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A NEO-KEYNESIAN MODEL OF NOMINAL WAGE DETERMINATION IN CANADA

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The views expressed in this report are those of the author; no responsibility for them should be attributed to the Bank. Comments on this work would be welcome.

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ABSTRACT

In this report, the author discusses four paradigms of wage determination: the neoclassical model, the neo-Keynesian model, the Phillips curve, and the expectations-augmented Phillips curve. He presents a general specification that includes the four different specifications as special cases. The estimated parameters invite interpretation as a neo-Keynesian wage model.

The RDX2 earnings variable is explained by the consumer price index, a product price deflator, normal productivity, a measure of labour-market tightness, U.S. wages, average hours, and the rate of change of employment. Finally, the estimated equation is analyzed within the context of the RDX2 macroeconomic model.

RÉSUMÉ

Dans ce rapport, l'auteur examine quatre modèles de détermination des salaires: le modèle néo-classique, le modèle néo-keynésien, la courbe de Phillips et la courbe de Phillips dotée d'anticipation inflationnistes. L'auteur présente également dans ce rapport une équation plus générale qui synthétise les quatre différents modèles en les traitant chacun comme cas d'espèce. Les valeurs estimées des paramètres favorisent le modèle néo-keynésien de détermination des salaires.

La variable 'Rémunération' du RDX2 est expliquée en fonction de l'indice des prix à la consommation, d'un indice de déflation des prix au producteur, de la productivité normale, d'un indice du niveau de tensions que connaît le marché du travail, du niveau des salaires aux Etats-Unis, de la moyenne des heures de travail et du taux de variation de l'emploi. Enfin, l'équation estimée est analysée dans le cadre du modèle macroéconomique RDX2.

1 INTRODUCTION AND SUMMARY

Despite its importance as possibly the most crucial behavioural relationship in macroeconomics, and despite recent political and popular concern about inflation and unemployment, economists have yet to reach a consensus on the correct wage equation. Above and beyond the question of choosing the relevant explanatory variables, two fundamental issues arise in the specification. First, should the analysis of the determination of wages be conducted in real or nominal terms? Second, do economic conditions, particularly labour-market conditions, determine the wage level or do they instead determine the rate of wage inflation? In other words, should the wage equation be specified as a static or as a dynamic model? Four conceptually different specifications arise from the various combinations of solutions to these two issues. In this report I present a general specification that includes the four different specifications as special cases. The estimated parameters invite interpretation as the static nominal model of wage determination, i.e., a neo-Keynesian wage model.

The data are taken from the Bank of Canada macroeconometric model, RDX2, data-base and the mnemonics are defined in the Appendix. The main wage (more precisely, quarterly average earnings) variable in RDX2, WQMMOB, will be explained by the consumer price index, a product price deflator, normal productivity, a measure of labour-market tightness, U.S. wages, average hours, and the rate of change of employment. The last term captures the phenomenon that new workers receive less than the average earnings. The equation provides a good

statistical fit over the whole sample period 1Q57-4Q74: the RB2 (corrected R^2) for J1P(WQMMOB), where J1P is the quarter-to-quarter percentage change operator, is .79, a respectable result in these circumstances; the estimated coefficients are stable over different estimation periods; and the estimated equation comes close to satisfying exactly the long-run growth conditions.

The Keynesian static nominal wage model implies that an expansionary policy permanently lowering the unemployment rate will result in a once-and-for-all increase in the wage (and therefore the price) level. We embed the wage equation in the rest of the RDX2 econometric model and shock the time path of the federal-employment policy instrument so as to generate an unemployment rate that is one percentage point less than the control solution in every quarter. Because of the long lags in the RDX2 model, primarily the lags in the price equations, the price level does not adjust instantaneously to its new equilibrium. At the end of 12 years, the (shock minus control) price level has attained its new equilibrium - one 4.4 percent higher - and stays at this level. This result is in marked contrast with the "natural rate" hypothesis according to which an attempt to maintain unemployment lower than the control solution will lead to accelerating (shock minus control) price inflation.

The conceptual framework is laid out in Section 2, the wage equation is developed in detail in Section 3 and is estimated and analyzed in Section 4, and simulation results are reported in Section 5.

