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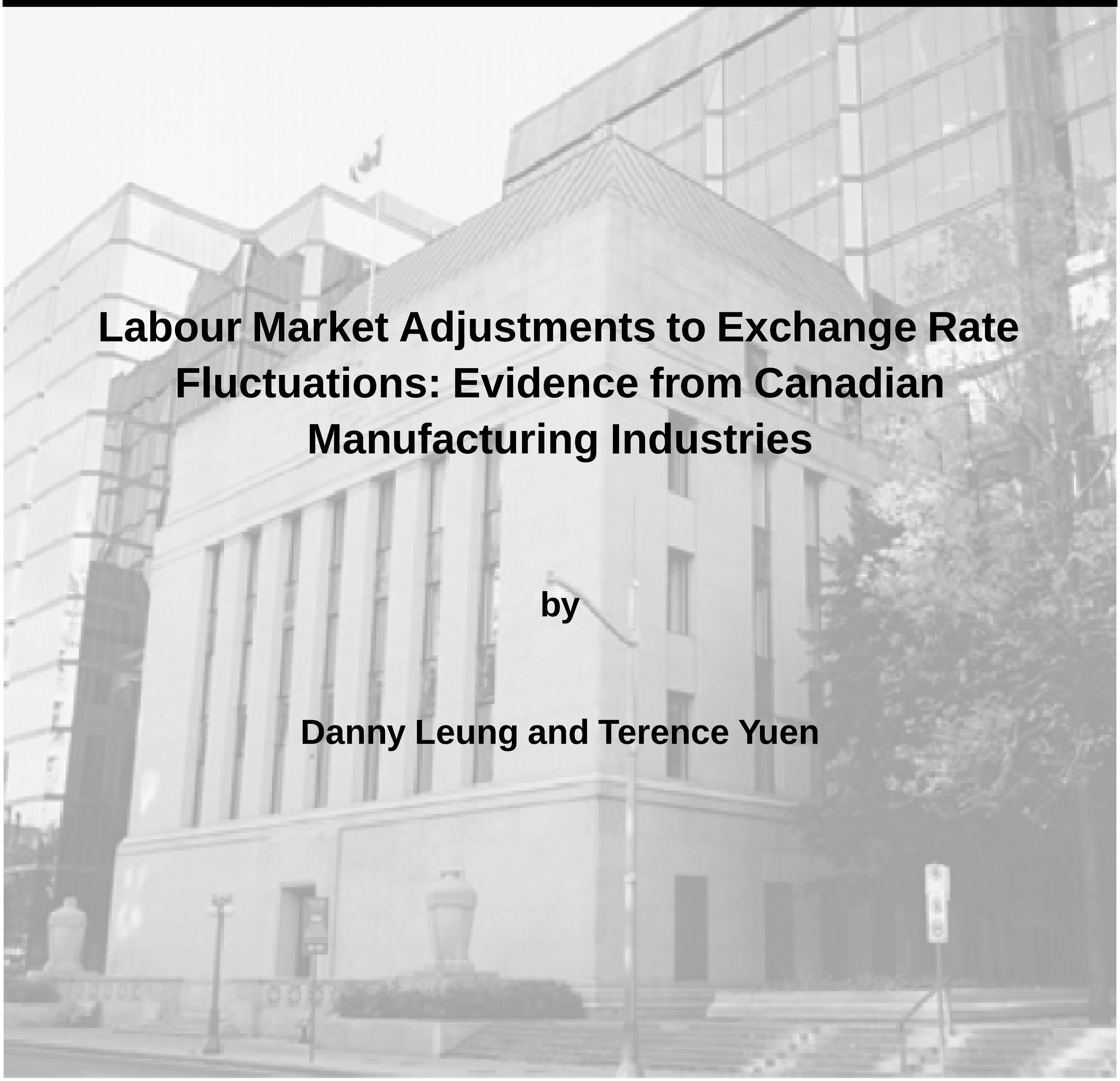

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The views expressed in this paper are those of the authors.
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Contents

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Abstract

The authors provide some of the first empirical evidence on labour market adjustments to exchange rate movements in Canadian manufacturing industries. Generalized method of moments estimates that control for endogeneity show that there are significant changes in labour input when a change in the exchange rate occurs. During the 1981–97 period, the cumulative effect of a 10 per cent depreciation (appreciation) of the Canadian dollar was a 10 to 12.5 per cent increase (decline) in labour input. The majority of this effect was due to the increase (decrease) in the demand for domestically produced goods both at home and abroad when a depreciation (appreciation) occurs. The authors find evidence that the responsiveness of labour input to exchange rate movements was greater in the 1990s than in the 1980s. They also find that industries with high and medium net trade exposures adjust their labour inputs more than industries with low trade exposures. The exchange rate effect on real wages is estimated to be virtually zero for all manufacturing industries.

JEL classification: F4, E23
Bank classification: Labour markets; Exchange rates

Résumé

Les auteurs sont parmi les premiers à présenter des données empiriques sur les ajustements du marché du travail à l'évolution du taux de change dans les industries manufacturières canadiennes. Selon leurs estimations, qu'ils obtiennent en utilisant la méthode des moments généralisés afin de tenir compte du problème d'endogénéité, cette évolution aurait une grande incidence sur le facteur travail. Les auteurs calculent qu'au cours de la période 1981-1997, une baisse (ou une hausse) de 10 % du dollar canadien fait augmenter (ou diminuer) l'emploi de 10 à 12,5 % au total. Cet effet est principalement attribuable à la progression (ou au recul) que connaît la demande de produits nationaux, tant au pays qu'à l'étranger, lorsque la monnaie se déprécie (ou s'apprécie). Les auteurs notent que la sensibilité du facteur travail aux variations du taux de change a été plus marquée dans les années 1990 que durant la décennie précédente. Ils observent également que les industries fortement ou moyennement ouvertes aux échanges ajustent davantage le facteur travail que les autres. Enfin, ils estiment que les mouvements du taux de change ont une incidence pratiquement nulle sur les salaires réels dans toutes les industries manufacturières.

Classification JEL : F4, E23
Classification de la Banque : Marchés du travail; Taux de change

1 Introduction

One of the key challenges for a monetary authority in a small open economy is to understand the impact of international factors on the domestic economy. In particular, the recent depreciation of the U.S. dollar against many other world currencies has sustained interest in examining the effects of exchange rate fluctuations. While the literature has a long tradition of estimating the exchange rate pass-through on prices,[1] only a limited amount of research has been devoted to examining the effects of the exchange rate on the labour market. The general perception is that a depreciation of the domestic currency stimulates employment through two main channels: stronger employment is induced by increasing demands in both domestic and export markets, and the substitution effect between labour and capital increases employment because of the rising cost of imported capital.

Most empirical studies in this area focus on U.S. manufacturing industries. Early work using data from the 1970s and 1980s indicates that an exchange rate appreciation leads to a significant decline in employment.[2] More recent papers, however, provide contrasting results. Campa and Goldberg (2001) conclude that the exchange rate has little impact on net employment, but a pronounced effect on wages in the United States. Furthermore, Goldberg and Tracy (2001) provide supportive evidence that wage adjustments occur for workers at times of job transition.

Very little work has been done in this area for other countries. Dekle (1998) examines the relationship between yen movements and employment in Japan. His results show that an appreciation of the exchange rate would lead to a sizable reduction in Japanese manufacturing employment in the long run. The only study related to Canada is in Burgess and Knetter (1998), which compares employment adjustments to exchange rate fluctuations across G-7 countries. For total manufacturing employment over the period 1972 to 1988,[3] the response to real exchange rate appreciations is negative and statistically significant only for the United

[1] See recent papers by Bailliu and Fujii (2004) and Anderton (2003).

[2] See Branson and Love (1988) and Revenga (1992).

[3] Separate analyses are conducted using employment data on agriculture, mining, construction, finance, and transport services.

Kingdom and Italy, but insignificant at the 10 per cent confidence level for Canada, France, Germany, Japan, and the United States.

This paper provides some of the first empirical evidence on how the labour market in Canadian manufacturing industries adjusted to exchange rate movements between 1981 and 1997. More specifically, this study contributes to the literature in three ways. First, while existing work has estimated the overall exchange rate impact, this paper separates the channels through which exchange rates affect the labour market. Assuming that exchange rate movements are passed through to the product and imported input prices, a depreciation stimulates employment through the output channel as the demand for domestically produced goods increases in both domestic and foreign markets; it also increases employment through the relative input price channel as imported inputs are substituted for cheaper labour. The extent to which each of these channels affects employment and wages is an important issue. Second, using disaggregated industry data at the 3-digit Standard Industrial Classification (SIC) level, we examine how the adjustment process differs across manufacturing industries in Canada. Theory suggests that export-oriented firms with weak monopoly power are more responsive to currency changes than those with low export exposure and a strong ability to adjust their profit margins. Third, there are reasons to believe that the employment sensitivity to exchange rates changes over the sample period. One common argument is that increasing trade exposure of the Canadian manufacturing industry over the past two decades would lead to higher sensitivity to exchange rate movements. Another issue is related to exchange rate volatility. Exchange rate fluctuations during periods of high volatility may not give a clear signal as to whether the movements are persistent or temporary. In this case, firms are more likely to delay their labour adjustment process, which implies lower responsiveness to exchange rates.

