International Business Cycle Transmissions and News Shocks

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Abstract

This paper examines how news shocks affect the business cycle comovements across countries. In the context of a dynamic stochastic general equilibrium model with GHH preferences, I use Bayesian estimation on data for the U.S. and Mexico from 1950 to 2010. The results show that there is evidence of comovements of business cycles across the two countries. While including news shocks appear to overestimate the aggregate fluctuations, it explains the across-country comovements better than the standard covariance matrix model. It implies that news shocks as a channel of business cycle transmissions deserves further investigation, possibly through modifications on the model and expanding estimations to other country pairs.

1 Introduction

The process of globalization has highlighted the interdependence among world economies. Economic fluctuations in one country can trigger those in another country—they can spill over to neighboring nations or even reach geographically distant places. This phenomenon is known as the international business cycle comovement or the synchronization of business cycles. One good example would be the Financial Crisis in 2008. The depression occurring in the U.S. greatly influenced the economies in Europe and spread around the world. It would be hard to treat the ongoing financial and debt crises, as well as the business cycle fluctuations across countries, independent of each other.

Moreover, people's anticipation of the 2008 Crisis had an impact—investors built their decisions on their anticipations, which potentially determined the future of some financial institutions. This is related to the studies on how news, or anticipated shocks, contribute to business cycle fluctuations. However, most of these studies concentrate in domestic environments.

In this paper, I take both streams of the literature and track whether news shocks work as transmission channels for business cycle comovements. In other words, I want to see how anticipation or beliefs on productivity shocks of a foreign country affect the domestic business cycle. The goal of this paper is to see the effects of news shocks on business cycle transmissions using the U.S. and Mexico as examples.

The paper is structured as follows: Section 2 reviews related literature on both international business cycle movements and the impact of news shocks; Section 3 presents the theoretical framework, including the anticipated shocks elements; Section 4 contains the Bayesian likelihood-based estimation results; Section 5 analyzes how the model compared to real world data; and Section 6 concludes. An appendix is also included with supplementary equations and data methodology.

2 Literature Review

Macroeconomic aggregates are often found to have similar cyclical regularity across countries. Consumption is procyclical and is less volatile than aggregate output. Investment, on the other hand, is often more volatile but procyclical; while hours worked exhibit the same level of volatility as output (Backus, Kehoe, and Kydland 1992). Therefore, it was a natural step to expand the studies on business cycles from closed economies to open economies. An open economy framework allows countries not only to carry out financial transactions in the international market, but also use the trade balance to smooth out consumption (Backus et al. 1992).

The international comovements of business cycles have a large discrepancy between theory and data in the 1992 study of Backus et al., featuring the postwar U.S. and some European countries' business cycles. Implementing a bivariate autoregressive process to treat the technology shocks between countries, the model predicted a larger correlation of consumption and productivity shocks across countries than the correlation between output fluctuations and productivity; in data it was the opposite. The terms of trade also have a larger deviation in the model than in the data. To be more specific, volatility of investment to output was three times larger than in the data while standard deviations on terms of trade were almost seven times larger. The authors also found that the degree of discrepancy on investment and net exports with empirical data are sensitive to model specifications and parameter values, though that of consumption and output is more robust (Backus et al. 1992).

One possible modification to reduce the gap between theoretical model predictions and empirical data is adding a trade relation persepctive. Bilateral trade relations tend to link business cycle movements together: the larger the trade volume, then the larger the transmission shock between the two economies. In particular, doubling the median trade intensity increases the output correlation of the country trading pair by roughly 0.06 (Kose and Yi 2005). By altering the typical two-country, free trade, and complete market model setting framework to include three countries with transportation costs and financial autarky, the impact of trade on output comovements across countries explains less than 10% of the variation for small trading country pairs, but gets larger as the country pairs increase trade intensity (Kose and Yi 2005). In general, the magnitude of effect from trade on output comovements between countries is much less in data than in theory, although this type of baseline model captures the right direction between trade and output synchronization. Adding more trade variables, such as controlling the third-country trade intensity and lowering transport costs, improves the GDP correlation across countries.

However, trade alone seems to fail to account for comovements in most cases. For shocks transmitted through financial markets and export-demand variations, only including terms of trade fell short to predict movements in aggregate macroeconomic variables, such as investment, output and total hours worked (Schmitt-Grohé 1997). Isolating the Canadian and the U.S. trading pair and taking interest rates as the transmission mechanism, technology innovations in U.S. output impacts the Canadian economy equilibrium through interest rates on available international financial assets. There is a positive relationship between the U.S. innovation and Canadian economy output but mixed results on employment showed that one-sector, open-economy model failed to understand the observed response in the Canadian macroeconomic variables. When altering the model to transmission through export demand fluctuations, theoretical impulse responses for output and hours worked were closer to empirical data but still not satisfactory. Introducing imperfect competition such as market power also did not alter the conclusion that trade alone was not sufficient to explain short-term fluctuations from the U.S. to Canada. This may be due to the lack of price movements in observed variable quantities (Schmitt-Grohé 1997).

The same approach can be applied to the neighboring countries in the South. Canova (2005) found that the interest rate channel of shocks transmission was more crucial than simple trade volume channel for the U.S. and a sample of Latin American countries. The U.S. monetary disturbances count for an important portion of Latin American output and inflation fluctuations. The pattern for these Latin American countries in the sample was also distinguishable from that of developed countries (Canova 2005). Nevertheless, this study appealed to the existence of international business cycle transmissions.

