



# Can structural small open-economy models account for the influence of foreign disturbances? ☆

Alejandro Justiniano <sup>a,\*</sup>, Bruce Preston <sup>b,c</sup>

<sup>a</sup> Federal Reserve Bank of Chicago, Research Department, 230 South La Salle St., Chicago, IL 60604, United States

<sup>b</sup> Department of Economics, Columbia University, 420 West 118th St, New York NY 10027, United States

<sup>c</sup> CAMA, Australian National University, Australia

## ARTICLE INFO

### Article history:

Received 17 October 2006

Received in revised form 4 December 2009

Accepted 9 December 2009

### Keywords:

Small open economy models

International comovement

Structural estimation

Bayesian analysis

Exchange rate disconnect

## ABSTRACT

This paper demonstrates that an estimated, structural, small open-economy model of the Canadian economy cannot account for the substantial influence of foreign-sourced disturbances identified in numerous reduced-form studies. The benchmark model assumes uncorrelated shocks across countries and implies that U.S. shocks account for less than 3% of the variability observed in several Canadian series, at all forecast horizons. Accordingly, model-implied cross-correlation functions between Canada and U.S. are essentially zero. Both findings are at odds with the data. A specification that assumes correlated cross-country shocks partially resolves this discrepancy, but still falls well short of matching reduced-form evidence. One central difficulty resides in the model's inability to account for comovement without generating counterfactual implications for the real exchange rate, the terms of trade and Canadian inflation.

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## 1. Introduction

This paper investigates whether an estimated microfounded semi-small open-economy model can reproduce the observed comovement in international business cycles. Focusing on Canada as the semi-small open economy, the starting point for the analysis is the large body of empirical work that identifies a significant influence of U.S. shocks on Canadian economic fluctuations.

There has been ample theoretical work seeking to replicate the observed comovement in economic activity across countries. Until recently, the empirical validation of these models largely relied on calibrations aimed at matching selected moments in the data—see the contributions of Backus et al. (1992, 1995), Stockman and Tesar (1995) and Baxter (1995) for a review. The new open-economy macroeconomics (NOEM) has since produced significant theoretical advancements in international macroeconomic modeling. Given the empirical success of closed-economy models built on similar foundations, it is not surprising that there is a growing literature estimating NOEM models. These include amongst others: Ambler et al. (2004), Bergin (2003, in press), Del Negro (unpublished), Ghironi (2000), Justiniano and Preston (2008b), Lubik and Schorfheide (2005, 2007), Lubik and Teo (in press) and Rabanal and Tuesta (unpublished).

To our knowledge, the ability of these NOEM models to explain the observed comovement in economic fluctuations has not been

previously systematically analyzed in this empirical literature. This paper fills this gap by evaluating a workhorse semi-small NOEM model in this particular dimension. The focal point is the model's ability to replicate the fraction of the variance in Canadian macroeconomic series attributed to U.S. shocks. We also contrast the cross-country correlation functions in the model and data, particularly for output.

The analysis is pursued using generalizations of the semi-small open-economy framework proposed by Gali and Monacelli (2005).<sup>1</sup> Following Monacelli (2005), we allow for deviations from the law of one price. In addition, we consider incomplete asset markets, a large set of disturbances, and incorporate other real and nominal rigidities (e.g., wage stickiness, indexation and habits) which have been found crucial in fitting closed-economy models as documented by Christiano et al. (2005) and Smets and Wouters (2007).

The model is estimated using Bayesian methods with data for Canada and the United States. Our baseline specification assumes that shocks across these two countries are independent. This contrasts with much of the international real business cycle literature which often assumes correlated cross-country technology shocks, but is consistent with all of the empirical NOEM studies cited above.<sup>2</sup> Under

<sup>1</sup> The model is technically a semi-small open-economy model, where domestic goods producers have some market power, but we shall nonetheless refer to it as a small open economy. Note also that our analysis appeals to an earlier interpretation in Gali and Monacelli (2005) of a small-large country pair, rather than as an analysis of a continuum of small open economies.

<sup>2</sup> For example, Gali and Monacelli (2005) consider the role of technology spillovers in their calibration study. But likelihood-based empirical studies have typically excluded this possibility.

☆ First version: 2005.

\* Corresponding author.

E-mail addresses: [ajustiniano@frbchi.org](mailto:ajustiniano@frbchi.org) (A. Justiniano), [bp2121@columbia.edu](mailto:bp2121@columbia.edu) (B. Preston).

independent shocks, the channels of transmission embedded in the model (e.g. risk sharing and expenditure switching effects) must account for the cross-country comovement in aggregate fluctuations.

The main contribution of this paper is to document that the baseline specification fails to account for the influence of foreign shocks. A structural variance decomposition reveals that all U.S. shocks combined cannot explain more than 3% of the variability in Canadian output, interest rates or inflation. Furthermore, model-implied cross-correlation functions between these two countries are estimated to be essentially zero. Both findings are in stark contrast with reduced-form empirical evidence in the same data. These results are shown to be robust across alternative specifications, priors and detrending methods.

Model parameters chosen based on previous calibrated studies can deliver both large shares of domestic variance being attributed to U.S. shocks and substantial cross-country correlation in some series. Therefore, our findings indicate that the inability to reproduce some international correlations—known as the quantity anomaly in the case of output (see Baxter and Crucini, 1995)—is exacerbated in estimated models. The results also suggest the need to be cautious in assuming that the empirical success of closed economy models built on similar microfoundations will readily translate to an open economy setting.

