Financial Shocks, Two Sector Labour Markets, and Unemployment

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Abstract

After the recent financial crisis, it is becoming increasingly important to understand how the Canadian labour market responds to domestic and international financial shocks. In this paper I develop and estimate a multi-sector small open economy DSGE model with both financial and labour market frictions. In particular, each sector has a segmented frictional labour market and firms in each sector can obtain external finance domestically and internationally. I estimate the model using Canadian data from 1991Q1 to 2010Q4. The preliminary findings suggest that the degree of the financial and labour market frictions is different for these two sectors. Domestic financial shocks explain 20% of the unemployment fluctuations in Canada: 8% is from tradable sector; 12% from non-tradable sector; however, international financial shocks explain little of labour market dynamics in Canada.

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1 Introduction

The recent literature has shown that financial shocks and frictions are important for accounting for unemployment fluctuations. For example, Christiano, Trabandt and Waletin (2007) estimate a small open economy model with both financial and labour market frictions using the Swedish data. They show that financial shocks explain about 10% of unemployment fluctuations. Zhang (2011a and b) estimate a closed economy model with similar frictions in both financial and labour markets and show that financial shocks account for around 30% of unemployment fluctuations in the US and Canada. However, these papers have not taken the labour market differences at the sectoral level into considerations.

A closer look of the Canadian data suggests that there is a significant difference in terms of long-run trend and short-run dynamics for employment between manufacturing industries and the other industries, and this difference could affect dynamics of aggregate unemployment. For instance, during the financial crisis, in Canada unemployment rate rose from 6.3% to 8.6%, and total job loss is 400,000. However, this loss is not evenly distributed. Manufacturing industries have been more affected than others, accounting for over one-half of the total job loss. Another interesting pattern emerging from the data is that manufacturing industries in general rely more on foreign debt. In 2008, about 30% of debt of the manufacturing industries is foreign debt, 50% higher than the industry average (20%). This also suggests that it is important to take into account sectoral differences when addressing the impact of foreign financial shocks.

The objective of the paper is to provide a quantitative analysis of the impact of foreign and domestic financial shocks on unemployment dynamics in Canada while taking into account the importance of sectoral differences. To achieve this goal, this paper proposes a small open economy DSGE model featuring financial and labour market frictions. The model is closely related to Dib, Mendicino and Zhang (2008). Dib, Mendicino and Zhang (2008) is a small open economy model featuring financial frictions in both tradable and non-tradable sectors. However, the labour market is competitive in their model, thus unemployment is absent in their model. This model replaces the competitive labour market in DMZ with a labour market with search frictions. In particular, I assume that the labour market is segmented across the two sectors. That is, unemployed workers need to decide which sector to search for jobs ex ante. Although there is no direct job mobility from tradable jobs to non-tradable jobs, an unemployed worker who has been separated from the tradable (non-tradable) sector always has chances to seek a job in the non-tradable (tradable) sector. I also relax the assumption in DMZ regarding how firms obtain foreign debt. DMZ makes a very cruel assumption that firms in the tradable sector obtain external finance only from foreign financial market; while firms in the non-tradable sector only from domestic financial market. In this paper, I relax this assumption so that firms in each sector can access both foreign and domestic financial markets, with tradable sector relies more foreign finance.

The frictions in the domestic financial market are modeled a la Bernanke, Gertler and Gilchrist (1999, hereafter BGG), which has been adopted by many other papers in the recent literature. En-
entrepreneurs acquire capital by using their own resources and bank loans. Due to information asymmetry, loans to these entrepreneurs are risky to domestic banks. BGG shows that this type of financial frictions give rise to risk premium that depends on entrepreneurs’ balance-sheet positions. Since entrepreneurs have access to foreign debt, they also face an exogenously foreign risk premium. The frictions in the labour market are modeled using a standard search and matching framework. The model also includes frictions in wage setting as in Gertler, Sala and Trigari (2008). In Gertler, Sala and Trigari (2008), wage contract is staggered--i.e. firms and workers do not negotiate wage contract every period. This type of wage setting frictions have an impact on the hiring decisions for the new employee but have no impact on on-going worker employer relationship as long as it is mutually beneficial. Thus, this setup is not subject to the Barro (1977) critique that wages are not allocational if employers and employees have a on-going relationships. The frictions in the labour and financial markets add a significant amount of complications to the model. In order to facilitate the aggregation, I follow Christiano, Trabant and Waletin (2007) and Zhang (2011a and b) to include employment agencies in the model. The model also has the other features that many have found useful for capturing the data. These include investment adjustment costs, nominal price rigidities and so on.

I estimate the model using Canadian data from 1991Q1 to 2010Q4. The main findings are as follows: First, the model does a decent job in terms of matching the data. The model not only is able to capture the fact that aggregate unemployment is much more volatile than output; but also able to generate labour market dynamics differences in the sectoral level. In particular, the model is able to capture the fact that employment in the manufacturing industries (tradable sector) is more volatile than that in the other industries (non-tradable sector). Second, the estimation results suggest that the degree of financial market frictions is different for these two sectors: the elasticity of external finance for the tradable sector is only one third of that for the non-tradable sector, suggesting tradable sector faces less financial market frictions. Third, domestic financial shocks, both in the tradable and non-tradable sectors, have significant effect on aggregate unemployment fluctuations. Together, these two shocks account for about 20% of the unemployment fluctuations in Canada. However, international financial shocks explain little of labour market dynamics in Canada.

The paper is organized as follows. In the next section, I document some empirical facts regarding sectoral differences. In section 3, I describe the model. In section 4 I discuss the data and estimation strategy. In section 5, I present the estimation results and discuss the effects of financial shocks and frictions on the Canadian labour market. In section 6 I offer some concluding remarks.
Table 1: Standard Deviations: tradable vs non-tradable

<table>
<thead>
<tr>
<th></th>
<th>Output</th>
<th>Employment</th>
<th>Wages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tradable</td>
<td>0.12</td>
<td>0.09</td>
<td>0.014</td>
</tr>
<tr>
<td>Non-tradable</td>
<td>0.02</td>
<td>0.01</td>
<td>0.028</td>
</tr>
</tbody>
</table>

2 Sectoral Difference: Some Empirical Facts

2.1 Output and employment

Throughout the paper, tradable sector refers manufacturing industries. The non-tradable sector includes the rest of the economy but excludes agriculture and natural resources. The top panel of Figure 1 shows the trend of output for both tradable and non-tradable sectors: for the past two decades, non-tradable output continually rises while the output of tradable sector stays flat. The bottom panel displays the dynamics of log output after taking out a linear trend, and it shows that the tradable sector experiences much more fluctuations than the non-tradable sector. Table 1 shows that the standard deviations of output in tradable sector is 6 times of that in non-tradable sector. Employment in these two sectors has the similar pattern. Figure 2 presents the trend and cyclical features of employment for both sectors. Employment in tradable sector declines, while employment in non-tradable sector rises steadily. Employment in the tradable sector is also much more volatile than that of non-tradable sector, having a standard deviation which is 9 times of that in the non-tradable sector (Table 1).

