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Downward Nominal Wage Rigidity, Inflation and Unemployment: New Evidence Using Micro-Level Data



by Dany Brouillette and Natalia Kyui

Canadian Economic Analysis Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
dbrouillette@bankofcanada.ca
nkyui@bankofcanada.ca

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Abstract

Recent evidence suggests that the extent of downward nominal wage rigidity (DNWR) in the Canadian labour market has risen following the 2008–09 recession (see Brouillette, Kostyshyna and Kyui 2016). This note studies whether DNWR can lead to a long-run trade-off between inflation and unemployment, especially at lower rates of inflation—a question that has important implications for the optimal level of inflation in the long run. The results suggest that the trade-off between unemployment and inflation remains weak despite the estimated increase in DNWR. In particular, the long-run Phillips curve is close to vertical at inflation rates of 2 per cent or more, in line with earlier findings (Crawford and Wright 2001). As a result, an increase in long-term inflation from 2 to 3 per cent would lower unemployment by about 0.1–0.2 percentage points. Overall, our results suggest that the benefits of raising the inflation target to attain a lower long-term unemployment level seem rather weak.

Bank topics: Labour markets; Inflation and prices; Econometric and statistical methods
JEL codes: E; E2; E24; E3; E31; J; J3; J30

Résumé

Selon une étude récente, la rigidité à la baisse des salaires nominaux (RBSN) sur le marché canadien du travail aurait pris de l'ampleur à la suite de la récession de 2008-2009 (voir Brouillette, Kostyshyna et Kyui, 2016). Dans la présente note, les auteurs examinent si la RBSN peut entraîner un arbitrage à long terme entre l'inflation et le chômage, surtout en contexte de bas taux d'inflation, une question qui a d'importantes implications pour le niveau d'inflation optimal à long terme. Les résultats portent à croire que l'arbitrage entre le chômage et l'inflation demeure faible malgré l'augmentation estimée de la RBSN. En particulier, la courbe de Phillips à long terme est presque verticale lorsque les taux d'inflation sont établis à 2 % ou plus, ce qui concorde avec les conclusions d'une étude antérieure (Crawford et Wright, 2001). Par conséquent, si le taux d'inflation à long terme augmentait pour passer de 2 à 3 %, le taux de chômage diminuerait d'environ 0,1 à 0,2 point de pourcentage. Dans l'ensemble, les résultats donnent à penser que le relèvement de la cible d'inflation afin d'atteindre à long terme un niveau de chômage plus bas est assez peu avantageux.

Sujets : Marchés du travail ; Inflation et prix ; Méthodes économétriques et statistiques
Codes JEL : E, E2, E24, E3, E31, J, J3, J30

1. Introduction

Recent evidence for Canada suggests that downward nominal wage rigidity (DNWR) is present in the labour market and that its effects on the average wage growth increased in the years following the 2008–09 recession (Brouillette, Kostyshyna and Kyui 2016). This note examines the impact of DNWR on the long-term unemployment level in Canada. In particular, we analyze whether DNWR can lead to a long-run trade-off between inflation and unemployment, especially at lower rates of inflation. This question has important implications for the optimal level of inflation in the long run and for the desirability of the Bank of Canada's current 2 per cent inflation-control target.²

The economic literature suggests that DNWR can lead to a long-run trade-off between inflation and unemployment, especially in a low-inflation environment (e.g., Tobin 1972; Benigno and Ricci 2011; and Daly and Hobijn 2014). Some earlier studies for Canada found that the long-term effect of DNWR on unemployment was negligible (Crawford and Wright 2001; Farès and Lemieux 2000; Faruqui 2000; and Farès and Hogan 2000). In contrast, some other studies such as Fortin (2013) argued that the combination of DNWR and low inflation pushed unemployment above the level at which it would have been in the absence of DNWR. Building upon earlier studies, this note aims to reassess the impact of DNWR on the long-run trade-off between inflation and unemployment using micro-level data.

