News-Driven International Business Cycles

Michiru Sakane *†
Department of Economics, Duke University

October 14, 2010

Abstract

This paper studies the international transmission effects of the news about the Total Factor Productivity (TFP) of the US to the Canadian and Japanese economy. First, using the Vector Error Correction Model (VECM), the impulse responses of Canadian and Japanese macroeconomic variables to the US news shock are estimated. Next, I develop and estimate a two-country RBC model with the preference introduced by Jaimovich and Rebelo (2008) and investment adjustment cost to generate booms in Canadian and Japanese variables in response to news about future US TFP. I find that international macroeconomic comovements can be generated by the news about future TFP in the US. Unlike previous studies, I show that the response of Canadian or Japanese TFP to the US news shock is important in order to generate the boom observed in the empirical analysis. Estimated value of the preference parameter indicates that eliminating the wealth effect on hours worked is important. I also show that low elasticity of substitution between domestically and foreign produced intermediate goods can also help explain the domestic boom created by the news shock, which highlights the importance of analyzing an open economy.

*Department of Economics, Duke University. E-mail: michiru.sakane@duke.edu
†This paper is a chapter of my dissertation at Duke University. I would like to thank my dissertation supervisor, Craig Burnside for his guidance and many discussions. I would also like to thank Pietro Peretto, Barbara Rossi and Juan Rubio-Ramirez for useful comments and suggestions. I am also grateful to Francesco Bianchi, Jeremy Chiu, Ippei Fujiwara, Charles Yuji Horioka, Cosmin Ilut, Nobuhiro Kiyotaki, Jouchi Nakajima, Masao Ogaki, Eiji Ogawa, Keisuke Otsu, Roberto Pancrazi, Etsuro Shioji, Alexandra Tabova, Marija Vukotić, Tsutomu Watanabe as well as seminar participants at Duke University, Hitotsubashi University, the 11th Macro Conference at Osaka University and Japanese Economic Association Spring Meeting in 2010 for helpful comments.
1 Introduction

This paper studies the international transmission effects of the news about the Total Factor Productivity (TFP) of the US to the Canadian and Japanese economy. Recent studies, e.g., Beaudry and Portier (2006), Beaudry, Dupaigne and Portier (2008), Christiano et al. (2008), Jaimovich and Rebelo (2006, 2008), Schmitt-Grohé and Uribe (2008), suggest that business cycles can be explained using the news about future productivity. Among others, empirical studies such as Beaudry and Portier (2006) showed that the news shock can be detected when a shock to stock prices that is orthogonal to the innovation in TFP is highly correlated with a shock that drives long-run movements in TFP. This evidence suggests that stock prices incorporate information about future TFP. Their empirical evidence shows that news shocks generate positive booms in domestic output, consumption, investment and hours. Beaudry, Dupaigne and Portier (2008) provide evidence that the news shocks transmit abroad and generate international comovements.

In this paper, I first use a Vector Error Correction Model (VECM) to estimate the impulse responses of Canadian and Japanese macroeconomic variables to the news shock of TFP in the US. This estimation method is based on Beaudry and Portier (2006) and Beaudry, Dupaigne and Portier (2008). Beaudry and Portier (2006) estimates the impulse responses of US macroeconomic variables to the news shock of TFP in the US. Whereas Beaudry, Dupaigne and Portier (2008) also estimated impulse responses of Canadian variables to the news shock of TFP in the US, I introduce a two-step estimation that utilizes all the information about the news so that I can identify the news better than they do. I find that Canadian and Japanese TFP significantly responds to US news shock. Next, I develop and estimate a two-country RBC model with a preference of the type suggested by Jaimovich and Rebelo (2006, 2008) and an investment adjustment cost to generate booms in Canadian and Japanese variables in response to news about future US TFP. Using this model and feeding actual TFP processes driven by the news shock, I find that international macroeconomic comovements can be generated by the news about future TFP in the US. Using a counterfactual analysis, I show that the response of Canadian and Japanese TFP to a US news shock is important in order to generate the boom observed in the empirical analysis. The estimated value of the preference parameter indicates that getting rid of the wealth effect on hours worked is important. I also find that low elasticity of substitution between domestically produced intermediate goods and foreign produced goods can also help explaining the domestic boom created by the news shock, which highlights the importance of analyzing in an open economy setting.

It is widely known that the standard real business cycle model does not ac-
count for comovements in either a closed or an open economy. A positive news shock increases consumption because of the wealth effect. The wealth effect increases leisure and labor hours decrease. The decrease in labor hours pushes the output down and investment decreases as well, since there is an increase in consumption. Several studies have tried to tackle this problem. Beaudry and Portier (2004) used a closed-economy model with strong complementarities between different production sectors in order to induce comovements between the variables. Beaudry, Dupaigne and Portier (2008) proposed an alternative model to generate international comovements in response to news about future TFP in foreign countries. They use a two-country model augmented with strong complementarity between domestically-produced and foreign-produced intermediate goods. Jaimovich and Rebelo (2006,2008) emphasized the importance of the preference structure. Since the wealth effect caused by positive news about future productivity, which is negative under standard preference structure such as Cobb-Douglas utility, is nil under GHH preference (after Greenwood et al. (1988)), the model gives rise to positive comovement by substitution effects. They also suggested that real rigidities such as the adjustment costs of investment and labor are important.

This paper contributes to the growing literature on the news-driven international business cycle in three ways. First, I make a tight link between the data and the model, which was lacking in the previous literature of news-driven international business cycles, especially in their diffusion process of the news about future TFP. In this paper, I take into account the fact that Canadian and Japanese TFP is also responding to the US news significantly. I show this fact using VECM estimation and feed this process into the model. Second, I use a two-country model with different size when I analyze the transmission of the news between the US and Canada. For the US and Canadian economy, it is more conventional to use a small open economy model. However, this shuts down a possible demand channel of the model. Third, this paper also focuses on the response of the terms of trade, which has not been considered by the previous literature on the transmission of news.

The organizations of this paper is as follows. In Section 2, I present empirical evidence using the VECM model to estimate the responses of Canadian and Japanese variables to the US news shock. Section 3 presents the model. Section 4 shows the results of quantitative analysis in which I compare the empirical and theoretical impulse responses. Section 5 concludes.
2 Empirical evidence

The goal of this section is to provide the empirical evidence of international spillover of the news about the US TFP to the macroeconomic variables of Canada and Japan. The identification and estimation methods follow and extend Beaudry and Portier (2006) and Beaudry, Dupaigne and Portier (2008).

2.1 Data

2.1.1 US data

In my empirical analysis, I use quarterly data. The data for the US is over the period 1948Q1 to 2006Q4. For my bivariate VECM specification, I use the US total factor productivity (TFP) and stock price (SP).

The US TFP series is defined as

$$\log TFP_t = \left[ \log Y_t - s_h \log H_t - (1 - s_h) \log K_t \right] / s_h$$

where \(Y\) is output, \(H\) is labor hours, \(K\) is capital, and \(s_h\) is the labor share estimated by the average of the labor share from 1948 to 2006 (its value is 0.678). The output measure for calculating TFP (\(Y\)) is the quarterly real GDP of the non-farm business sector. The capital series (\(K\)) is the real capital input in the private business sector. Since the original series of the real capital input is available only at an annual frequency, I interpolate to obtain a quarterly series. The measure of hours worked (\(H\)) is the hours index in the non-farm business sector.