After taking endogeneity into account using generalized method of moments (GMM) estimation, we find significant changes in labour input after changes occur in the real exchange rate. A depreciation (appreciation) of the Canadian dollar increases (decreases) labour input primarily because of stronger (weaker) output demand in the domestic and export markets.

For the period 1981–97, we find a short-run elasticity of 0.2 and a long-run elasticity of 0.75 through this channel. Including the effect through the imported inputs channel raises the long-run elasticity to between 1.00 and 1.25, depending on how the effect through the imported inputs channel is inferred. We find evidence that the effect of exchange rate movements on labour input was greater in the 1990s than in the 1980s, and that industries with high net trade exposures are more responsive in their labour adjustments than those with low trade exposures. The exchange rate effect on real wages is virtually zero and imprecisely estimated for all Canadian manufacturing industries.

This paper is organized as follows. Section 2 presents the theoretical model and discusses the possible channels in which the labour market adjusts to real exchange rate changes. Section 3 introduces the data that are used in the empirical analysis. Section 4 provides the results from the empirical analysis. Section 5 offers some conclusions.

2 Theoretical Framework

It has been well documented in the literature that employment adjustments are costly (Hamermesh and Pfann 1996). A dynamic factor demand model is a common framework in which to capture the slow employment response to shocks. Although we do not estimate a structural model in the empirical analysis, in this section we provide a theoretical framework for the channels through which the exchange rate affects employment and wages.

A representative firm maximizes expected future profits subject to a production function and labour adjustment costs. That is,

$$\pi_t = \max E_t \left[\sum \beta^\tau \left(PY_{t+\tau} \cdot QY_{t+\tau} - PL_{t+\tau} \cdot QL_{t+\tau} - PZ_{t+\tau} \cdot QZ_{t+\tau} \right) - c\left(\Delta QL_{t+\tau} \right) \right], \quad (1)$$

subject to

$$QY_t = F\left(QL_t, QZ_t\right), \quad (2)$$

$$c\left(\Delta QL_t\right) = \frac{\theta \left(\Delta QL_t\right)^2}{2}, \quad (3)$$

where β is the discount factor that is assumed to be constant over time, and E_t is the conditional expectation on all the information available at time t. The firm produces one output, QY, for both the domestic and export markets using two types of inputs: quasi-fixed labour, QL, and variable input, QZ.[4] Assuming that the firm is not a price taker in the output market, PY represents the inverse demand function of QY. PL and PZ denote the input prices of QL and QZ, respectively. The adjustment cost structure of labour takes the quadratic form shown in (3).

Solving the firm's maximization problem yields the well-known partial-adjustment equation for the optimal demand for labour input[5]:

$$QL_t^D = \nu QL_{t-1} + (1-\nu)(1-\beta\nu) E_t \left[\sum (\beta\nu)^\tau \widetilde{QL}_{t+\tau} \right], \tag{4}$$

where $\widetilde{QL}$ is the long-run desired level of labour input in the absence of adjustment costs. Equation (4) shows that labour input does not instantaneously adjust to its long-run equilibrium. The dynamic labour demand at time t depends on the last-period labour input, QL_{t-1}, and the discounted average of expected future values of $\widetilde{QL}$. The speed of adjustment, ν, is increasing with the adjustment parameter, θ. Hence, the higher is θ, the slower is the adjustment to the long-run optimal level.

Assuming that changes in $\widetilde{QL}$ are considered permanent such that $E_t\left(\widetilde{QL}_{t+\tau}\right) = \widetilde{QL}_t$, and taking the log approximation of (4), yields:

$$\ln QL_t^D = \nu \ln QL_{t-1} + (1-\nu) \ln \widetilde{QL}_t. \tag{5}$$

The next step is to derive an expression for the long-run equilibrium of labour input, $\widetilde{QL}_t$. In the case where the product market is monopolistically competitive and the production technology takes a Cobb-Douglas form, the optimal labour input can be expressed as a linear function of relative input prices[6]:

$$\ln \widetilde{QL}_t = \alpha_0 + \alpha_1 \ln RPL_t + \alpha_2 \ln RPZ_t + \alpha_3 \ln X_t, \tag{6}$$

[4] For simplicity, it is often assumed that inputs other than labour can be fully adjusted to their optimal level in the short run.

[5] Details of the complete derivation are provided by Nickell (1981).

[6] Details of the complete derivation are provided by Dekle (1998).

where RPL is the relative price of labour (PL/PY), RPZ is the relative price of other inputs (PZ/PY), and X is an array of economic conditions to control for demand shifts. Substituting (6) into (5) gives the following reduced-form expression for dynamic labour demand:

$$\ln QL_t^D = \chi_0 + \chi_1 \ln QL_{t-1} + \chi_1 \ln RPL_t + \chi_2 \ln RPZ_t + \chi_3 \ln X_t. \tag{7}$$

To complete the model and solve for the equilibrium labour input and wages, a simple model of labour supply is assumed:

$$\ln QL_t^S = \lambda_0 + \lambda_1 \ln RPL_t + \lambda_2 \ln W_t, \tag{8}$$

where the economic conditions, W, in this equation do not necessarily have to be the same as those, X, in (7). Equation (8) can be combined with (7) such that

$$QL_t^D = QL_t^S. \tag{9}$$

In this framework, for a given wage rate, there are two direct channels in which the real exchange rate (RER) can affect the labour demand in (7),

$$\frac{\partial \ln QL_t^D}{\partial \ln RER_t} = \chi_2 \frac{\partial \ln RPZ_t}{\partial \ln RER_t} + \chi_3 \frac{\partial \ln X_t}{\partial \ln RER_t},$$

where RER is defined as the domestic currency against foreign currencies. The first channel is the input substitution channel. Assuming that part of the variable input is imported, the price of the variable input, RPZ, is a function of the exchange rate. $\frac{\partial RPZ}{\partial RER} > 0$ because a depreciation of the exchange rate increases the cost of imported capital and imported intermediate inputs. To the extent that labour is a substitute for these other inputs, demand for labour will rise; i.e., $\chi_2 > 0$. On the other hand, if labour is a complement, the opposite will occur; i.e., $\chi_2 < 0$.

Second, there is the output channel. The demand conditions, X, are a function of the real exchange rate. $\frac{\partial X}{\partial RER} > 0$ implies that a depreciation of the exchange rate would improve the product demand conditions, and hence the labour demand for $\chi_3 > 0$. The intuition is that a depreciation of the domestic currency makes imports relatively more expensive for domestic consumers, and exports relatively cheaper for foreign buyers. As a domestic firm, the overall product demand increases as the competition from imports lessens and demand for exports rises. As a result, more inputs, including labour, are used to create more output.

These two basic channels are influenced by a wide array of economic circumstances. An industry's exposure to trade has a large impact on the strength of both these channels. The output channel $\left(\frac{\partial X}{\partial RER}\right)$ would be stronger if the industry was more export-oriented or if it faced more import competition. The substitution channel $\left(\frac{\partial RPZ}{\partial RER}\right)$ would be stronger if the industry imported many of its inputs.

Product market structure also heavily influences the response of labour demand to an exchange rate change. In the case of monopolistic competition with zero profit, a depreciation would lead to an increase in output, and hence labour demand, as outlined above. The implications are quantitatively different in the case of oligopolistic markets. Industries with high markup ratios that price to market can respond to exchange rate fluctuations by altering their product prices in both domestic and foreign markets. As a result, the exchange rate effects on the labour demand through the output channel are dampened, and adjustments are mostly reflected in the industry profit margins.[7] Therefore, the effects of the exchange rate on the labour market are inversely related to the degree of monopoly power.

Likewise, the supply conditions and the labour market structure play a role in determining the equilibrium employment and wages. General slackness (tightness) in the labour supply would lead to more (less) adjustment on labour input, and less (more) real wage adjustment.

Furthermore, exchange rate volatility may affect the size of the adjustment in a dynamic framework. Because of adjustment costs, it is important during the adjustment process to determine the nature of the shocks. Firms do not change their labour demand if the shocks are transitory. When exchange rates are very volatile, it is difficult for firms to distinguish whether the movements are persistent or temporary. Employment adjustments are likely to be delayed until the signal is clear enough. Therefore, uncertainty tends to lower the

[7] The theoretical models as well as the empirical evidence in Allayannis and Ihrig (2001) and Bodnar, Dumas, and Marston (2002) show that the responsiveness of profits to changes in exchange rates increases with industry markups.

employment sensitivity to exchange rates. A change in the exchange rate when the series is volatile is likely to elicit smaller changes in wages and labour input.