Section 2 updates the Phillips curve estimates under the presence of DNWR in Canada, following Crawford and Wright (2001). Section 3 examines the robustness of the results to various measures of inflation expectations and time periods, and reviews the evolution of the relationship between unemployment, inflation and wages over time. Finally, Section 4 concludes.

² The Bank of Canada uses monetary policy to achieve a 2 per cent inflation-control target, within a target range of 1 to 3 per cent, as part of its mandate to promote the economic and financial welfare of Canada. This inflation-control target is renewed every five years by the government and the Bank of Canada. The last renewal was in 2016.

2. Revisiting the Phillips Curve in Canada: Does DNWR Affect the Long-Run Trade-off Between Inflation and Unemployment?

2.1 Setting the empirical framework

DNWR might affect the long-run trade-off between inflation and unemployment by making the long-run Phillips curve non-vertical at low rates of inflation. Using recent micro-level data from Major Wage Settlements (MWS) and various measures of inflation expectations, we update the estimates of the long-run Phillips curve in the presence of DNWR provided by Crawford and Wright (2001).³

We use a Tobit model with time-dependent variance and a stochastic threshold to derive the notional wage distribution as described by equation 1:⁴

$$\Delta w_{it} = \begin{cases} \Delta w_{it}^n, & \text{if } \beta X_{it} + \varepsilon_{it}^n > k_{it}, \\ 0, & \text{if } \beta X_{it} + \varepsilon_{it}^n \leq k_{it}, \end{cases} \quad (1)$$

where indices i and t represent a negotiated contract in MWS and time, respectively. Δw_{it} is the observed change in hourly wages while $\Delta w_{it}^n = \beta X_{it} + \varepsilon_{it}^n$ is the notional wage change—the wage change in absence of DNWR. Explanatory variables X_{it} are listed below and parameter k_{it} represents the stochastic threshold defined as $k_{it} = k_0 + \mu_{it}$, with $\mu_{it} \sim N(0, \sigma_\mu^2) = N(0, e^{\gamma_0})$. The random term of the notional wage distribution is also assumed to be normally distributed with time-dependent variance: $\varepsilon_{it}^n \sim N(0, \sigma_\varepsilon^2) = N(0, e^{(\alpha_0 + \alpha_1 t)})$. Moreover, ε_{it}^n is assumed to be uncorrelated with μ_{it} .

Equation 1 implies that the expected wage change is given by

$$E[\Delta w_{it}] = Prob(\Delta w_{it}^n > k_{it}) \cdot E(\Delta w_{it}^n | \Delta w_{it}^n > k_{it}) = \Phi(\tilde{z}) \cdot \beta X + \sigma_\varepsilon \cdot \phi(\tilde{z}), \quad (2)$$

³ The MWS database collects all negotiated contracts in unionized businesses or organizations in Canada with at least 500 employees: <http://www.labour.gc.ca/eng/resources/info/datas/wages/index.shtml>

⁴ The stochastic threshold (Nelson 1977) is intended to capture menu costs. This issue may arise because it could be more costly for a firm to offer a small wage change rather than a wage freeze. Such wage freezes are not related to DNWR and need to be accounted for.

where $\tilde{z} = \frac{(\beta X - k_0)}{\eta}$ with $\eta = \sqrt{\sigma_\varepsilon^2 + \sigma_\mu^2}$; ϕ and Φ are the normal probability density and cumulative density functions, respectively, and $\Phi(\tilde{z})$ represents the proportion of contracts with a positive wage change, i.e., contracts unaffected by DNWR and menu costs ($Prob(\Delta w_{it}^n > k_{it})$). The expected change in the notional wage is defined by

$$\Delta w^n \equiv \beta X \equiv \beta_0 + \beta_1 U + \beta_2 \pi^e + \beta_3 \Delta LP. \quad (3)$$

U is the unemployment rate, π^e represents expected inflation and ΔLP is the change in labour productivity.