2 FOUR CONCEPTUAL SPECIFICATIONS OF A WAGE EQUATION: STATIC OR DYNAMIC, NOMINAL OR REAL

Let W denote the nominal wage rate, p the price level, u the unemployment rate, and q the output per worker. The operational measures of these variables are discussed later together with such issues as whether the unemployment rate is indeed the correct measure of labour-market tightness.

2.1 Static Real Wage Equation (Neoclassical Model)

The neoclassical model states that the labour market, which in that model is always in equilibrium, determines the real wage. Treating productivity as predetermined, the neoclassical model is

$$W/p = f \qquad (1)$$

where f represents the solution of the demand and supply curves for labour.

If we wish to incorporate q as endogenous to the economic system and if we assume for simplicity a Cobb-Douglas production function, then neoclassical distribution theory makes the real wage proportional to the output per worker, i.e.,

$$W/p = fq \qquad (2)$$

2.2 Static Nominal Wage Equation (Keynesian Model)

In the Keynesian model, the labour market should be regarded as determining <u>nominal</u> wages. As Leijonhufvud puts it (1968, p. 97),

"Keynes' 'theoretically fundamental' objection to the Classical theory of the labour market is that it misrepresents the nature of the wage bargain in presuming that it does not matter whether the analysis of the determination of wages is conducted in 'real' or money terms (and in opting for the former as more convenient)."

According to the Keynesian objection, the labour market ought to be analyzed in terms of nominal wages, not real wages. The important Keynesian observation is that the labour market is not at full employment because the labour market, unlike an auction market, lacks a clearing mechanism. As Okun argues (1975, p. 358), non-auction markets such as the customer-supplier relationship in product markets and the "career" labour market will be characterized by non-neoclassical wage and price behaviour. The Okun-Leijonhufvud-Keynes argument calls for a nominal wage model. The simplest Keynesian wage model is

$$W = f(u) \qquad (3)$$

A decrease in the unemployment rate induces a once-and-for-all increase in the nominal wage.

The neo-Keynesian revival led by Sargan (1964) and Kuh (1967) used the level of the unemployment rate, together with productivity and the price level, to determine the level of the nominal wage. The neo-Keynesian theory implies, assuming the standard loglinear specification,

$$\log W = c + a \log p + b \log q - du, \quad 0 < a < 1 \qquad (4)$$

According to Phelps' (1970, p. 129) interpretation of the neo-Keynesian models, "The underlying theory is apparently that a rise of aggregate demand creates bottlenecks and hence a rise of wages in certain areas and skills at the same time that it increases employment; once these bottlenecks have melted away and employment has reached its new and higher level there is no longer upward wage pressure. On this theory, money wage increases go hand in hand with employment growth and not intrinsically with a high level of the employment rate."

A more elementary and traditional Keynesian interpretation of equation (4) is that workers bargain for a nominal wage, while prices, productivity, and unemployment are determinants of the wage bargain. The deviation of the price coefficient from unity represents the degree of money illusion in the labour market. The output-per-man term can be interpreted in a bargaining context as workers bargaining for a share of productivity gains; if a and b both equal one, workers bargain for a fixed share of the output. In most econometric models (e.g., MPS, the M.I.T.-Penn.-S.S.R.C. model), increased productivity raises real wages via the price channel as lower normal unit labour costs lowers prices. The neo-Keynesian equation (4) provides a direct channel from productivity to nominal wages to real wages.

Wage rigidity - a slow speed of adjustment toward equilibrium (equation 4) - is another factor which makes nominal wages unresponsive. Wage rigidity may arise from either the Keynesian notion

emphasizing the non-neoclassical behaviour of the labour market or from the existence of long-term contractual obligations. If the speed of adjustment is low, a static-equilibrium wage model will not be appropriate.

A typical contract for non-salaried employees, who comprise approximately 70 percent of the total, runs for two years. Compensation of salaried employees, the remaining 30 percent, generally changes once yearly. This implies a mean contract length of .7 x 8 + .3 x 4 = 6.8 quarters and a maximum adjustment speed of 1/6.8 = .15 (per quarter) toward equilibrium (equation 4). For an estimated adjustment speed of at least .15, it can be concluded that there is no evidence of Keynesian-type slow adjustment beyond that imposed by contractual obligations.