Figure 3 shows the long-run trend and cyclical fluctuations for the average hourly earning for both tradable and non-tradable sectors. For the long-run trend, there is not much difference between these two sectors. However, the non-tradable sector seems to experience more variations in wages than the tradable sector. Table 1 shows that the wages in the non-tradable sector is about two times as volatile as that in the tradable sector.

2.2 Foreign debt

IMF country report (2008) suggests that a quarter of financing of Canadian corporations is raised in the U.S. Data source from Statistic Canada also suggests the same. Table 2 is from the survey of suppliers of business financing. In 2008, for all industries, almost 20 per cent of the total debt is foreign debt; while for manufacturing industry, the fraction is even higher—close to 30 per cent. Although there is a slight decrease after 2008, foreign debt remains a significant portion of total debt financing for Canadian corporations, especially for manufacturing industry.

\[1\text{The non-tradable sector includes utility, construction, wholesale and retail trade, transportation, information, finance and insurance, professional services, administrative and support, waste management, education and health and}

3
Table 2: Fraction of foreign debt

<table>
<thead>
<tr>
<th></th>
<th>All industry</th>
<th>Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>0.19</td>
<td>0.28</td>
</tr>
<tr>
<td>2009</td>
<td>0.17</td>
<td>0.23</td>
</tr>
<tr>
<td>2010</td>
<td>0.17</td>
<td>0.24</td>
</tr>
</tbody>
</table>

3 The Model

I consider a small open economy which consists of three sectors: tradable, non-tradable and imported-goods sectors. Labour market for tradable and non-tradable sectors are segmented. In each labour market, there are employment agencies post vacancies and hire workers who seek jobs in that sector. The sector-specific employment agencies supply labour services to the entrepreneurs in that sector. Entrepreneurs produce sector-specific intermediate goods by using labour services and capital. Since entrepreneurs need to borrow to finance capital purchase, they are subject to financial frictions. Entrepreneurs supply intermediate goods to retailers in each sector, which produce final goods for each sector. There is a representative household, which has a large family structure. A fraction of the members in the household are unemployed, the rest are either employed in the tradable sector or non-tradable sector. The household consume, save both in domestic bonds and foreign bonds, pay tax and receive profits from retailers in each sectors. In addition, there are capital producers who produce capital, a government that balances the budget, and a central bank that implements a simple interest rate rule. In what follows, I describe the role of each agent in the model.

3.1 Household

Each member in the household consumes, holds both nominal domestic bonds $B_t$ and foreign bonds $B^*_t$ denominated in foreign currency, receives dividends from retailers $\Pi_t$, and pays taxes $T_t$. At time $t$, a fraction of household members are employed ($n_t$), and a fraction of household members are unemployed ($u_t = 1 - n_t$). For the employed household members, $n^T_t$ of them are employed in the tradable sector, and $n^N_t$ of them are employed in the non-tradable sector. For the unemployed household members, $u^T_t$ of them seek for jobs in the tradable sector, and $u^N_t$ of them seek for jobs in the non-tradable sector. The employed family members earn nominal wages $W^T_t$ and $W^N_t$ respectively. The unemployed members receive unemployment benefits $ub_t$. Following Andolfatto (1996) and Merz (1995), family members are assumed to be perfectly insured against the risk of being unemployed, and thus consumption is the same for each family member. The budget constraint for the
A representative household maximizes lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t),$$

where

$$u(c_t) = \mu_t c_t^{1-\sigma} / (1-\sigma),$$

where $c_t$ is consumption of final goods in period $t$ and where $\mu_t$ is a preference shock which follows

$$\log \mu_t = \rho \log \mu_{t-1} + \epsilon_t, \quad \epsilon_t \sim i.i.d. N(0, \sigma_e^2).$$

The first-order conditions yield:

$$\lambda_t \mu_t = \beta E_t \left[ \frac{R_t \lambda_{t+1} \mu_{t+1}}{\pi_{t+1}} \right],$$

(2)

$$\lambda_t \mu_t = \beta E_t \left[ \frac{R_t^s \kappa_s \lambda_{t+1} \mu_{t+1}}{s_t \pi_{t+1}^s} \right],$$

(3)

where $\pi_t = P_t/P_{t-1}$ is the CPI inflation rate and $s_t = e_t P_t^*/P_t$ is the real exchange rate, where $P_t^*$ is a foreign price index. Equations (2) and (3) imply the uncovered interest rate parity (UIP) condition:

$$\frac{R_t}{\kappa_t R_t^s} = \frac{e_{t+1}}{e_t}. $$

where $e_t$ is the nominal exchange rate. The foreign bond return rate, $\kappa_t R_t^*$, depends on the foreign interest rate $R_t^*$ and a country-specific risk premium $\kappa_t$, that is assumed to be increasing in the foreign-debt-to-GDP ratio:

$$\kappa_t = \exp \left( \nu \frac{\tilde{B}_t^*}{P_t y_t} \right),$$

where $\nu > 0$ is a parameter determining the foreign-debt-to-GDP ratio, $y_t$ is total real GDP and $\tilde{B}_t^*$ is the total level of indebtedness of the economy.

Given the budget constraint equation (1), the representative household chooses $c_t$, $B_t$, and $B_t^*$ to maximize lifetime utility

$$P_t c_t + B_t + \frac{e_t B_t^*}{\kappa_t R_t^s} + T_t \leq W_{T,t} n_{T,t} + W_{N,t} n_{N,t} + u b_t (1 - n_t) + R_{t-1} B_{t-1} + e_t R_{t-1}^* B_{t-1}^* + \Pi_t,$$

(1)

where both $W_T^T$ and $W_T^N$ are determined by Nash bargaining between employment agencies and workers, and the labour supply $n_T^T$ and $n_T^N$ are determined by a search and match process. $e_t$ is nominal exchange rate. The foreign bond return rate, $\kappa_t R_t^*$, depends on the foreign interest rate $R_t^*$ and a country-specific risk premium $\kappa_t$, that is assumed to be increasing in the foreign-debt-to-GDP ratio:

$$\kappa_t = \exp \left( \nu \frac{\tilde{B}_t^*}{P_t y_t} \right),$$

where $\nu > 0$ is a parameter determining the foreign-debt-to-GDP ratio, $y_t$ is total real GDP and $\tilde{B}_t^*$ is the total level of indebtedness of the economy.
3.2 Employment agencies

Following Christiano, Trabandt and Waletin (2007) and Zhang (2011a and b), I model employment agencies as intermediaries between the representative household (who supply labour) and entrepreneurs (who demand labour to produce wholesale goods). The labour market is modelled using a standard search model. On the one hand, the employment agencies post vacancies, bargaining wages with workers; on the other hand, these agencies combine labour supplied by households into homogeneous labour services and supply them to entrepreneurs at a competitive price. The labour market is segmented, i.e. employment agencies in the tradable sector post vacancies for tradable sector, while those in the non-tradable sector post vacation for their own. Unemployed workers need to decide which sector jobs to search. Unemployed workers seeking for tradable sector jobs are denoted as \( u_{T,t} \), and unemployed workers seeking for non-tradable sector jobs are denoted as \( u_{N,t} \). In equilibrium, searching for jobs in either sector gives the same expected payoff for the unemployed workers.

