Commodity Price Fluctuation, Exchange Rate and Employment in Northern Ontario

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A small number of resource-based industries dominate the economy of Northern Ontario. These include the primary sectors of mining and forestry and the forest-based manufacturing sectors of wood, pulp and paper, and primary steel. In 1992, the primary mining and forestry sectors accounted for about 7.5 percent of total employment and the forest-based manufacturing industries accounted for 10.2 percent of the total labour force in the regional economy. Using employment based location quotient (LQ) indicators, in 1992, relative to Canada, Northern Ontario exhibited strong specialization in only a few key sectors, namely the primary sectors of forestry (LQ = 3.1) and mining (LQ = 4.3), forest-based manufacturing industries (LQ=2.4), and primary metal industries (LQ = 5.2). Northern Ontario's relative concentration in these industries suggests that local production per capita is significantly higher than provincial and national levels. For a complete discussion of the structure of Northern Ontario economy, see Jankowski and Moazzami (1993).

The resource-based industries have linked Northern Ontario's economy with the provincial, national and global economies. It is precisely this link which makes the level of employment in Northern Ontario sensitive to national and international forces. The major international factor affecting the Northern Ontario economy is the variation in commodity prices for the region's export products. These prices are set in world markets and variations in prices are a function of supply and demand. National policies, with respect to interest rates and exchange rates, also exert a significant influence on the ability of Northern Ontario producers to compete internationally. Interest rate changes, through their effect on capital flows and hence exchange rates, directly affect the ability of Northern Ontario producers to compete internationally. Changes in interest

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rates also affect the cost of capital which in turn influences investment in the region.

The impact of the resource-based industries on Northern Ontario's economy goes well beyond their respective shares of total employment. The importance of these industries becomes clear when we classify the regional economy into two sectors: the export, or "base" sector and the non-export, or "service" sector. The base sector consists of all economic activity whose ultimate market lies outside the region, while the service sector is comprised of that portion of total economic activity whose ultimate market is local. The resource-based industries have historically dominated the economic base of Northern Ontario and have traditionally played the role of an engine of growth for the economy. In terms of the importance of the primary sectors of Northern Ontario, the region produces all the metals and about 20 percent of non-metal mineral commodities in Ontario. In addition, most of the resource-based commodities produced in Northern Ontario are exported to the United States (see Statistics Canada (1990), *Exports by Countries*, Cat. 65-003). Other important components of the economic base in Northern Ontario are transportation, education, government and health services.

We hypothesize that the level of activity in the base sector has been responsible for a significant part of the variation of total employment in the region. The direct implication of this hypothesis is that the growth of the non-base sector in Northern Ontario has been dependent upon the level of activities in the base sector. This, as we discuss later, has serious implications for future development prospects for Northern Ontario. We can further hypothesize that the level of activity in the export or the base sector has been very sensitive to changes in international prices and exchange rates. From the regional economic management point of view, fluctuations in international prices or the exchange rate would lead to comparable fluctuations in earnings which effect the planned level of investment and, therefore, the level of employment in the resource-based industries. The joint implication of the above two hypotheses is that variations in international prices for Northern Ontario's export commodities and exchange rates explain a significant portion of the variation in total employment in the region. In other words, the growth of employment in Northern Ontario is tightly linked to market opportunities for its resource commodities.

This paper has two objectives. The first objective is to examine the validity of the hypothesis that fluctuations in Northern Ontario's commodity export prices and movements in the exchange rate explain a significant portion of the variability of total employment in the region. To examine this, we have employed the variance decomposition methodology developed by Sims (1981). Our second objective is to measure the sensitivity of employment to changes in international prices and exchange rates by estimating the long-run price and exchange rate elasticities of regional employment using the methodology proposed by Wickens and Breusch (1988). While the production of resource commodities in Northern Ontario depends on international commodity price movements, the examination of the determinants of commodity prices is not the focus of this paper. For an examination of the long-run tendencies of resource-commodity prices, see Moazzami and Anderson (1994).