The standard partial adjustment process toward equilibrium will be

$$\dot{W}/W = r(c + a \log p + b \log q - du - \log W) \qquad (4a)$$

which can be rewritten (redefining the coefficients) as

$$\dot{W}/W = c - r \log W + a \log p + b \log q - du \qquad (5)$$

In the limit, as r approaches infinity, equations (4a) and (5) reduce to the purely static model (4); if r is large, equation (5) approximates the static model. If signed contracts rigidly specified the level of wages for the duration of the contract, contractual

obligations would place an upper limit of .15 on r, the response speed. Post-contract labour-market conditions and price developments do affect wages via worker reclassification and COLA clauses. The general process that causes the actual wage rate to differ from that originally specified is termed "wage drift" (Taylor et al. 1973, p. 14). I shall estimate r to be .34, which implies significant wage drift, and show that the static equilibrium model with partial adjustment is appropriate.

2.3 Dynamic Nominal Wage Equation

The simplest Phillips curve states

$$\dot{W}/W = f(u) \qquad (6)$$

The Phillips curve is very different from the Keynesian model; a once-and-for-all change in the unemployment rate leads to a permanent change in the wage-inflation rate, whereas in the Keynesian model it only induces a permanent change in the wage level.

Lipsey (1960) has given a rationale for equation (6) as representing a Walrasian adjustment through time where u is a measure of excess supply in the labour market. An alternative measure of disequilibrium is the neoclassical measure of excess demand, in Clowerian terminology the "notional" excess demand. Following McCallum (1974), a neoclassical model of labour demand and supply can be established with productivity and the real wage as explanatory variables and then the notional excess demand is proportional to (c - a log (W/p) + b log q), generating the McCallum formulation of the

Phillips curve

$$\dot{W}/W = c - a \log(W/p) + b \log q \qquad (7)$$

The following Phillips curve incorporates both the neoclassical and the Keynesian measure of excess demand

$$\dot{W}/W = c - a \log W + a \log p + b \log q - du \qquad (8)$$

Suppose the long-run price equation represents a fixed markup on nominal costs and in the long-run labour costs are a fixed proportion of total costs. The long-run price equation thus determines the long-run real wage and the price equation can be written as

$$\log p = \log W - \log q + \text{constant} \qquad (9)$$

The combination of equations (8) and (9), gives $\frac{\partial \dot{p}/p}{\partial u} = \frac{\partial \dot{W}/W}{\partial u} = -d$. A sustained decrease in the unemployment rate leads to a permanent increase in the inflation rate. Equation (8), the underlying theory of which is based on the Phillips curve, generates a Phillips curve downward-sloping tradeoff.

Suppose, on the other hand, the long-run price equation displays an elasticity of less than one with respect to nominal costs. While this non-homogeneity may be theoretically unappealing, this property is not uncommon in estimated price equations. In RDX2 (1976 version), for example, the estimated elasticity of the CPI with respect to total

costs is only .87. In that case the price equation may be written as

$$\log p = \alpha \log W - \log q + \text{constant}, \quad \alpha < 1 \qquad (9a)$$

Equations (9a) and (8) can be solved to show that a sustained decrease in the unemployment rate leads, in the long run, to an increase in the wage (and price) level with no change in the inflation rate in the long run. When discussing the theory involved I assume $\alpha = 1$ and regard equation (8) as generating a Phillips curve tradeoff, but the property $\alpha < 1$ is important for the reported RDX2 simulation results.

2.4 Dynamic Real Wage Equation (Natural Rate)

In his famous Presidential address, Friedman (1968) states that the standard Phillips curve, equation (6), "contains a basic defect - the failure to distinguish between nominal and real wages." Friedman argues that money wages will respond both to excess demand and to expected changes in prices. Friedman (1975, equation (1)) respecifies the Phillips curve relation as an expectations-augmented Phillips curve.

$$\dot{W}/W = f(u) + E(\dot{p}/p) \qquad (10)$$

where E is the expectations operator.

The general case, including equations (10) and (6) as polar cases, is

$$\dot{W}/W = f(u) + hE(\dot{p}/p), \quad 0 \leq h \leq 1 \qquad (10a)$$

The expectations term critically affects the long-run, inflation-unemployment tradeoff. Under any reasonable expectations process, $E(\dot{p}/p)$ will asymptotically approach $\dot{p}/p$. If the long-run price equation is homogeneous in nominal costs, for long-run analysis we may write

$$\dot{p}/p = \dot{W}/W - g \qquad (11)$$

where g is the exogenous rate of technical progress.