The basic model features of the employment agencies are as follows. At the beginning of period \( t \), in each sector \( i \), each employment agency \( j \) posts \( v_{i,t}(j) \) vacancies to attract new workers, and employs \( n_{i,t}(j) \) workers. The total number of vacancies and the number of employed workers are \( v_{i,t} = \int v_{i,t}(j) \, dj \) and \( n_{i,t} = \int n_{i,t}(j) \, dj \). The number of unemployed workers at the beginning of period \( t \) is

\[
u_t = 1 - n_t = 1 - n_{T,t} - n_{N,t} = u_{T,t} + u_{N,t}.
\]

The number of new hires \( m_{i,t} \) is governed by a standard Cobb-Douglas aggregate matching technology:

\[
m_{i,t} = \mu_{i,m} u_{i,t}^{\sigma_m} v_{i,t}^{1-\sigma_m}.
\]

For an employment agency, the value of adding another worker at time \( t \) is the price of selling one unit of labour service \( p_{i,t} \), minus the wage cost \( \frac{w_{i,t}(j)}{p_{i,t}} \) and vacancy costs \( \frac{\kappa_i}{2} x_{i,t}(j)^2 \), plus the continuation value of the filled vacancy:

\[
J_{i,t}(j) = p_{i,t} - \frac{w_{i,t}(j)}{p_{i,t}} - \frac{\kappa_i}{2} x_{i,t}(j)^2 + (\rho + x_{i,t}(j)) \beta E_t \Lambda_{t,t+1} J_{i,t+1}(j),
\]

where \( x_{i,t}(j) \) is the hiring rate for employment agency \( j \), and \( \rho \) is the probability of a match that survives to the next period. The value of employment for a new worker at employment agency \( j \) at time \( t \), \( V_{i,t}(j) \), is

\[
V_{i,t}(j) = w_{i,t}(j) + \beta E_t \Lambda_{t,t+1} [\rho V_{i,t+1}(j) + (1 - \rho) U_{i,t+1}],
\]

\footnote{This leaves the equilibrium conditions associated with the production of wholesale goods unaffected, even though the labour market is frictional.}
where $w_{i,t}(j)$ is the real wage. The value of unemployment, $U_{i,t}$ is

$$U_{i,t} = ub_t + \beta E_t \Lambda_{t,t+1} [s_{i,t+1}^l V_{i,t+1} + (1 - s_{i,t+1}^l)U_{i,t+1}],$$

where $ub_t$ is the unemployment benefit, $s_{i,t+1}^l$ is the probability of being employed versus unemployed next period, and $V_{i,t}$ is the average value of employment for a new worker at time $t$. The workers’ surplus for having a job at employment agency $j$, $H_{i,t}(j)$, is

$$H_{i,t}(j) = V_{i,t}(j) - U_{i,t}.$$

Given that

$$U_{T,t} = U_{N,t},$$

it implies that

$$\beta E_t \Lambda_{t,t+1} s_{T,t+1} H_{T,t}(j) = \beta E_t \Lambda_{t,t+1} s_{N,t+1} H_{N,t}(j).$$

That is, for an unemployed worker, the expected payoff of searching for either sector jobs must be equal. In equilibrium, a lower job finding rate in one sector must be compensated by a relatively higher surplus for workers having a job in that sector.

Employment agencies and workers negotiate a nominal wage $w_{i,t}^n(j)$ to maximize the joint product of the workers’ surplus $H_{i,t}(j)$ and the employment agencies’ surplus $J_{i,t}(j)$. However, every period, each employment agency has only a fixed probability $1 - \lambda$ to negotiate with workers. Thus, the Nash bargaining problem between employment agencies and workers is

$$\max H_{i,t}(j)^\eta J_{i,t}(j)^{1-\eta},$$

s.t.

$$w_{i,t}^n(j) = w_{i,t}^n*$$

with probability $1 - \lambda$

$$= w_{i,t-1}^n\pi$$

with probability $\lambda$,

where $\pi$ is the steady-state inflation rate. The equation for the real wage $w_{i,t}^*$ derived from this staggered contracting is

$$\Delta_t w_{i,t}^* = \eta (p_{i,t}^l + \frac{K}{2} \sigma_{i,t}^2 (i)) + (1 - \eta) (\bar{b} + s_{i,t+1}^l \beta \Lambda_{t,t+1} H_{i,t+s+1}) + \lambda \rho \beta E_t \Lambda_{t,t+1} \Delta_{t+1} w_{i,t+1}^*.$$  

(4)

The first term of equation (4) is the worker’s contribution to the match, and the second is the worker’s opportunity cost. These are conventional components for Nash bargaining solutions for wages. The third term is from the staggered multi-period contracting. Finally, the aggregate real wage $w_{i,t}$ can

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3See Gertler and Trigari (2009) for details about the average value of employment.
be expressed as
\[ w_{i,t} = (1 - \lambda)w_{i,t}^* + \lambda \pi \frac{1}{\pi_{i,t}} w_{i,t-1}. \]

### 3.3 Entrepreneurs (intermediate good producers)

There are entrepreneurs in both tradable and non-tradable sectors. Following Bernanke, Gertler and Gilchrist (1999), entrepreneurs are risk-neutral and have a finite life. In each sector \(i\), at each period \(t\), entrepreneur \(j\) uses capital \(k_{i,t}\) and labour services \(l_{i,t}\) to produce wholesale goods \(y_{i,t}\) by using a Cobb-Douglas technology,

\[ y_{i,t}(j) = A_{i,t}(k_{i,t}(j))^{\alpha}(l_{i,t}(j))^{1-\alpha}. \]

Entrepreneurs purchase capital at price \(q_{i,t}\) from capital producers, using both the entrepreneurs’ own net worth \(N_{i,t}\) and bank loans. Bank loans can be from domestic market \(B_{i,t}\), or from international market \(B_{i,t}^*\). Entrepreneurs experience idiosyncratic shocks, which can lead them to default; however, only entrepreneurs observe the realization of the idiosyncratic shocks. Given this asymmetric information problem between entrepreneurs and banks, the optimal loan contract in Bernanke, Gertler and Gilchrist (1999) is such that entrepreneurs pay a risk premium on loans. Thus, for domestic loans, this external finance premium, \(s(.)\), depends on an entrepreneur’s balance-sheet position, and at the aggregate level it can be characterized by

\[ rp_{i,t} = s \left( \frac{q_{i,t}k_{i,t+1}}{N_{i,t+1}} \right), \]

where \(rp'(.) > 0\) and \(rp(1) = 1\). Equation (5) expresses that in each sector, the external finance premium increases with leverage. For the loans from the international market, the entrepreneurs are subject to an foreign risk premium \(rp^*\), which is decided by aggregate balance-sheet position in the foreign country. In order to determine the relative size of \(b_t(j)\) and \(b_t^*(j)\) for each sector, I assume there is a country-specific risk premium \(\kappa_{i,t}\) so that