The paper is organized as follows. Section 2 discusses the construction of a Northern Ontario commodity price index that summarizes price fluctuations for the region's major export commodities. In this section, we also construct a real exchange rate index and discuss the implications of changes in this index and the commodity price index for the level of employment in the region. Section 3 examines the hypothesis that variations in the international prices of Northern Ontario export commodities and the exchange rate explain a significant portion of the variation in total employment in the region. In section 4, we estimate the long-run price and exchange rate elasticities of employment. Section 5 summarizes the results and discusses some policy implications.

Commodity Price Fluctuations, Exchange Rate Movements and Employment in Northern Ontario

The Northern Ontario commodity price index constructed in this study includes prices for the major mineral and manufactured products of the region. The mineral commodities included in the index are copper, gold, nickel and zinc. These mineral products comprise more than 85 percent of the value of total mineral products produced in Northern Ontario. They are also among the top seven leading mineral products produced in Canada (see, *Canadian Minerals Yearbook* 1991).

Table 1 presents Northern Ontario's production of minerals in millions of 1991 dollars and as a percentage of total Canadian production. Table 1 shows that Northern Ontario accounts for a significant percentage of Canada's total production of these minerals. In terms of the link between Northern Ontario and international markets only about 4.3 percent of the total nickel produced was consumed in Canada. The rest was exported to other countries. Consumption as a percentage of total copper produced in Canada was equal to 23.9 percent in 1990.

In terms of the value of exports, Ontario exported about $688.7 million of copper (49 percent of total Canadian export), $1,338 million of nickel (91 percent of Canada's export), and $293 million of zinc (33 percent of Canadian exports) to other countries in 1990 (Statistics Canada, *Exports by Countries*, Cat. 65-003).

In addition to the top four mineral commodities, the Northern Ontario commodity price index includes major manufactured products, that is, iron and steel, wood and paper and allied products. About 80 percent of the manufacturing employment in the region is engaged in the production of the manufac-

TABLE 1 Production of Leading Mineral Commodities in Northern Ontario (N.O.) and Canada (in millions of 1991 dollars)

Year	Copper N.O.	% of Canada	Gold N.O.	% of Canada	Nickel N.O.	% of Canada	Zinc N.O.	% of Canada
1984	730.26	40.51	561.54	33.34	1205.21	76.24	537.58	27.86
1985	771.85	37.71	576.41	36.09	1215.18	77.09	392.98	25.44
1986	663.94	37.85	938.94	44.84	909.41	74.46	431.21	28.89
1987	809.66	35.62	1214.64	45.83	1039.17	68.84	408.61	24.39
1988	1034.39	37.78	1236.00	46.33	1993.32	64.69	617.76	23.85
1989	1002.93	38.60	1242.54	49.33	2186.40	66.80	623.00	20.91
1990	909.42	35.45	1215.05	47.78	1421.33	66.06	562.00	23.41
1991	708.86	33.85	1029.60	43.67	1219.28	66.50	273.19	19.78

Source: Statistics Section, Mines and Minerals Division, Ontario Ministry of Northern Development and Mines.

tured commodities included in the index.

We have constructed the Northern Ontario commodity price index as a weighted average of the prices in U.S. dollars of the top four mineral commodities, namely copper, gold, nickel and zinc, and major manufactured products, namely iron and steel, wood and paper and allied products. The weight assigned to each commodity is equal to the value of its production in Northern Ontario in 1986. Figure 1 shows the fluctuations in Northern Ontario's commodity price index for the period 1970-91. For comparative purposes, the Canadian CPI is also shown in the figure. Figure 1 shows that the commodity price index rose significantly during the 1970s, increasing from 37.67 in 1970 to 100 in 1980, a growth rate of about 16.6 percent per year. However, from 1980 to 1986, the index declined in nominal terms from 100 in 1980 to 93.97 in 1986. The nominal value of the commodity index increased during 1986-88. This rise in the commodity price index during this period was due to the general increase in commodity prices prior to the downturn caused by the North American recession. The commodity price index declined significantly during 1990-91.