Define the function f - g = F. The long-run wage inflation-unemployment tradeoff is derived by solving equations (10) and (11):

$$\dot{W}/W = F(u)/(1-h) \qquad (12)$$

If $h < 1$, the long-run Phillips curve is well behaved. If $h = 1$, the solution explodes unless $F(u) = 0$. That value of u satisfying $F(u) = 0$ is the "natural" rate of unemployment, the only value of u feasible for the long run. If u is maintained at less than the natural rate, F will always exceed zero and the system will generate accelerating inflation, lending the term "accelerationist" to the hypothesis $h = 1$.

Friedman (1968) observes that the function F (and the natural rate) is not immutable but may change because of influences such as demographic factors and legislation. He "use(s) the term 'natural' for the same reason Wicksell did - to try to separate the real forces

from monetary forces."

2.5 The Inflation-Unemployment Tradeoff According to the Various Models

In the long run, the inflation-unemployment tradeoff (Phillips curve) is, according to the Phillips curve theory, downward sloping. According to the "natural rate of unemployment" model it is vertical,[1] and according to the Keynesian model horizontal.

Wachter (1976) observes that "some ... adopt the view that the wage system is driven increasingly by prices rather than by demand pressures in the labor market. Making matters worse, the price equation has almost uniformly been estimated to follow costs, but not demand pressures, in the goods markets .... What emerges ... is ... wages ... follow some combination of their own lagged values .... In the extreme, these models are akin to a natural-rate theory of wage inflation .... Rather than being vertical, the Phillips curve is horizontal." Wachter cites Weintraub (1958) as constructing one of the earliest post-Keynesian models in which changes in inflation are not, and never were, caused by aggregate demand. Weintraub recently (1976, p. 619) reiterated his view and expressed the hope that "Maybe, considering Hicks's initial influence on the group [of most of the modern Keynesians], they will come to admit exogenous (spontaneous) money wage shifts." While the neo-Keynesian wage equation (4) also generates a horizontal long-run Phillips curve, it is not because aggregate demand never affects inflation but rather because aggregate

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1. In his 1976 Nobel lecture, Friedman (1977) "conjecture(s) that a modest elaboration of the natural-rate hypothesis is all that is required to account for a positive relation between inflation and unemployment."

demand induces a permanent change in the wage level.

2.6 The General Model of Wage Determination

To determine which of the four models is most appropriate, I have developed a general specification that includes the various models as special cases. Consider the following specification:

$$\dot{W}/W = c - r \log W + a \log p + b \log q - du + hE(\dot{p}/p) \qquad (13)$$

If r is large and exceeds a, and if h = 0, the equation reduces to equation (5), the Keynesian model. If r = a and h = 0, the equation reduces to equation (8), the McCallum extension of the Phillips curve. While I have not developed the neoclassical, static, real model in its full glory, it can be developed as a special case of equation (13) where r is large and r = a. I found that r is large, exceeds a, and h is indistinguishable from zero, and I conclude that the Keynesian model is the empirically valid model of wage determination for the dependent wage variable used in this study.

3 VARIABLES ENTERING THE WAGE EQUATION

We now discuss in detail which explanatory variables ought to enter the wage equation and will interpret the wage equation as an extension of equation (5), the Keynesian model.

3.1 The Dependent Wage Variable, WQMMOB

Unfortunately, there is no data series in Canada that adjusts earnings for overtime changes and interindustry shifts. I have chosen the basic RDX2 wage variable, WQMMOB, quarterly earnings in mining,

manufacturing, and other business, as the dependent variable. In RDX2, WQMMOB is calculated as Y/NMMOB where Y, labour income in mining, manufacturing, and other business, and NMMOB, employment in mining, manufacturing, and other business, are both derived from establishment surveys (the ES-1 and ES-2 reports). Prior to 1961, only large establishments (over 20 employees) were surveyed and WQMMOB is a less reliable data series for the earlier period. The variable WQMMOB represents wage costs less fringe benefits.

3.2 Incorporation of HAWMM, Average Weekly Hours Worked in Mining and Manufacturing

Since WQMMOB represents average quarterly earnings, and since the extant contracts (for non-salaried employees) are specified not in terms of quarterly earnings but in terms of hourly wages, an increase in HAWMM (average hours worked in mining and manufacturing by hourly rated employees) will have a direct instantaneous impact on WQMMOB. It is assumed that in the long run the variable that is, in effect, being negotiated is not hourly wages but quarterly earnings and that in the long run WQMMOB is therefore independent of HAWMM, for given values of p, q, and u. The term J1P(HAWMM) is therefore added on the right-hand side of the Keynesian model, equation (5), and a positive coefficient is expected so as to incorporate the phenomenon that an increase in HAWMM to a permanently higher level will raise short-run WQMMOB but will not raise the equilibrium value.

