What's News in International Business Cycles

Daniele Siena *

Banque de France

Preliminary Draft

15 February 2017

Abstract

The role of news shocks in international business cycles is first evaluated using a structural factor-augmented VAR model (FAVAR). An *international* FAVAR model is shown to be necessary to recover the correct news shocks in open economies, except the US, without incurring in the 'non-fundamentalness' problem. Then, a standard two-country, two-good real business cycle model, featuring news shocks, investment adjustment costs and variable wealth elasticity of the labor supply is used to match and explain the empirical evidence. News shocks are only marginal drivers of international business cycles synchronization.

Keywords: Factor-augmented VAR, News Shocks, International Business Cycles, Fundamentalness

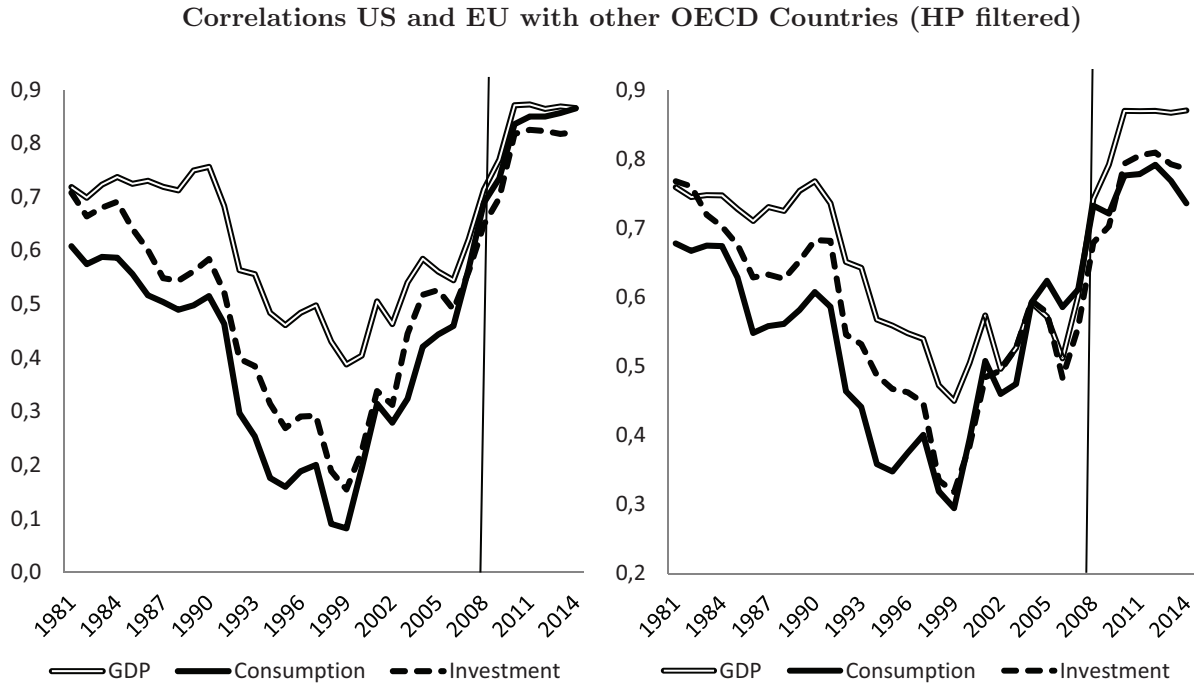
JEL Classification: C32 F41 F44

*Banque de France, 49-1374 DERIE-SEMSI, 31, rue Croix des Petits Champs, 75049 Paris cedex 01, France. E-mail: daniele.siena@banque-france.fr. Phone: +33142922666.

I especially thank Tommaso Monacelli for very valuable discussions and suggestions. Also, I would like to thank Paul Beaudry, Ambrogio Cesa-Bianchi, Simona Delle Chiaie, Filippo Ferroni, Franck Portier, Luca Sala, Martin Uribe and seminar participants at Bocconi University, the BdF-FJJ workshop, the 11th Dynare Conference and the BdF-IRBC conference for valuable insights. All remaining errors are mine. The views expressed in this paper are those of the author alone and do not reflect those of the Banque de France.

1 Introduction

Until the end of the nineties international real business cycles (IRBC) strongly de-synchronized (Heathcote and Perri, 2003). Since the 2000's IRBC started to persistently re-synchronize (Figure 1).[1] This paper investigates the role of news shocks, i.e. certain changes in today's expectation of future fundamentals, as an IRBC synchronizing force by identifying internationally *fundamental* news shocks and estimating their cross-border spillovers. Results are rationalized using a standard two-country general equilibrium model.