3 Data

This paper primarily uses the 1981–97 vintage of the KLEMS database. The KLEMS data are from the Canadian Productivity Accounts. KLEMS provides data on both prices and quantities for output, capital, labour, energy, materials, and services inputs for many Canadian industries.[8] This paper focuses on the 21 manufacturing industries of KLEMS because data for other industries are incomplete.[9] Labour input in KLEMS is quality-adjusted hours worked.[10] Additionally, along with the price of capital, KLEMS provides a measure of the user cost.[11]

In addition to KLEMS, U.S. real gross domestic product (GDP) and Canadian consumption expenditure are obtained from widely available sources.[12] The exchange rate is the real C-6 effective exchange rate computed by the Bank of Canada. The C-6 is a weighted average of the bilateral rates between Canada and six major foreign currencies.[13] An increase in C-6 is a depreciation of the real effective exchange rate. Other data used in the analysis include Dion's (1999–2000) measure of net trade exposure for each manufacturing industry.

[8] See Baldwin and Harchaoui (2002) for more details on the source of this data.

[9] There are, in fact, 22 manufacturing industries in KLEMS. One of these industries, refined petroleum and coal products, is excluded from our sample due to missing data.

[10] A Jorgenson, Gallop, and Fraumeni (1987) style approach is used to create the quality-adjusted measure of labour input. Data on hours worked are tabulated for workers grouped by age, education level, employment class, and industry of work. Income shares are used to aggregate across these different groups. Groups with higher income shares are thus given more weight. See Gu et al. (2002) for more details.

[11] See Harchaoui and Tarkhani (2002) for more detail on the distinction between capital services and capital stock, and on how the user cost of capital is constructed.

[12] See Appendix A for more information on these and other variables used in the empirical analysis.

[13] The C-6 countries are the United States, the Economic and Monetary Union (EMU) countries, Japan, the United Kingdom, Switzerland, and Sweden. Derived from Canadian merchandise trade flows between 1994 and 1996, the corresponding weights for each country are 0.8584, 0.0594, 0.0527, 0.0217, 0.0043, and 0.0035, respectively. Note that currencies from each EMU country are used before 1999. The nominal C-6 index has been based to 1992; i.e., C-6 = 100 in 1992. To obtain the real C-6 exchange rates, the nominal C-6 index is multiplied by the ratio of the GDP deflators between Canada and the weighted average of the C-6 countries. The real C-6 and Canada-U.S. bilateral exchange rates are strongly correlated because of the dominant U.S. trading weight in the C-6 calculation. Lafrance and St-Amant (1999) find that the difference between the two measures of the real exchange rate is statistically insignificant.

As a lead-in to the regression analysis, Figure 1 plots the movements of the real exchange rate and quality-adjusted hours worked in the manufacturing sector.[14] Movements of the real exchange rate between 1981 and 1997 can be broken into three distinct periods. The Canadian dollar depreciated in the 1980s before it appreciated 14.3 per cent between 1987 and 1991. After 1991, the real exchange rate depreciated again. One interesting feature in Figure 1 is that the real exchange rate appears to lead movements in labour input.

Figures 2 to 4 show the industry profiles of labour input. Industries are equally divided into high, medium, and low trade groups, according to their average net trade exposure over the sample period. Also, for ease of comparison, industry labour inputs are detrended using the Hodrick-Prescott filter. Theory predicts that export-oriented firms tend to be more sensitive to changes in the exchange rate. Figures 2 to 4, however, show that there is no clear distinction across the trade groups. A prominent feature is that most industry patterns are similar to the aggregate picture in Figure 1.

Figures 1 to 4 suggest that a depreciation (appreciation) of the Canadian dollar tends to increase (decrease) manufacturing employment with a lag of about one year. Whether this is a causal relationship or the result of the influence of a third unidentified factor has yet to be determined. Detailed empirical analysis will be performed in the next section.

4 Empirical Findings

Many empirical specifications have been used to measure the labour market's response to an exchange rate change. They can be divided into two groups. The first type, used by Revenga (1992) and Campa and Goldberg (2001), takes into account both labour demand and supply.

[14] More precisely, Figure 1 plots quality-adjusted hours worked in the manufacturing sector excluding the hours worked in the refined petroleum and coal industry.

Equations (7) and (8) are combined to yield labour input and wage regressions[15]:

$$\begin{aligned}\Delta \ln(QL_{it}) &= \alpha_0 + \alpha_1 \Delta \ln(QL_{it-1}) + \alpha_2 \Delta \ln(RER_t) \\ &\quad + \alpha_3 \Delta \ln(C_t) + \alpha_4 \Delta \ln(USGDP_t) + \alpha_5 \Delta \ln(RUC_{it}) \\ &\quad + \alpha_6 \Delta \ln(RPE_{it}) + \alpha_7 \Delta \ln(RPM_{it}) + \alpha_8 \Delta \ln(RPS_{it}) + \Delta \varepsilon_{it}^{L},\end{aligned} \tag{10}$$

and,

$$\begin{aligned}\Delta \ln(RPL_{it}) &= \beta_0 + \beta_1 \Delta \ln(QL_{it-1}) + \beta_2 \Delta \ln(RER_t) \\ &\quad + \beta_3 \Delta \ln(C_t) + \beta_4 \Delta \ln(USGDP_t) + \beta_5 \Delta \ln(RUC_{it}) \\ &\quad + \beta_6 \Delta \ln(RPE_{it}) + \beta_7 \Delta \ln(RPM_{it}) + \beta_8 \Delta \ln(RPS_{it}) + \Delta \varepsilon_{it}^{W}.\end{aligned} \tag{11}$$

Industry-specific input prices include the relative user cost of capital, RUC, the relative price of energy, RPE, the relative price of materials, RPM, and the relative price of services, RPS. Economic conditions that shift demand are the real exchange rate, RER, Canadian consumption spending, C, and U.S. real GDP, $USGDP$.

An alternative specification used by Dekle (1998) is based only on the dynamic labour demand equation (7). Substituting in the industry-specific input prices and economic conditions gives:

$$\begin{aligned}\Delta \ln(QL_{it}) &= \gamma_0 + \gamma_1 \Delta \ln(QL_{it-1}) + \gamma_2 \Delta \ln(RER_t) + \gamma_3 \Delta \ln(RPL_{it}) \\ &\quad + \gamma_3 \Delta \ln(C_t) + \gamma_4 \Delta \ln(USGDP_t) + \gamma_5 \Delta \ln(RUC_{it}) \\ &\quad + \gamma_6 \Delta \ln(RPE_{it}) + \gamma_7 \Delta \ln(RPM_{it}) + \gamma_8 \Delta \ln(RPS_{it}) + \Delta \varepsilon_{it}.\end{aligned} \tag{12}$$

Since the relative price of labour is included in (12), the interpretation of the regression changes. Both wages and labour input adjust in the system of equations (10) and (11). On the other hand, in (12) the relative price of labour is given; labour supply is assumed to be perfectly elastic.

[15] More specifically, after equations (7) and (8) are combined, they are also first-differenced to remove the industry-specific constants.

Dekle (1998) prefers the dynamic labour demand in (12) because specification errors in the labour supply lead to specification errors in equilibrium conditions (10) and (11), and because the parameter estimates in (12) are easier to interpret.

We do not take a stand on which specification is preferred. Instead, both types of specification are estimated.

One econometric issue that needs to be addressed in the empirical work is the problem of endogeneity. It is well known that the lagged dependent variable, ΔQL_{it-1}, is correlated with the error terms.[16] The industry-specific prices may also be endogenous. To control for endogeneity, Arellano and Bond's (1991) GMM estimator is used. It deals with the endogeneity problem by using lagged levels of the explanatory variables as instruments. The Arellano-Bond estimator, however, produces unsatisfactory results in some cases. While lagged levels of the regressors are arguably uncorrelated to the error term in the current time period, the validity of lagged levels as instruments also depends on how correlated they are to the variables they are instrumenting. Since Staiger and Stock's (1997) seminal work on weak instruments, much work has been done on identifying weak instruments, inference in the presence of weak instruments, and finding methods that are more robust to weak instruments. Much of this work has been done in the context of time-series analysis.[17] In the context of panel data analysis, Alonso-Borrego and Arellano (1999) have shown that lagged levels can be weakly correlated to the corresponding first differences, especially in the case where the dependent variable or regressors are highly persistent. In these cases, Alonso-Borrego and Arellano suggest using Blundell and Bond's (1998a) system-GMM estimator. The system-GMM estimator builds upon the Arellano-Bond estimator. In addition to the moment conditions recommended by Arellano and Bond, Blundell and Bond suggest using lagged differences as instruments in the levels equation.[18] Monte Carlo simulations in Blundell and Bond (1998a) show that imposing the additional restrictions substantially reduces

[16] Nickell (1981) derives an expression for the bias for standard fixed-effects estimation in dynamic panels.

[17] See Stock, Wright, and Yogo (2002) for a survey of some of the literature on weak instruments in the time-series context.