A second contribution of this paper is to document that the international comovement problem can only be partially resolved by introducing disturbances that are correlated across countries. To do this, each Canadian structural shock is written as the sum of two orthogonal components: a disturbance common to the same type of shock in the U.S. block, and a country-specific disturbance. This decomposition can be viewed as a rough approximation to reduced-form dynamic factor models that have been used for business cycle analysis.<sup>3</sup>

When all U.S. shocks are common to the domestic block the DSGE model gets closer to matching the reduced-form variance decomposition. However, there are at least three reasons for not viewing this specification as a panacea for the model's inability to replicate the observed influence of foreign disturbances. First, at medium to long horizons the fraction of output variation explained by U.S. disturbances is still below the reduced-form evidence. Second, this specification engenders an extreme version of the exchange rate disconnect puzzle—see Devereux and Engel (2002). Third, some of the induced correlations are difficult to rationalize on structural grounds.

A third contribution of our analysis is to elucidate reasons for the model's failure in this crucial dimension. The inability to match the comovement in the data gets reflected in cross-correlation amongst supposedly orthogonal innovations in our baseline model. These correlations point to a complex pattern of covariation, beyond pairing the same type of disturbance across countries, explaining the limited success of the common shocks models. More promising guidance for future research is given by the observation that while U.S. shocks can a priori match some bivariate cross-country correlations, they also have strong counterfactual predictions, particularly involving the real exchange rate, the terms of trade and domestic inflation. This tension helps understand, at least in part, why the estimated model shuts down international linkages and indicates ample scope to improve the transmission mechanism of foreign disturbances in this class of models.

This paper broadly relates to the international business cycle literature and recent empirical work with NOEM models. More closely related is Adolfson et al. (2007) who present a state-of-the-art model, more richly specified than the one considered here. While their model performs very well in several dimensions, an earlier version, Adolfson et al. (2005), reported variance decompositions revealing little transmission of foreign-sourced disturbances from the European

Union to Sweden—a property that is not remarked upon. Similar observations apply to an extension of this framework by Christiano et al. (in press), and de Walque et al. (in press) in a two-country model for the U.S. and the Euro Area. We also build on Schmitt-Grohe (1998) who evaluates whether a calibrated small open-economy real business cycle model can replicate impulse responses to a single foreign output shock, extracted from a bivariate U.S.–Canada vector autoregression.<sup>4</sup> Our results suggest that in estimation the failure to capture international linkages may be worse than when the model is calibrated.

## 2. Evidence on international linkages

A central empirical regularity that international business cycle models seek to explain is the observed cross-country comovement amongst economic variables. This section documents a number of statistics suggesting that comovement is a salient feature of U.S. and Canadian business cycles, understanding that earlier literature testifies to the generality of these insights in other economies. This close link is not surprising considering the U.S. accounts for 75% of Canada's average trade share.<sup>5</sup>

### 2.1. Data

We use data for twelve series that in Section 4 constitute the observable series in the estimated DSGE model. These are: real per-capita output, inflation, nominal interest rates, real wages and hours in both the U.S. and Canada, as well as the bilateral terms of trade and the real exchange rate. Details of the data are in Appendix A. Consistent with the model presented later, output and real wages are expressed in log deviations from a common linear trend. The real exchange rate and the terms of trade are given in log differences. Section 6 evidences the robustness of our results to alternative detrending of these series. Inflation and interest rates are expressed as percentages and, like hours, are not transformed, except that all series are demeaned. The sample runs from 1982q1 to 2007q1, although the first 8 quarters are used to initialize the Kalman filter.

### 2.2. Reduced-form evidence

The solid black lines in Fig. 1 give the sample cross-correlations between Canadian and lagged U.S. series, at lags zero through four. The remaining lines correspond to the estimated DSGE model and are discussed in Section 4. For presentation purposes only we exclude these statistics for the terms of trade and the real exchange rate but discuss them later on.

For many series these cross-correlations are large at various lags and rarely equal to zero. For example, the contemporaneous correlations between Canadian and U.S. output, inflation, nominal interest rates and wages are: 0.69, 0.45, 0.83 and 0.72, respectively. This is consistent with earlier studies on international comovement, such as Backus et al. (1992), Stockman and Tesar (1995) and Ambler et al. (2004).

We rely on two statistical models to compute the variance share of these Canadian series that is attributable to U.S. shocks. The first model is a VAR subject to the exclusion restriction of no feedback from Canada to the U.S. that is embedded in the DSGE model. It is formally a seemingly unrelated regression (SUR). Variance decompositions are

<sup>4</sup> Schmitt-Grohe (1998) concludes that financial and trade linkages are not capable of reproducing the strong response of Canadian hours, output and investment to innovations in U.S. GNP. She suggests that these difficulties might be alleviated by the introduction of sticky prices. Our analysis reveals that the inability to capture the influence of foreign shocks persists in an estimated model even when various nominal rigidities are considered.

<sup>5</sup> In our sample, 1/2 the share of U.S. imports in total Canadian imports plus 1/2 the share of total Canadian exports oriented to the U.S. equals 75.1%.

<sup>3</sup> In a closed-economy setting, Boivin and Giannoni (2006) establish a formal link between DSGE and dynamic factor models.

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