(a) USA (b) EU

Figure 1: Output, consumption and investment international correlations for a rolling window from 1963:1-1981:1 to 1994:1-2014:4 between US or EU and the rest of the industrialized countries. The x-axis identifies the the last year of the 17 years rolling window. The methodology follow Heathcote and Perri (2003)

In a world where financial markets are internationally integrated, news shocks can be an important source of economic synchronization.[2] As shown by Beaudry and Portier (2006), news shocks, by affecting the values of financial assets, generate immediate effects in the

[1]The international correlation of GDP, consumption and investment have increased starting in 1999 and reached levels above the maximum registered in the eighties, peaking after the Great Recession.

[2]Throughout the paper we define news shocks as *certain* changes in today's expectation of future productivity fluctuations.

economy before actual changes in business cycle drivers. Therefore also internationally, in a world in which agents have access to complete set of domestic and international Arrow-Debreau securities, news shocks can contemporaneously and equally influence economies across borders (Beaudry *et al.* (2011), Sakane (2013) and Lambrias (2013)). This can be a force of IRBC synchronization and the aim of the paper is to evaluate the size and plausibility of this channel.

Two are the main contributions of the paper. First, it estimates the domestic and cross-border economic response to news shocks. In order to do that it shows that even to identify domestic news shock it is crucial to include all available *international* information, especially for non-US economies. This is necessary to avoid the problem of 'non-fundamentalness' which persists even after having accounted for all available domestic information (i.e. using a factor-augmented VAR model, as in Forni *et al.* (2014)). Second, it rationalize the evidence by showing how a standard two-countries two-goods real business cycle model featuring investment adjustment costs and different wealth elasticities of labor supply can match the evidence.

Identifying news structural shocks can be complicated. Small-scale VARs or vector error correction (VECM) models have hard time to identify structural shocks having a delayed effect on macroeconomic variables. Estimates are, in fact, affected by non-fundamentalness, as found by Leeper *et al.* (2008), Fève *et al.* (2009) and Forni and Gambetti (2010). Forni *et al.* (2014) show that the problem can be muted by using all available information, conveyed by the first n-principal components extracted from a full list of macroeconomic variables. By following the same approach we show that all domestic information might not be sufficient. In fact, in a integrated world, business cycles conditions can be more and more affected by the international macroeconomic environment. Missing to account for this information can result in news shocks still subject to international non-fundamentalness.

We test for the relevance of international information by checking if structural news shocks, identified using a VAR augmented with a properly selected number of domestic-factors, are true innovations to past available information coming from a foreign country. In practice, we construct a large dataset including all macroeconomic information for Canada, euro area

and the US.[3] We extract country specific principal components and we run a cross-country orthogonality test between the estimated domestic shocks and international lagged principal components. The main result is twofold: first, Canadian and euro area news shock are not-orthogonal to past US information. Second, US news shocks are instead well identified just using domestic information. This suggests that Canada and euro area news are importantly affected by the US economy, but not viceversa.

We therefore proceed by identifying news shock as anticipated movements in productivity which are orthogonal to both domestic and international macroeconomic information. The international role of these shocks is estimated using a VARX approach, treating foreign news shocks as completely exogenous to the domestic economy. Results are s*ummarized by impulse-response functions and variance decomposition.* As hinted by the orthogonality test, the size of spillovers changes depending on the source of the news shock, with a larger cross-border effect for US news. Interestingly we find that while GDP, investment and consumption are co-moving across-countries in response to a news shock, employment is not.

In order to explain these results, we introduce anticipated shocks in a standard two-country, two-good real business cycle model with complete financial markets. As shown by previous work, a simple two country stochastic growth model, like Backus *et al.* (1994) (henceforth BKK), fails to match IRBC synchronization if assuming complete international financial markets.[4] This explains why financial integration was proposed as a driver of the de-synchronization experienced in the 90's (Heathcote and Perri (2003)). However, since then, financial interconnection did not revert back.[5] This explains why we look for an explanation of the observed re-synchronization maintaining the assumption of complete financial markets. We show how anticipated productivity shocks, conversely from unanticipated innovations, can generate a positive cross-country correlation of GDP, consumption and investment.

Empirically, Levchenko and Pandalai-Nayar (2015) also study the role of TFP, news and sentiments for international business cycle synchronization. Consistently, the paper finds that when focusing on technology, news shock are important for international co-movements,

[3]We select, following Forni *et al.* (2014), 77 series for Canada, 81 for the euro area and 99 for the US.

[4]The existence of a full set of state-contingent assets implies perfect distribution of risks among domestic and foreign agents and efficient allocation of resources, meaning positively correlated consumption but negative correlated output, employment and investments.