In the long run, inflation (π) is assumed to be equal to the difference between the expected wage change and labour productivity growth:

$$\pi = E[\Delta w] - \Delta LP. \quad (4)$$

Equations 2, 3 and 4, together with the assumptions that $\pi = \pi^e$ and $\beta_2 = \beta_3 = 1$, imply the Phillips curve⁵

$$\pi = \frac{\widehat{\beta}_1(U - U_{NR})\Phi(\tilde{z}) + \widehat{\sigma}_\varepsilon\phi(\tilde{z})}{1 - \Phi(\tilde{z})} - \Delta LP, \quad (5)$$

which captures the long-run trade-off between inflation and unemployment. The natural rate of unemployment, $U_{NR} \equiv -\frac{\widehat{\beta}_0}{\widehat{\beta}_1}$, is defined as the value of the unemployment rate for which the Phillips curve becomes vertical. If inflation is indeed high enough, DNWR is not binding, $\Phi(\tilde{z})$ tends to 1 and the trade-off between inflation and unemployment disappears. If instead inflation is sufficiently low, the slope of the Phillips curve is negative, and raising inflation reduces the unemployment rate. Equation 5 also shows that this trade-off between inflation and unemployment is not linear since \tilde{z} is a function of both U and π .

We estimate the model in the following way. First, equation 1 is estimated via maximum likelihood using micro-level data. Estimated parameters ($\widehat{\beta}_0$, $\widehat{\beta}_1$, $\widehat{\sigma}_\varepsilon$, $\widehat{\sigma}_\mu$ and \widehat{k}_0) are then used in equation 5, which can be finally solved for the unemployment rate (U) as a function of inflation. The next section discusses estimation results in more detail.

⁵ We restrict coefficients on the labour productivity growth and inflation expectations to be equal to 1 as done in the literature. See, for instance, Crawford and Wright (2001) and Fortin (2013).

2.2 Phillips curve estimation results

For the dependent variable, we use the wage change in the first year for each MWS contract between January 1984 and May 2015. We choose realized provincial inflation rates (measured with the provincial consumer price index [CPI]) as a measure of inflation expectation. This measure provides a long monthly historical series and allows us to use, for each firm, the inflation rate for the province in which the firm is based. Since labour productivity growth data are quarterly, we assume the quarterly growth for each month of the quarter.

Table 1 shows the estimated coefficients of equation 1 under the presence of DNWR for the entire sample, as well as for private and public organizations. The estimation results suggest a negative relationship between the unemployment rate and the long-term inflation level, as expected. The natural rate of unemployment $\left(-\frac{\hat{\beta}_0}{\hat{\beta}_1}\right)$ is estimated at 5.4 per cent for the specification using the full sample.⁶ However, this estimated level is sensitive to the chosen period and measure of inflation expectations, as we discuss in more detail in the next section.

The Phillips curve estimation suggests that the trade-off between inflation and the unemployment rate is quite small for an inflation rate around 2 per cent (**Chart 1**). At this level, the Phillips curve returns a value of 5.8 per cent for the unemployment rate, which is 0.4 percentage points higher than the natural rate of unemployment. If inflation were to increase from 2 to 3 per cent, the unemployment rate would decline from 5.8 to 5.5 per cent. On the other hand, if inflation were to decline from 2 to 1 per cent, the unemployment rate would increase from 5.8 to 6.3 per cent.

Chart 1 also shows the importance of conducting the analysis with both private and public sectors. The slope of the long-term Phillips curve for the public sector is flatter at a low level of inflation compared with the private sector—consistent with the presence of more DNWR in this sector as documented in Brouillette, Kostyshyna and Kyui (2016)—meaning that for a given decrease in inflation, the increase in the unemployment rate is larger for the public sector than for the private sector. Using only one sector would therefore lead to an underestimation or overestimation of the long-term trade-off between inflation and unemployment.

⁶ Estimated trade-offs in **Chart 1** and **Chart 2** are based on the assumption that labour productivity growth is equal to its historical average of 1.2 per cent.