[18] Arellano and Bover (1995) were actually the first to suggest the use of these additional moment conditions, but Blundell and Bond (1998a) presented the necessary assumptions for the system-GMM estimator.

the weak instrument bias; the level restrictions remain informative even when the instruments for the first differences are weak.[19] In theory, the Blundell-Bond system GMM procedure is an improvement upon the Arellano-Bond estimator. The validity of the system-GMM procedure, however, rests on the assumption that the dependent variable is mean-stationary conditional on the industry-specific time trends. Panel unit root tests suggest that all the $\ln(QL_i)$ series follow a unit root. Im, Pesaran, and Shin's (1997) test fails to reject the null hypothesis that all $\ln(QL_i)$ series are non-stationary. P-values of between 0.117 and 0.997 are obtained, depending on whether a deterministic trend is allowed and how many lagged differences (up to six) are allowed. Similarly, Hadri's (2000) test strongly rejects (at the 1 per cent level) the null hypothesis that all of the $\ln(QL_i)$ series are stationary.[20] Given that labour input is non-stationary, the Blundell-Bond estimator should not be used.[21]

Before testing for weak instruments, a test of exogeneity is performed to determine which variables need to be instrumented. First, all industry-specific variables in equation (10) are treated as endogenous and the model is estimated using instrumental variables regression.[22] Then the model is re-estimated assuming that only the lagged dependent variable $\Delta \ln(QL_{t-1})$ is endogenous and that all the industry-specific prices (RUC, RPE, RPM, and RPS) are exogenous. Whether industry-specific prices are exogenous can be tested by comparing the estimates from these two models based on the Hausman (1978) specification test. Staiger and Stock (1997) show that using the estimate of the error variance from the efficent estimator (i.e., assuming exogenous industry input prices, in our case) provides robust test statistics in the presence of weak instruments. The Durbin-Wu Hausman test statistic of $\chi^2(4)$ is 4.57, which is smaller than the critical value at the 10 per cent confidence level. The

[19] Blundell and Bond's (1998a) findings are supported by many recent empirical papers. For example, see Blundell and Bond (1998b), Loayza, Schmidt-Hebbel, and Serven (2000), Bond, Hoeffler, and Temple (2001), Alonso-Borrego and Sanchez-Mangas (2001), and de Abreu Pessoa, Pessoa, and Rob (2003).

[20] See Appendix C for more details on the results of these tests.

[21] The non-stationarity of labour input may also lead to problems with the Arellano-Bond estimator, because non-stationary lagged levels may not be appropriate instruments for a stationary $\Delta \ln(QL_{it-1})$. However, Bun and Kiviet (2001) have shown that, for small samples, the additional bias in the Arellano-Bond estimator due to non-stationarity is small.

[22] All the aggregate variables are treated as exogenous. The excluded instruments include $\ln(QL_{it-2})$, $\ln(QL_{t-3})$, $\ln(RUC_{t-2})$, $\ln(RUC_{t-3})$, $\ln(RPE_{t-2})$, $\ln(RPE_{t-3})$, $\ln(RPM_{t-2})$, $\ln(RPM_{t-3})$, $\ln(RPS_{t-2})$, $\ln(RPS_{t-3})$.

null hypothesis that the industry-specific prices are exogenous cannot be rejected. Thus, only the lagged dependent variable needs to be instrumented.

To check whether the instruments for labour input are weak, a test suggested by Stock, Wright, and Yogo (2002) is used. $\Delta \ln(QL_{it})$ is regressed on $\ln(QL_{it-1})$, $\ln(QL_{it-2})$, and the exogenous variables. The resulting F-statistic (from a test of the joint significance of the instruments) is then examined.[23,24] We find that the F-statistic from the regression, 25.95, is greater than the critical value needed to deem the instruments as adequate.[25]

4.1 Labour input

Arellano-Bond estimates of (10) are reported in column one of Table 1a. We find that the effect of an exchange rate depreciation on labour input through the output channel is significant. The short-run elasticity is 0.20 and the long-run elasticity is 0.75.[26] In other words, a 10 per cent depreciation leads to a 7.5 per cent increase in labour input in manufacturing in the long run. It is important to note that all input prices, besides the price of labour, are held constant. Therefore, the estimated effect of the exchange rate on labour input is solely from the output channel. The 90 per cent confidence interval around a short-run point estimate of 0.2 is 0.1 and 0.3, while the 90 per cent confidence interval around the long-run elasticity of 0.75 is 0.2 and 1.3.

The effect of an exchange rate depreciation on labour input through the price of im-

[23] Stock, Wright, and Yogo (2002) suggest this test in the context of two-stage least squares. The F-statistic is a function of the concentration ratio, a parameter that has an important effect on the distribution of the two-stage least-squares estimator. Whether this technique can be directly applied in the context of panel data estimation is unclear. Nevertheless, it should provide some indication of whether the instruments are weak.

[24] Arellano and Bond (1991) suggest that all lagged levels of the dependent variable be used as instruments. Any lagged level, $\ln(QL_{it-j})$, $j \geq 2$, is a valid instrument for $\Delta \ln(QL_{it-1})$, since they are uncorrelated with the error terms in (10) and (11). In all the Arellano-Bond estimates given in this paper, two lagged levels of each regressor are included as instruments. See Appendix B for more information on the choice of instrument lag length.

[25] Stock and Yogo (2003) tabulate the critical values for this test and the test that applies when there is more than one endogenous variable.

[26] The specification in column one of Table 1a passes two specification tests. First, the null hypothesis of no second-order autocorrelated errors is not rejected. Second, a Sargan-Hansen test of overidentifying restrictions fails to reject the validity of the instruments. The long-run elasticity is computed as $\alpha_2/(1-\alpha_1)$, the coefficient on the exchange rate divided by one minus the coefficient on the lagged dependent variable.

ported capital is small. Given full exchange rate pass-through into imported machinery and equipment (M&E) prices, and given that the average share of imported M&E over the sample period is 52 per cent, a 10 per cent depreciation leads to a 5.2 per cent increase in the price and user cost of M&E.[27] Since M&E is roughly one-third of total capital, this implies a 1.7 per cent increase in the user cost of capital. Using the estimated coefficient on $\Delta \ln(RUC_{it})$, a 1.7 per cent increase in the user cost of capital leads to a 0.08 per cent decrease in labour input in the short run, and a 0.3 per cent decrease in the long run. The negative coefficient on $\Delta \ln(RUC_{it})$ does not imply that labour and capital are complements. The fall in industry output due to the rise in the user cost of capital may decrease labour input, offsetting the expected substitution effect.

The effect of an exchange rate depreciation on labour input through the price of imported material inputs can be similarly inferred. The average share of imported intermediate inputs over the sample period is 45 per cent. A 10 per cent depreciation thus implies a 4.5 per cent increase in the price of material inputs. Using the estimated coefficient on $\Delta \ln(RPM_{it})$, this results in a 1.4 per cent increase in labour input in the short run and a 5.3 per cent increase in the long run; the size of the effect through the price of imported intermediate material inputs is almost comparable to that through the output channel.

Caution must be used in interpreting the estimated effects through the price of the imported inputs channel. First, the estimates are upper bounds, because full pass-through is assumed. Furthermore, because full pass-through is assumed when the user cost of capital and the price of material inputs are constructed by Statistics Canada, their movements may not accurately reflect the changes in the user cost and the price of material inputs faced by the industries.

Another way to gauge the size of the exchange rate's effect through the price of imported inputs is to omit the user cost of capital and the price of material inputs from the regression. The coefficient on the exchange rate should then capture not only the effect of the output channel but the price of the imported inputs channel as well. Based on the results in column

[27] The user cost of capital is roughly proportional to the price of investment. See Leung and Yuen (2005) for more details.

one of Table 1a, the estimated coefficient on the exchange rate should get smaller when the user cost is dropped, and larger when the price of materials is dropped. Column two of Table 1a shows the results when the user cost is dropped from the regression. The estimated coefficient on the exchange rate rises. This is not in line with the finding in column one that suggests a depreciation should cause a fall in labour input through the user cost of capital. Column three of Table 1a gives the results when the price of material inputs is omitted. The estimated coefficient on the exchange rate rises, as expected, but not to the degree suggested by the results in column one. The estimated coefficient rises from 0.20 to 0.25, but an increase to 0.34 is needed to get the same combined effect of the output and the price of imported material inputs suggested in column one.

When both the user cost and the price of intermediate inputs are omitted in column four, the estimated coefficient on the exchange rate should give the effect of an exchange rate depreciation on labour input through all channels. We find a short-run elasticity of 0.31 and a long-run elasticity of 1.03. Given that the short- and long-run effects through the output channel are 0.2 and 0.75, respectively, the exchange rate works predominantly through the output channel.