In general, U.S. economy fluctuations are often of natural concern for Latin American countries because of geographical, trade, and financial connections. Identified as the major source of shock to Latin American and the Caribbean countries, the U.S. economy led to aggregate demand variation spillover on real GDP growth and price inflation to its neighboring countries. At the same time, economic agents' anticipation on the US growth and production factor prices through trade and financial relations also affect Latin America's economic activities, such as industrial plans to increase production capacity for anticipated growth in the U.S. (Kandil 2009).

Next we turn to examine how anticipation triggers economic fluctuations. In the past, the source for business cycle fluctuations has been on shocks with certainty. Increasingly though, recent studies have explored the effect of anticipated shocks, or the "News Shocks," on domestic economies.

It is therefore natural to question whether news shocks are a good candidate to explain economic fluctuations. Opposed to a vector auto-regressive (VAR) approach, the dynamic stochastic general equilibrium model with Bayesian and classical maximum likelihood estimation showed that anticipated shocks accounted for roughly one half of variations on consumption, investment, hours, and aggregate output, according to Schmitt-Grohé and Uribe (2012). More specifically, forward-looking economic agents would use information from the realization of anticipated innovations to determine their current choice of labor supply, consumption, and investment, which in turn allowed for the examination on the volatility of anticipated innovations.

More evidence on news-driven business cycle fluctuations includes Barsky and Sims' (2011) approach using VAR, which contained minimum theoretical restrictions compared to dynamic stochastic general equilibrium (DSGE) models. Mainly implementing a utilization-adjusted measure of aggregate TFP, the news shock here is identified as "the shock orthogonal to the

TFP innovation that best explains future variation in measured TFP" (Barsky and Sims 2011). Under this approach, news shocks accounted, to a smaller degree, for the volatility of consumption and to a larger degree, that of output. The related impluse responses are also generally consistent with the results of standard macroeconomic models.

Given that the above studies are identified for domestic economies, when extended to open economy, news on future TFP increases led to positive comovements among GDP, hours worked, consumption and investment. When disaggregating the picture, fluctuations of GDP from the news shocks were much smaller in small open economies than those in the U.S. (Kamber, Theodoridis, and Thoenissen 2014). This study restricted the news shocks as purely domestic future TFP increase and identified financial frictions as a measurement of firm behaviors when facing anticipated future TFP increase. Through a vector autoregressive model of order K, the authors found that after a positive news shock net trade is countercyclical in most countries they tested, except for Canada. For other macroeconomics variables, the study found relative heterogeneity between countries, which is in contrast with the findings for the U.S. from several other studies. This may due to the effect from common global shocks on the small open economies (Kamber et al. 2014).

Since news shocks imply that the information is common to all countries, these common shocks led to the comovements in business cycles within and across countries. Through a two-country two-sector news shocks model, it can be seen that news on domestic future TFP improvement creates a boom and transmits abroad. A similar two-country real business cycle model, on the other hand, failed to reproduce similar results of data from U.S. and Canada as well as Germany and Austria (Beaudry, Dupaigne, and Portier 2008). The implication from this study was that eventhough the news shocks were only realized in one country, because of the openness of the information itself, the shocks acted simultaneously on national and international business cycles. It is worth noticing that from the news shock in technology, we see rises of imports in the bigger economy in both pairs of countries (i.e. the U.S. and Germany). This effect propagated to each country's trading partner (i.e. Canada and Austria)

(Beaudry et al. 2008).

In this paper I am going to follow the same approach as Schmitt-Grohé and Uribe (2012). Although we do see trading partners sometimes express stronger degrees of business cycle synchronization, the scope of this paper urges me to stay at a rather first-stage model where trade elements are not included. I will only focus on how anticipated shocks work on business cycle fluctuation transmissions.

3 Theory

This section presents the theoretical framework using Jaimovich—Rebelo (2009) utility functional form. Since I am interested in the transmission part of business cycles, the theory indicates a model of two countries, A and B. However, the assumption is that each country's economy is identical with a representative household and a representative firm, with no government presence. Moreover, the consumption bundle is supposed to be the same for both countries (that is, they do not trade on consumption goods) and domestic consumers have the same preference towards consumption and leisure. Therefore, the benchmark of one country is presented below.

3.1 Household

The representative household chooses infinite sequences of consumption $\{C_t\}$, leisure $\{l_t\}$, and investment $\{I_t\}$ to maximize the utility

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, l_t)$$

where $\beta \in (0,1)$ denotes the time discount factor. I normalize the total time endowment to unity, thus, the household's labor supply is given by $h_t = 1 - l_t$. The utility takes the form:

$$U(C_t, l_t) = \frac{(C_t - \psi(1-l_t)^\theta X_t)^{1-\sigma} - 1}{1-\sigma}$$

where

$$X_t = C_t^\gamma X_{t-1}^{1-\gamma}$$

The household (in either country) is assumed to have physical capital stock, denoted as K_t that follows the law of motion of capital

$$K_{t+1} = (1-\delta)K_t + I_t \tag{1}$$

where δ denotes depreciation rate of period t, with $\delta \in [0,1]$.