3.3 New Workers

New workers tend to receive lower earnings than established workers, not only because they are less productive but also for

institutional reasons. The term J1P(NMMOB) is therefore added to the right-hand side of equation (5). A once-and-for-all increase in the level of NMMOB temporarily raises J1P(NMMOB); as the new workers become established workers, the temporary downward pressure on average wages ceases. Taylor et al. (1973, p. 51) mention that in the tobacco industry relatively low-paid workers are hired when employment expands, thereby causing average earnings to drop. I found this phenomenon to be of major aggregate importance.

3.4 The Influence of the U.S. Wage: The International Transmission of Inflation

Many studies, e.g., Perry (1975), have found the U.S. wage rate to be an important explanatory variable in a Canadian wage equation. Since the U.S. wage rate turns out to be very significant, I have considered various rationales for inclusion of a U.S. wage in a Canadian wage equation.

Neoclassical arguments suggest that the real U.S. wage will affect the real Canadian wage rate. In principle, international labour mobility provides a direct mechanism for the equalization of real-wage rates.[1] Another factor tending to equalize the two real-wage rates is that Canadian unions may moderate their real-wage demands lest higher real-wage costs induce businesses to shift plant and equipment investment to the United States.

The Scandinavian model of inflation provides a similar rationale for the inclusion of a real U.S. wage in a Canadian wage equation.

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1. Taylor et al. (1973, p. 21) and Caves and Reuber (1971, p. 219) argue, however, that there is very little labour mobility between the U.S. and Canada and that international labour flows do not bring the two markets into a joint equilibrium.

The model specifies (Aukrust, 1970) that nominal wages are proximately determined by the domestic price of traded goods. Although our wage equation already includes a Canadian price index, the price of traded goods may diverge from the general price index and the U.S. nominal wage (corrected by the exchange rate) should provide additional information about the price of traded goods.

According to Keynesian bargaining theory, wage developments in the U.S. may serve as signals leading to wage emulation. Socioeconomic institutional linkages - in particular the communications media and the international trade unions - facilitate the transmission of these signals. If bargainers regard exchange-rate deviations as transient, or if the emulation is faithfully imitative, nominal Canadian wage developments may be explained by U.S. nominal wage developments.

Nominal wage parity provides the extreme example of wage emulation. The Auto-Workers Wage and Production Parity Agreement provided for "elimination of the differential between the U.S. and Canadian wage rates ... for wage parity purposes, U.S. and Canadian dollars are presumed to be on a par with each other, each unit of one currency being equal to the corresponding unit of the other, regardless of the exchange rate" (Collective Bargaining Review, No. 2, 1968, Canada Department of Labour). Although the number of industries operating under direct wage parity is limited, such agreements may have important spillover effects.

The non-neoclassical Keynesian bargaining models suggest that the U.S. wage should not be corrected for exchange-rate variations and I

therefore include PL2, the U.S. wage rate, on the right-hand side of equation (5). Attempts to correct PL2 by the exchange rate resulted in an inferior fit and I therefore follow Taylor et al. and Perry who do not correct for exchange-rate variations. I fully recognize that the concept of nominal wage parity will possibly be inoperative if the exchange rate differs greatly from parity, but I do find that over the relevant range (the range typified by historical variations), unadjusted PL2 is the preferred variable.

3.5 Which Price Variable Enters the Price Equation?

If price enters the wage equation because workers bargain for a standard of living, the relevant price variable is a cost of living index, say PCPI, the consumer price index. If price enters because workers bargain for a fraction of net output, an appropriate price variable would be PGPP, the price deflator for (value added) gross private business product.