The final column in Table 1a gives the results of using ordinary least squares (OLS) to estimate (10). The bias on the OLS estimate of the coefficient of the lagged dependent variable is negative and large. The coefficient on $\Delta \ln(QL_{i,t-1})$ falls from 0.74 to 0.45. This has a substantial impact on the long-run effect of the exchange rate through the output channel. It falls from 0.75 to 0.32. The bias on the lagged dependent variable when OLS is used does not appear to affect the coefficients on the other regressors significantly.

The robustness of the results in Table 1a is tested by adding lags and the relative price of labour to (10). Table 1b reports the findings from these robustness checks. In column two, $\Delta \ln(RER_{t-1})$ and a lag of every other explanatory variable are included in the regression. The addition of the lagged exchange rate decreases the point estimate of the long-run exchange rate elasticity from 0.75 to 0.55. Furthermore, the long-run elasticity and the coefficients on $\Delta \ln(RER_t)$ and $\Delta \ln(RER_{t-1})$ are not statistically significant. The Schwartz criterion suggests, however, that the fit of the model with lags is not preferred over the model without. Column three of Table 1b adds the growth of the relative price of labour, $\Delta \ln(RPL_t)$, to the specification in column one. Adding the relative price of labour leads to the dynamic labour demand equation (12) suggested by Dekle (1998), rather than the equilibrium specification proposed by Campa and Goldberg (2001) used to this point.[28] The coefficient on the relative price of labour is negative and significant, as expected. Its addition lowers the long-run exchange rate elasticity only slightly, to 0.73. Adding lags to equation (12) increases the long-run elasticity to 0.78, but, as in the previous case, the Schwartz criterion suggests that the model without additional lags is preferred.

Overall, we find that a change in the exchange rate affects labour input in manufacturing substantially. The total effect of a 10 per cent depreciation is a 10 to 12.5 per cent increase in labour input, with the output channel accounting for the majority (7.5 percentage points) of that increase. The effect through the imported inputs channel accounts for the rest of the increase. The strength and decomposition of the impact of an exchange rate change through this channel depends on how the size of the impact is inferred. For the coefficients on the user cost and the price of material inputs, we find a larger total impact and a larger impact through the price of material inputs. For the change in the coefficient on the exchange rate when the user cost and the price of materials are dropped, in turn, from the regression, we find a smaller total impact and a larger impact through the user cost of capital.

4.2 Wages

We next examine the real wage adjustment to changes in the exchange rate. Table 2a reports Arellano-Bond estimates of equation (11) and some variants of (11). The results provided in Table 2a mirror those provided in Table 1a. Column one of Table 2a gives Arellano-Bond estimates of equation (11) with all the industry-specific prices. The user cost of capital is omitted in column two, the price of materials is omitted in column three, and both the

[28] $\Delta \ln(RPL_t)$ is treated as endogenous and instrumented by $\ln(RPL_{t-2})$ and $\ln(RPL_{t-3})$. We repeat the test for weak instruments for the case of two endogenous variables, and we again find that the instruments are adequate.

user cost and the price of material inputs is omitted in column four. The coefficient on the real exchange rate is statistically insignificant in each of the first four columns of Table 2a. There is some evidence that the exchange rate may have an impact through the price of the imported inputs channel, because the coefficients on the user cost of capital and price of materials is significant in column one. Their signs, however, are not consistent with the results in Table 1a. Table 1a suggests that a rise in the user cost of capital leads to a decline in labour input, but Table 2a suggests that wages should also rise. Similarly, Table 1a suggests that a rise in the price of materials leads to an increase in labour input, but Table 2a suggests that wages should fall in this case. These results are difficult to explain and underline the problems in inferring the effect of an exchange rate depreciation through the coefficients on the user cost and the price of materials. The final column in Table 2a provides OLS estimates of (11). Unlike the OLS estimates of (10), none of the coefficients, including the one on $\Delta \ln(QL_{i,t-1})$, is much different from the ones obtained using the Arellano-Bond estimator.

Table 2b reports the Arellano-Bond results when a lag of the exchange rate and other explanatory variables are included in equation (11). Surprisingly, the coefficient on $\Delta \ln(RER_{t-1})$ is statistically significant and negative, which implies that a depreciation has a negative effect on wages. This negative effect, however, is cancelled out by the positive coefficient on $\Delta \ln(RER_t)$, yielding a long-run elasticity of zero.

Overall, we find that the exchange rate does not have a strong impact on wages. Even if an exchange rate effect was inferred through the coefficients on the user cost and price of materials, the impact would be negligible.

4.3 Differences across industries

Empirical results thus far have concentrated on the average effect of the exchange rate for the manufacturing sector as a whole. In other words, the coefficients on the exchange rate in Tables 1 and 2 are constrained to be the same across industries. These results, however, could be obscuring the labour adjustments that occur in specific manufacturing industries. As Campa and Goldberg (2001) show, the exchange rate effects are increasing in the degree of industries' export orientation and declining in the share of imported input. Campa and Goldberg also find that the price-over-cost markup ratio plays an important role in determining the size of the labour adjustment to exchange rate shocks. They find that wage and labour adjustment occur predominantly in low-markup industries.

Tables 3 and 4 explore how the exchange rate effect through the output channels varies along the margins discussed above. Labour input adjustment across trade groups is examined in Table 3. The upper panel of Table 3 replicates the specifications estimated in Table 1b, except that the coefficient on the real exchange rate is allowed to vary across across industry groups that have low, medium, and high net trade exposure.[29] Evidence of labour input adjustment is consistently found in industries that have high and medium trade exposure. Furthermore, the point estimates for the long-run elasticity for industries that have high and medium trade exposure are consistently larger than for those that have low trade exposure.

The above analysis is repeated with industry groupings based on the average markup ratios.[30] The middle panel of Table 3 reports the long-run labour elasticities for the low- and high-markup groups. There is no evidence to suggest that there is more adjustment in low-markup industries. In some specifications, the long-run elasticity is higher for the low-markup industries, but in other cases the opposite is true.

Table 4 provides evidence of wage adjustment to exchange rate changes for different industry groups. Consistent with the results in Tables 2a and 2b, the long-run exchange rate effect on real wages is statistically insignificant for all trade exposure and markup groups.

4.4 Differences across time periods

The volatility of exchange rate movements has changed over time in Canada. As noted in section 2, there are reasons to believe that employment and wage adjustment to a change in

[29] The classification is based on the industry average between 1981 and 1997.

[30] Average markup ratios are calculated for each industry using Roeger's (1995) methodology. Roeger shows that the difference between the primal and dual-based measures of total factor productivity is solely a function of the markup ratio if constant returns to scale and full capacity utilization are assumed.

the exchange rate is likely to be stronger when the exchange rate is less volatile. To address this issue, we look at three common measures of volatility using the monthly nominal C-6 exchange rates: (i) the coefficient of variation of the monthly level, (ii) the standard deviation of the monthly growth rates, and (iii) the conditional variance from a GARCH (1, 1) model.[31] Following Harchaoui, Tarkhani, and Yuen (2003), exchange rate movements are divided into two regimes: high- and low-volatility. Year t is classified in the high-volatility regime if at least two of the volatility measures are 0.5 standard deviations above their sample mean. Under this classification, exchange rate movements in 1982, 1988, 1990, and 1992 to 1995 are in the high-volatility regime. The coefficient on the real exchange rate is allowed to vary across high- and low-volatility regimes. The results are reported in the bottom panels of Tables 3 and 4. As expected, labour adjustment is stronger in low-volatility regimes across all specifications. In fact, the long-run exchange rate elasticity is statistically insignificant for high-volatility regimes in all specifications.

We next examine whether the exchange rate effects on wages and labour input have changed between the 1980s and 1990s. A notable change in the Canadian economy is that the trade exposure of the manufacturing sector has increased over the past couple of decades. A potential implication is rising labour market sensitivity to exchange rate fluctuations. To determine whether labour markets are more sensitive, the interaction terms $\Delta \ln(RER_t) * D_t^{80}$ and $\Delta \ln(RER_t) * D_t^{90}$ are entered into equations (10), (11), and (12) in place of $\Delta \ln(RER_t)$, where D_t^{80} is one if $1981 \leq t \leq 1990$ and zero otherwise, and D_t^{90} is one if $t \geq 1991$ and zero otherwise. The results are reported in Table 5. We find that the coefficients on $\Delta \ln(RER_t) * D_t^{90}$ are larger than the coefficients on $\Delta \ln(RER_t) * D_t^{80}$ in both (10) and (12). This implies that there was more labour adjustment in the 1990s. The long-run elasticity increases from 0.61 to 1.25 in (10), and from 0.48 to 0.78 in (12). The coefficient on the interaction terms for the wage adjustment equation (11) is not statistically significant.

[31] For detailed comparisons across three exchange rate volatility measures between 1981 and 1997, see Harchaoui, Tarkhani, and Yuen (2003).

5 Conclusion

Theory predicts that a depreciation of the domestic currency may stimulate employment due to stronger output demands and the substitution between labour and capital. While most existing studies focus on U.S. manufacturing, limited work has been done for Canada. In this paper, we have provided some of the first empirical evidence on labour market adjustments to exchange rate movements in Canadian manufacturing industries between 1981 and 1997.