\[ \kappa_{i,t} = \exp \left( \upsilon_e B_{i,t}^* \right), \]

where \(\upsilon_e > 0\) is a parameter determining the foreign-debt-to-net worth ratio. Thus the one-period profit function for entrepreneurs \(j\) is

\[ \pi_{i,t}(j) = \frac{B_{i,t}(j)}{P_t} + \frac{e_t B_{i,t}^*(j)}{P_t} + p_{i,t} y_{i,t} + q_{i,t} (1 - \delta) k_{i,t}(j) \]

\[ -p_{i,t} l_{i,t}(j) - R_{t-1} r_p_{i,t-1} \frac{B_{i,t-1}(j)}{P_t} - R_{t-1}^* \kappa_{i,t-1} r_p_{i,t-1}^* \frac{e_t B_{i,t-1}(j)}{P_t} \]

\[ -q_{i,t} k_{i,t+1}(j), \]

\[ \text{(6)} \]
where $p_{it}^w$ is the relative price for the wholesale goods the entrepreneurs produce in sector $i$, and $p_{it}^l$ is the labor service price in sector $i$. The entrepreneur $j$ chooses $l_{i,t}(j), k_{i,t+1}(j), b_{i,t}(j)$ and $b_t^*(j)$ to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \pi_{i,t}(j).$$

The first order conditions yields:

$$l_{i,t}(j) : p_{it}^w \frac{\partial y_{i,t}(j)}{\partial l_{i,t}(j)} = p_{it}^l,$$

$$k_{i,t+1}(j) : -q_{i,t} + E_t[\partial y_{i,t+1}(j)] + q_{i,t+1}(1 - \delta) = 0,$$

$$b_{i,t}(j) : 1 - E_t[\frac{R_t r_{p_{it}}} {\pi_{t+1}}] = 0.$$

and

$$b_t^*(j) : 1 - E_t[\frac{s_t R_{\ast} \kappa_{i,t} r_{p_{it}^*}} {s_t \pi_{t+1}^*}] = 0.$$

Define the expected return on capital in each sector as

$$E_t r_{i,t+1}^k = \frac{E_t[\frac{p_{i,t+1}^w \alpha y_{i,t+1}} {k_{i,t+1}} + q_{i,t+1}(1 - \delta)]}{q_{i,t}}.$$  

In each sector, the expected return on capital must equal to the expected costs of external finance, that is,

$$E_t r_{i,t+1}^k = E_t[\frac{R_t r_{p_{it}}}{\pi_{t+1}}].$$

The demand for foreign debt for each sector is determined by

$$E_t r_{T,t+1}^k = E_t[\frac{s_{t+1} R_{i,t}^\Gamma_{i,t} r_{p_{it}^*}} {s_t \pi_{t+1}^*}],$$

and

$$E_t r_{N,t+1}^k = E_t[\frac{s_{t+1} R_{i,t}^\Gamma_{i,t} r_{p_{it}^*}} {s_t \pi_{t+1}^*}].$$

The aggregate net worth in each sector is given by

$$N_{i,t+1} = \gamma_i \eta_i^\Gamma (R_{i,t} r_{p_{it}} - \frac{R_{t-1} r_{p_{i,t-1}}}{\pi_{t-1}} b_{i,N,t-1} - \frac{s_{t+1} R_{i,t}^\Gamma_{i,t-1} r_{p_{it}^*}} {s_{t-1} \pi_{t-1}^*} b_{i,t-1}^*),$$

where $\eta_i^\Gamma$ is the survival rate of entrepreneurs for each sector. $\gamma_{i,t}$ is a financial wealth shock, an exogenous shock to the survival probability of entrepreneurs in sector $i$, which follows an AR(1) process:

$$\log \gamma_{i,t} = \rho \log \gamma_{i,t-1} + \epsilon_{i,t}^\gamma, \quad \epsilon_{i,t}^\gamma \sim i.i.d. N(0, \sigma_{\epsilon_{i,t}}^2).$$
The aggregate net worth of entrepreneurs at the end of period $t$, $N_{i,t+1}$, is the sum of equity held by entrepreneurs surviving from period $t - 1$.

For the entrepreneurs that are going out of business, they will consume their residue equity:

$$c_{e_{i,t+1}} = (1 - \gamma_{i,t} \eta_{i,t}) (r_{i,t} q_{i,t-1} k_{i,t} - \frac{R_{t-1} r_{i,t-1} b_{i,t-1}}{\pi_t} - \frac{s_t R_{t-1} r_{i,t-1} p_{t}^{*} b_{i,t-1}^{*}}{s_{t-1} \pi_{t}^{*}}).$$

The aggregate demand for labour services is relatively simple. Given that the aggregate production function is constant returns to scale,

$$y_{i,t} = k_{i,t}^{\alpha} (z_{i,t} l_{i,t})^{1-\alpha},$$

the aggregate labour demand equation can be written as

$$p_{w_{i,t}} (1 - \alpha) y_{i,t} l_{i,t} = p_{l_{i,t}},$$

where $l_{i,t}$ is the labour services supplied by employment agencies in sector $i$, $(1 - \alpha) \frac{y_{i,t} l_{i,t}}{l_{i,t}}$ is the marginal product of labour services, $p_{w_{i,t}}$ is the relative price for wholesale goods and $p_{l_{i,t}}$ is the relative price for labour services.

### 3.4 Capital producers

Capital producers use investment goods to produce new capital purchased from entrepreneurs. At the end of the period $t$, they buy investment goods $I_{i,t}$, at real price $p_{I,t} = P_{I,t}/P_{t}$ to produce sector-specific capital that can be used by entrepreneurs at time $t + 1$. Capital production in each sector is assumed to be subject to an investment-specific shock, $\tau_{i,t}$, which follows an AR(1) process

$$\log \tau_{i,t} = \rho_{i,x} \log \tau_{i,t-1} + \epsilon_{i,t}; \epsilon_{i,t} \sim i.i.d. N(0, \sigma_{\epsilon_{i,t}}^{2}).$$

Following Christiano, Eichenbaum and Evans (2005), we assume that capital producers in sector $i = \{ T, N \}$ face investment adjustment costs $S(I_{i,t}, I_{i,t-1})$, such that in steady state $S = S' = 0$ and $S'' > 0$, and $\chi_{i} > 0$ is an investment adjustment cost parameter. The production of each capital stock yields the following time-$t$ profit function

$$\Pi_{i} = q_{i,t} I_{i,t} \tau_{i,t} - q_{i,t} I_{i,t} S(I_{i,t}, I_{i,t-1}) - p_{I,t} I_{i,t}. \quad (11)$$

The aggregate stock of capital evolves as follows:

$$K_{i,t+1} = I_{i,t} \tau_{i,t} - I_{i,t} S(I_{i,t}, I_{i,t-1}) + (1 - \delta) K_{i,t}. \quad (12)$$
3.5 Sectoral good producers

There are sectoral good producers in all three sectors: tradable, non-tradable and imported good sectors. The sectoral good producers in the tradable and non-tradable sectors buy tradable, non-tradable input from entrepreneurs, and those in imported good sector buy foreign homogeneous intermediate inputs, and differentiate them slightly into \( z_{i,t}(j) \) and sell the product at price \( p_{i,t}(j) \). The final good for each sector \( i, z_{i,t} \), is the composite of individual variety, \( z_{i,t} = \left[ \int_0^1 y_{i,t}(j) \frac{d j}{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \).