In higher dimensional systems, I also use output, consumption, investment, exports and imports. For output, I use real GDP. For the consumption measure, I use real personal consumption expenditures. For the investment measure, I use real fixed private investment. For the exports and imports measure, I use real exports and imports of goods and services. See Appendix A for more details.

2.1.2 Canadian data

I construct the Canadian TFP series in the same way as (1)\(^1\). All the Canadian data except hours worked and capital series are over the period 1961Q1 to 2006Q4. Hours worked is over the period 1966Q1 to 2006Q4 and the capital series is over the period 1961Q4 to 2006Q4. The output measure is real GDP and the capital measure is the real capital series constructed by the Bank of Canada. I calculate the measure of hours worked using data from the Bank of Canada\(^2\).

\(^1\)Rhys Mendes (Bank of Canada) kindly gave me the dataset for Canada.

\(^2\)I calculate the measure of hours worked as follows. First, I multiply the Canadian population series by the participation rate series. I multiply that series by the employment rate calculated using the
In higher dimension systems, I also use consumption, investment, exports, imports, the trade balance and terms of trade. For the consumption measure, I use real personal expenditure on consumer goods and services. For the investment measure, I use real investment in non-residential structures and equipment. For exports and imports, I use real exports and imports. Terms of trade is defined as the import price deflator divided by the export price deflator. For the trade balance, in order to incorporate the effect of the terms of trade, I first multiply the series of real imports by the terms of trade, subtract this series from real exports, and then divide by real GDP. This definition is consistent with that of the model I describe in Section 3.

2.1.3 Japanese data

I construct the Japanese TFP series in the same way as (1). All the Japanese data except the hours worked series are collected over the period 1955Q2 to 2006Q4. Hours worked is over the period 1960Q1 to 2006Q4. The output measure is real GDP and the capital measure is the gross capital stock of private enterprises. Hours worked series is the aggregate weekly hours worked.

As in the Canadian case, I also use consumption, investment, exports, imports, the trade balance and terms of trade in higher dimension systems. For the consumption measure, I use real private consumption. For the investment measure, I use real non-residential investment. Exports, imports, terms of trade and the trade balance measure are defined in the same way as in the Canadian case.

2.2 Identification of the news shock: Evidence from the bivariate VECM of $TFP$ and $SP$

In this subsection, I identify the news shock that occurred in the US using two variables: US TFP and US stock price (S&P 500) following Beaudry and Portier (2006). I use quarterly data from 1948Q1 to 2006Q4. An augmented Dickey-Fuller test suggests that these two variables are I(1) variables. Johansen’s cointegration test indicates there is a cointegration between these two variables at the 90% level. Therefore, I estimate a bivariate Vector Error Correction Model (VECM) instead of VAR. I use five lags in VECM following the result of the likelihood ratio test.

I estimate the following VECM model using Johansen’s maximum likelihood

Unemployment rate to get the employment series. Then I multiply this by the average hours worked series to get the total hours worked.

3See Appendix for the explanation of data in detail.

4See page 143 of Lütkepohl (2005) for detail.
Following Beaudry and Portier (2006), I identify the news shock by the sequential scheme. We can write the above VECM model using the following Wold representation:

$$\begin{bmatrix} \Delta TFP_{t}^{US} \\ \Delta SP_{t} \end{bmatrix} = C(L) \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}$$

where $C(L) = I + \sum_{i=1}^{\infty} C_{i}L^{i}$. $I$ is the identity matrix and $L$ is the lag operator.

In order to identify the news shock, I use two different orthogonalization schemes. First, the short-run identification scheme has a Wold (MA) representation as

$$\begin{bmatrix} \Delta TFP_{t}^{US} \\ \Delta SP_{t} \end{bmatrix} = \Gamma(L) \begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \end{bmatrix}$$

where $\Gamma(L) = \sum_{i=0}^{\infty} \Gamma_{i}L^{i}$ and $\epsilon_{t} \equiv [\epsilon_{1t} \epsilon_{2t}]$ are the structural residuals whose variance covariance matrix is assumed to be an identity matrix and the $(1,2)$ element of $\Gamma_{0}$ is zero. The latter means that a shock on $SP$, $\epsilon_{2t}$, does not have any short-run impact on $TFP$.

Second, the long-run identification scheme has a Wold representation as follows:

$$\begin{bmatrix} \Delta TFP_{t}^{US} \\ \Delta SP_{t} \end{bmatrix} = \tilde{\Gamma}(L) \begin{bmatrix} \tilde{\epsilon}_{1t} \\ \tilde{\epsilon}_{2t} \end{bmatrix}$$

where $\tilde{\Gamma}(L) = \sum_{i=0}^{\infty} \tilde{\Gamma}_{i}L^{i}$ and $\tilde{\epsilon}_{t}$ is the structural residual matrix whose variance covariance matrix is assumed to be an identity matrix. For this second scheme, I impose a restriction that the $(1,2)$ element of $\tilde{\Gamma}(1)$, i.e., the long-run matrix, equals zero. This ensures that the shock to $TFP$, $\tilde{\epsilon}_{1t}$, does not have any long-run impact on $SP$.

---

5See Hansen (2000) for the explanation of the derivation of the Wold representation in the case of the VECM model.
The resulting impulse responses are presented in Figure 1. The top graph presents the impulse response of $TFP$ corresponding to the $\epsilon_2 t$ shock (from short-run identification) and the $\tilde{\epsilon}_1 t$ shock (from long-run identification). As can be seen from this figure, the responses from these two identification schemes have highly similar dynamics. On the one hand, the shock on $SP$, $\epsilon_2$, which does not have a contemporaneous impact on $TFP$, has a long-run effect on $TFP$. On the other hand, the shock on $TFP$, $\tilde{\epsilon}_1 t$, which does not have a long-run effect on $TFP$, has no contemporaneous impact on $TFP$.

Similarly, the bottom graph in Figure 1 presents the response of $SP$ corresponding to these two identification schemes. The responses are again highly correlated. These results together imply that stock prices incorporate the information of the future increase in productivity before the actual productivity goes up.

The scatter plots of $\epsilon_2 t$ and $\tilde{\epsilon}_1 t$ are shown in Figure 2. As can be seen from the figure, the $\epsilon_2 t$ and $\tilde{\epsilon}_1 t$ line up on the 45 degree line, which also supports the high correlation between these shocks.

This evidence indicates that a shock to stock prices that is orthogonal to the innovation in productivity is almost perfectly correlated with a shock that drives long-run movements in productivity. This means that stock prices incorporate information about future productivity. Therefore, the two structural shocks I derived are interpreted as news shock series, which is consistent with the result of Beaudry and Portier (2006).