3.2 Firm

For the representative firm, the production technology is identical for both countries. Output is given by:

$$Y_t = z_t F(K_{Ft}, h_{Ft}) \tag{2}$$

where F follows the Cobb-Douglas form

$$F(K_F, h_F) = K_F^{1-\alpha} h_F^\alpha \tag{3}$$

Each period, the representative firm in each country rents domestic capital and labor from the corresponding representative household and pays back rents, r_t^i, and wage, w_t^i. From the firm and household's conditions above, the representative household in either country faces the general budget constraint

$$C_t + I_t = r_t K_t + w_t h_t \tag{4}$$

It is straightforward that at equilibrium of the representative firm, output is equal to production.

$$Y_t = z_t K_t^{1-\alpha} h_t^{\alpha}$$

Thus, equivalently, we have

$$C_t + I_t = Y_t$$

The stochastic TFP process is also standard as:

$$z_{t+1} = \rho z_t + \mu_{t+1}$$

Based on Schmitt-Grohé and Uribe (2012), estimation showed that the value of γ is close to 0. Jaimovich-Rebelo show that$\gamma = 0$ collapses their preferences to a GHH functional form (Greenwood, Hercowitz, and Huffman, 1988).

With no government or the existence of distorting taxes, the problem with GHH preference can be set up as a social planner problem, correspondingly:

$$\max_{\{C_t, l_t, I_t\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{(C_t - \psi(1-l_t)^{\theta})^{1-\sigma} - 1}{1-\sigma} \tag{5}$$

$$\text{s.t. } C_t + I_t = z_t K_t^{1-\alpha}(1-l_t)^{\alpha} \tag{6}$$

$$K_{t+1} = (1-\delta)K_t + I_t \tag{7}$$

$$h_t + l_t = 1 \tag{8}$$

3.3 Adding News Shocks

3.3.1 News Shocks

Since I want to explore whether news shocks on TFP affect business cycles, I provide a short description of the news shocks. The shocks to each economy in each period are considered to have an anticipated component and an unanticipated component. The news shocks, also known as anticipated shocks, are news that the households received in the previous periods that is going to affect their expectations for the current period (or future periods), therefore, changing their consumption, leisure and labor supply decisions. Since in this paper, we look at the news shocks on TFP, we only consider the change to the stochastic process of TFP from the news. Using the logic above, news shocks on TFP are going to change households' expectations on TFP for current or future periods. This will change their decision on consumption choices, or labor supply, and thus create fluctuations.

The anticipated shocks from previous periods are going to get materialized in the current period; however, the effect from the anticipated shock may not be observable as we take into account the unanticipated shocks to the current period. In other words, news shocks are not secured to really happen—their effect on the actual economy may be cancelled out by the unanticipated shocks.

We also assume that for each period, the agents in the economy get to know news that are going to be realized at most 4 periods in the future (assuming quarterly data, 4 periods will mean one year ahead).

The news shock process (z_t^i for country i) to technology takes the form as follows:

$$z_t^A = (1 - \rho_A) z_{ss} + \rho_A z_{t_1}^A + \mu_{z,t}^A \tag{9}$$

$$z_t^B = (1 - \rho_B) z_{ss} + \rho_B z_{t_1}^B + \mu_{z,t}^B \tag{10}$$

where

$$\mu^i_{z,t} = \epsilon^{0,i}_{z,t} + \epsilon^{1,i}_{z,t-1} + \epsilon^{2,i}_{z,t-2} + \epsilon^{3,i}_{z,t-3} + \epsilon^{4,i}_{z,t-4}, \qquad i = A, B \tag{11}$$

$\mu_{z,t}$ represents the innovations of country i, and z_{ss} stands for the stead state TFP value. $\epsilon^{j,i}_{z,t}, j = 0, 1, 2, ...$ denotes j-period anticipated changes in the level of z_t for country i. For a specific country i, following Schmitt-Grohe and Uribe (2008), $\epsilon^2_{z,t-2}$ is the period $t-2$ information set that gets materialized in z_t only in period t; in other words, $\epsilon^2_{z,t-2}$ denotes a 2-period anticipated shock in z_t.

With this new property, μ_t no longer has a mean of 0, and $E_t\mu_{t+1}$ is no longer 0. In other words, the agents in this economy model have more information than just having the current and past values of μ_t: they can observe the TFP news $\epsilon^0_{z,t}, \epsilon^1_{z,t}, \epsilon^2_{z,t}, \epsilon^3_{z,t}$ and $\epsilon^4_{z,t}$ in period t. Therefore, the agents in the economy could forecast future values of μ_t:

$$\begin{aligned}
E_t\mu_{t+1} &= \epsilon^1_{z,t} + \epsilon^2_{z,t-1} + \epsilon^3_{z,t-2} + \epsilon^4_{z,t-3} \\
E_t\mu_{t+2} &= \epsilon^2_{z,t} + \epsilon^3_{z,t-1} + \epsilon^4_{z,t-2} \\
E_t\mu_{t+3} &= \epsilon^3_{z,t} + \epsilon^4_{z,t-1} \\
E_t\mu_{t+4} &= \epsilon^4_{z,t} \\
E_t\mu_{t+m} &= 0; \qquad m \geq 5
\end{aligned}$$

3.3.2 News Shocks with Two Countries

Since the topic for this paper is the transmission of international business cycles under news shocks, we want to somehow form a connection on shocks between the two countries in our model.