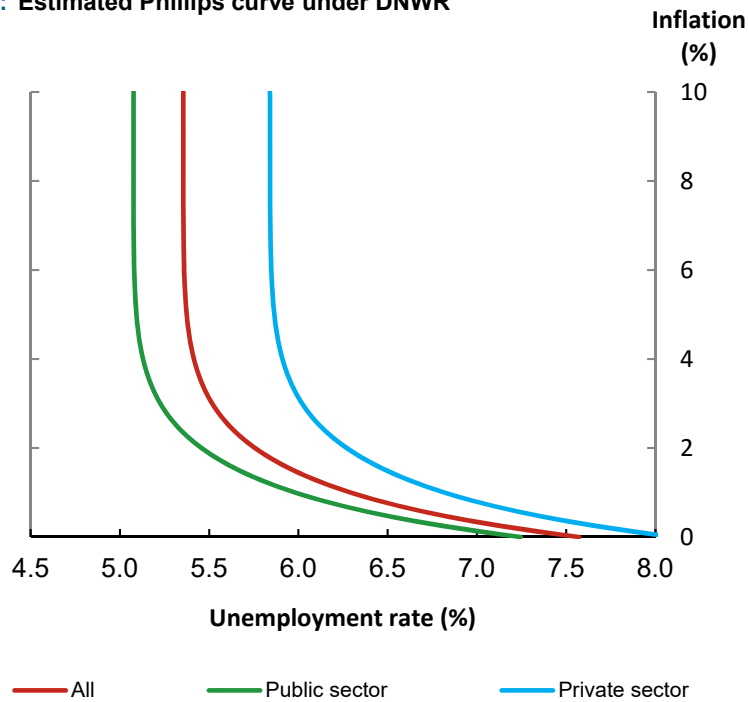
Table 1: Estimated coefficients for the notional wage change with DNWR

	Whole sample 1984–2015	Private 1984–2015	Public 1984–2015
<i>LP growth</i> (β_3)	1.0	1.0	1.0
<i>Provincial CPI</i> (β_2)	1.0	1.0	1.0
<i>Unemployment rate</i> ($\hat{\beta}_1$)	-0.4394*** (0.0161)	-0.4493*** (0.0260)	-0.4357*** (0.0206)
$\hat{\beta}_0$	2.3524*** (0.1365)	2.6239*** (0.2222)	2.2113*** (0.1729)
\hat{k}_0	0.6806*** (0.0213)	0.5933*** (0.0360)	0.7233*** (0.0265)
$\hat{\alpha}_0$	1.1356*** (0.0182)	1.2132*** (0.0278)	1.0795*** (0.0242)
$\hat{\alpha}_1$	-0.0005*** (0.0001)	-0.0008*** (0.0001)	-0.0002*** (0.0001)
$\hat{\gamma}_0$	-0.9582*** (0.0538)	-0.8685*** (0.0831)	-1.0814*** (0.0776)
<i>Observations</i>	12,749	4,840	7,909

Note: Standard errors in parentheses; *** p-value < 0.01.

Sources: Major Wage Settlements and authors' calculations

Chart 1: Estimated Phillips curve under DNWR



Source: Bank of Canada calculations

3. How Robust Are These Results to Different Model Specifications?

This section explores the sensitivity of the Phillips curve estimations to different measures of inflation expectations and to different time periods. Taking into account the range of estimates, we conclude that the natural rate of unemployment is around 6 per cent over the 1994–2015 period and the long-run trade-off between inflation and the unemployment rate remains modest for an inflation rate around 2 per cent.

3.1 Inflation expectations and the long-run Phillips curve

We study the robustness of the model presented in the previous section to different measures of inflation expectations. Namely, we use provincial CPI, Department of Finance Canada’s two-year inflation expectations (FIN), the Bank of Canada’s market-based measure of three-year inflation expectations (Market), and Consensus Economics’ two- to three-year inflation expectations (CE). For the measure from Consensus Economics we estimate the model using 1995–2015 data, while for all other measures we use the 1994–2015 period. Furthermore, we also include the first three measures of inflation expectations in one model, assuming that the underlying inflation expectations could be a linear combination of these three measures, with the weights being directly estimated along with the parameters of the Phillips curve.