2.3 Empirical evidence of international spillover of the news about the US TFP to the Canadian and Japanese TFP

In this section, I present empirical evidences regarding the performance of the Canadian and Japanese TFP in response to the news about future productivity in the US.

The data on the Canadian TFP is constructed only from 1966Q1 since the data of hours worked is available only from that quarter. Figure 3 plots the TFP processes in log for the US and Canada. The likelihood ratio test on cointegration does not reject the hypothesis of cointegration. The series of Japanese TFP is from 1960Q1. Figure 4 plots the TFP processes in log for the US and Japan. Again, the result of the likelihood ratio test on cointegration does not reject the hypothesis of cointegration. Therefore we assume that the processes are cointegrated and use the VECM model for the estimation. I set up a three-variable VECM equation as
follows.

\[
\begin{bmatrix}
\Delta TFP_{US}^t \\
\Delta S_P^t \\
\Delta TFP_{i}^t
\end{bmatrix} =
\begin{bmatrix}
\tilde{\gamma}_1 \\
\tilde{\gamma}_2 \\
\tilde{\gamma}_3
\end{bmatrix} +
\begin{bmatrix}
\tilde{\gamma}^{(0)}_1 \\
\tilde{\gamma}^{(0)}_2 \\
\tilde{\gamma}^{(0)}_3
\end{bmatrix}
\begin{bmatrix}
\tilde{\zeta}_{11} \\
\tilde{\zeta}_{12} \\
\tilde{\zeta}_{13}
\end{bmatrix}
\begin{bmatrix}
\Delta TFP_{US}^{t-1} \\
\Delta S_P^{t-1} \\
\Delta TFP_{i}^{t-1}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\tilde{\gamma}^{(1)}_1 \\
\tilde{\gamma}^{(1)}_2 \\
\tilde{\gamma}^{(1)}_3
\end{bmatrix}
\begin{bmatrix}
\tilde{\zeta}_{11} \\
\tilde{\zeta}_{12} \\
\tilde{\zeta}_{13}
\end{bmatrix}
\begin{bmatrix}
\Delta TFP_{US}^{t-1} \\
\Delta S_P^{t-1} \\
\Delta TFP_{i}^{t-1}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\tilde{\gamma}^{(k)}_1 \\
\tilde{\gamma}^{(k)}_2 \\
\tilde{\gamma}^{(k)}_3
\end{bmatrix}
\begin{bmatrix}
\tilde{\zeta}_{11} \\
\tilde{\zeta}_{12} \\
\tilde{\zeta}_{13}
\end{bmatrix}
\begin{bmatrix}
\Delta TFP_{US}^{t-k} \\
\Delta S_P^{t-k} \\
\Delta TFP_{i}^{t-k}
\end{bmatrix}
\]

\[
+ \ldots \ldots \ldots +
\]

\[
\begin{bmatrix}
u_{1t} \\
u_{2t} \\
u_{3t}
\end{bmatrix},
\]

(5)

where $TFP_{US}$ is the US TFP series, $SP$ is the stock price in the US and $TFP_{i}$ is the Canadian or Japanese TFP series.

Since the available samples for the Canadian TFP and Japanese TFP are much shorter than that of the US TFP, I use following procedure to estimate the response of the Canadian or Japanese TFP to the US news shock so that I can utilize more information on the news of the US TFP. First, I impose the upper 2 by 2 matrices in the coefficient matrices in (5) to be equal to the coefficients obtained from the bivariate VECM with the US TFP and stock price in (2).

Next, I regress $\Delta TFP_i^t$ on all other variables as follows and load the obtained coefficients in (5). Here I assume the cointegrating relationship between the US TFP and Canadian or Japanese TFP to be $[1, -1]$. Therefore, we estimate the following equation using OLS:

\[
\Delta TFP_{i}^t = \tilde{\gamma}_3 + \begin{bmatrix}
\tilde{\gamma}^{(0)}_3 \\
\tilde{\gamma}^{(0)}_3 \\
\tilde{\gamma}^{(0)}_3
\end{bmatrix}
\begin{bmatrix}
\tilde{\zeta}_{31} \\
\tilde{\zeta}_{32} \\
\tilde{\zeta}_{33}
\end{bmatrix}
\begin{bmatrix}
TFP_{US}^{t-1} \\
SP_{t-1} \\
TFP_{i}^{t-1}
\end{bmatrix}
\]

\[
+ \ldots \ldots + \begin{bmatrix}
\tilde{\gamma}^{(k)}_3 \\
\tilde{\gamma}^{(k)}_3 \\
\tilde{\gamma}^{(k)}_3
\end{bmatrix}
\begin{bmatrix}
\tilde{\zeta}_{31} \\
\tilde{\zeta}_{32} \\
\tilde{\zeta}_{33}
\end{bmatrix}
\begin{bmatrix}
\Delta TFP_{US}^{t-k} \\
\Delta S_P^{t-k} \\
\Delta TFP_{i}^{t-k}
\end{bmatrix}
\]

\[
+ u_{3t},
\]

(6)

Finally, I calculate the impulse response of $TFP_{i}^t$ on the structural error series, $\epsilon_{2t}$, which was identified in the bivariate VECM in the previous section. The iden-
tification is done by regressing the reduced error, \( u_{3t} \), on the structural error series, \( \epsilon_{2t} \), which I obtained in previous section. This gives the response of the Canadian or Japanese TFP to the news shock that occurred in the US.

Figure 5 shows the first 40-period responses of US and Canadian TFP to the news about future TFP in the US. Figure 7 shows only the response of the Canadian TFP to news with a 90% confidence band constructed using a bootstrap of 1000 replications. The immediate response of the US TFP to news is bigger compared to that of the Canadian TFP. The Canadian TFP is responding slowly at the beginning and converge slowly to the same level as the US TFP over time.

Figure 6 shows the responses of the US and Japanese TFP to the news about the future TFP in the US. Figure 8 shows only the response of the Japanese TFP. The immediate response of the Japanese TFP to the news is nearly zero, however, it has a persistent and significant increase over time. This converges slowly to the same level as the US TFP.

2.4 Empirical evidence on the international transmission of US news shock

In order to obtain further insight, I also study the international transmission effects of the news shock. The variables of interest are consumption, investment, hours, and output as well as the trade variables (export, import, trade balance and the terms of trade) of Canada and Japan.

2.4.1 Estimated responses of Canadian and Japanese macroeconomic variables to a US news shock

I estimate a higher dimensional system using US productivity \( (TFP^{US}) \), US stock prices \( (SP) \) and other macroeconomic variables of interest. I first estimate an 8-variable system with \( TFP^{US}, SP \), Canadian or Japanese output, consumption, investment, hours worked, terms of trade and the trade balance. I also estimate the responses of exports and imports. When I estimate the responses of exports and imports, I replace the trade balance and the terms of trade with these variables. The results are robust in various other specifications of the system\(^{6}\).