Traditionally, we would assume the technology shock process takes on a bivariate autoregression:

$$\boldsymbol{\lambda}_{t+1} = \boldsymbol{A}\boldsymbol{\lambda}_t + \boldsymbol{\epsilon}_{t+1}$$

where λ stands for TFP and $\boldsymbol{\lambda_{t+1}}$ is known by the agents. $\boldsymbol{A}$ is the coefficient matrix where the off-diagonal elements are spillovers. The innovations $\boldsymbol{\epsilon}_t$, which are "serially independent multivariate normal random variables" (Backus, Kehoe and Kydland, 1992), have covariance matrix $\boldsymbol{V}$. This covariance matrix includes contemporaneous correlation between the two countries' innovations. In other words, we can see that there exists a correlation between the two innovations' standard deviations. In this case, the innovation matrix $\boldsymbol{\epsilon}_t$ takes the form:

$$\begin{bmatrix} \varphi_t \\ \nu_t \end{bmatrix} = \begin{bmatrix} \sigma_\varphi^2 & \psi\sigma_\varphi\sigma_\nu \\ \psi\sigma_\varphi\sigma_\nu & \sigma_\nu^2 \end{bmatrix}$$

where φ_t and ν_t represents the innovations for the two countries, respectively. The two off-diagonal entries represent the co-variance. The coefficient ψ is the degree of the effect from the co-variant shocks on the domestic economy. It can be seen that by construction, this makes the shocks to innovations on one country coming from within and from the shocks of another country.

With the news shocks added, it is impossible to use the innovations matrix $\boldsymbol{\epsilon}_t$ expression as the innovations are not simply the current period's error term. However, at the same time, we need to keep the connections between the two countries as the channel for international business cycle transmission.

What I did was that I assumed the news shocks or the anticipated news from country A is going to affect the innovations in country B. In other words, people in country B learned the news on TFP of country A (i.e. TFP shocks)—they are going to change their behavior, which will lead to changes in country B's innovations. This implies the simplest modification on the news shock innovations expression from equation (10):

$$\mu^A_{z,t} = \epsilon^{0,A}_{z,t} + \epsilon^{1,A}_{z,t-1} + \epsilon^{2,A}_{z,t-2} + \epsilon^{3,A}_{z,t-3} + \epsilon^{4,A}_{z,t-4} + \epsilon^{1,B}_{z,t-1} + \epsilon^{2,B}_{z,t-2} + \epsilon^{3,B}_{z,t-3} + \epsilon^{4,B}_{z,t-4} \tag{12}$$

$$\mu^B_{z,t} = \epsilon^{0,B}_{z,t} + \epsilon^{1,B}_{z,t-1} + \epsilon^{2,B}_{z,t-2} + \epsilon^{3,B}_{z,t-3} + \epsilon^{4,B}_{z,t-4} + \epsilon^{1,A}_{z,t-1} + \epsilon^{2,A}_{z,t-2} + \epsilon^{3,A}_{z,t-3} + \epsilon^{4,A}_{z,t-4} \tag{13}$$

Equations (11) and (12) thus give us the expression of news shocks we are going to use for the estimation section, but first we look at the first order conditions.

3.3.3 First Order Conditions of the Economy

Since the representative household and firm are the same for both countries, this part follows the above one country sample economy.

The associated Lagrangian for the social planner problem is

$$\begin{aligned}\mathcal{L} =& E_0 \sum_{t=0}^{\infty} \beta^t [\frac{(C_t - \psi(1-l_t)^\theta)^{1-\sigma} - 1}{1-\sigma} + \lambda_t(z_t K_t^{1-\alpha} h_t^\alpha - C_t - I_t) \\ & + \eta_t((1-\delta)K_t + I_t - K_{t+1}) + \phi_t(1 - h_t - l_t)]\end{aligned}$$

where λ, η and ϕ are non-negative multipliers. Thus, the first order conditions are:

$$\begin{aligned}
C_t &: [C_t - \psi(1-l_t)^{\theta}]^{-\sigma} - \lambda_t = 0 \\
l_t &: [C_t - \psi(1-l_t)^{\theta}]^{-\sigma}(-\psi\theta)(1-l_t)^{\theta-1}(-1) - \phi_t = 0 \\
h_t &: \alpha\lambda_t z_t K_t^{1-\alpha} h_t^{\alpha-1} - \phi_t = 0 \\
I_t &: -\lambda_t + \eta_t = 0 \\
K_{t+1} &: -\eta_t + \beta E_t[(1-\alpha)\lambda_{t+1} z_{t+1} K_{t+1}^{-\alpha} h_{t+1}^{\alpha} + \eta_{t+1}(1-\delta)] = 0 \\
\lambda_t &: z_t K_t^{1-\alpha} h_t^{\alpha} - C_t - I_t] = 0 \\
\eta_t &: [(1-\delta)K_t + I_t - K_{t+1}] = 0 \\
\phi_t &: 1 - h_t - l_t = 0
\end{aligned}$$

along with the stochastic process

$$z_t = (1-\rho) + \rho z_{t-1} + \mu_t$$

where μ_t takes on the form of news shock for country A and B

$$\begin{aligned}
\mu_t^A &= \epsilon_{z,t}^{0,A} + \epsilon_{z,t-1}^{1,A} + \epsilon_{z,t-2}^{2,A} + \epsilon_{z,t-3}^{3,A} + \epsilon_{z,t-4}^{4,A} + \epsilon_{z,t-1}^{1,B} + \epsilon_{z,t-2}^{2,B} + \epsilon_{z,t-3}^{3,B} + \epsilon_{z,t-4}^{4,B} \\
\mu_t^B &= \epsilon_{z,t}^{0,B} + \epsilon_{z,t-1}^{1,B} + \epsilon_{z,t-2}^{2,B} + \epsilon_{z,t-3}^{3,B} + \epsilon_{z,t-4}^{4,B} + \epsilon_{z,t-1}^{1,A} + \epsilon_{z,t-2}^{2,A} + \epsilon_{z,t-3}^{3,A} + \epsilon_{z,t-4}^{4,A}
\end{aligned}$$

It is also important to keep in mind that the expected values of these anticipated shocks are all zeros as they all materialized in the current period.