The price index that minimizes the sectoral good producers cost function is \( p_{i,t} = \left[ \int_0^1 p_{i,t}(j)^{1-\varepsilon} d j \right]^{\frac{1}{1-\varepsilon}} \).

Following Calvo (1983), in each period, only a fraction \( 1 - \nu_i \) of retailers reset their prices, while the remaining retailers keep their prices unchanged. The retailer chooses \( p_{i,t}(j) \) to maximize its expected real total profit over the periods during which its prices remain fixed:

\[
E_t \sum_{s=0}^{\infty} \nu s \Delta p_{s,t+i} \left[ \left( \frac{p_{i,t}(j)}{p_{i,t}^{*}} \right) y_{i,t+i}(j) - mc_{i,t+i} y_{i,t+i}(j) \right],
\]

where \( mc_{i,t} \) is the real marginal cost, which is the price of wholesale goods relative to the price of sectoral final goods \( (p_{i,w,t}/p_{i,t}) \). The real marginal cost for imported intermediate goods is \( e_t P^* t \) for a given nominal exchange rate, \( e_t \), and foreign price level, \( P^* t \). \( \Delta p_{i,t} = \beta^i c_{t+i}/c_t \) is the stochastic discount factor. Let \( p^*_i \) be the optimal price chosen by all firms adjusting at time \( t \).

The first-order condition is:

\[
p^*_i = \left( \frac{\varepsilon}{\varepsilon - 1} \right) \frac{E_t \sum_{s=0}^{\infty} \nu s \Delta p_{s,t+i} mc_{i,t+i+1} y_{i,t+i+1}(\frac{1}{p_{i,t+i}})^{1-\varepsilon}}{E_t \sum_{s=0}^{\infty} \nu s \Delta p_{s,t+i} y_{i,t+i}(\frac{1}{p_{i,t+i}})^{1-\varepsilon}}.
\]

The aggregate price evolves according to:

\[
p_{i,t} = [\nu_ip_{i,t-1}^{1-\varepsilon} + (1 - \nu_i)(p^*_i)^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}.
\]

Retailers in the tradable sector produce goods for domestic use, \( z_{T,dt} \), and exports, \( z_{T,et} \), so that \( z_{T,t} = z_{T,dt} + z_{T,et} \). Following Obstfeld and Rogoff (1995), we assume the producers’ currency pricing behavior in the manufacturing sector. Thus, the law of one price holds for exported domestic goods. However, due to the presence of nominal rigidities in the import sector, exchange rate movements are partially passed through to domestic prices. The aggregate foreign demand function for exports
of manufactured goods under the assumption of producer currency pricing is

\[ z_{T,t}^e = \varpi \left( \frac{e_t P_{T,t}}{P_t^*} \right)^{-\nu} Y_t^*, \] (13)

where \( Y_t^* \) is foreign output. The elasticity of demand for domestic manufactured goods among foreigners is \(-\nu\), and \( \varpi > 0 \) is a parameter determining the fraction of domestic manufactured-goods exports in foreign spending. Since the economy is small, exports represent an insignificant fraction of foreign expenditures and have a negligible weight in the foreign price index.

### 3.6 Aggregate final goods producers

There is a representative firm that acts in a perfectly competitive market and uses sectoral output to produce final consumption and investment goods, \( x_t^j \), with \( j = \{C, I\} \), according to the following CES technology:

\[ x_t^j = \left( \omega_T^{\frac{1}{\nu_j}} \left( z_{T,t}^p \right)^{\frac{\nu_j-1}{\nu_j}} + \left( \omega_N^{\frac{1}{\nu_j}} \left( z_{N,t}^p \right)^{\frac{\nu_j-1}{\nu_j}} \right) + \left( \omega_F^{\frac{1}{\nu_j}} \left( z_{F,t}^p \right)^{\frac{\nu_j-1}{\nu_j}} \right) \right)^{\frac{\nu_j}{\nu_j-1}}, \] (14)

where \( \omega_T, \omega_N, \) and \( \omega_F \) denote the shares of domestically-used tradable, non-tradable, and imported composite sectoral goods, \( z_{N,t}^p, z_{N,t}^n, z_{F,t}^p \), respectively, in the final good, where \( \omega_T + \omega_N + \omega_F = 1 \), and \( \nu_j > 0 \) is the elasticity of substitution between sectoral goods.

\[ p_t^j = \left( \omega_T^{\frac{1}{\nu_j}} \left( p_{T,t}^p \right)^{1-\nu_j} + \left( \omega_N^{\frac{1}{\nu_j}} \left( p_{N,t}^p \right)^{1-\nu_j} \right) + \left( \omega_F^{\frac{1}{\nu_j}} \left( p_{F,t}^p \right)^{1-\nu_j} \right) \right)^{\frac{1}{1-\nu_j}}. \] (15)

### 3.7 Government

The government is assumed to balance its budget,

\[ g_t = T_t, \]

where \( g_t \) follows an AR(1) process,

\[ \log g_t = (1 - \rho_x) \log g_{ss} + \rho_x \log g_{t-1} + \epsilon_t^g, \epsilon_t^g \sim i.i.d.N(0, \sigma_{\epsilon^g}^2). \]

### 3.8 Monetary policy rules

The central bank adjusts the nominal interest rate \( r_t^n \) according to a simple interest rate rule:

\[ \frac{r_t^n}{\pi} = \left( \frac{r_{t-1}^n}{\pi} \right)^{\rho_r} \left( \frac{\pi_t}{\pi} \right)^{\rho_{\pi_x}} \left( \frac{y_t}{y} \right)^{\rho_y} \left( 1 - \rho_{\pi_x} \right) e^{\epsilon_t^r}, \]
where $r^n$, $\pi$ and $y$ are the steady-state values of $r^n_t$, $\pi_t$ and $g_t$, and $\varepsilon^m_t$ is a monetary policy shock that follows

$$\varepsilon^m_t \sim i.i.d. N(0, \sigma^m).$$

$\rho_\pi$, $\rho_y$ and $\rho_r$ are policy coefficients chosen by the central bank.

### 3.9 Rest of the world

Given that Canada is a small open economy, I assume that domestic developments do not affect the rest of the world. However, the foreign economy has an impact on the Canadian economy. Following DMZ, for simplicity, I assume that the foreign output, foreign interest rate, foreign risk premium and inflation exogenous and follow AR(1) processes.

### 3.10 Aggregation and equilibrium

The resource constraint is

$$z_t k^\alpha_t l^{1-\alpha}_t = c_t + i_t + g_t + \frac{K_N}{2} x^2_{N,t} n_{N,t} + \frac{K_T}{2} x^2_{T,t} n_{T,t} + cT + cN.$$

Furthermore, for the labour market,

$$l_{T,t} = n_{T,t},$$

and

$$l_{N,t} = n_{N,t}.$$

### 4 Estimation

#### 4.1 Calibrated values

I use Bayesian techniques to estimate the model for the Canadian economy. I use and the data sample spans from 1991Q1 to 2010Q4. Some parameters need to be calibrated to match the salient features of the Canadian economy, Table 3 reports these parameters and their calibrated values.