Figure 9 shows the point estimates of the responses of Canadian output, consumption, investment and hours worked. A number of interesting results emerge. Output and consumption have big booms immediately after the shock occurs. After period two, their responses become flatter, however, they rise significantly. Hours

\(^{6}\)I also estimate other specifications of the system for use in an impulse response matching estimation in Section 4.3. I choose 5 lags for Canada and 3 lags for Japan using the likelihood ratio test.
worked also exhibits a persistent rise, but initially it has a different dynamic. It has a boom until period 4 and becomes flatter after that. Investment also has a pattern of persistent rise. The investment boom lasts until period 4 after the shock and it exhibits a flatter pattern after period 4.

Figure 10 shows the responses of Canadian exports, imports, terms of trade and the trade balance. As can be seen, the response of exports has a big initial boom. After period 5, it has a pattern of persistent increase. The response of imports also has an initial boom and persistent increase later, but the initial boom seems milder than that of exports. The response of the terms of trade, which is defined as the import price divided by the export price, has a pattern of persistent decline, although it is not significant. The trade balance has a slightly hump-shaped pattern. It initially has a big boom and becomes persistent later.

Figure 11 shows the responses of the Japanese output, consumption, investment and hours worked. The shapes of the responses of the Japanese variables have important differences compared to the Canadian responses. Output, consumption and investment do not have immediate booms after the shock occurs. The impact effect is nearly zero, however, their responses rise persistently later on. Hours worked exhibits an initial boom. It peaks at period 3 and persistently declines after that.

Figure 12 shows the responses of Japanese exports, imports, terms of trade and the trade balance. Exports and imports do not have an immediate response, however, exhibits a persistent rise. The terms of trade declines persistently. The initial response of the terms of trade is significantly negative. The response of the trade balance is not significant, however, the point estimate has a slightly positive response to the news.

2.4.2 Estimated responses of US macroeconomic variables to US news shock

Although the main focus of this paper is the response of Canadian variables, I also estimated the responses of US variables to a US news shock. I estimate a 6-variable system with $TFP$, $SP$, output, consumption, investment and hours worked. Figure 13 presents the results. The responses of output, consumption and hours have a large boom immediately after the shock. After that, they show a persistent increase. Investment has a significant boom after the shock and after period 3 it has a persistent pattern. Exports and imports exhibit initial booms as well.
3 The Model

This section describes the model economy. The model is a two-country model based on Backus, Kehoe and Kydland (1994) augmented with a different country size, the preference of the type suggested by Jaimovich and Rebelo (2006, 2008), and investment adjustment cost. Two countries are indexed by \( i = \{1, 2\} \). All the variables are in per capita terms unless otherwise noted. Each country is the economy which consists of a representative household, an intermediate good sector and a final good sector. The household has preference over consumption and leisure. The intermediate goods sector produces goods using capital and labor. The final goods sector produces final goods using intermediate goods. The shocks to the economy are the productivity shocks of Country 1 (Canada or Japan) and Country 2 (the US) driven by news about future productivity in the US, which are identified in the previous section.

3.1 Household

The representative household chooses consumption, leisure, investment and borrowing. The lifetime utility of the household is:

\[
\max E_0 \sum_{t=0}^{\infty} \beta^t U(C_{it}, 1 - N_{it}, S_{it}).
\]

where \( C_{it} \) denotes the consumption of country \( i \) and \( N_{it} \) is the hours worked in country \( i \). For the function \( U(C_{it}, 1 - N_{it}, S_{it}) \), following Jaimovich and Rebelo (2006, 2008), I assume the preference as:

\[
U(C_{it}, 1 - N_{it}, S_{it}) = \left( C_{it} - \psi N_{it}^{\kappa} S_{it} \right)^{1-\gamma}
\]

where \( S_{it} = C_{it}^{\kappa} S_{it-1}^{1-\kappa} \) and \( \kappa \in (0, 1] \). It is convenient to use this preference since it nests two types of preference. When \( \kappa = 0 \), this preference becomes the GHH preference, which was named after Greenwood et al. (1988)\(^7\). On the other hand, when \( \kappa = 1 \), this preference becomes the KPR preference, which was named after King, Plosser and Rebelo (1988). With \( \kappa = 0 \) (GHH preference), there is no wealth effect on hours worked. However, with \( \kappa = 1 \) (KPR preference), a wealth effect on hours worked emerges.

The household’s budget constraint for the household in country 1 is given by:

\[
C_{1t} + X_{1t} + q_{1t}^a E_t Q_{t,t+1} B_{1t+1} = q_{1t}^a (W_{1t} N_{1t} + r_{1t}^k K_{1t}) + q_{1t}^a B_{1t},
\]  

\(^7\)If we set \( \kappa = 0 \), this preference becomes not consistent with steady-state growth. Therefore, when I solve the model with the case of GHH preference, I use \( \kappa = 0.001 \), which is a small number.
where $X_{1t}$ denotes investment, $q_{1t}$ is the relative price of intermediate goods produced in Country 1. $Q_{t,t+1}$ is the stochastic discount factor to price the security, $B_{1t+1}$. Here I assumed that the complete market assumption holds.

The budget constraint for household in country 2 is written similarly as:

$$C_{2t} + X_{2t} + q^{a}_{2t} E_t Q_{t,t+1} B_{2t+1} = q^{b}_{2t} (W_{2t} N_{2t} + r^{b}_{2t} K_{2t}) + q^{b}_{2t} B_{2t}. \quad (8)$$

The capital accumulation is done according to following law of motion:

$$K_{it+1} = (1 - \delta) K_{it} + \left[ 1 - \Phi \left( \frac{X_{it}}{X_{it-1}} \right) \right] X_{it}, \quad (9)$$

where $\Phi(x) = (\phi/2) (x - \mu_x)^2$ and the function $\Phi$ satisfies $\Phi(\mu_x) = 0$, $\Phi'(\mu_x) = 0$ and $\Phi''(\mu_x) = \phi > 0$. This function $\Phi(\cdot)$ denotes the adjustment cost for investment. By introducing this, we can rule out an overshooting of the investment possibly caused by the shocks.

Letting $\lambda_{1t}$, $\mu_{1t}$ and $\nu_{1t}$ be a Lagrangian multiplier for the household’s maximization problem, the optimal conditions for the household for consumption, leisure, bond holding, capital, investment and $S_{1t}$ are:

$$U_c (C_{1t}, 1 - N_{1t}, S_{1t}) - \eta_{1t} \kappa C_{1t}^{\kappa-1} S_{1t}^{1-\kappa} = \lambda_{1t}, \quad (10)$$

$$U_n (C_{1t}, 1 - N_{1t}, S_{1t}) + \lambda_{1t} q^{a}_{1t} W_{1t} = 0, \quad (11)$$

$$\beta E_t \lambda_{1t+1} q^{a}_{1t+1} = \lambda_{1t} E_t Q_{t,t+1} q^{a}_{1t}, \quad (12)$$

$$\beta E_t \lambda_{1t+1} q^{a}_{1t+1} r_{1t+1} + \beta \mu_{1t+1} (1 - \delta) - \mu_{1t} = 0, \quad (13)$$

$$-\lambda_{1t} + \mu_{1t} \left[ 1 - \frac{\phi}{2} \left( \frac{X_{1t}}{X_{1t-1}} - \mu_x \right)^2 - \phi \left( \frac{X_{1t}}{X_{1t-1}} - \mu_x \right) \frac{X_{1t}}{X_{1t-1}} \right] X_{1t} = 0 \quad (14)$$

$$U_s (C_{1t}, 1 - N_{1t}, S_{1t}) + \eta_{1t} - \beta E_t \left[ \eta_{1t+1} C_{1t}^{\kappa} S_{1t}^{1-\kappa} \right] = 0 \quad (15)$$

The optimal conditions for the households in Country 2 can be written in a similar fashion.