Let $Y_t = z_t K_t^{1-\alpha} h_t^{\alpha}$ and $\Omega_t = C_t - \psi(1-l_t)^{\theta}$, the intratemporal condition of the economy is

$$\psi\theta(1-l_t)^{\theta-1} = \alpha Y_t h_t^{-1} \tag{14}$$

and intertemporal

$$\Omega_t^{-\sigma} = \beta E_t \Omega_{t+1}^{-\sigma}[(1-\alpha)z_{t+1}K_{t+1}^{\alpha}h_{t+1}^{\alpha} + (1-\delta)] \tag{15}$$

The corresponding log-linearization equations can be found in the Appendix.

4 Estimation Results

To test the effects of news shocks on business cycles transmissions, I chose the country pair of the U.S. and Mexico from 1950 to 2010. Since this paper is only the first step to test the effect of news shocks on international business cycle transmission, I did not incorporate the trade effects, interest rates, or other frictions in the estimation model.

Since quarterly per capita data are not available for Mexico, I used the annual data instead. This also implies a minor modification to our news shock equations: in our model, I assumed quarterly GDP data, which makes 4 periods of anticipated news shocks reasonable. With annual data, I adjusted to a simple, 1 period of anticipated news shock (implying that agents are only going to receive news at most for one year ahead in the current period).

I have implemented the log-linearized version of the model, (where calculation process can be found in the appendix,) which means that all observables are in percent deviations from steady state. The observables used in the estimations are percent deviations of real GDP per capita, corresponding consumption ratio, and per capita total hours worked ratio. All of them are accompanied by measurement error terms.

Although the standard model presumed a mutual effect from news shocks, my particular country choice led me to think that the news shocks on Mexican economy are not going to affect the U.S. consumers' behavior. Therefore, for this paper, the effect of news shocks only took on one direction as from the U.S. to Mexico, where

$$z_t^{US} = (1 - \rho^{US}) + \rho^{US} z_{t-1}^{US} + \mu_t^{US}$$

with

$$\mu_t^{US} = \epsilon_{z,t}^{0,US} + \epsilon_{z,t-1}^{1,US}$$

and

$$z_t^{MEX} = (1 - \rho^{MEX}) + \rho^{MEX} z_{t-1}^{MEX} + \mu_t^{MEX}$$

with

$$\mu_t^{MEX} = \epsilon_{z,t}^{0,MEX} + \epsilon_{z,t-1}^{1,MEX} + \epsilon_{z,t-1}^{1,US}$$

For estimation results, I ran 500,000 repetitions with 3 chains. Parameters such as α, β followed the majority of studies where α is set to be 0.64 and $\beta = 0.99$. Then the first pair of parameters was the depreciation rates. I kept the annual depreciation rate of capital in the U.S. to be 8% with standard deviation of 2% under a beta distribution. I also assumed that the Mexican capital depreciation rate is higher, which I set with an annual rate of 12%, 2% standard deviation under a beta distribution. The persistence of TFP, namely ρ, took on values of 0.95 for the U.S. and 0.90 for Mexico. For the other two pairs of parameters, ψ and θ, I followed the paper by Jaimovich and Rebelo (2009), so I set both $\psi = 5.1755$ and both $\theta = 1.4$. The two σ are set to be 1.0001 to correspond to near logarithmic utility.

The posterior mean for the depreciation rates came out to be 6.9% and 8.67%, respectively. The persistence of TFP for the US and Mexico has posterior mean of 0.438 and 0.496, respectively. Both values are much lower than my priors. The estimated values of ψ are very close to the calibrated value from Jaimovich—Rebelo (2009), which came out to be 5.184 and 5.172. On the other hands, the posterior means of two θs are much larger, with the U.S. to be 4.048 and Mexico to be 4.083.

For the news shocks part, I obtained posterior estimations for the unanticipated shocks: for the U.S., the standard deviation of the unanticipated shocks is 1.64% while that of Mexico is a little bit higher, 1.91%. The anticipated shocks for one-year forward have higher standard deviations. For the US, the standard deviation of news shocks for the next year is 3.3%. For Mexico, the shocks are expected to be of higher magnitude. The estimation results show that one-year ahead, news shocks have standard deviation of 3.63%, a slightly higher value than the U.S.. Overall, the shock sizes of Mexico are consistently higher than the U.S., although by a very small amount. The prior and posterior of all parameters can be found in the table 1 below.

Table 1: Posterior Distribution, model with news

	Prior			Posterior	
Parameter	Distrib.	Mean	SD	Mean	Conf.Interval
δ1	Beta	0.08	0.02	0.069	[0.0432,0.0948]
δ2	Beta	0.1	0.02	0.0866	[0.0597,0.1119]
ρ1	Beta	0.9	0.2	0.4382	[0.1372,0.7241]
ρ2	Beta	0.8	0.2	0.4964	[0.2877,0.7149]
ψ1	Gamma	5.1755	1	5.1838	[3.5118,6.8219]
ψ2	Gamma	5.1755	1	5.172	[3.5478,6.8387]
θ1	Gamma	1.4	0.3	4.0484	[3.8492,4.2193]
θ2	Gamma	1.4	0.3	4.0826	[3.9143,4.2193]
ε_us0	Inverse_Gamma	0.04	0.02	0.0164	[0.0127,0.0200]
ε_mx0	Inverse_Gamma	0.04	0.02	0.0191	[0.0143,0.0240]
ε_us1	Inverse_Gamma	0.08	0.02	0.033	[0.0286,0.0365]
ε_mx1	Inverse_Gamma	0.08	0.02	0.0363	[0.0306,0.0417]

Notes: SD = Standard Deviation, Beta = the parameter takes on a beta distribution prior, ε_us0 = the unanticipated shock to the U.S. in the current period, ε_us1 = the anticipated shock to the U.S. one-period forward.