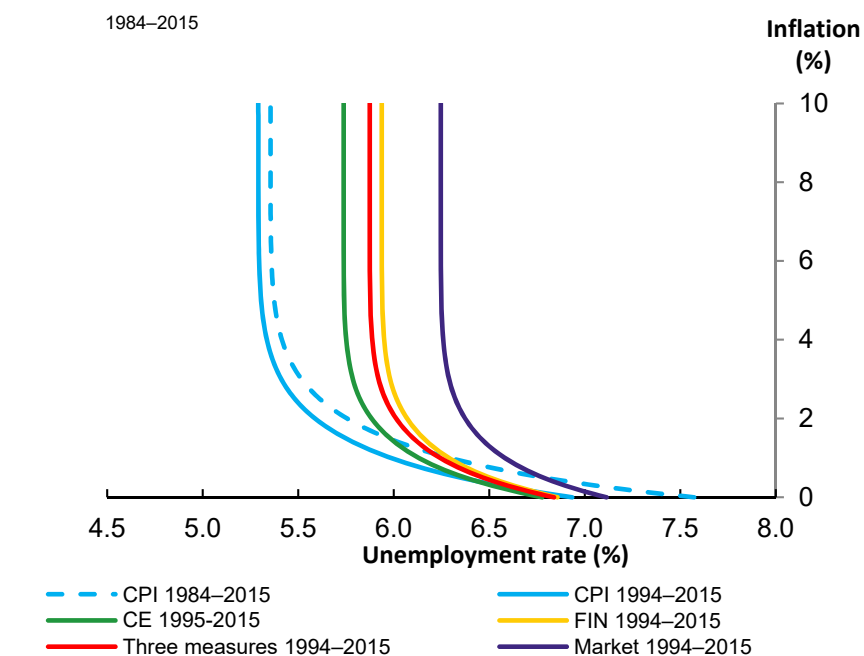
Chart 2 depicts the resulting Phillips curves using different inflation expectation measures. **Table 2** summarizes the levels of the unemployment rate corresponding to different inflation levels, as given by the estimated Phillips curve, as well as the estimated natural rate of unemployment. These results suggest that the estimated level of the natural rate of unemployment depends on the model specification, but remains around 6 per cent (see the last row in **Table 2** for details).

Importantly, over the period 1994–2015, the long-run trade-off between inflation and unemployment is found to be robust to different measures of inflation expectations. In particular, we find that an increase in the long-term inflation level from 2 to 3 per cent might lower the long-term unemployment level by 0.1–0.2 percentage points. Furthermore, an increase in the inflation level above 3 per cent would not significantly decrease the unemployment rate. In contrast, if the inflation level decreases from 2 per cent down to 1 per cent, the long-term unemployment level will rise by 0.2–0.4 percentage points. These results suggest that the long-run trade-off between inflation and unemployment is larger at inflation levels below 2 per cent. Indeed, the magnitude of the trade-off between inflation and unemployment is estimated to be two times lower at inflation levels just above 2 per cent relative to inflation levels below 2 per cent. Therefore, the long-run Phillips curve is close to vertical at inflation

rates of 2 per cent or more. This result is in line with earlier findings for Canada, for instance by Crawford and Wright (2001).

Finally, if we compare estimated Phillips curves over 1984–2015 and 1994–2015 (using provincial CPI as the inflation expectation measure), the slope becomes steeper after 1994, suggesting thus a decline in the long-run trade-off between inflation and unemployment under the presence of DNWR.