### 3.2 Intermediate goods sector

The intermediate goods sector is producing intermediate goods using capital, $K_{it}$ and labor, $N_{it}$. The production function in the intermediate sector is the standard Cobb-Douglas function of capital and labor:

$$Y_{it} = Z_{it}^{1-\theta} K_{it}^{\theta} N_{it}^{1-\theta}. \quad (16)$$
where $Z_{it}$ denotes the level of productivity in Country $i$. Then the profit maximization problem for a firm in the intermediate goods sector is:

$$\max_{N_{it}, K_{it}} Y_{it} - w_{it} N_{it} - r_{it} K_{it},$$

subject to $K_{it}, N_{it} \geq 0$.

The optimal conditions for the intermediate sector are:

$$r_{it} = \theta Z_{it}^{1-\theta} \left( \frac{K_{it}}{N_{it}} \right)^{\theta-1},$$

where $r_{it}$ denotes the rental rate of capital in Country $i$, and

$$w_{it} = (1 - \theta) Z_{it}^{1-\theta} \left( \frac{K_{it}}{N_{it}} \right)^{\theta},$$

where $w_{it}$ is the real wage in Country $i$. Capital and labor are assumed to be immobile.

### 3.3 Final goods sector

The final goods sector is producing final goods using intermediate goods as inputs. Letting $a_{it}$ and $b_{it}$ denote the intermediate goods produced in Country 1 and 2, the production functions for final goods are the following Armington aggregator introduced by Armington (1969):

$$F_{1t}(a_{it}, b_{it}) = \left[ \omega_1^{\frac{1}{\sigma}} a_{it}^{\frac{\sigma-1}{\sigma}} + (1 - \omega_1)^{\frac{1}{\sigma}} b_{it}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}},$$

and

$$F_{2t}(a_{2t}, b_{2t}) = \left[ (1 - \omega_2)^{\frac{1}{\sigma}} a_{2t}^{\frac{\sigma-1}{\sigma}} + \omega_2^{\frac{1}{\sigma}} b_{2t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}.$$

Here, $\sigma$ denotes the elasticity of substitution between domestic and foreign goods.

The profit maximization problem for a firm in the final goods sector is:

$$\max_{a_{it}, b_{it}} F_{i} - q_{i}^{a} a_{i} - q_{i}^{b} b_{i}$$

subject to $a_{it}, b_{it} \geq 0$.

The optimal conditions for the final goods sector are:

$$a_{it} = (q_{1t}^{a})^{-\sigma} \omega_1 F_{1t}$$

$$b_{it} = (q_{1t}^{b})^{-\sigma} (1 - \omega_1) F_{1t}$$

$$a_{2t} = (q_{2t}^{a})^{-\sigma} (1 - \omega_2) F_{2t}$$

$$b_{2t} = (q_{2t}^{b})^{-\sigma} \omega_2 F_{2t}$$
3.4 International risk sharing

Following Chari et al. (2002), by iterating the first order condition for state-contingent securities in Country 1 and 2, we obtain the following international risk sharing condition under the complete market assumption:

\[
\frac{U_c(C_{2t}, 1 - N_{2t}, S_{2t})}{U_c(C_{1t}, 1 - N_{1t}, S_{1t})} = RER_t. \tag{25}
\]

where \( RER \) denotes the real exchange rate. It is defined as \( RER_t \equiv q_{1t}^a/q_{2t}^a \).

3.5 Market clearing conditions

Market clearing for the intermediate goods sector is:

\[
\Pi_1 Y_{1t} = \Pi_1 a_{1t} + \Pi_2 a_{2t}, \tag{26}
\]

and

\[
\Pi_2 Y_{2t} = \Pi_1 b_{1t} + \Pi_2 b_{2t}. \tag{27}
\]

where \( \Pi_1 \) denotes the ratio of Country 1’s population in the world and \( \Pi_2 \) denotes the population of Country 2 in the world. We assume that \( \Pi_1 + \Pi_2 = 1 \).

For the final goods market,

\[
F_{1t} = C_{1t} + X_{1t} \tag{28}
\]

and

\[
F_{2t} = C_{2t} + X_{2t} \tag{29}
\]

3.6 Other variables of interest

The terms of trade for Country 1 is defined as the relative price of imported goods and exported goods:

\[
TOT_t = \frac{q_{bt}^b}{q_{at}^a}. \tag{30}
\]

The trade balance of Country 1 over the GDP of Country 1 is defined as

\[
TB_{1t} = \frac{\Pi_2 a_{2t} - \Pi_1 \left( \frac{q_{bt}^b}{q_{at}^a} \right) b_{1t}}{\Pi_1 Y_{1t}}. \tag{31}
\]
3.7 The choice of the processes of TFP

In this model, I take the TFP processes of Country 1 (Canada or Japan) and Country 2 (the US) as exogenous. In contrast to the standard assumption of international real business cycle models, I choose TFP processes obtained from (2) and (5) in the VECM estimation discussed in Section 2.

My approach here is motivated by two facts about actual TFP processes. First, what the empirical analysis in Section 2 shows is that the TFP processes are driven by the slow diffusion process of the news. In previous theoretical literature on the news-driven business cycles, it is more common to assume that the agents in the model anticipate that the actual materialization of the TFP occurs at some point in the future, not currently. However, according to the VECM results, the TFP responds to the news about future TFP slowly but contemporaneously. This empirical result makes sense in light of the slow adoption of technological innovation. Second, according to the estimation results in Section 2.3, there is a significant international spillover effect of the news. In the previous theoretical literature such as Beaudry, Dupaigne and Portier (2008), foreign TFP is not positively affected by the domestic TFP process driven by the news. However, in my paper, since there is strong empirical evidence of this, I feed the estimated TFP processes of Canada or Japan into the model as well. In Section 4.4, using a counterfactual experiment, I show the importance of feeding the TFP processes of Canada or Japan driven by the US news.

Since all the model equations are converted in stationary terms, I convert the TFP variables in levels into the growth rate terms and feed into the model.