After controlling for endogeneity using GMM estimation, we found labour market adjustment to exchange rate changes. A depreciation (appreciation) of the Canadian dollar increases (decreases) labour input through the output channel. The short-run elasticity is 0.2 and the long-run elasticity is 0.75. Including the effect through the imported inputs channel raises the long-run elasticity to between 1.00 and 1.25, depending on how the effect through the imported inputs channel is inferred. The effect of the exchange rate on real wages is estimated to be virtually zero for all manufacturing industries.

Furthermore, our empirical results have shown that the effect of the exchange rate on labour input varies in three ways. First, industries with high and medium trade exposures are more responsive in their labour input adjustments. Second, labour input does not adjust to changes in the exchange rate in periods of high exchange rate volatility. Third, our findings suggest that, in recent periods, labour input has been more sensitive to exchange rate fluctuations. This is consistent with the rising trade exposures of most manufacturing industries.

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Table 1a: Exchange Rate Changes and Labour Input

	(1)	(2)	(3)	(4)	OLS
$\Delta \ln(QL_{i,t-1})$	0.7352*	0.7092*	0.7161*	0.6960*	0.4490*
	(0.0998)	(0.1086)	(0.1040)	(0.1120)	(0.0604)
$\Delta \ln(RUC_{it})$	-0.0441**	—	-0.0314***	—	-0.0356*
	(0.0180)		(0.0155)		(0.0137)
$\Delta \ln(RPE_{it})$	-0.2499*	-0.2789*	-0.2449*	-0.2714*	-0.2221*
	(0.0576)	(0.0601)	(0.0607)	(0.0626)	(0.0580)
$\Delta \ln(RPM_{it})$	0.3090**	0.2447**	—	—	0.3159*
	(0.1138)	(0.1156)			(0.0811)
$\Delta \ln(RPS_{it})$	-0.1052	-0.0525	-0.0778	-0.0407	-0.1259**
	(0.0877)	(0.0872)	(0.0916)	(0.0904)	(0.0634)
$\Delta \ln(RER_t)$	0.1997*	0.2923*	0.2521*	0.3148*	0.1766**
	(0.0587)	(0.0670)	(0.0678)	(0.0751)	(0.0724)
Long-run elasticity	0.7541**	1.0053**	0.8880**	1.0348**	0.3205**
	(0.3262)	(0.4234)	(0.3568)	(0.4119)	(0.1415)
Ho: No AR(2) errors (p-value)	(0.866)	(0.191)	(0.943)	(0.361)	—

Notes: The dependent variable is $\Delta \ln(QL_{it})$. Standard errors are in parentheses.
*, **, and *** denote significance at the 1, 5, and 10 per cent level, respectively.
All specifications include $\Delta \ln(C_t)$ and $\Delta \ln(USGDP_t)$.

Table 1b: Exchange Rate Changes and Labour Input

	(1)	(2)	(3)	(4)
$\Delta\ln(QL_{i,t-1})$	0.7352*	0.7712*	0.6927*	0.7819*
	(0.0998)	(0.0822)	(0.0993)	(0.0850)
$\Delta\ln(RPL_{it})$	—	—	-0.5170**	-0.4263**
			(0.2301)	(0.1894)
$\Delta\ln(RPL_{i,t-1})$	—	—	—	0.2778**
				(0.1320)
$\Delta\ln(RER_t)$	0.1997*	0.0604	0.2258**	0.0307
	(0.0587)	(0.1122)	(0.0802)	(0.1110)
$\Delta\ln(RER_{t-1})$	—	0.0675	—	0.1390
		(0.1245)		(0.1048)
Long-run elasticity	0.7541**	0.5587	0.7347**	0.7780
	(0.3262)	(0.4049)	(0.3775)	(0.4886)
Schwartz criterion	-5.445	-5.374	-5.558	-5.557

Notes: The dependent variable is $\Delta\ln(QL_{it})$. Standard errors are in parentheses. All specifications include $\Delta\ln(RUC_{it})$, $\Delta\ln(RPE_{it})$, $\Delta\ln(RPM_{it})$, $\Delta\ln(RPS_{it})$, $\Delta\ln(C_t)$, and $\Delta\ln(USGDP_t)$.
* and ** denote significance at the 1 and 5 per cent level, respectively.

Table 2a: Exchange Rate Changes and Wages

	(1)	(2)	(3)	(4)	OLS
$\Delta\ln(QL_{i,t-1})$	-0.0725	-0.0607	-0.0654	-0.0574	-0.0127
	(0.0657)	(0.0665)	(0.0682)	(0.0694)	(0.0439)
$\Delta\ln(RUC_{it})$	0.0200**	—	0.0126	—	0.0199**
	(0.0108)		(0.0102)		(0.0090)
$\Delta\ln(RPE_{it})$	0.3487*	0.3612*	0.3445*	0.3547*	0.3393*
	(0.1063)	(0.1060)	(0.1037)	(0.1036)	(0.0520)
$\Delta\ln(RPM_{it})$	-0.1870*	-0.1577**	—	—	-0.1167**
	(0.0658)	(0.0625)			(0.0590)
$\Delta\ln(RPS_{it})$	0.6726*	0.6491*	0.6570*	0.6423*	0.6200*
	(0.1782)	(0.1738)	(0.1757)	(0.1726)	(0.0806)
$\Delta\ln(RER_t)$	-0.0592	-0.1015	-0.0938	-0.1184	-0.0506
	(0.0792)	(0.0759)	(0.0759)	(0.0763)	(0.0516)
Ho: No AR(2) errors (p-value)	(0.871)	(0.784)	(0.974)	(0.767)	—

Notes: The dependent variable is $\Delta\ln(RPL_{it})$. Standard errors are in parentheses.
* and ** denote significance at the 1 and 5 per cent level, respectively.
All specifications include $\Delta\ln(C_t)$ and $\Delta\ln(USGDP_{it})$.

Table 2b: Exchange Rate Changes and Wages

	(1)	(2)
$\Delta\ln(QL_{i,t-1})$	-0.0716	-0.0850
	(0.0663)	(0.0701)
$\Delta\ln(RER_t)$	-0.0495	0.1390
	(0.0782)	(0.0945)
$\Delta\ln(RER_{t-1})$	—	-0.1802*
		(0.0624)
Long-run elasticity	-0.0495	-0.0413
	(0.0782)	(0.0907)
Schwartz criterion	-6.384	-6.507

Notes: The dependent variable is $\Delta\ln(RPL_{it})$. Standard errors are in parentheses.
All specifications include $\Delta\ln(RUC_{it})$, $\Delta\ln(RPE_{it})$,
$\Delta\ln(RPM_{it})$, $\Delta\ln(RPS_{it})$, $\Delta\ln(C_t)$, and $\Delta\ln(USGDP_t)$.
* denotes significance at the 1 per cent level.

Table 3: Long-Run Labour Input Elasticity by Industry Groups

	(1)	(2)	(3)	(4)
A. Net Trade Exposure				
Low	0.4838	-0.0512	0.2512	0.2310
	(0.2385)	(0.6336)	(0.2253)	(0.5732)
Medium	0.8647**	1.3710**	0.6547***	1.5600***
	(0.4264)	(0.6983)	(0.3872)	(0.8346)
High	0.9425**	0.7961***	0.6910***	1.0455**
	(0.4968)	(0.4780)	(0.4092)	(0.5307)
B. Markup Ratios				
Low	0.6006**	0.4674	0.4972***	0.5338
	(0.2746)	(0.3426)	(0.2991)	(0.5082)
High	0.6962**	0.3592	0.4271***	0.4196
	(0.3246)	(0.4802)	(0.2304)	(0.4217)
C. Exchange Rate Volatility				
Low	0.9669**	2.8780*	0.7322**	3.764**
	(0.4985)	(1.071)	(0.3090)	(1.8532)
High	0.2014	-0.8406	0.2426	-1.1919
	(0.4338)	(0.8514)	(0.4000)	(1.0528)

Notes: Standard errors are in parentheses.
*, **, and *** denote significance at the 1, 5, and 10 per cent level, respectively.

Table 4: Long-Run Wage Elasticity by Industry Groups

	(1)	(2)
A. Net Trade Exposure		
Low	-0.0592	-0.0512
	(0.0762)	(0.6336)
Medium	-0.0352	0.0578
	(0.0971)	(0.1136)
High	-0.0515	0.0416
	(0.0836)	(0.0889)
B. Markup Ratios		
Low	-0.0592	0.0105
	(0.0781)	(0.0751)
High	-0.0410	0.0804
	(0.0858)	(0.0914)
C. Exchange Rate Volatility		
Low	0.0058	0.1075
	(0.0843)	(0.0965)
High	-0.1167	-0.1472
	(0.1096)	(0.1645)

Note: Standard errors are in parentheses.