In addition to fluctuations in the commodity price index, changes in the value of Canadian currency vis-à-vis other currencies affect the prices that producers of export commodities in Northern Ontario receive and thus directly influence the level of economic activity and employment in the region. We define the exchange rate as the value of foreign currency per unit of Canadian dollar. Different trade weighted indexes (also called the effective exchange rate) based on a weighted basket of currencies can be constructed according to the composition of the trading partners. For example, the Bank of Canada has constructed a G-10 effective exchange rate based on the currencies of Canada's major trading partners and the International Monetary Fund (IMF) produces a

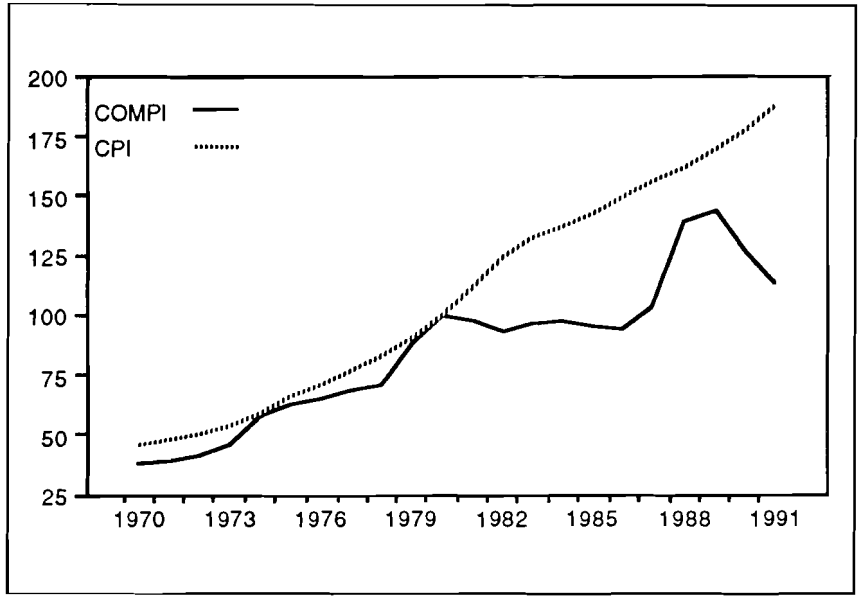

FIGURE 1 Commodity Price Index and CPI (1980 = 100)

multilateral index of effective exchange rates. Chambers and Percy (1992), in their study of Western Canada, constructed an exchange rate index which consisted of a weighted average of the currencies of the major trading partners of Western Canada. However, the bulk of Northern Ontario's production of newsprint, lumber, and pulp is exported to the United States. Most of the mineral commodities of Northern Ontario are also marketed through the U.S. In addition, almost all of Northern Ontario's export commodities are denominated in U.S. dollars. For these reasons, we have used the Canada-U.S. exchange rate in our analysis and this is shown in Figure 2 for the period 1970-91. The vertical axis measures the value of the Canadian dollar in terms of U.S. currency (multiplied by 100). Figure 2 shows that since the adoption of flexible exchange rates, the value of the Canadian dollar in terms of the U.S. currency has changed significantly. The Canadian dollar depreciated (with the exception of a slight appreciation in 1979) throughout 1973-86 and appreciated during 1986-91. Fluctuations in the external value of the Canadian dollar can play a stabilizing role if they offset changes in commodity prices. For example, when export commodity prices in international markets are falling, the adverse effect on Northern Ontario producers can be partially mitigated by a depreciation of the Canadian dollar. Conversely, when commodity prices are rising, the boom effect of increased revenue will be reduced by an appreciation of the Canadian dollar. Exchange rate fluctuations that play a stabilizing role

are usually referred to as counter-cyclical. Exchange rate fluctuations can be pro-cyclical in the sense of having an adverse effect on domestic producers. For example, an appreciation of the exchange rate adversely affects domestic producers if it occurs when commodity prices are falling.