For most of the parameters that govern the sectoral shares, I use the calibrated values in Dib, Mendicino and Zhang (2008). The calibrated value for the discount factor, $\beta$, is set to 0.99, which implies an annual steady-state real interest rate of 4 percent which matches the average observed in the estimation sample. The curvature parameter in the utility function, $\gamma$, is set to 2, implying an elasticity of intertemporal substitution of 0.5. The capital shares in the production of tradable and non-tradable goods, $\alpha_T$ and $\alpha_N$, are set to 0.35 and 0.3, which are close to the values suggested by Macklem et al. (2000). The capital depreciation rate, $\delta$, is assumed to be common to both tradable and non-tradable sectors and set to 0.025, a value commonly used in the literature. The shares of tradable, non-tradable, and imported goods in the production of consumption good, $\omega^C_T$, $\omega^C_N$, and $\omega^C_F$, equal 0.2, 0.58 and 0.22, respectively, to match the average ratios observed in the data for the estimation period. Since the share of imported good in the production of the investment good is
higher than that in consumption good production. I set $\omega^f_T$, $\omega^I_N$, and $\omega^I_F$ equal to 0.2, 0.4 and 0.4, respectively.

The parameter measuring the degree of monopoly power in the intermediate-goods markets, $\theta$, is set to be equal to 6, which implies a 20 percent markup in the steady-state. Based on Dib (2003), both the elasticity of substitution between tradable, non-tradable and imported goods in the production of final consumption goods, $\nu_C$, and the elasticity of demand for domestic manufactured-goods among foreigners, $\nu$, are set equal to 0.8. The elasticity of substitution between tradable, non-tradable and imported goods in the production of final investment goods, $\nu^I$, is set equal to 0.6, implying that imported goods are less substitutable in producing investment than against the consumption good production.

The steady-state gross domestic and foreign inflation rates, $\pi$ and $\pi^*$, equal 1.0048 and 1.0052, respectively, which are the historical averages over the estimation sample for Canada and the U.S. Following Dib, Mendicino and Zhang (2008), I calibrate the parameter $\nu$ to match a foreign-debt-to-GDP of about 10 percent as in the data. The parameters determining the steady-state leverage ratios for tradable and non-tradable sectors, $k_T$ and $k_N$, are set to 0.7 and 0.6, respectively, which is suggested by King and Santor (2008). In calibration, the following functional form is used for the external finance premium:

$$s_t = \left( \frac{q_t k_{t+1}}{N_{t+1}} \right)^{\chi},$$

(16)

where $\chi$ is the elasticity of the external risk premium with respect to leverage and $\chi > 0$. $\chi$ can be viewed as a “reduced-form” parameter capturing financial market frictions.

For most of labour market parameters, I use values from Zhang (2011a and b). The bargaining power parameter, $\eta$, is set to 0.5, which is commonly used in the literature. The elasticity of matches to unemployment, $\sigma_m$, is set to 0.5, the midpoint of values typically used. Following the suggestion of Zhang (2008), the job-separation rate, $1 - \rho$, is set to 0.09, matching the average job duration of 2.8 years in Canada; the job-finding rate $s^f$ is set to 0.927, matching the fact that one-third of the unemployed workers find jobs within one month. I normalize the mean of market tightness to 1, which implies that the value of $\mu_m$ in the matching function equals the quarterly job-finding rate. Following Gertler, Sala and Trigari (2008), I express $\tilde{b}$, the steady-state flow value of unemployment, as

$$\tilde{b} = \tilde{b}(p^* + \kappa x^2),$$

(17)

where $\tilde{b}$ is the fraction of the worker’s contribution to the job. Following Shimer (2005), I set $\tilde{b}$ to 0.4.

There are several new parameters that arise from the fact that the labor market is segmented and entrepreneurs can borrow from both domestic and foreign lenders. The survival rate of jobs in tradable sector, $\rho_T$, is set to 0.94, which is taken from Tapp (2011). The steady-state unemployment rate for tradable sector $u_{ss,T}$, and the ratio of employed workers in tradable sector is set to $\theta$ are set to 0.015 and 0.2 respectively to match the data. I use debt allocation data from survey of suppliers of
Table 3: Calibration of the parameters

<table>
<thead>
<tr>
<th>Param.</th>
<th>Definition</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>discount factor</td>
<td>0.99</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>inverse of intertemporal substitution of consumption</td>
<td>2</td>
</tr>
<tr>
<td>$\nu^C$</td>
<td>elasticity of substitution between sectors, consumption</td>
<td>0.8</td>
</tr>
<tr>
<td>$\nu^I$</td>
<td>elasticity of substitution between sectors, investment</td>
<td>0.6</td>
</tr>
<tr>
<td>$\theta$</td>
<td>intermediate good elasticity of substitution</td>
<td>6</td>
</tr>
<tr>
<td>$\alpha_T$</td>
<td>capital share, tradable</td>
<td>0.35</td>
</tr>
<tr>
<td>$\alpha_N$</td>
<td>capital share, non-tradable</td>
<td>0.30</td>
</tr>
<tr>
<td>$\delta_T$</td>
<td>capital depreciation rate, tradable</td>
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</tr>
<tr>
<td>$\delta_N$</td>
<td>capital depreciation rate, non-tradable</td>
<td>0.025</td>
</tr>
<tr>
<td>$\omega^C_T$</td>
<td>share of tradable good, consumption</td>
<td>0.20</td>
</tr>
<tr>
<td>$\omega^C_N$</td>
<td>share of non-tradable good, consumption</td>
<td>0.58</td>
</tr>
<tr>
<td>$\omega^I_T$</td>
<td>share of tradable good, investment</td>
<td>0.20</td>
</tr>
<tr>
<td>$\omega^I_N$</td>
<td>share of non-tradable good, investment</td>
<td>0.40</td>
</tr>
<tr>
<td>$\nu$</td>
<td>parameter of country-specific risk premium</td>
<td>0.03</td>
</tr>
<tr>
<td>$k_T$</td>
<td>steady-state leverage, tradable</td>
<td>0.7</td>
</tr>
<tr>
<td>$k_N$</td>
<td>steady-state leverage, non-tradable</td>
<td>0.6</td>
</tr>
<tr>
<td>$\pi$</td>
<td>steady-state domestic inflation rate</td>
<td>1.0048</td>
</tr>
<tr>
<td>$\pi^*$</td>
<td>steady-state foreign inflation rate</td>
<td>1.0052</td>
</tr>
<tr>
<td>$\rho$</td>
<td>aggregate survival rate of jobs</td>
<td>0.91</td>
</tr>
<tr>
<td>$\rho_T$</td>
<td>survival rate of jobs in tradable sector</td>
<td>0.94</td>
</tr>
<tr>
<td>$s^l$</td>
<td>aggregate job-finding rate</td>
<td>0.927</td>
</tr>
<tr>
<td>$\eta$</td>
<td>bargaining power of workers</td>
<td>0.5</td>
</tr>
<tr>
<td>$\tilde{b}$</td>
<td>parameter for unemployment flow value</td>
<td>0.4</td>
</tr>
<tr>
<td>$\sigma_m$</td>
<td>elasticity in matches to unemployment</td>
<td>0.5</td>
</tr>
<tr>
<td>$u_{ss,T}$</td>
<td>steady-state unemployment rate for tradable</td>
<td>0.015</td>
</tr>
<tr>
<td>$\theta$</td>
<td>ratio of employed workers in tradable sector</td>
<td>0.2</td>
</tr>
</tbody>
</table>
business financing to calibrate $\nu^T$ and $\nu^N$. This survey suggests that from 2008 to 2010, the average ratio of foreign debt to total debt is 25% for tradable sector; and 17% for non-tradable sector. I calibrate $\nu^T$ and $\nu^N$ to match these ratios.