Table 5: The Output Channel in the 1980s and 1990s

	$\Delta\ln(QL_{it})$	$\Delta\ln(QL_{it})$	$\Delta\ln(RPL_{it})$
$\Delta\ln(QL_{i,t-1})$	0.7324*	0.6362*	-0.0732
	(0.0984)	(0.1103)	(0.0659)
$\Delta\ln(RER_t)*D_t^{80}$	0.1643*	0.1754***	-0.0040
	(0.0619)	(0.1042)	(0.0948)
$\Delta\ln(RER_t)*D_t^{90}$	0.3345*	0.2823*	-0.2128
	(0.1270)	(0.1646)	(0.1442)
$\Delta\ln(RPL_{it})$	—	-0.5960**	—
		(0.2406)	
Long-run elasticity	0.6140*	0.4822	-0.0040
1981–90	(0.2819)	(0.3017)	(0.0948)
Long-run elasticity	1.2504**	0.7758	-0.2128
1991–97	(0.6967)	(0.5597)	(0.1442)

Notes: Standard errors are in parentheses.
All specifications include $\Delta\ln(RPE_{it})$, $\Delta\ln(RPM_{it})$,
$\Delta\ln(RPS_{it})$, $\Delta\ln(C_t)$, and $\Delta\ln(USGDP_t)$.
*, **, and *** denote significance at the 1, 5, and 10 per cent level, respectively.

Figure 1: Real Exchange Rate and Labour Input (1981=1.00)