There are many differences between PGPP and PCPI. The PGPP is a Paasche deflator while PCPI is a Laspeyres index. Inasmuch as PGPP differs from PCPI because of the fundamental Paasche-Laspeyres distinction, PCPI is not necessarily a better measure of the "true" cost of living than is PGPP. A more important distinction between PGPP and PCPI is that PGPP includes non-consumption components of final demand, in particular investment, government expenditures, and net exports, while PGPP does not include a deflator for housing rental. The variables PGPP and PCPI react very differently to an increase in the price of imports. The impact effect of this foreign-price increase is to raise PCPI, but if corporations initially absorb

much of the foreign-price increase (as they do in the RDX2 model), PGPP, a deflator for value added, may even fall.

To analyse further the PCPI versus PGPP issue, suppose there is an increase in the cost of living (e.g., coffee shock) but domestic industry does not enjoy an increase in its product price. Employers will suffer more if PCPI affects nominal wages while employees suffer more if a value-added deflator affects nominal wages. Franco Modigliani (1975, p. 444)feels that "employers would be willing to compensate their workers for an increase in the cost of living; and further, when the cost of living rose, people would tend to raise their reservation wage." George Perry and Arthur Okun question (1975 p. 445) such standard-of-living arguments and note that "while employers might wish to compensate their workers for rising living costs, they might not be in a position to do so." Perry (1975) notes that the existence of cost-of-living escalators does not assure the consumer price index a role in wage equations. He includes both the nonfarm deflator and consumer prices as explanatory variables and finds that for both the United States and Canada the private nonfarm deflator dominates consumer prices in importance. Fischer (1976, p. 17) emphasizes that workers are more risk averse than employers and therefore the CPI is appropriate. I include both PCPI and PGPP and find, in support of Modigliani and the risk-aversion theory and contrary to Perry, the consumer price index to be the more important price variable.

3.6 The Measure of q, Output Per Man

Price equations typically (Nordhaus, 1972, p. 35) set price as a

markup over normal unit labour costs, defined as wages divided by normal productivity. To remove transient fluctuations in productivity, economists have typically taken 12-quarter moving averages when calculating normal productivity. For analogous reasons, q is measured in equation (5) not by contemporaneous output per man but rather by the RDX2 construct UGPPA/NMMOBD, the output per man determined by solving the RDX2 production function. The ratio UGPPA/NMMOBD is an increasing function of the capital/output ratio and a time trend.

3.7 Indicator of Labour-Market Tightness

Although in Section 2 I followed Phillips' original work and took the unemployment rate as the measure of labour-market tightness, the recent high unemployment rates together with high inflation rates have spawned a search for alternative tightness measures. Both labour demand and supply can be measured by conceptually different constructs. Labour supply may be represented by NL, the labour force. (The RDX2 variable NMMOBS is essentially NL with a correction made for frictional unemployment and employment outside of mining, manufacturing, and other business.) It can also be represented by NPOP, adult population, which would be more appropriate if individuals who have not formally entered the labour force are recognized by wage negotiators as desirous of work and therefore exert downward pressure on wages. Labour demand can be measured as NE, total employed persons or as NMMOBD, the desired level of employment determined by solving the RDX2 production function for the given level of aggregate demand. At a time when vacancies are high, the desired level of employment

will indicate more tightness than the actual level of employment.

The various measures of demand and supply generate different demand/supply ratios. The employment rate, NE/NL, equals 1 - .01 RNU, where RNU is the unemployment rate. Moore (1975) in the United States and Green (1976) in Canada advocate NE/NPOP, the employment ratio. The ratio NMMOBD/NMMOBS is used in the RDX2 (1976) wage equation. I find that the geometric mean of these last two measures, $\sqrt{(NE/NPOP)*(NMMOBD/NMMOBS)}$, which I denote as H, the hybrid measure of labour-market tightness, provides the best statistical fit. If the variable H in the estimated equation (15) is replaced by the tightness variable RNU, the RB2 drops from .79 to .74. During the expansionary period 4Q70-4Q72, the measure H appropriately displayed increasing tightness, rising from .71 to .78, while the unemployment rate displayed increasing slack, growing from 5.7 to 6.1.

3.8 Seasonal and Other Dummies

Since the RDX2 data are not seasonally adjusted, the constrained dummy variables QC1, QC2, and QC3 are included, where QCi = Qi - Q4 and Qi is the ith-quarter seasonal dummy. Following RDX2, two other dummies are also used, QDB (= 1 until 1Q61) and QDG (= 1 after 1Q61), because before 1961 only large establishments were surveyed.