3.8 Competitive equilibrium

The competitive equilibrium in this model consists of sequences of allocations for $i = 1, 2$, $\{C_{it}, S_{it}, X_{it}, K_{it+1}, B_{it+1}, N_{it}, Y_{it}, F_{it}, a_{it}, b_{it}\}_{t=0}^{\infty}$ and prices $\{w_{it}, r_{it}, q_{at}^{k}, q_{bt}^{*}\}_{t=0}^{\infty}$ such that, taking $\{B_{10}, B_{20}, K_{0}\}$ and exogenous sequences $\{Z_{1t}, Z_{2t}\}_{t=0}^{\infty}$ as given,

- $\{C_{it}, S_{it}, X_{it}, K_{it+1}, B_{it+1}, N_{it}\}_{t=0}^{\infty}$ solves the households’ problem.
- $\{Y_{it}, F_{it}, a_{it}, b_{it}\}_{t=0}^{\infty}$ solves the firms’ problem.
- Market clearing conditions and the resource constraint are satisfied.
4 Quantitative analysis

4.1 Parameter values

The stochastic discount factor, $\beta$, is set equal to 0.99. I set the capital depreciation rate, $\delta$, as 0.025. The capital share of output is set to $\alpha = 0.32$, since the labor share calculated using US data is 0.68. The steady state imported goods share, $b_{Y_1}$, for Canada $^8$ is set to 0.32, the degree of openness, $1 - \omega_1$, is also calibrated to be 0.32. Since I assume that the Canadian population at the steady state is 1/10 that of the US, the steady state imported goods share for the US, $1 - \omega_2$, is calibrated to 0.032. The imported goods share for Japan, $b_{Y_2}$, is set to 0.1. This means $1 - \omega_1$ is also 0.1 in the case of the two-country model of the US and Japan. I assume that the Japanese population at steady state is half that of the US, $1 - \omega_2$ is calibrated to 0.05 in the case of the two-country model of the US and Japan.

The elasticity of substitution between consumption and leisure, $\gamma$, is set equal to 2. Following Jaimovich and Rebelo(2008), I set the preference parameter $\nu$ as 1.4. I calibrated $\psi$ so that the steady state values of hours worked, $N_{1t}$ and $N_{2t}$, become 0.2.

For $\kappa$, $\phi$ and $\sigma$, I take two different approaches. In the first approach, I assume hypothetical values for these parameters. For the GHH-type preference, I set $\kappa$ equal to 0.001, which is very small. Under this parameter, the wealth effect on the labor supply is very small or negligible. For the KPR-type preference, I assume $\kappa = 1$. Under this type of preference, there is a substantial wealth effect on labor supply. For $\phi$, the investment adjustment cost parameter, I use either $\phi = 0$ (no adjustment cost), $\phi = 5$ (with adjustment cost) or $\phi = 500$ (with adjustment cost in Japan)$^9$. The latter value is the estimated value in Schmitt-Grohé and Uribe (2008). For $\sigma$, the elasticity of substitution between domestically produced intermediate goods and foreign produced intermediate goods, I assume either $\sigma = 1.5$ (for the standard assumption) or $\sigma = 0.3$ (for low elasticity of substitution). The former value is used in Backus, Kehoe and Kydland (1994), which is taken as a standard assumption in the previous literature.

In the second approach, I estimate the values of $\kappa$, $\phi$ and $\sigma$ using an impulse response matching estimation, which I explain in a later section.

$^8$This value is taken from Raffo(2006) (WP version).

$^9$This value is calculated using the data on share of real import in real GDP.

$^{10}$For the two-country model of the US and Japan, it is hard to generate positive investment response with $\phi = 5$. 

16
4.2 Impulse response analysis with calibrated parameter values

This section compares the empirical and theoretical impulse responses to the news shock. Before estimating the parameters, I assume some hypothetical values for the GHH preference parameter, $\kappa$, the investment adjustment cost parameter, $\phi$ and the elasticity of substitution between domestically and foreign produced intermediate goods, $\sigma$, in order to obtain intuitions. Figures 14 and 15 display these model-based impulse responses for Canadian variables assuming different sets of parameter values along with empirical responses which I described in an earlier section. Figure 16 displays the results for the US variables. The dark solid line and the shaded region are the point estimate and 90\% confidence bands for the empirical impulse response.

A line with diamonds denotes the response of the variable in the case of a standard KPR preference ($\kappa = 1$), no investment adjustment cost ($\phi = 0$) and the elasticity of substitution between domestically and foreign produced goods under the standard assumption ($\sigma = 1.5$). While the immediate response of Canadian consumption is positive, the response of hours worked is negative. This is because of the large wealth effect driven by the positive news about future TFP. The impact on the investment is negative because of this wealth effect and this drives the negative response of output. Since there occurs a positive increase in the US TFP, the price of intermediate goods produced in the US declines, which means an appreciation of the terms of trade.

A line with crosses denote the response of the variable in the case of the standard KPR preference ($\kappa = 1$), investment adjustment cost ($\phi = 5$) and the elasticity of substitution between domestically and foreign produced goods under the standard assumption ($\sigma = 1.5$). In this case, it avoids the large decline of investment, however, the response is still negative. Hours worked and thus output has a negative response because of the wealth effect.

Line with squares denote the case of GHH preference ($\kappa = 0.001$), investment adjustment cost ($\phi = 5$) and the elasticity of substitution between domestically and foreign produced goods under the standard assumption ($\sigma = 1.5$). GHH preferences get rid of the negative wealth effect. Interestingly, the model-based response of exports becomes positive. This is because the Canadian intermediate goods firm is producing more goods. The response of US imports becomes correspondingly positive. Canadian imports of intermediate goods has a larger positive response compared to the case of $\kappa = 1$. However, it is still hard to match the response of the trade balance. The point estimate of the empirical response in the Canadian trade balance is positive.

Then I further introduce the assumption of low elasticity of substitution between
domestically and foreign produced goods. A line with circles denotes this case of GHH preference ($\kappa = 0.001$), investment adjustment cost ($\phi$) and the low elasticity of substitution between domestically and foreign produced goods ($\sigma = 0.3$). As can be seen, this helps explain the positive response of the Canadian trade balance. However, it comes with the cost of worsening the match of the terms of trade. Since demand for Canadian goods increases with the lower elasticity, the Canadian exports and thus output have a larger positive response compared to the previous case. Correspondingly, consumption and hours have a larger response as well.

Figures 17 and 18 display the results of the Japanese variables. Similar to the case of Canada, in the case of the standard KPR preference ($\kappa = 1$), no investment adjustment cost ($\phi = 0$) and the elasticity of substitution between domestically and foreign produced goods under the standard assumption ($\sigma = 1.5$), as expressed in the line with diamonds, the immediate responses of investment, hours, and thus output are negative, while the response of consumption is positive because of the wealth effect.

Then I further assume a GHH preference (line with squares). Then hours worked exhibits a positive response and thus generates a positive response of output. However, the response of the trade balance is still far from the point estimate obtained in the empirical analysis. Assuming low elasticity of substitution between domestically and foreign produced goods (line with circles), the response of exports becomes close to the point estimate and the response of the trade balance becomes positive. However, it comes with the cost of worsening the match of terms of trade.

4.3 Estimation of $\kappa$, $\phi$ and $\sigma$ using impulse response matching estimation

Now I estimate $\kappa$ and $\phi$ by matching the model-based impulse responses to the news with the empirical VECM estimates. First, I collect the empirical impulse responses to the vector in $IR_{\text{data}}$ and choose $W$ to be a diagonal matrix with the variance of impulse responses along its diagonal. The parameters are estimated using the following minimization problem:

$$
\min_{\Theta} \left( IR(\Theta) - IR_{\text{data}} \right) W^{-1} \left( IR(\Theta) - IR_{\text{data}} \right).
$$

(32)

where $\Theta = \{\kappa, \phi, \sigma \nu\}$. $IR(\Theta)$ denotes a vector that consists of model-based impulse responses.