To examine the effect of fluctuations in the Canadian exchange rate on the Northern Ontario economy, Figure 3 shows the fluctuations in the real commodity price index and the real exchange rate during the 1970-91 period. The real commodity price index is obtained by deflating the nominal commodity price index by the GDP deflator. The real exchange rate is calculated by deflating the nominal exchange rate by the relative GDP deflators for Canada and the U.S. Figure 3 shows that for most of the last two decades, fluctuations in the real exchange rate have been counter-cyclical and have had a moderating influence on the Northern Ontario economy. However, during the early 1980s, the decline of the real commodity price index was accompanied by real exchange rate appreciation, which was pro-cyclical. This reduced the competitive position of Northern Ontario's export industries. From 1988 through 1991, the decline in real commodity prices was once more accompanied by a significant appreciation of the real exchange rate, which again adversely affected Northern Ontario's economy and worsened regional recessionary conditions.

In the next section, the extent to which variations in the commodity price index and the exchange rate explain the variation in the level of employment in Northern Ontario is examined.

Variability and Causal Ordering of Employment, Commodity Prices and the Exchange Rate

This section examines the hypothesis that the variations in commodity prices and the exchange rate are the major causes of changes in the level of employment in Northern Ontario. There are different ways that this hypothesis can be examined. One approach is to employ the causality test introduced by Granger (1969). A variable Y is said to be Granger caused by a variable X if the information contained in past and present values of X helps to improve the forecasts of the Y variable. The Granger test regresses Y on lagged values of Y and lagged values of X and tests whether the lagged values of X are jointly insignificant. If they are, then X does not cause Y.

Another closely related approach, which has been popularized by Sims (1977, 1981) and others, is that of innovation accounting. The Granger causality concept measures the percentage of variation in a variable which can be explained by a distributed lag of other variables in a system. Innovation accounting, on the other hand, measures the percentage of variation in a variable which can be explained by a distributed lag of "surprises" or "innovations" in other variables. This procedure traces out the reaction of a system to a shock

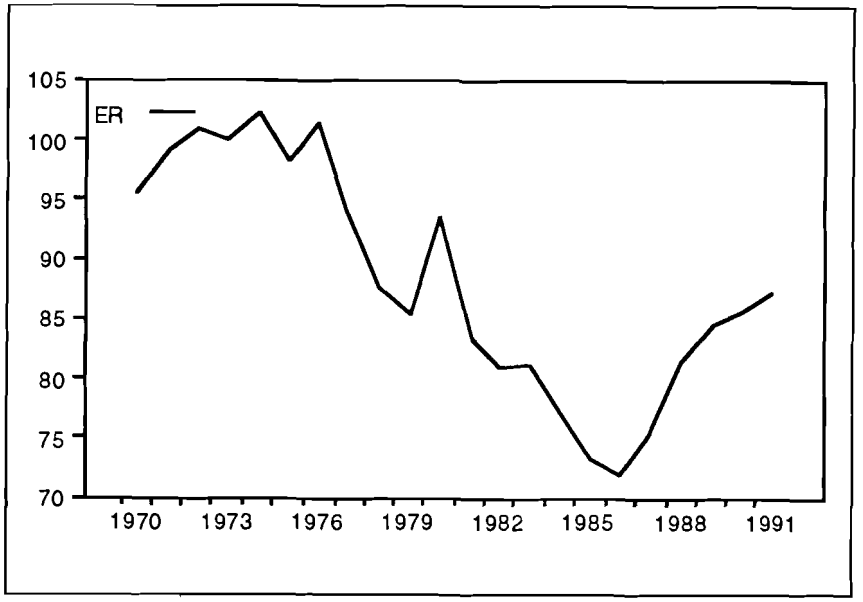

FIGURE 2 Canadian Exchange Rate (Nominal Values)