4.2 Data and priors

The data sample spans from 1991Q1 to 2010Q4, and includes nine series of quarterly Canadian data: output in tradable sector, output in non-tradable sector, consumption, investment, government spending, nominal interest rate, inflation, risk premium and real exchange rate. Output is measured by real GDP. Consumption is measured by real expenditures of non-durable goods, semi-durable goods and services. Investment is measured by the sum of business gross fixed capital formation, investment in inventories and real expenditure of durable goods. Data on these real variables are expressed in per capita terms using the civilian population aged 15 and up. The nominal interest rate is measured by the overnight rate in quarterly terms. Inflation is the quarter-to-quarter growth rate of the core CPI. Risk premium is measured by difference between business prime lending rates and nominal interest rate. The real exchange rate is measured by multiplying the nominal U.S./CAN exchange rate by the ratio of U.S. to Canadian prices. I use US data for the foreign variables. I use U.S. quarterly real GDP per capita for foreign output, federal funds rate in quarterly term for foreign interest rate, the quarter to quarter growth rate of the GDP deflator for foreign inflation, and the spread between U.S. business prime lending and federal funds rates for foreign risk premium. The series of tradable output, non-tradable output, consumption, investment, government spending, foreign output and real exchange rate are logged and linearly detrended. The series of domestic and foreign nominal interest rate, domestic and foreign inflation, and domestic and foreign risk premium are demeaned.

I use Bayesian techniques to estimate the model. Since the dynamics of the key variables for the rest of the world are exogenous to the Canadian economy, I estimate the AR(1) processes governing the foreign shocks first. Following the literature, I assume that foreign shocks’ autoregressive coefficients to follow a beta distribution with mean 0.6; and the standard deviations of the shocks to follow an Inverted Gamma distribution with mean 0.5 percent and standard deviation 2. Table 6 reports the priors and the modes for the posterior distribution.

Given the estimates of the foreign shocks, I estimate the rest of the parameters for the domestic economy. There are nine behavioral parameters: the elasticity of the external risk premium for both tradable and non-tradable sectors $\chi^T$ and $\chi^N$; the investment adjustment cost parameter for both tradable and non-tradable sectors $\xi^T$ and $\xi^N$; the Calvo price parameters for both tradable, non-tradable and imported good sectors $\nu^T$, $\nu^N$ and $\nu^F$; the Calvo wage parameters for both tradable and non-tradable sectors $\lambda^T$ and $\lambda^N$; and the Taylor rule parameters $\rho_{\pi}$, $\rho_{y}$ and $\rho_{r}$. I also estimate the first-order autocorrelations of all the exogenous shocks and their respective standard deviations.

The priors for the above domestic parameters and shock processes are also chosen by following the literature: I use Beta distributions for all parameters bounded in the $[0,1]$ range. This
applies to the shocks’ autoregressive coefficient, whose mean I set to 0.6. The parameters of nominal stickiness for price and wages are also assumed to follow a beta distribution with mean 0.67, which corresponds to changing prices and wages every 3 quarters on average. Gamma and Inverted Gamma distributions are assumed for parameters that are supposed to be positive. The priors on the investment adjustment cost and risk-premium elasticity are in line with previous literature. For the standard deviation of the shocks we assume an Inverted Gamma distribution with mean 0.5 percent and standard deviation 2. I follow previous literature also in setting the priors on the monetary policy parameters. The prior assumptions on the monetary policy parameters allow for a range of interest-rate inertia between 0 and 1, and a positive response to inflation. I use a normal distribution for the reaction to output in order to allow for a negative response. The priors are reported in Tables 5 and 6.
Table 6: Estimation Results (Domestic Block)–B

<table>
<thead>
<tr>
<th>Panel A: Autoregressive parameters</th>
<th>Prior</th>
<th>Posterior mode</th>
</tr>
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<tbody>
<tr>
<td>Technology,T</td>
<td>$\rho_z$</td>
<td>beta (0.6,0.1)</td>
</tr>
<tr>
<td>Technology,NT</td>
<td>$\rho_z$</td>
<td>beta (0.6,0.1)</td>
</tr>
<tr>
<td>Preference</td>
<td>$\rho_e$</td>
<td>beta (0.6,0.1)</td>
</tr>
<tr>
<td>Investment,T</td>
<td>$\rho_\tau$</td>
<td>beta (0.6,0.1)</td>
</tr>
<tr>
<td>Investment,NT</td>
<td>$\rho_\tau$</td>
<td>beta (0.6,0.1)</td>
</tr>
<tr>
<td>Government</td>
<td>$\rho_g$</td>
<td>beta (0.6,0.1)</td>
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<tr>
<td>Financial,T</td>
<td>$\rho_\gamma$</td>
<td>beta (0.6,0.1)</td>
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<tr>
<td>Financial,NT</td>
<td>$\rho_\gamma$</td>
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</table>

Panel B: Standard deviations

<table>
<thead>
<tr>
<th>Panel B: Standard deviations</th>
<th>Prior</th>
<th>Posterior mode</th>
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</thead>
<tbody>
<tr>
<td>Technology,T</td>
<td>$\sigma_{e^z}$</td>
<td>invg (0.005,2)</td>
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<tr>
<td>Technology,NT</td>
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<td>invg (0.005,2)</td>
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<tr>
<td>Monetary</td>
<td>$\sigma_{e^m}$</td>
<td>invg (0.005,2)</td>
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<td>$\sigma_{e^\tau}$</td>
<td>invg (0.005,2)</td>
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<td>Investment,NT</td>
<td>$\sigma_{e^\tau}$</td>
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<tr>
<td>Preference</td>
<td>$\sigma_{e^e}$</td>
<td>invg (0.005,2)</td>
</tr>
<tr>
<td>Government</td>
<td>$\sigma_{e^g}$</td>
<td>invg (0.005,2)</td>
</tr>
<tr>
<td>Financial,T</td>
<td>$\sigma_{e^\gamma}$</td>
<td>invg (0.005,2)</td>
</tr>
<tr>
<td>Financial,NT</td>
<td>$\sigma_{e^\gamma}$</td>
<td>invg (0.005,2)</td>
</tr>
</tbody>
</table>
5 Results