4 THE ESTIMATED WAGE EQUATION

By combining the ideas discussed above, and adding the various factors to equation (5), the following specification can be derived:

$$
\begin{aligned}
J1P(WQMMOB) = {} & g\ QDB + h\ QDG + i\ QC1 + j\ QC2 \\
& + k\ QC3 - r \log J1L(WQMMOB) + A \log J1L(PCPI) \\
& + a \log J1L(PGPP) + b \log J1L(UGPPA/NMMOBD) \\
& + d\ H + s \log J1L(PL2) + m\ J1P(HAWMM) \\
& - v\ J1P(NMMOB) \qquad (14)
\end{aligned}
$$

Prices, productivity, and wages appear in the one-period lagged form, J1L, because it is assumed that wage bargainers are unaware of these current developments. The letters g, h, i, j, and k represent the coefficients on the dummies. All the other coefficients are required by theory to be positive.

Accordingly, the following equation was estimated (OLS, 1Q57-4Q74). The t-statistics are in brackets.

$$
\begin{aligned}
J1P(WQMMOB) = {} & 20.8\ QDB + 20.3\ QDG - .4\ QC1 \\
& \quad (.8) \qquad (.8) \qquad (1.3) \\
& + .5\ QC2 + .1\ QC3 - 34.4 \log J1L(WQMMOB) \\
& \quad (1.9) \quad (.9) \qquad (4.8) \\
& + 14.6 \log J1L(PCPI) + 5.4 \log J1L(PGPP) \\
& \quad (1.6) \qquad\qquad (.9) \\
& + 14.8 \log J1L(UGPPA/NMMOBD) + 16.8 \log J1L(PL2) \\
& \quad (3.2) \qquad\qquad\qquad (2.6) \\
& + 21.0\ H + .29\ J1P(HAWMM) - .41\ J1P(NMMOB) \qquad (15) \\
& \quad (5.9) \quad (3.3) \qquad\qquad (6.8)
\end{aligned}
$$

see = .51 RB2 = .79 dw = 2.11

All the coefficients possess the hypothesized sign. The regression also provides a good fit to the last two years of the sample period, 1Q73-4Q74, a period generally considered difficult to model, with a single-equation mean absolute error of only .35.

The neoclassical Phillips curve, equation (8), implies (in the notation of equation (14)) that $(a + A)/r = 1$ (real-wage neutrality) while the Keynesian bargaining model implies that $(a + A)/r < 1$. The estimated value of $(14.6 + 5.4)/34.4 = .57$ implies non-neoclassical determination of nominal wages. The estimate of r, 34.4, is considerably above 15, implying that the static model is relevant and that there is significant wage drift (see page 7). Nominal wages respond to economic developments more quickly than is implied by the typical length of wage contracts. The regression coefficients validate the static nominal model and support Solow's contention (1977, p. 49) that "The evidence for the existence of a 'natural rate of unemployment' is very weak. Indeed, the weight of the evidence is probably against it..."

Another (not unrelated) test of the bargaining model relates to the fact that the bargaining model implies that PL2 enters the wage equation, while the neoclassical model implies that the relevant variable is PL2*PFX, PL2 corrected by the exchange rate. Regression (15) was rerun with PL2 replaced by PL2*PFX and the RB2 dropped from .79 to .76, implying that the U.S. wage enters because of bargaining reasons. Equation (15), which implies that nominal Canadian wages are determined by the U.S. nominal wage and domestic prices, with a (Canadian) price elasticity of only .57, would not be relevant in the

very long run if the exchange-rate were to diverge very much from parity, because wage-parity agreements would break down, raising the price elasticity. For the period 1957-74, one predominantly characterized by exchange-rate stability, the price elasticity is much less than unity. The long-run partial elasticity of nominal wages with respect to prices is .57, with respect to output per man is b/r = (14.8/34.4) = .43, and with respect to U.S. nominal wages is s/r = (16.8/34.4) = .49. (An inflationary disturbance that raises both U.S. wages and Canadian prices by 1 percent will raise Canadian wages by (14.6 + 5.4 + 16.8)/34.4% = 1.07%.) The short-run elasticities are .20, .148, and .168, respectively, and the convergence is constrained to be exponential.

Both PCPI and PGPP enter the wage equation and PCPI is the more significant, both statistically, and in magnitude, in accordance with the risk-aversion theory. I support Modigliani at Perry's expense.