The alternative model, which does not include news, took the classical bivariate covariance matrix from Backus et al. (1992), where I set the correlation term of the two shocks to be a uniform distribution between -1 and 1.

5 Model Comparison

Here I compare the models with and without news to the real world data. First, it is important to understand how the aggregate variables react to news shocks graphically. First I present the impulse-response functions from data simulation on news shocks model. For convenience, the variables from the U.S. are labeled "1"s and those from Mexico are labeled "2"s in the graphs. Moreover, k, c, h, y, x, z, l stand for capital, consumption, hours worked, output, investment, TFP, and leisure, respectively. By model construction, the U.S. and Mexico are treated in the same way, which lead to the same level of deviation quantitatively.

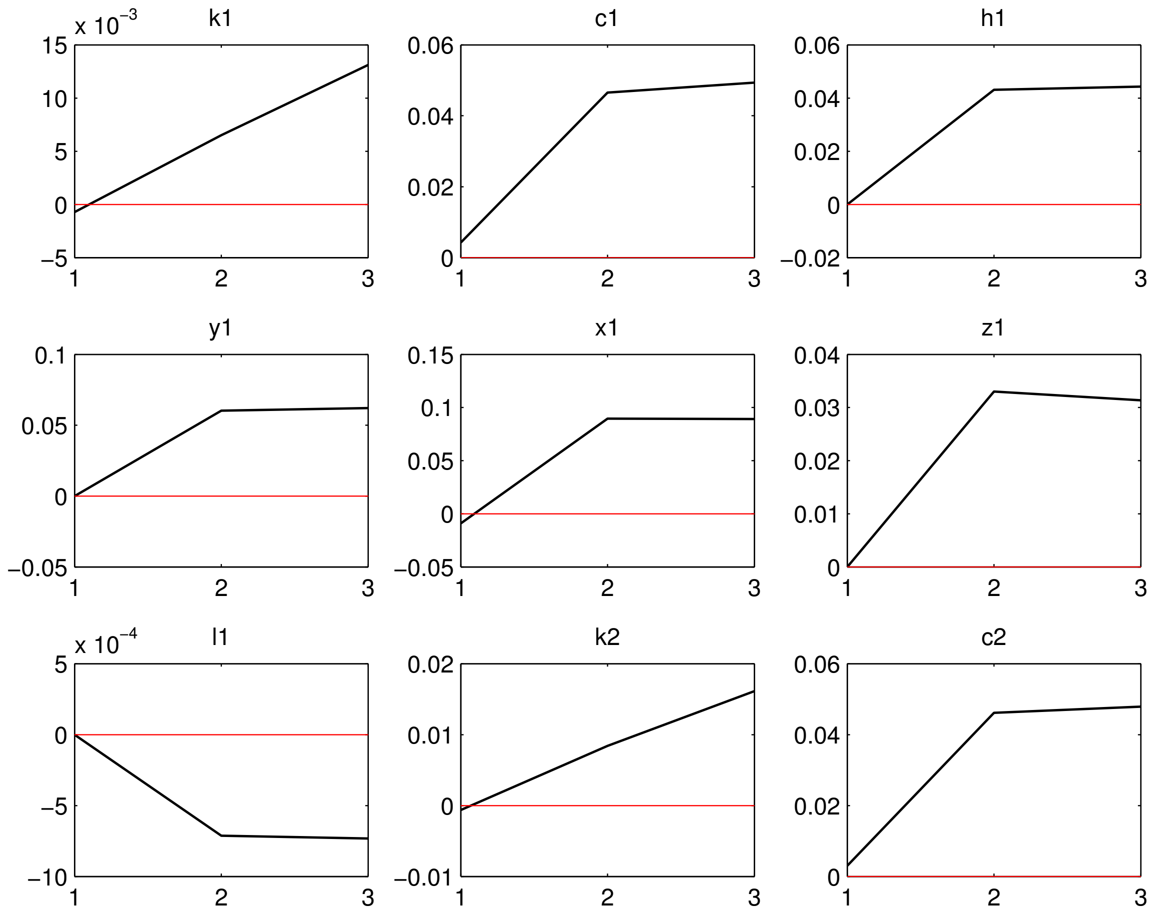

Figure 1: Anticipated Shock to U.S. TFP.