Chart 2: Estimated Phillips curves



Source: Bank of Canada calculations

Table 2: Unemployment rate—inflation trade-off under different specifications of the Phillips curve

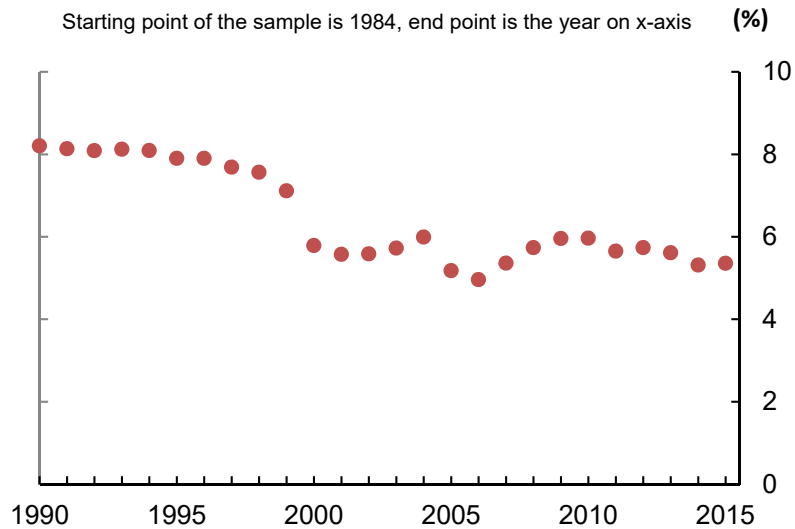
<i>UR</i> (by model)	CPI 1984–2015	CPI 1994–2015	FIN 1994–2015	Market 1994–2015	CE 1995–2015	Three measures 1994–2015
$\pi = 0\%$	7.6	6.9	6.9	7.1	6.8	6.8
$\pi = 1\%$	6.3	6.0	6.3	6.6	6.1	6.2
$\pi = 1.5\%$	6.0	5.7	6.2	6.5	6.0	6.1
$\pi = 2.0\%$	5.8	5.6	6.1	6.4	5.9	6.0
$\pi = 2.5\%$	5.6	5.5	6.0	6.3	5.8	6.0
$\pi = 3.0\%$	5.5	5.4	6.0	6.3	5.8	5.9
$\pi = 4.0\%$	5.4	5.3	5.9	6.3	5.8	5.9
U_{NR}	5.4	5.3	5.9	6.2	5.7	5.9

Note: U_{NR} stands for the natural rate of unemployment, a value of the long-term unemployment rate when long-term inflation increases to infinity (in the frame of the long-run Phillips curve).

3.2 Changes in the natural rate of unemployment over time

We find that the natural rate of unemployment depends significantly on the periods used in the estimation. For instance, using pre-2000 data, we obtain estimates very similar to Crawford and Wright (2001). In particular, they estimate the natural rate of unemployment to be around 7.3 per cent using the 1978–99 sample. We get an estimate of 7.1, using data over the 1984–99 period. As soon as we add more recent years, the estimated value of the natural rate of unemployment declines. **Chart 3** shows the estimated natural rate of unemployment for different samples, all starting in 1984 and ending in the year reported on the horizontal axis. According to these estimates, the natural rate of unemployment has declined since the late 1990s and is now estimated to be around 5.4 per cent, using the 1984–2015 period and provincial CPI measure (represented by the last data point in **Chart 3** and listed in **Table 2**).