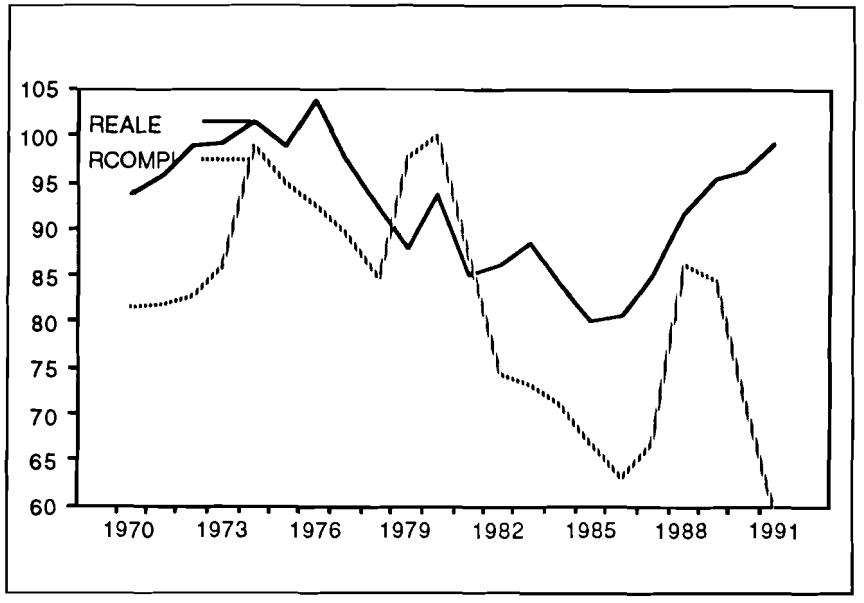

FIGURE 3 Real Exchange Rate and the Real Commodity Price Index

or innovation in one of the variables. According to the Wald decomposition theorem, each series in a linear time series model can be represented as a linear combination of current and past innovations in the variables in the system. These innovations, which are by construction serially uncorrelated, can also be transformed to become contemporaneously uncorrelated or orthogonized. Using this procedure, the variability in a variable, such as employment, can be unambiguously decomposed into components attributable to other variables in the system. Table 2 presents the results of a decomposition of the variance of employment in a three variable system consisting of employment, real commodity prices and real exchange rates. These results are based on an autoregressive model which is linear in the logarithms of employment, real commodity prices and the real exchange rate, using four lags for each variable and a constant term.

The entries in Table 2 give the percentage of variation in employment explained by orthogonalized innovations in real commodity prices and the real exchange rate. (The order of orthogonalization is as listed in Table 2). The sum of the entries in each row at each point of time adds up to one hundred. Table 2 shows that the first step variance of employment is entirely explained by its own innovations. As the time horizon lengthens, the percentage of variation of employment explained by the real commodity price index and the real exchange rate increases. Table 2 shows that, at a four year time horizon, about 80% of the variation of total employment in Northern Ontario is explained by innovations in commodity prices and exchange rates. We can also observe that the percentage of variation explained by commodity prices is much higher than that explained by exchange rate movements. This result provides strong support for the hypothesis that employment change in Northern Ontario is primarily determined by movements in international prices for its major commodity exports and changes in the exchange rate.

To examine the sensitivity of employment in Northern Ontario to other variables, such as domestic interest rates and the international business cycle, we experimented with a four variable system that included employment, the commodity price index, exchange rates and either the interest rate or U.S. real output. We used real output in the United States as a proxy for the international business cycle. We found that neither interest rates nor U.S. output added significantly to the variability already explained by commodity prices and exchange rates.[1] This can be attributed to the fact that the effects of interest rates and the international business cycle on the level of employment in Northern Ontario are captured through their impacts on the exchange rate and commodity prices, respectively.

1. None of the estimated coefficients of all lags of the interest rate or U.S. output were significant at the 5% level.

TABLE 2 Three Variable Innovation Accounting: Percentage of 4 Year Forcast-Error Variance of Employment Explained

Forcast Horizon Year	Innovations In		
	Employment in Northern Ontario	Real Commodity Prices	Real Exchange Rates
1	100	0.0	0.0
2	42.5	49.7	7.8
3	35.5	53.4	11.1
4	20.8	61.7	17.5