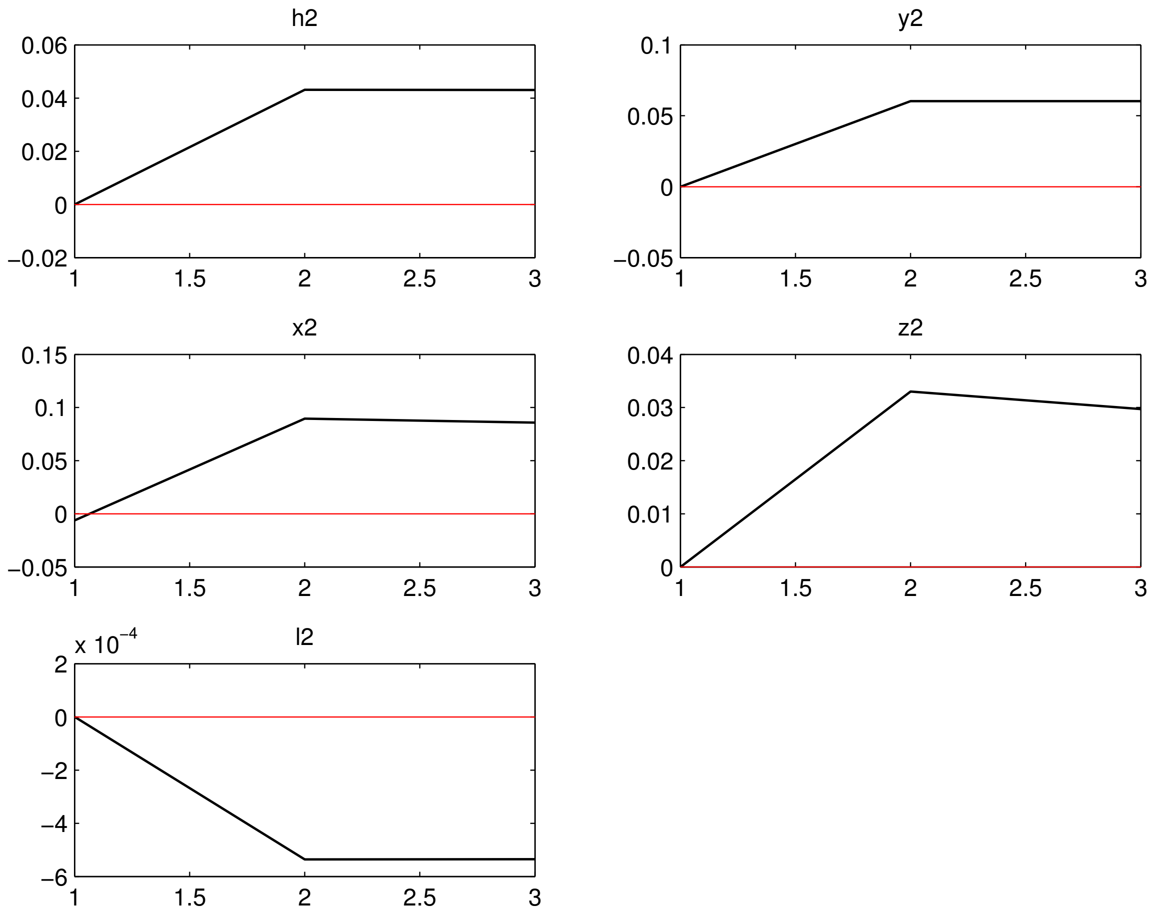

Figure 2: Continued: Anticipated Shock to U.S. TFP.

For a positive one-standard deviation one-period forward TFP news shock in the U.S., we can see from figures 1 and 2 that fundamentals across countries do not change in period one. However, capital in both countries drops by 0.1% while consumption increases by around 0.5% in period 1. This explains what news does to an economy—when people learn about positive TFP coming in the next period (period 2), even when fundamentals as TFP do not change in this period, they are still going to consume more and save less, which results in the drop of capital.

In the next period, period 2, the one-period forward news gets materialized. Thus, we see the fundamentals change, such as the increase in TFP in the U.S.. All variables are procyclical, except for leisure in both countries. All variables essentially carry quantitatively the same level of deviation from steady state. The fact that variable pairs (consumption pair, hours pair, etc.) move in the same direction in both the U.S. and Mexico reflects the business cycle transmissions part of my model.

It is then crucial to see if quantitatively, adding news shocks explain the business cycle transmissions. If we do assume business cycle transmissions exist, there should be significant correlations of variables between the U.S. and Mexico, which implies comovements. The results are summarized in the table below.

Table 2: Correlation Comparison between Models

variables	real world	news	covariance
Y1Y2	0.2283	0.8599	0.9361
C1C2	0.1459	0.8877	0.9481
H1H2	0.3973	0.8599	0.9361
X1X2	0.2993	0.8176	0.9116

Notes: Y1Y2 stands for correlation between the two output; C1C2 stands for the correlation between consumption; H1H2 stands for correlation between hours worked; X1X2 stands for the correlation between investment

Based on Table 2, we can see that the model with news shocks added outperformed the one using simple covariance matrix model in all variables pairs. Both models overestimate the comovements between variables, at least for the U.S.—Mexico pair. The prediction on correlation between output in the news shock model is about 3.77 times larger than the empirical correlation; however, this is closer to the empirical data than the model without news added, whose prediction is 4.1 times larger. The news shock model predictions on consumption variable pair and hours worked variable pair are also closer to the empirical data. It predicts a 0.888 correlation between the U.S. and Mexico on consumption, which is 6 times larger than the data, compared to the 0.948 correlation, 6.5 times larger prediction from the no news model. The empirical data further shows a 0.397 correlation between the two countries' total hours worked, the news model predicts a 0.860 correlation, still lower than the 0.936 correlation from no news model. Investment results are also consistent with the other ones. The news model prediction of 0.818 correlation is 2.73 times higher than empirical data; nonetheless, it is better than the no news model, which shows a correlation of 0.912. Overall, it seems that the biggest discrepancy between my model and the data is on consumption; nevertheless, the correlation signs are consistent across models.