Chart 3: Estimates of the natural rate of unemployment over different periods



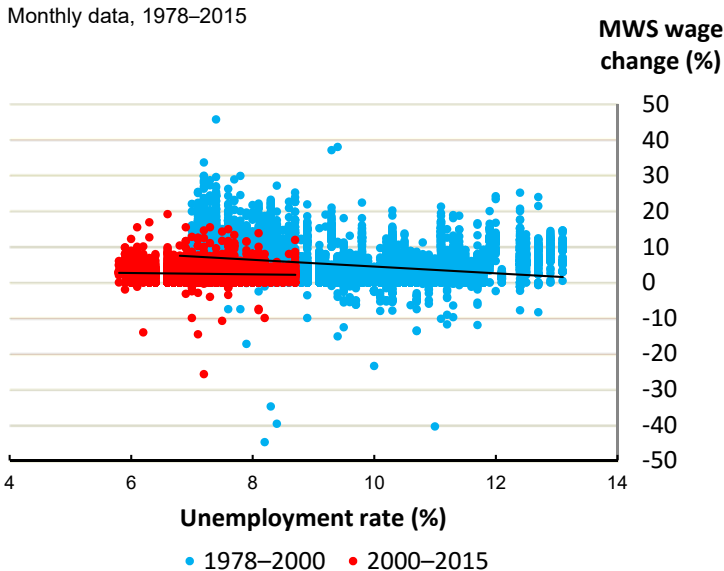
Sources: Major Wage Settlements and Bank of Canada calculations

Last observation: 2015

Chart 3 also suggests that the natural rate of unemployment decreased by about 2 percentage points around 2000, which brings the question of whether the fundamental relationship between key economic variables has changed.

Chart 4 and **Chart 5** plot the MWS wage growth—the data used for the Phillips curve presented in the previous section—against inflation and unemployment, before and after 2000. Each dot represents a single agreement in a given month and year. The red dots represent data points after 2000, while the blue dots represent pre-2000 data points. The striking feature of these charts is that the expected negative relationship between wage growth and unemployment and the positive relationship between wage growth and inflation have collapsed after 2000. The slopes post-2000—the short lines over the red dots—retain the right sign but are now much closer to zero. While identifying the cause of the decline in the natural rate of unemployment is beyond the scope of this study, **Chart 4** and **Chart 5** suggest that structural changes may have played a role after 2000. Additionally, **Chart 6** and **Chart 7** show that these weaker relationships hold for both the 2001–08 and 2009–15 periods (thus, before and after the 2008–09 recession).

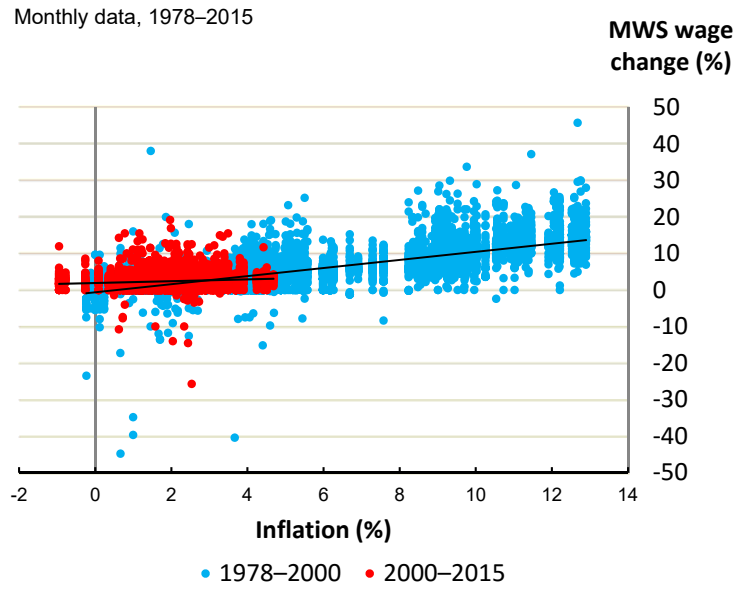
Chart 4: Scatter plot of wage growth (MWS) and unemployment rate in Canada



Sources: Major Wage Settlements, Statistics Canada and Bank of Canada calculations