[5]For the years before the Great Recession, see Lane and Milesi-Ferretti (2007), among others.

especially at medium run. However, it also highlights the importance of a non-technology shock for cross-border spillovers: US sentiments shocks can explain a high share of Canadian fluctuations. Theoretically, Beaudry *et al.* (2011), Sakane (2013) and Lambrias (2013) show that news shocks can be driver of cross-country co-movements. Our contribution is to show that a fairly standard framework can be slightly modify to explain the evidence of spillovers of well identified domestic news shocks. Davis (2014) proposes a different channel for the IRBC sychnronization. It shows that depending on the type of the financial integration experienced (wealth vs. balance sheet effects), we could have both an increase and a decrease in international business cycle co-movements. If the wealth effect dominates, as predicted by the standard IRBC model with incomplete financial markets, we will have a decrease in the synchronization. Otherwise we could have an increase in the cross-country correlations if the balance sheet effect dominates.[6] We will exclude from this well understood channel and focus only on productivity news shocks

The paper is organized as follows. Section 2 first computes the IRBC co-movements, updating the work by Heathcote and Perri (2003). Then it estimates the domestic response and spillovers to news productivity shock, showing that to properly identify them it is important to consider all available international information. Section 3 rationalize the empirical results using a two-country, two-goods real business cycle model, showing that investment adjustment costs and variable elasticity of the labor supply are important ingredient to match the evidence. Section 5 concludes.

[6]For a full descriptions of the empirical analysis and the theoretical mechanism behind the wealth and the balance effects we cross-refer to Davis (2014). The wealth effect mechanism was mentioned before and it will be explained later. The main idea is that shocks have an important wealth effect that spreads among countries. Instead, the intuition behind the balance sheet effect is the following: a shock to home country affects the balance sheet of firms/banks. The shock, through financial linkages, affects also the balance sheets of the foreign country in the same direction. If, due to some financial friction or borrowing constraint, the size of the bank balance sheet is important for the flow of credits in the economy, we have that the shocks will have the same impact in both countries, generating co-movements.

2 International Real Business Cycles

2.1 Measuring New Changes in Business-Cycle Synchronization

Focusing on the United States, Canada and euro area (EA) we compute levels and evolutions of the business cycle correlations with the rest of the world. We closely follow Heathcote and Perri (2003), updating their sample from 1960:1 to 2014:4 (Figure 1).

Table 1: Cross-country correlations (HP filtered)

Country	Period	GDP	Consumption	Investment	Employment
Rest of the World = EU15 + Japan					
USA	1961:1-2012:2	0.72	0.55	0.65	0.42
	1961:1-1980:1	0.65	0.56	0.66	0.56
	1980:2-2002:2	0.32	0.17	0.26	0.15
	2002:3-2012:2	0.90	0.82	0.82	0.58
Rest of the World = OECD (minus home country)					
USA	1961:1-2012:2	0.78	0.67	0.72	
	1961:1-1980:1	0.69	0.60	0.66	
	1980:2-2002:2	0.51	0.25	0.40	
	2002:3-2012:2	0.92	0.88	0.85	
European Union (15)	1961:1-2012:2	0.82	0.65	0.77	
	1961:1-1980:1	0.75	0.72	0.75	
	1980:2-2002:2	0.54	0.41	0.52	
	2002:3-2012:2	0.92	0.82	0.86	
USA	1961:1-2012:2	$Corr(\frac{\lambda_H}{\lambda_F}, RER)$	-0.09		
EU	1961:1-2012:2	$Corr(\frac{\lambda_H}{\lambda_F}, RER)$	0.05		

Home country: the USA, Canada and EA; Foreign country: Rest of the world measured both as the sum of the the other countries plus Japan (see Heathcote and Perri (2003)) or as the sum of industrialized countries minus the home country (OECD - home). Data are taken from OECD Quarterly National Account fore the period Q1:1961-Q2:2012. Data on GDP, consumption, gross fixed capital formation and employment are used Government consumption is subtracted from GDP to avoid that episodes of wars could bias the results. Appendix 6.1 provides the details on the data used.

We consider respectively USA, Canada and EA as the home country and compute the rest of the world as the sum of the other countries plus Japan or as the sum of all OECD countries, minus the home country. Results are sensitive to the set of countries we consider as the foreign economy but, qualitatively, the results are similar. Table 1 summarizes the results.

As shown by Heathcote and Perri (2003), from 1960 to 2000, US, Canada and EA business cycles have become less synchronized with the cycle in the rest of the world. However, starting in 2000, the international business cycle synchronization picked up again. This is not just a

consequence of the great Recession, as it can be seen in Figure 1. At the beginning of 2012, synchronization reached values above the average between 1963 and 1974. The same cycle applies to all the series considered, not only for GDP or consumption.