5.1 Estimates

Table 5 reports the mode of the posterior distribution of the behavioral parameters. The risk premium elasticity parameter for the tradable sector, $\chi^T$, is estimated to be around 0.02, which is about one third of the value for the non-tradable sector. This suggests that the financial frictions the tradable sector faces is less than that for the non-tradable sector. The estimates of Calvo wage contract parameters, $\lambda^T$ and $\lambda^N$, are 0.70 and 0.52 respectively, suggesting a mean of 3.3 quarters between wage contracting periods for the tradable sector, and around 2 quarters for the non-tradable sector. The degree of price stickiness for the tradable and non-tradable sectors, $\nu^T$ and $\nu^N$, are about the same, 0.77. The imported sector seems to experience a higher price rigidity, $\nu^F$, estimated to be 0.91, which implies an average price-adjustment duration of 11 quarters. The capital adjustment cost parameter for the tradable sector, $\xi^T$, is 0.38, also lower than its counterpart for the non-tradable sector, which is 0.48. For the monetary policy reaction function parameters, $\rho_\pi$ (the Taylor rule inflation parameter) is estimated to be 0.59, and the reaction coefficient to the output gap, $\rho_y$, is estimated to be 0.02, suggesting that policy responds very little to the output gap. There is a relatively high degree of interest rate smoothing, given that the coefficient on the lagged interest rate is estimated to be 0.90.

Table 6 reports the estimates of the shock processes. Among all the shocks, the investment-specific shock in the non-tradable sector is estimated to be most persistent, with a coefficient of 0.99; while the preference shock is estimated to be most volatile, with a coefficient of 0.027. It is worth noting that the estimated financial wealth shocks are quite different for the tradable and non-tradable sectors: in the tradable sector, the shock to the financial wealth has a first-order serial coefficient of 0.67, and a standard deviation of 0.02; while in the non-tradable sector, the financial wealth shock is more persistent, with a serial coefficient of 0.94, but less volatile, with a standard deviation of 0.005.

5.2 Fit of the model

Table 7 compares the standard deviations of the key variables in the model against the data. Overall, the model does a good job of matching the Canadian economy. The model performs particularly well in matching the volatility in aggregate output $y$, nominal interest rate $r$ and inflation $\pi$. The standard deviation for unemployment rate generated by the model, 0.17, is greater than what the data suggests (0.10); however, the model is able to capture the important empirical fact that unemployment is much more volatile than output at the business cycle frequency. The model is also able to generate the high volatility for the real exchange rate $s$.

The model is also able to capture the sectoral difference that is reported in Section 2. Table 8 reports the comparison of standard deviations for the sectoral output, employment and wages between the model and the data. The model predicted standard deviations for the output in the...
tradable and non-tradable sectors are 0.12 and 0.02, respectively; the standard deviations for the employment are 0.09 and 0.01, respectively. For wages, the model-generated standard deviation for the tradable sector is 0.02; while it is 0.03 for the non-tradable sector. This shows that the model is able to match the cyclical sectoral difference: comparing the two sectors, output and employment are more volatile for the tradable sector; while wages are less volatile.

Table 8: Relative Standard Deviations: Model vs. Data

<table>
<thead>
<tr>
<th></th>
<th>yt</th>
<th>yn</th>
<th>nt</th>
<th>nn</th>
<th>wt</th>
<th>wn</th>
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</thead>
<tbody>
<tr>
<td>Data</td>
<td>0.12</td>
<td>0.02</td>
<td>0.09</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
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<tr>
<td>Model</td>
<td>0.08</td>
<td>0.05</td>
<td>0.05</td>
<td>0.02</td>
<td>0.09</td>
<td>0.08</td>
</tr>
</tbody>
</table>

### 5.3 Sources of Canadian labour market fluctuations

Given the estimation results of the shock processes, I simulate the model to examine the contribution of each shock to the variations in the key macro variables in the Canadian economy. Table 9 shows the results. In line with the literature, technology and investment-specific shocks are important driving forces for the Canadian business cycle fluctuations. The technology shock in the tradable sector explains about 25 per cent of the fluctuations in output and consumption. Investment-specific shock in the tradable sector explains about 30 per cent of the variations in output, 30 per cent of the variations in consumption, and almost 70 per cent in unemployment. The shocks to financial wealth in the two sectors turn out to be important as well. Together, the two financial shocks explain about 20 per cent of the variations in output, 25 per cent in consumption, and almost 60 per cent of the fluctuations in investment. Financial shocks are also important for accounting for variations in aggregate unemployment rate. The two shocks explains about 20 per cent of the fluctuations in unemployment, 8 per cent is from the financial shock in the tradable sector and 12 per cent from the financial shock in the non-tradable sector.

Financial shocks in the foreign country turn out not to be important. The foreign monetary policy shock has the most impact on the Canadian economy. All together, the four foreign shocks account for about 25 per cent of the variations in the real exchange rate, and about 10 per cent of the variations in output and investment.
Table 9: Variance Decomposition of the Key Variables

<table>
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5.4 Model dynamics after a positive financial shock

After a positive financial wealth shock, the unemployment rate declines. I use Figure 4 to illustrate the mechanism. Figure 4 shows the model dynamics after a positive financial wealth shock in the tradable sector. After the shock, the aggregate unemployment rate declines. This is because a positive financial wealth shock increases the survivor rate of entrepreneurs in the tradable sector, leading the aggregate net worth to rise. This pushes down the external finance premium, leading entrepreneurs in the tradable sector to increase their demand for capital by increasing investment. The rise in demand for capital is accompanied by a rise in demand for labour. The asset price rises with the reduced demand for capital, and this further increases entrepreneurs’ net worth (the financial accelerator effect) in the tradable sector. Employment agencies post more vacancies due to the rise in the aggregate demand for labour. As a result, the probability of a worker finding a job in the tradable sector increases. Unemployment rate in the tradable sector rises briefly and falls, this is because given the high job finding rate in the tradable sector, some unemployed workers that originally seek jobs in the non-tradable sector change to seek jobs in the tradable sector. This leads that unemployment rate in the non-tradable sector declines while unemployment rate in the tradable sector rises briefly in the initial periods after the shock.

6 Conclusions

In this paper, I developed a small open economy DSGE model with frictions in both financial and labour markets. In particular, I assume that labour markets for tradable and non-tradable sectors are segmented, and the firms in each sector can access both domestic financial market and international financial market. I find that these features allow the model to be able to capture the sectoral difference observed in the data. I estimate this model using Canadian data from 1991Q1 to 2010Q4, and use the estimated model to assess the importance of domestic and international financial frictions and shocks in driving movements in the labour market. I find that domestic financial shocks explain about 20 per cent of the variations in unemployment for the Canadian labour market; however, I do not find the international financial shock has significant effect on the Canadian economy.
References


Figure 1: Output-trend and cyclical fluctuations
Figure 2: Employment-trend and cyclical fluctuations
Figure 3: Wages-trend and cyclical fluctuations
Figure 4: Model dynamics after a financial wealth shock