Last observation: 2015

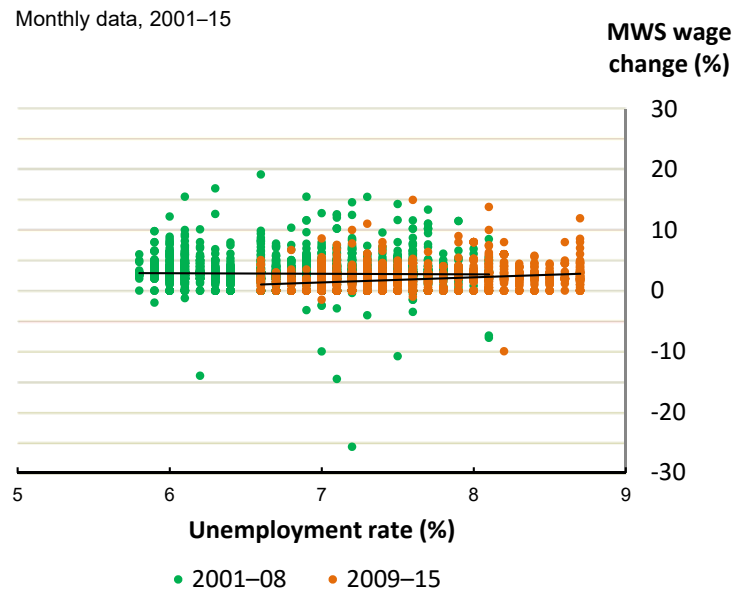
Chart 5: Scatter plot of wage growth (MWS) and inflation in Canada



Sources: Major Wage Settlements, Statistics Canada and Bank of Canada calculations

Last observation: 2015

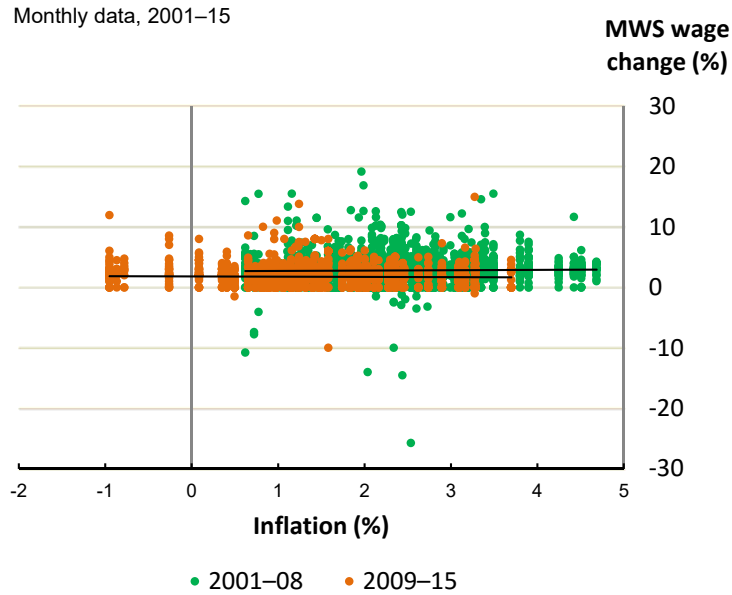
Chart 6: Scatter plot of wage growth (MWS) and unemployment rate in Canada



Sources: Major Wage Settlements, Statistics Canada and Bank of Canada calculations

Last observation: 2015

Chart 7: Scatter plot of wage growth (MWS) and inflation in Canada



Sources: Major Wage Settlements, Statistics Canada and Bank of Canada calculations

Last observation: 2015

4. Conclusion

Overall, the results suggest that the impact of DNWR on the long-run trade-off between unemployment and inflation remains weak. This trade-off might even have become weaker during recent decades, despite the increasing importance of DNWR in the Canadian labour market. We demonstrate that the long-run Phillips curve is close to vertical at inflation rates of 2 per cent or more, in line with earlier findings, such as Crawford and Wright (2001). We estimate that the natural rate of unemployment is around 6 per cent over the 1994–2015 period. Additionally, we document that the natural rate of unemployment has decreased since the late 1990s. Our analysis suggests that an increase in long-term inflation from 2 to 3 per cent would lower unemployment by about 0.1–0.2 percentage points. Consequently, the benefits of raising the inflation target to attain a lower long-term unemployment seem rather weak.

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