2	0.63	1.76	0.26	0.01	0.45
a,i,B,3	0.63	2.41	0.05	0.00	0.47
a,i, B,2	0.63	2.40	0.06	0.00	0.47
c,ii,A,1	0.81	2.42	0.18	0.45	0.08
c, ii,B,1	0.60	1.91	0.82	0.10	0.00
c,ii,A,3	0.68	1.54	0.20	0.34	0.36
c,ii,A,2	0.82	2.22	0.43	0.40	0.14
c,ii,B,3	0.45	1.43	0.02	0.26	0.16
c, ii,A,2	0.67	1.88	0.77	0.21	0.06
c, i, A,1	0.82	2.43	0.16	0.57	0.13
c, i,B,1	0.61	1.91	0.83	0.18	-0.07
c,i,A,3	0.69	1.54	0.20	0.27	0.37
c, i,A,2	0.82	2.23	0.39	0.56	0.19
c,i,B,3	0.45	1.43	0.02	0.30	0.05
c, i, B,2	0.67	1.89	0.79	0.27	0.02

Some models fit the data well, displaying higher R^2 values, while others, particularly those with rational expectations, show relatively low R^2 values averaging around 0.45. Rejected models demonstrate issues such as serial correlation and heteroscedasticity. Therefore, the estimates are rejected and were not reported in this paper.

5. CONCLUSION

5.1 Concluding Comments

The Setterfield article, published in the European Economic Review (Volume 36, Issue 1, January 1992, Pages 119-136), had a significant impact garnering 67 citations and 16 references. He concludes that different, though entirely reasonable, decisions about how variables are measured have great consequence for NAIRU estimates. He likens the search for a NAIRU to searching for a will o' the wisp.

This research paper closely follows the Setterfield methodology and attempts to replicate his results. However, Setterfield did not test for stationarity and does not report a full array of diagnostic tests. If we had followed Setterfield and not used diagnostic tests, we may have reached many erroneous conclusions. For example, we may have concluded that the long run Phillips was non-vertical. But the equations embodying this result failed diagnostic testing and were rejected. The question arises to what extent is the Setterfield conclusion – that trying to find the NAIRU is like searching for a will o' the wisp – influenced by using equations that would fail diagnostic tests.

In this study the equations that passed diagnostic tests contained estimates of the NAIRU that were remarkably consistent. It suggests that decisions about how variables are measured have very little impact on NAIRU estimates. The difference between NAIRU estimates from the "preferred equations" was 0.26 percentage points, while the difference suggested by the “less preferred equations” was 0.34. It appears that the NAIRU is relatively well defined and not a will o’ the wisp at all.

5.2 Limitations of the Study

1. This study has followed Setterfield in incorporating the lagged rate of change of wages in the wage change equation. It would be interesting to drop this term, since it has no strong theoretical basis.

2. We know higher payroll taxes increase the cost to the employer of hiring labour. Therefore, in the short run, increases in payroll taxes decrease employment growth and increase unemployment. But the long-run incidence of a tax depends on the relative elasticities of the supply and demand curves. Since labor supply is relatively inelastic, most empirical estimates suggest that labor ends up paying payroll taxes by having lower take-home wages than they would otherwise have. So, changes in payroll taxes can explain temporary changes in the natural rate, but not permanent changes. There have been periods such as the early 1990s, when payroll taxes increased at a rapid rate, which might have temporarily increased the natural rate of unemployment – or perhaps slowed down its rate of decrease. This study used the level of the payroll tax rate in the estimations, not its rate of change. It would be interesting to see whether using the rate of change in the payroll tax rate had better explanatory power.

3. This study has assumed that changes in costs coming from imported intermediate imports have a 100% pass through onto current prices. It would be interesting to

experiment with having a moving average influence from this variable. This would cushion year-to-year changes.

4. Some variables were found to be non-stationary using Phillips Perron test for unit root. This could typically violate the assumptions of the Ordinary Least Squares (OLS) method. Despite this, OLS was employed because variables were stationary with Augmented Dickey Fuller test and the primary objective was to replicate the work of Setterfield, who used a similar approach. Future research should consider refining the econometric methods that account for non-stationarity observed in Phillip Perron test for unit root.

5. A key limitation of this research is that the coefficient on the unemployment rate (UR) is unexpected and counterintuitive. This poses a puzzling challenge for the analysis.

6. The analysis did not include a dummy variable for the unemployment rate (UR) during the COVID-19 period, which could have provided more nuanced insights.

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DATA SOURCE

Our full dataset spans the years 1997-2023 and includes entire Canada. The following are the sources of variables we utilize in our research.

Minimum wage ratio: Ratio of minimum wages and average hourly earnings

Description for Chart 1 - Minimum wage and average hourly earnings in Canada, 1975 to 2014 obtianed from publication on statcan.

website: https://www150.statcan.gc.ca/n1/pub/11-630-x/2015006/c-g/desc1-eng.htm

Consumer Price Index: We obtain our inflation rate as a rate of change of CPI

Table: 18-10-0005-01 (formerly CANSIM 326-0021)

Website: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1810000501

Unemployment rate: Obtained from Statcan

Table: 14-10-0023-01 (formerly CANSIM 282-0008)

Website: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410002301

Productivity growth: Total Factor Productivity at Constant National Prices for Canada, Index 2017=1, Annual, Not Seasonally Adjusted. Obtained as index number from Federal Reserve Bank of St. Louis. Economic Research Division

Website: https://fred.stlouisfed.org/

https://fred.stlouisfed.org

Union coverage by industry, annual (x 1,000) 1 2: Obtained as union density as a percentage of labour force, union density as a percentage of non-Agric paid worker (Not included), union density as a percentage of all employees.

Table: 14-10-0070-01 (formerly CANSIM 282-0078)

Release date: 2024-01-05

Website: https://www150.statcan.gc.ca/n1/en/catalogue/1410007001

DOI: https://doi.org/10.25318/1410007001-eng

Main Product: Union coverage by industry, annual

EI Generosity

1. EI payment per recipient calculated as

   I. Proportion of UI recipients. (EI expenditure divided by labor force)

   II. Deflated by maximum duration of UI (Weeks)

   III. Divided by Net of Average weekly wage (80% AWW)

2. Fortin index measure of EI: Employment insurance regular income benefit characteristics, monthly, seasonally adjusted.

Calculated as the product of three variables:

coverage: the proportion of the labor force insured.

1. replacement rate: the ratio of net after-tax unemployment benefits to a net after-tax wage equal to 80 percent of the average weekly wage; and
2. Duration ratio: the ratio of the maximum duration of benefits to the minimum number of weeks of work required for qualification to benefits.

Note: The replacement rate is calculated by taking the net after-tax unemployment benefits and dividing it by the net after-tax wage that is equivalent to 80% of the average weekly wage. This ratio helps determine how well unemployment benefits replace typical earnings and can be used to gauge the effectiveness of the unemployment insurance system in maintaining the standard of living for unemployed individuals.

Source: Maximum duration of UI (Weeks)Table: 14-10-0008-01 (formerly CANSIM 276-0018), https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410000801

Labour force characteristics by industry, annual (x 1,000)1,

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410002301

Employment insurance benefit characteristics by class of worker, monthly, unadjusted for seasonality. Tables: 14-10-0007-01 (formerly CANSIM 276-0017),

https://www150.statcan.gc.ca/n1/en/catalogue/1410000701

Person received. (R) Table: 14-10-0138-01 (formerly CANSIM 276-0001).

Employment Insurance Program (E.I.), income beneficiaries by province, type of income benefit, sex and age.

https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1410013801

CURRICULUM VITAE

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