Estimation of Price and Exchange Rate Elasticities

In the previous section, we found that movements in the Northern Ontario real commodity price index and the real exchange rate explain a significant portion of the changes in the level of employment in Northern Ontario. An increase in the international prices of the region's major commodity exports stimulates production and employment. On the other hand, a decline in international commodity prices discourages investment and, therefore, after a period of adjustment, reduces regional employment levels. In general, therefore, we expect a positive relationship between changes in the international commodity prices of Northern Ontario export products and changes in the level of employment in the region. Since the commodity price index developed in this study is entirely based on U.S. commodity prices, it does not take into account the effect of changes in the exchange rate on Northern Ontario's economy. In general, an appreciation of the exchange rate reduces earnings of domestic export-oriented industries. This generally reduces investment levels and, therefore, employment in the region. Similarly, a depreciation of the exchange rate increases the revenue of the export industries. This leads to a higher level of production and employment in the region. In general, we expect a negative relationship between changes in the exchange rate and changes in the level of employment in the region.

The relationship between changes in employment levels and changes in commodity prices and the exchange rate in Northern Ontario can be written as:

$$Y_t = \alpha + \beta X_t + \delta Z_t + \epsilon_t \qquad (1)$$

where Y_t, X_t, and Z_t are percentage changes in employment, the real commodity price index and real exchanges rates, respectively and ϵ_t is a random disturbance term. As noted above, we expect the coefficient β to be positive and δ to be negative. The coefficient β measures the percentage change in employment caused by a percentage change in the real commodity price index. Simi-

larly, the coefficient δ measures the percentage change in employment caused by a percentage change in the real exchange rate.

Estimating the effect of the fluctuations in the commodity prices and exchange rates on the level of employment in the form of equation (1) suggests that there are no lags in the adjustment process of employment to changes in prices and exchange rate. It is conceivable that the level of employment responds with a lag to changes in the commodity prices and exchange rate. Moreover, changes in commodity prices and the exchange rate can effect the level of employment after a certain period of time. To allow for the presence of lags in the adjustment of the level of employment to changes in commodity prices and the exchange rate, we rewrite equation (1) as follows:

$$Y_t = \alpha + \Sigma_i \phi_i Y_{t-i} + \Sigma_i \beta_i X_{t-i} + \Sigma_i \delta_i Z_{t-i} + \epsilon_t \quad (2)$$

In the absence of autocorrelation, equation (2) can be estimated by Ordinary Least Squares (OLS) and the resulting estimates can be used to calculate the long-term or total effect of changes in commodity prices and exchange rates on the level of employment as follows:

$$\Theta_1 = (\Sigma_i \beta_i)/(1 - \Sigma_i \phi_i) \quad (3)$$
$$\Theta_2 = (\Sigma_i \delta_i)/(1 - \Sigma_i \phi_i) \quad (4)$$

The coefficients Θ_1 and Θ_2 are the long-run price and exchange rate elasticities of employment in Northern Ontario. In addition to calculating these coefficients, we would have to use the estimated equation (2) to calculate the standard errors of these long-run elasticities. The above procedure is computationally inefficient because of the two-step procedure involved. It would be better if we could find a way to estimate the long-run coefficients and their standard errors directly. This can be done by using a transformation proposed by Wickens and Breusch (1988). Following them, we transform model (2) by subtracting $(\Sigma_i \phi_i)Y_t$ from each side of (2), re-arranging and re-normalizing to give

$$Y_t = \alpha - \lambda \Sigma_i \phi_i (Y_t - Y_{t-i}) + \lambda(\Sigma_i \beta_i) X_t - \lambda\Sigma_i \beta_i (X_t - X_{t-i}) + \lambda(\Sigma_i \delta_i) Z_t - \lambda\Sigma_i \delta_i(Z_t - Z_{t-i}) + \lambda\epsilon_t \quad (5)$$

where

$$\lambda = 1/(1 - \Sigma_i \phi_i) \quad (6)$$

Thus, the estimated coefficients on X_t and Z_t are the long-run elasticities. The short-run impacts of changes in commodity prices and the exchange rate are captured by the estimated coefficients on the differenced terms. The only problem in estimating equation (5) is related to the presence of the current dependent variable among the explanatory variables of this model. To solve