Although the model is consistently overestimating the comovements of variables between the country pair, the news shock model does perform better. This means that even under a standard RBC model framework with no frictions, adding news shocks to understand international business cycle transmissions worths more researching.

6 Conclusion

In this paper, I have looked at how news shocks effect international business cycle transmissions. With a standard RBC model framework but with GHH preference and expanded to two countries, I was able to compare it to the co-variance matrix model introduced by Backus et al. (1992). Both models overestimated the correlations of aggregate variables by a large amount. However, both models' results are consistent in sign with empirical facts and the model with news outperformed in all four variable comovement correlations.

The model I used here is a standard real business cycle model with GHH preferences, as indicated by news shocks related literature (Schmitt-Grohé and Uribe 2012, Jaimovich and Rebelo 2009). However, given the scope of this paper, I did not include any frictions and did not expand the experiment to other country pairs. Since the model with news performed better, it is worth further pursuing through, for example, adding news shocks on growth or adding a government sector.

Another step could be to look for adding trade relations, based on recent literature. In other words, future research can add a trade element to consumption rule so that households from country A also consume goods from country B. In this way, we can test the effect of news shocks from a trade perspective, which could be more precise.

In general, the results from this paper are not conclusive, although I have shown that the news shock model is better than the simple co-variance matrix in explaining international business cycle transmissions.

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A Appendix

A.1 Steady State and Log-Linearization

Steady state of the model:

$$
\begin{aligned}
Y &= \frac{1-\beta(1-\delta)}{\beta(1-\alpha)}K \equiv \omega_y K \\
K &= \left(\frac{\alpha \omega_y^{\frac{\alpha-\theta}{\alpha}}}{\psi\theta}\right)^{\frac{1}{\theta-1}} \\
h &= \omega_y^{\frac{1}{\alpha}} K \\
l &= 1-h \\
I &= \delta K \\
C &= (\omega_y - \delta)K \\
\Omega &= C - \psi(1-l)^{\theta}
\end{aligned}
$$

along with the stochastic process.

Log-Linearization of the model:

$$
\begin{aligned}
\hat{y}_t &= \hat{z}_t + (1-\alpha)\hat{K}_t + \alpha\hat{h}_t \\
\Omega\hat{\Omega}_t &= C\hat{C}_t + \psi\theta h^{\theta-1} l\hat{l}_t \\
(1-\theta)l\hat{l}_t &= h\hat{y}_t - h\hat{h}_t \\
\sigma\hat{\Omega}_t &= \sigma E_t\hat{\Omega}_{t+1} - \beta(1-\alpha)YK^{-1}E_t\hat{Y}_{t+1} + \beta(1-\alpha)YK^{-1}\hat{K}_{t+1} \\
0 &= h\hat{h}_t + l\hat{l}_t \\
y\hat{y}_t &= C\hat{C}_t + I\hat{I}_t \\
\delta\hat{I}_t &= \hat{K}_{t+1} - (1-\delta)\hat{K}_t
\end{aligned}
$$

along with the stochastic process of TFP.

A.2 Data Appendix

In this appendix, we explain in detail the data and methodology applied to obtain the observables used for our estimation.

A.2.1 Output Observables

The output observables are real GDP per capita data as ”PPP Converted GDP Per Capita (Laspeyres), at 2005 constant prices” from Penn World Table 7.1. The first problem I face is that the data contain a trend, so I detrend the data to match my model. Since I used the log-linearization version, my observables should match the form as percent deviations from trend. So I created a time series from 1950 to 2010 ($T = 1, 2, ..., 61$), and regressed the logged GDP data against time. Taken into consideration that the depression in 1980s in Mexico, a linear detrending process may not be sufficient. Thus, I also included quadratic and cubic terms for time variable in the regression. The regression for both countries' output took the form:

$$ln(GDP_i) = \alpha_0 + \beta_1 time + \beta_2 time^2 + \beta_3 time^3$$

A.2.2 Consumption and Hours Worked Observables

Consumption data also came from Penn World Table 7.1. However, given the raw data are the ratio of consumption to output, and output includes government sector and net exports, I reconstruct the data to match model where $Y_t = I_t + C_t$, by first finding the sum of consumption and investment calculated based on the raw data, then re-calculating consumption and investment ratios under the revised GDP form.

The annual per capita hours worked raw data come from The Conference Board's Total Economy Database. Based on model construction where $h_t + l_t = 1$, I changed the hours worked to a ratio of hours to total working time available. The measurement of annual total working time available is 5200 hours ($= 52 * 100$).

Since both consumption and hours worked are already in percent terms, I regressed the data directly. Similarly to GDP observables, the residuals were percent deviations from trend and thus observables used in this paper. I chose the combinations of time variables on the right hand side based on regression results. For regressions where all variables were statistically significant, I chose the ones with the lowest mean square errors (MSE). The regressions for consumption and hours worked took the form:

$$consumption_{US} = \alpha_0 + \beta_2 time^2$$

$$hours_{US} = \alpha_0 + \beta_1 time + \beta_3 time^3$$

$$consumption_{MEX} = \alpha_0 + \beta_1 time + \beta_2 time^2 + \beta_3 time^3$$

$$hours_{MEX} = \alpha_0 + \beta_1 time + \beta_2 time^2$$

When doing model comparisons, I used the same procedures as above to find the percent deviation of investment and consumption with the logged value, instead of using a ratio to output.