The estimated coefficients nearly satisfy the long-run homogeneity conditions. If U.S. wages grow in the long run at the rate of (Canadian inflation + Canadian productivity), the long-run homogeneity conditions necessary for the wage equation to sustain a neoclassical growth path become (A + a + s)/r = 1 and (b + s)/r = 1. The estimated values are 1.07 and .92 respectively.

Specification (14) does not include any $E(\dot{p}/p)$ term as prices only enter as a catch-up term. Workers bargain to compensate for past price changes but do not display forward-looking behaviour and do not demand higher wage settlements to compensate for future price increases during the contract. The predominance of front end loading

is consistent with a catch-up phenomenon.

Equation (15) can be solved recursively to generate the rate of wage inflation as a geometric lag on past price inflation rates with coefficients summing to .57, the long-run partial elasticity. This response is identical to that implied by an expectations-augmented Phillips curve if the expected rate of price inflation is generated by the same geometric lag on past inflation. It should, therefore, be very difficult to include both a catch-up term and an expectations term because most models of expectation, in particular the adaptive expectations model, approximate geometric distributed lags. I attempted to include other price expectations measures, including the RDX2 construct PCPICE, but none entered significantly.

5 THE UNEMPLOYMENT-INFLATION TRADEOFF: SIMULATIONS WITH RDX2

The Keynesian static nominal-wage equation implies that the long-run Phillips curve is horizontal, and that a sustained lower unemployment rate will result in the long run in a higher wage (and price) level with no change in the long-run inflation rate. A movement to the higher price level generates short-run inflation.

Equation (15) was embedded in the RDX2 model and the variable NGPAF, employment in federal administration and defence, was shocked so that the unemployment rate was one percentage point less than the control solution in every quarter. (The shock I actually ran lowers RNU by only .1 but for expositional purposes I assume linearity and suppose RNU to be lowered by 1). The simulations were run with the RDX2 version incorporating the interest-rate reaction function. A

dynamic simulation was run over the historical period 1Q63-4Q74. The shock-control values of the annual percentage rate of price inflation are, seriatim for this 12-year dynamic simulation, .3, .4, .3, .3, .3, .4, .6, .6, .7, .4, .2, -.1, a total change of 4.4. By the end of the 12-year simulation, the shock-control price level has settled at its new equilibrium level 4.4 percent higher than the control solution and the rate of inflation has returned to the control rate. We observe that the RDX2 model with the neo-Keynesian equation (15) generates a long-run, horizontal, inflation-unemployment tradeoff, as predicted by the neo-Keynesian model.

Because the price sector of RDX2 is not homogeneous in costs, I repeated the experiment with a modified homogeneous version of the price sector. The results are very similar; at the end of 12 years the rate of price inflation has receded to the control rate and the shocked price level is 5.0 percent higher than the control solution.

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GLOSSARY OF RDX2 MNEMONICS USED IN THIS PAPER

HAWMM	Average weekly hours worked in mining and manufacturing.
NE	Total employed persons (excluding armed forces).
NGPAF	Employment in federal public administration and defence.
NL	Labour force.
NMMOB	Paid employees in mining, manufacturing, and other business.
NMMOBD	Desired level of employment in mining, manufacturing, and other business.
NMMOBS	Approximation to the potential labour force in mining, manufacturing, and other business.
NPOP	Noninstitutional population 14 years of age and over.
PCPI	Consumer price index.
PCPICE	Expected annual rate of change in Consumer Price Index.
PFX	Spot exchange rate (Canadian dollars per U.S. dollar).
PGPP	Price deflator for gross private business product.
PL2	Employee compensation rate in U.S. nonfarm private domestic business.
Q1	First-quarter seasonal dummy.
Q2	Second-quarter seasonal dummy.
Q3	Third-quarter seasonal dummy.
Q4	Fourth-quarter seasonal dummy.
QC1	First-quarter constrained dummy variable, equals Q1-Q4.

QC2	Second-quarter constrained dummy variable, equals Q2-Q4.
QC3	Third-quarter constrained dummy variable, equals Q3-Q4.
QDB	Variable in wage equation, equals 1.0 from 1Q52 to 1Q61, zero elsewhere.
QDG	Variable in wage equation, equals 1.0 from 2Q61 forward, zero elsewhere.
RNU	Unemployment rate.
UGPPA	UGPP (gross private business product) adjusted to remove unintended inventory change.
WQMMOB	Quarterly earnings in mining, manufacturing, and other business.

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