this problem, we estimated equation (5) using the instrumental variable method. The advantage of the instrumental variable estimation is that it provides direct estimates of the long-run elasticities and their standard errors and thus does not require further computations as would be the case with the OLS estimation of model (2). Wickens and Breusch (1988) have proved that the estimates of the long-run elasticities obtained from estimating the transformed model (5) via instrumental variables is numerically identical to those calculated from the OLS estimates of the original equation (2) provided that all the predetermined variables of the original equation are used as instruments. Therefore, to procure an optimum set of instruments, we need to specify the lag structure of the original model (2). To determine the optimum order of lags, the sequential procedure suggested by Hsiao (1979) based on Akaike's Final Prediction Error criterion is employed.[2] Table 3 presents the estimation results of equation (5).[3] Table 3 shows that the estimated long-run elasticities are significantly different from zero and have the correct signs. The short-run effects are captured by the first differenced terms. The estimated long-run price elasticity is equal to 0.18 implying that a one percent increase (decrease) in the Northern Ontario real commodity price index leads to 0.18 percent increase (decrease) in the level of employment in the region. The estimated long-run exchange rate elasticity is equal to -0.37 implying that a one percent increase (decrease) in the real exchange rate leads to 0.37 percent decrease (increase) in the level of employment in Northern Ontario.

Conclusion

The main objective of this paper has been to examine the relationship between employment, international commodity prices and exchange rates on the Northern Ontario economy. For this, we first constructed a commodity price index which summarized the international price fluctuations of the major commodity exports of the region. Then, using variance decomposition methodology, we established that variations in the real commodity price index and the real exchange rate explain about 80% of the variation in the level of regional employment. Finally, using the methodology proposed by Wickens and Breusch

2. We allowed for up to four lags of each variable in the estimated equation. However, only the first difference of employment and commodity prices turned out to be statistically significant.
3. To ensure the validity of the estimated results for drawing statistical inferences, we subjected the estimated equation to a series of diagnostic tests. The Lagrange multiplier test (Breusch and Pagan, 1980) was used to test for the possibility of the presence of first order autocorrelation. The result labelled as t(LM) in Table 2 suggests no evidence of autocorrelation in the dynamic model. The LM test proposed by Engle (1982) was used to test the hypothesis that the errors follow a first order ARCH model. Results indicated no evidence of heteroskedasticity in the residuals.

TABLE 3 Estimates of the Coefficients of Model (5), 1971-91

Variable	Coefficient	t-statistic
Constant	1.84	2.20
X_t	0.18	1.99
Z_t	-0.37	2.10
$Y_t - Y_{t-1}$	-0.53	5.73
$X_t - X_{t-1}$	0.11	1.75
R^2 = 0.84		
D.W. = 1.93		
SEE = 2.91		
t(LM) = 0.21		

(1988), we estimated the long-run commodity price and exchange rate elasticities of employment in Northern Ontario.

Our findings clearly demonstrate that total employment in Northern Ontario is very sensitive to fluctuations in the level of activity in the base or export sector of the region. This implies that a decline in the economic base results in an overall decline in regional economic activity. Due to low productivity growth and a significant rise in the unit labour cost in major resource-based industries, combined with an overall decline in the commodity prices, the economic base of the region has been experiencing a general decline during the post-1980 period (see, Jankowski and Moazzami 1993). Significant growth of the government sector in the region during the 1980s to a large extent compensated for the decline of the economic base in Northern Ontario. Without increased government employment, the impact of downsizing in the regional resource-based industries would have been much greater. However, given the current fiscal crisis and the need to reduce deficits, it is unlikely that government employment will continue to increase. This implies that Northern Ontario's economic viability and prosperity face an unprecedented challenge. The high degree of dependency on a few resource-based industries in the region is the result of the absence of any conscious regional development strategy to diversify the economy. Although Northern Ontario's comparative advantage has been based on resource extraction and semi-processing, bulk commodities are a weakening base on which to maintain a long-term trading pattern. The long-term prosperity of the region is, therefore, dependent on its ability to undertake a successful diversification strategy.

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