I use the information criterion advocated by Hall et al. (2007) to choose the optimal lags to match. Using the Relevant Impulse Response Selection Criterion (RIRSC), I decided to match 11 lag responses of Canadian output, consumption, investment hours worked, terms of trade and the trade balance. The estimated values
are $\kappa = 0.01$ (std. error 0.007), $\phi = 87.11$ (std. error 30.15), $\sigma = 0.18$ (std. error 0.06) and $\nu = 2.95$ (std. error 0.05) for Canada. For Japan, the estimated values are $\kappa = 0.01$ (std. error 0.001), $\phi = 3045.6$ (std. error 7347.7), $\sigma = 0.68$ (std. error 0.006) and $\nu = 2.08$ (std. error 0.106). The results are presented in Figures 19, 20 and 23. A line with stars denotes the model-based response using estimated parameters. As the figures show, the Canadian output, consumption, investment and hours worked match well with the point estimates. The responses of exports, imports and the trade balance are qualitatively the same as point estimates. It is difficult to get rid of the overshooting of the terms of trade, however, the response is qualitatively the same.

The low estimated value of $\kappa$, 0.01 indicates that eliminating the wealth effect on hours worked is important. The estimated value of $\sigma$, the elasticity of substitution, is also low relative to the value used as the standard assumption ($\sigma = 1.5$). Lower elasticity means there is a complementarity between domestically and foreign produced intermediate goods. As can be seen in the previous subsection, this also helps to explain the domestic boom.

For Japan, the results are presented in Figures 21 and 22. In the Japanese case, the model does not match the empirical response of investment. Therefore, the estimated parameter of investment adjustment cost becomes arbitrarily large. However, the responses of output, consumption and hours worked are qualitatively the same as the empirical response. The model replicates the appreciation of the terms of trade.

### 4.4 A counterfactual experiment where the Canadian or Japanese TFP does not respond to a US news shock

This subsection justifies the importance of feeding the response of Canadian or Japanese TFP to a US news shock into the model. To show this, I conduct a counterfactual experiment assuming a zero response of the Canadian or Japanese TFP to a US news shock. Parameter values are assumed to be the same as in the previous section.

The results are presented in Figures 19, 20, 21 and 22. A dashed line denotes the response from this counterfactual experiment. As can be seen, if I do not feed the Canadian TFP process driven by the US news shock, then the responses of output, consumption, investment and hours are much lower than the point estimates. The Japanese TFP process is also important to explain the response of output and consumption. Therefore, the response of the Canadian or Japanese TFP to a US news shock is important to match the empirical responses.
5 Conclusion

In this paper, I study the international transmission effects of news about US Total Factor Productivity (TFP) using the Canadian and Japanese data. Using the Vector Error Correction Model (VECM), I estimate the impulse responses of the macroeconomic variables of Canada and Japan to the news shock of a US TFP. I find that the Canadian TFP responds to the US news positively and significantly. Japanese TFP exhibits a significant and persistent rise after the shock. Then I construct and estimate a two-country RBC model with Jaimovich-Rebelo preferences and investment adjustment cost. By feeding the actual TFP processes driven by the news shock obtained in the empirical analysis, I find that the international transmission effects can be generated by the news about future TFP in the US. In order to generate the comovements to match the data, I show that the preference parameter that generates a lower wealth effect on hours worked, investment adjustment cost and lower substitution of elasticity between domestically and foreign produced intermediate goods are important. Using a counterfactual experiment, I also show that the response of the Canadian TFP or Japanese TFP to US news shock is important.
References


A The Data

A.1 US Data

- Population: I used the data from The U.S. Government Printing Office. Table B-34 in http://www.gpoaccess.gov/eop/tables09.html The original data is taken from Department of Commerce (Bureau of Census).

- GDP for calculating TFP: Real GDP (non-farm business sector). Source: Bureau of Economic Analysis (BEA), "Table 1.3.6. Real Gross Value Added by Sector, Chained Dollars".

- Output: Real GDP (gross). Source: BEA, "Table 1.3.6. Real Gross Value Added by Sector, Chained Dollars" in NIPA Table. (Series ID: GDPC1)

- Consumption: Real personal consumption expenditures. Source: BEA, series taken from FRED database. (Series ID: PCECC96)

- Investment: Real fixed private investment, quarterly data in annual level. Source: BEA, series taken from FRED database. (Series ID: FPIC1)


- Stock price: Nominal stock price divided by the deflator explained below. Standard & Poors 500 composite stock prices index, downloaded from Global Financial Database. I obtained monthly data from 1939M1 and converted into quarterly series. I used closing price.

- Deflator: Price index of business sector. Source: BEA, "Table 1.3.4. Price Indexes for Gross Value Added by Sector".


- Exports: Real exports of goods and services, 1 decimal. Source: FRED database.

- Imports: Real imports of goods and services, 1 decimal. Source: FRED database.

A.2 Canadian data

Data were kindly given by Bank of Canada.
- Capital: Calculated by Bank of Canada.
- Hours worked: Using the population data, I multiplied the series by participation rate obtained from Bank of Canada. I multiplied that by employment rate which I calculated using data of unemployment rate to get the employment data. Then I multiplied that by the series of average hours worked to get total hours worked.
- Canadian terms of trade: Defined as import deflator divided by export deflator. Source: SourceOECD database.

### A.3 Japanese data

- Hours worked: Aggregate weekly hours worked. Source: "Roudouryoku Chosa," Statistics Bureau, Ministry of Internal Affairs and Communications.
• Japanese terms of trade: Defined as import deflator divided by export deflator.
  Source: SourceOECD database.
Figure 1: Identification of the US News Shock

Note: The blue line with circles denotes the impulse response estimated using a short-run identification. The red line with stars denotes the impulse response estimated using a long-run identification. This corresponds to the response of $TFP^{US}$ to $\epsilon_2$. This corresponds to the response of $TFP^{US}$ to $\tilde{\epsilon}_1$. The black lines indicate a 90% confidence band using a short-run identification.
Figure 2: A Scatter Plot of $\epsilon_2$ against $\tilde{\epsilon}_1$
Figure 3: The US and Canadian TFP Processes
Figure 4: The US and Japanese TFP Processes
Figure 5: The Responses of the US TFP and Canadian TFP to a News About Future US TFP. Note: The line with circles is the impulse response of the US TFP and the line with stars is the impulse response of the Canadian TFP to a US news shock.
Figure 6: The Response of the US TFP and Japanese TFP to a News About Future US TFP. Note: The line with circles is the impulse response of the US TFP and the line with stars is the impulse response of the Japanese TFP to a US news shock.
Figure 7: The Estimated Response of the Canadian TFP to a News About Future US TFP. Note: The solid lines and the shaded regions are the point estimate and 90% confidence bands.
Figure 8: The Estimated Response of the Japanese TFP to a News About Future US TFP. Note: The solid lines and the shaded regions are the point estimate and 90% confidence bands.
Figure 9: The Estimated Responses of the Canadian Variables to a News About Future US TFP. Note: The solid lines and the shaded regions are the point estimate and 90% confidence bands.
Figure 10: The Estimated Responses of the Canadian Variables to a News About Future US TFP Note: The solid lines and the shaded regions are the point estimate and 90% confidence bands.
Figure 11: The Estimated Responses of the Japanese Variables to a News About Future US TFP. Note: The solid lines and the shaded regions are the point estimate and 90 % confidence bands.
Figure 12: The Estimated Responses of the Japanese Variables to a News About Future US TFP. Note: The solid lines and the shaded regions are the point estimate and 90% confidence bands.
Figure 13: The Estimated Responses of the US Variables to a News About Future US TFP. Note: The solid lines and the shaded regions are the point estimate and 90% confidence bands.
Figure 14: The Responses of the Canadian Variables to a News About Future US TFP in the Model

Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. In following three cases, I set the elasticity of substitution between domestically produced and foreign produced intermediate goods, $\sigma$, equal to 1.5 (standard assumption). A line with diamonds denotes the response of the variable in the case of the KPR preference ($\kappa = 1$) and no investment adjustment cost ($\phi = 0$). A line with crosses denotes the case with the KPR preference ($\kappa = 1$) and investment adjustment cost ($\phi = 5$). A line with squares denotes the case with the GHH preference ($\kappa = 0.001$) and the investment adjustment cost ($\phi = 5$). A line with circles denotes the case with GHH preference ($\kappa = 0.001$), the investment adjustment cost ($\phi = 5$), and low elasticity of substitution between domestically produced and foreign produced intermediate goods ($\sigma = 0.3$).
Figure 15: The Responses of the Canadian Trade Variables to a News about Future US TFP in the Model

Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. In following three cases, I set the elasticity of substitution between domestically produced and foreign produced intermediate goods, $\sigma$, equal to 1.5 (standard assumption). A line with diamonds denotes the response of the variable in the case of the KPR preference ($\kappa = 1$) and no investment adjustment cost ($\phi = 0$). A line with crosses denotes the case with the KPR preference ($\kappa = 1$) and the investment adjustment cost ($\phi = 5$). A line with squares denotes the case with the GHH preference ($\kappa = 0.001$) and the investment adjustment cost ($\phi = 5$). A line with circles denotes the case with the GHH preference ($\kappa = 0.001$), the investment adjustment cost ($\phi = 5$), and low elasticity of substitution between domestically produced and foreign produced intermediate goods ($\sigma = 0.3$).
Figure 16: The Responses of the US variables to a News About Future US TFP in the Model Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. In following three cases, I set the elasticity of substitution between domestically produced and foreign produced intermediate goods, $\sigma$, equal to 1.5 (standard assumption). A line with diamonds denotes the response of the variable in the case of the KPR preference ($\kappa = 1$) and no investment adjustment cost ($\phi = 0$). A line with crosses denotes the case with the KPR preference ($\kappa = 1$) and the investment adjustment cost ($\phi = 5$). A line with squares denotes the case with the GHH preference ($\kappa = 0.001$) and the investment adjustment cost ($\phi = 5$). A line with circles denotes the case with the GHH preference ($\kappa = 0.001$), the investment adjustment cost ($\phi = 5$), and low elasticity of substitution between domestically produced and foreign produced intermediate goods ($\sigma = 0.3$).
Figure 17: The Responses of the Japanese Variables to a News About Future US TFP in the Model

Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. In following three cases, I set the elasticity of substitution between domestically produced and foreign produced intermediate goods, $\sigma$, equal to 1.5 (standard assumption). A line with diamonds denotes the response of the variable in the case of the KPR preference ($\kappa = 1$) and no investment adjustment cost ($\phi = 0$). A line with crosses denotes the case with the KPR preference ($\kappa = 1$) and the investment adjustment cost ($\phi = 5$). A line with squares denotes the case with the GHH preference ($\kappa = 0.001$) and the investment adjustment cost ($\phi = 5$). A line with circles denotes the case with the GHH preference ($\kappa = 0.001$), the investment adjustment cost ($\phi = 5$), and low elasticity of substitution between domestically produced and foreign produced intermediate goods ($\sigma = 0.3$).
Figure 18: The Responses of the Japanese Trade Variables to a News About Future US TFP in the Model

Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. In following three cases, I set the elasticity of substitution between domestically produced and foreign produced intermediate goods, $\sigma$, equal to 1.5 (standard assumption). A line with diamonds denotes the response of the variable in the case of the KPR preference ($\kappa = 1$) and no investment adjustment cost ($\phi = 0$). A line with crosses denote the case with the KPR preference ($\kappa = 1$) and the investment adjustment cost ($\phi = 5$). A line with squares denote the case with the GHH preference ($\kappa = 0.001$) and the investment adjustment cost ($\phi = 5$). A line with circles denotes the case with the GHH preference ($\kappa = 0.001$), the investment adjustment cost ($\phi = 5$), and low elasticity of substitution between domestically produced and foreign produced intermediate goods ($\sigma = 0.3$).
Figure 19: The Responses of the Canadian Variables to News About Future US TFP in the Model with Estimated Parameters Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. A line with stars denotes the model-based response with estimated parameters and feeding both the Canadian and US TFP processes driven by a US news shock. The dashed line denotes the model-based response from counterfactual experiment without feeding the Canadian TFP process driven by a US news shock.
Figure 20: The Responses of the Canadian Trade Variables to a News About Future US TFP in the Model with Estimated Parameters

Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. A line with stars denotes the model-based response with estimated parameters and feeding both the Canadian and US TFP processes driven by a US news shock. The dashed line denotes the model-based response from counterfactual experiment without feeding the Canadian TFP process driven by a US news shock.
Figure 21: **The Responses of the Japanese Variables to a News About Future US TFP in the Model with Estimated Parameters**

Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. A line with stars denote the model-based response with estimated parameters and feeding both the Japanese and US TFP processes driven by a US news shock. The dashed line denotes the model-based response from counterfactual experiment without feeding the Japanese TFP process driven by a US news shock.
Figure 22: The Responses of the Japanese Trade Variables to a News About Future US TFP in the Model with Estimated Parameters

Notes: The solid lines and the shaded regions are the point estimate and 90% confidence bands for the empirical impulse response. A line with stars denote the model-based response with estimated parameters and feeding both the Japanese and US TFP processes driven by a US news shock. The dashed line denotes the model-based response from counterfactual experiment without feeding the Japanese TFP process driven by a US news shock.
Figure 23: Responses of US variables to news about future US TFP in the model. Notes: The solid line and the shaded region are the point estimate and 90% confidence bands for the empirical impulse response. Line with stars denote the model-based response with estimated parameters and feeding both Canadian and US TFP processes driven by the US news shock. The dashed line denotes the model-based response from counterfactual experiment without feeding Canadian TFP processes driven by the US news shock.