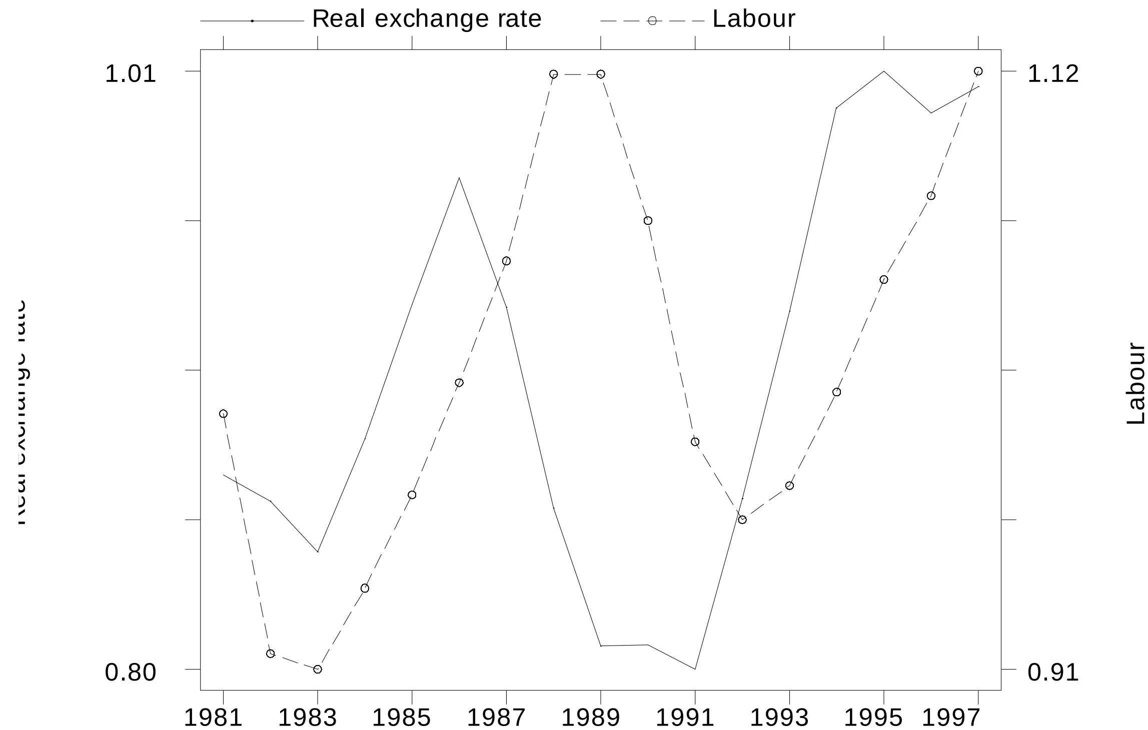


Figure 2: Real Exchange Rate and Detrended Labour Input, Low Trade Exposure

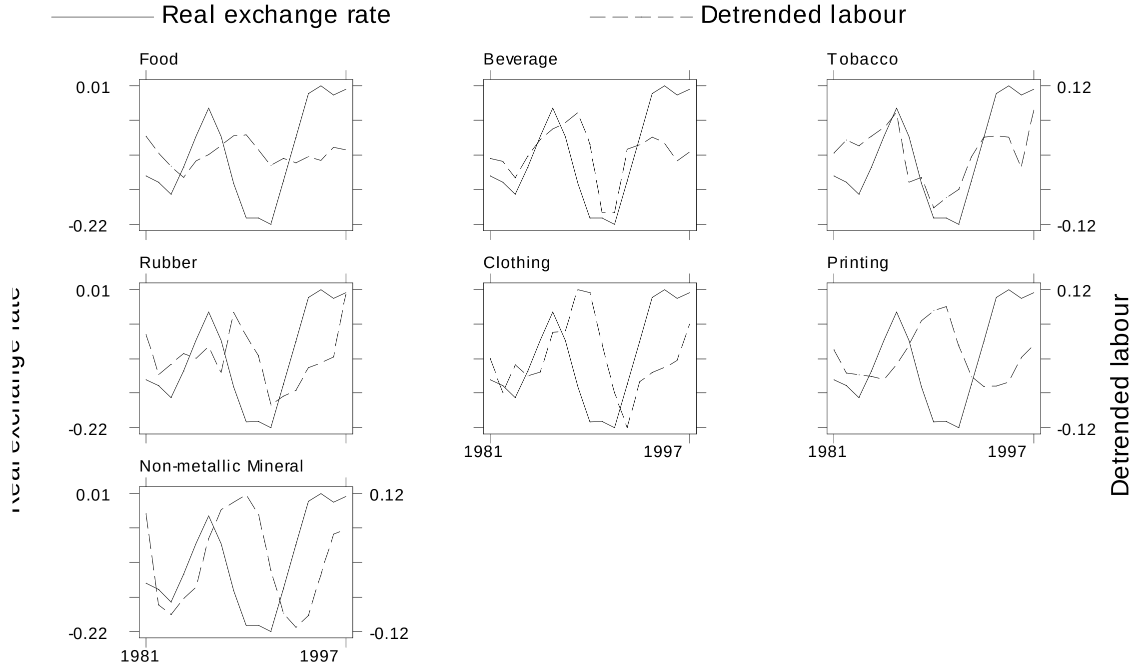


Figure 3: Real Exchange Rate and Detrended Labour Input, Medium Trade Exposure

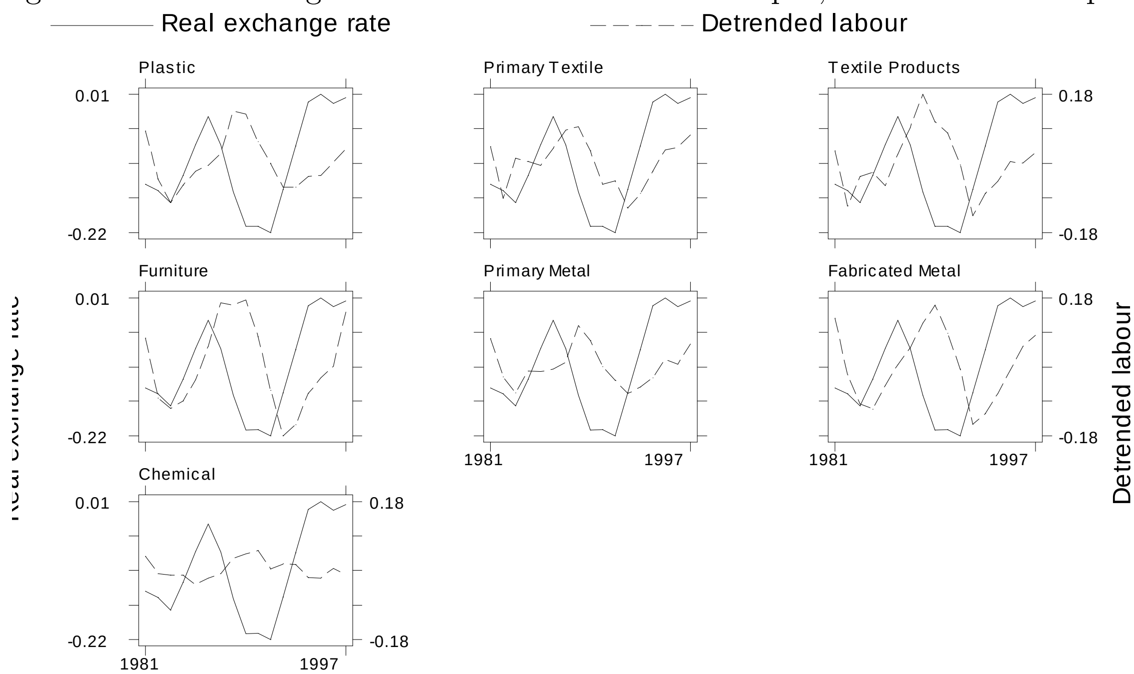
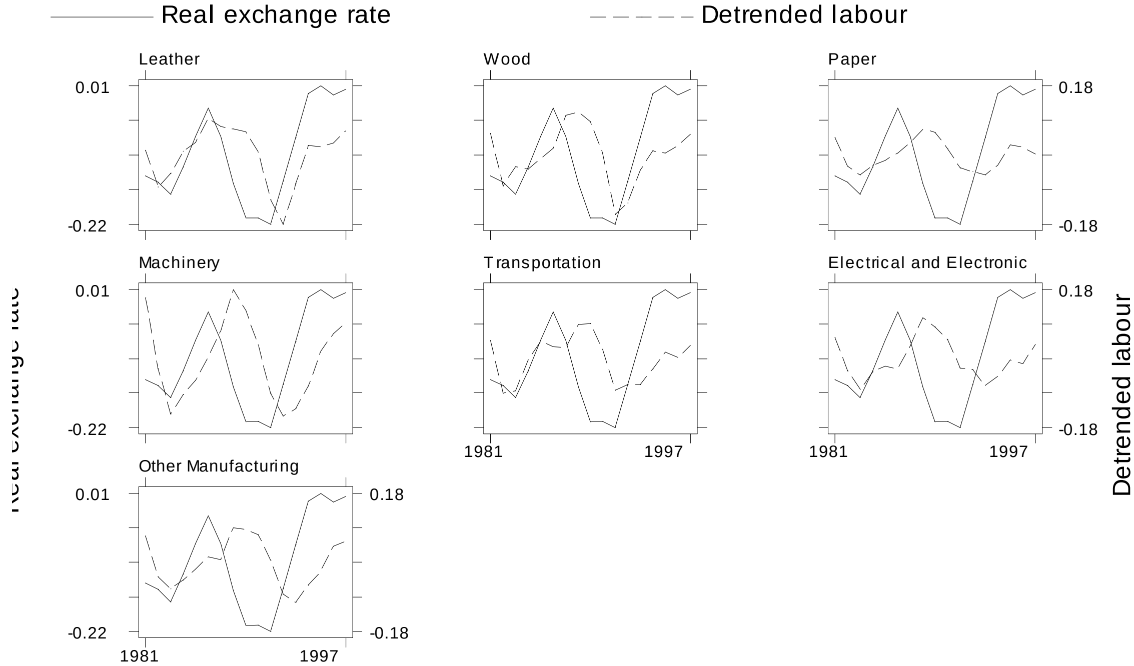


Figure 4: Real Exchange Rate and Detrended Labour Input, High Trade Exposure



Appendix A: Data

The main source of data is the KLEMS data from the Canadian Productivity Accounts. These data are from Statistics Canada and are publicly available to individuals that purchase Baldwin and Harchaoui (2002). There are 22 manufacturing industries in this data, but only 21 of them are included in our analysis, because of the incomplete data in refined petroleum and coal products. The 21 manufacturing industries are: 1) food, 2) beverage, 3) tobacco products, 4) rubber products, 5) plastic products, 6) leather products, 7) primary textile, 8) textile products, 9) clothing, 10) wood, 11) furniture and fixture, 12) paper and allied products, 13) printing and publishing, 14) primary metal, 15) fabricated metal products, 16) machinery (except electrical), 17) transportation equipment, 18) electrical and electronic products, 19) non-metallic mineral products, 20) chemical and chemical products, and 21) other manufacturing.

The data are at the industry level and are annual. Variables that come from this data set are: QL is the quantity of labour (quality-adjusted hours), RPL is the relative price of labour (the industry-specific price of labour deflated by the price of industry output), RPE is the relative price of energy (the industry-specific price of energy deflated by the price of industry output), RPM is the relative price of materials (the industry-specific price of materials deflated by the price of industry output), RPS is the relative price of services (the industry-specific price of services deflated by the price of industry output), and RUC is the relative user cost of capital (the industry-specific user cost of capital deflated by the price of industry output).

Other data used in this paper include C and RER. C is real consumer expenditure in Canada and RER is the real effective exchange rate. Finally, net trade exposure (the fraction of output exported minus the fraction of intermediate inputs imported plus import competition) is used. See Dion (1999–2000) for more detail on how the measure of net trade exposure is constructed.

Appendix B: Instruments for the Arellano and Bond Estimates

For the Arellano and Bond (1991) estimator, differenced endogenous regressors are instrumented by their lagged levels. The Arellano-Bond estimates in this paper are based on using two lagged levels as instruments for each regressor. This appendix explains why two lags are chosen. The number of lagged levels to be included is somewhat arbitrary, but can be guided by specification tests and common sense. The table below gives estimates of the specification from Table 2a, column one, for one, two, three, four, and eight lagged levels. The OLS estimates of the specification in levels (industry-specific dummies are included) are given in the final row.

	$\Delta \ln(RER_t)$	$\Delta \ln(QL_{t-1})$	Sargan-Hansen
One lag	0.1965*	0.6337*	14.87
	(0.0540)	(0.1975)	[13]
Two lags	0.1997*	0.7352*	14.76
	(0.0587)	(0.0998)	[26]
Three lags	0.2084*	0.8104*	16.18
	(0.0630)	(0.0717)	[38]
Four lags	0.2415*	0.8956*	16.39
	(0.0718)	(0.0503)	[49]
Eight lags	0.3026*	0.9220*	16.80
	(0.0725)	(0.0503)	[83]
OLS	0.3424*	0.9065*	—
	(0.0673)	(0.0234)	

Notes: * denotes significance at the 1 per cent level.
Standard errors are in parentheses.
Degrees of freedom for the Sargan-Hansen test are in brackets.

Regardless of the number of instruments chosen, the Sargan-Hansen test of overidentifiying restrictions fails to reject the null hypothesis that instruments are correlated with the error term. Furthermore, since the set of instruments in the case of one lag is a strict subset of the set of instruments in the case of two lags, etc., the Difference Sargan-Hansen test can be used to test the validity of the additional instruments at each stage. At each stage, we find that the validity of the additional instruments cannot be rejected. As a result, the specification tests would suggest that eight lagged levels should be used as instruments. As more and more instruments are included, however, the results converge to those of the OLS levels regression. Similar results are found for regressions examining wage adjustment.

The addition of more lagged levels tends to lead to an "overfitting" problem, where all the movements of the instrumented regressors are explained by the instruments. Two lagged levels are chosen because it appears the overfitting problem manifests itself when three lagged levels are used. It may be argued that including only one lagged level is appropriate, but, given the possibility of a weak instrument problem, as much information as possible on the exogenous fluctuations of the variables should be included.

Appendix C: Panel Unit Root Tests

The validity of the Blundell-Bond methodology rests on the assumption that the dependent variable is mean stationary. To test whether this assumption holds, panel unit root tests can be performed. Two tests are performed: Im, Pesaran, and Shin's (1997) test and Hadri's (2000) Lagrange multiplier test. The null hypothesis in the Im, Pesaran, and Shin (IPS) test is non-stationarity of all the dependent variable series in the panel, whereas the null hypothesis in Hadri's test is stationarity of all the dependent variable series in the panel. The results of these tests are given in Table C1. Test statistics are reported with and without the assumption of a deterministic trend. Furthermore, we report IPS test statistics that allow for up to six lagged differences of the dependent variable, and Hadri's test statistics that allow for up to an AR(6) process in the error term.

Table C1: Panel Unit Root Tests

	1981–97			
	IPS (p-value)		Hadri (z-score)	
Lag	No trend	Trend	No trend	Trend
A: Log of labour input				
0	0.997	0.996	22.063	11.761
1	0.980	0.914	15.629	6.162
2	0.908	0.978	10.355	3.754
3	0.797	0.816	7.966	3.326
4	0.865	0.250	6.763	4.096
5	0.390	0.117	6.154	6.002
6	0.411	0.952	5.880	9.177
B: Log of the relative price of labour				
0	0.314	0.073	24.137	9.676
1	0.504	0.263	16.746	3.782
2	0.403	0.283	11.403	2.569
3	0.557	0.192	8.855	3.116
4	0.749	0.116	7.478	5.095
5	0.815	0.553	6.673	8.512
6	0.912	0.043	6.172	12.901

In all but one case, the IPS test fails to reject the non-stationarity of both the log of labour input and the log of the relative price of labour. Non-stationarity is generally more likely to be rejected when a deterministic trend is allowed, and non-stationarity is less likely to be rejected when the longer time series is used.

Hadri's test rejects (at the 1 per cent level) the null hypothesis of stationarity in every case. Similar to the IPS test, stationarity is generally less likely to be rejected when a deterministic trend is allowed, and generally more likely to be rejected when the longer time series is used.

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