Table 1 in addition tells us that those empirical regularities that are in contrast with the standard IRBC model are still important: a) GDP is constantly more cross correlated than consumption; b) GDP, investment and employment are strongly correlated across industrialized countries and it is even more so in the last ten years; c) the correlation between realtive cross-country consumption and the real exchange rate is negative in the United States and positive but small in the European Union.

2.2 The Role of News Shocks

To test if news shocks are a synchronizing force or not we need first to identify then. The seminal paper by Beaudry and Portier (2006) and others, like Barsky and Sims (2011), show us how to do it using different structural VARs specifications. However often, but not always (see Beaudry *et al.* (2015) and Forni *et al.* (2016)), identifying shocks with delayed effects on macroeconomic variables can be problematic (Leeper *et al.* (2008), Fève *et al.* (2009) and Forni and Gambetti (2010), among others). This is true as data used by the econometricians might not contain sufficient information to correctly recover true structural shocks. Enriching the information set on top of structural VARs specification can help solving the problem. This intuition is grounding the work by Forni *et al.* (2014) which shows that using factor VAR models, which allows to include a larger set of information, helps overcoming the issue, often labeled as 'non-fundamentalness' (Forni *et al.*, 2009). In a closed economy environment this is shown to be sufficient.

Economies are however more and more interconnected and subject to economic and financial spillovers. Given the goal of our paper, we need to be sure that news shocks are also internationally fundamental. We need to test if domestic information is indeed sufficient to identify news shock. Proceeding country by country, we follow Forni and Gambetti (2014) and test if news shocks identified with a domestic FAVAR model with a properly selected number of principle components are orthogonal to the lagged information extracted from foreign economies. We do this respectively for the United States and Canada in the period

1981:1-2014:4 and for the Euro Area in the period 1995:1-2014:4 using different FAVAR specification proposed in the literature. We focus here on the cleanest FAVAR specification, also used by Forni *et al.* (2014) as a baseline, proposed by Beaudry and Portier (2006) using TFP productivity and real stock prices, where news do not move TFP on impact but move real stock prices.[7] Table 2, 3 and 4 summarize the result of this test. They report the p-value of the F-test of a regression of the news shocks estimated with a FAVAR model with h principal components on one lag of the first-differenced $h+1$ domestic and foreign principal components.

Table 2: US Fundamentalness test of domestic FAVAR with domestic and CA factors

Domestic FAVAR h-domestic factors h-foreign factors	Domestic Principal components (from h + 1 to j)								
	2	3	4	5	6	7	8	9	10
1	0,20	0,28	0,10	0,10	0,02	0,02	0,01	0,02	0,01
	0,06	0,06	0,09	0,06	0,10	0,11	0,10	0,15	0,21
2		0,82	0,07	0,09	0,00	0,00	0,00	0,00	0,00
		0,27	0,31	0,04	0,06	0,07	0,09	0,14	0,20
3			0,05	0,10	0,19	0,14	0,22	0,31	0,40
			0,32	0,13	0,26	0,15	0,21	0,31	0,42
4				0,71	0,86	0,88	0,95	0,93	0,97
				0,37	0,65	0,10	0,18	0,28	0,38
5					0,82	0,81	0,90	0,93	0,97
					0,84	0,07	0,14	0,25	0,35
6						0,85	0,98	0,99	1,00
						0,05	0,09	0,18	0,28
7							0,96	0,98	1,00
							0,20	0,29	0,45
8								0,65	0,88
								0,34	0,59
9									0,51
									0,59

Note:

Two are the main results. First, in line with Forni *et al.* (2014), US news shocks are well identified by using just domestic information. In fact, past information coming both from Canada and from the Euro Area, the two largest US trade partners, cannot help to predict US news shocks once all domestic information is properly included in the estimation.[8] This can be seen by focusing on the black lines of Table 2. Following Forni *et al.* (2014) procedure, we

[7] In the appendix others FAVAR specification, short and long run restrictions are also tested.

[8] Table 2 shows the orthogonality test with respect to Canadian information in 1981q1-2014q4. The same result applies to the EA in 1995q1-2014q4. Table available in the online appendix.

would select three as the minimum number of principal components to include in our FAVAR model. News shocks identified by a FAVAR with 3 or more additional domestic principal components are indeed significantly unforecastable using additional past foreign information. In fact, the orthogonality of news shocks from past Canadian and EA information is never rejected. Anticipated cycles in the US are isolated from the rest of the world.

Table 3: CA Fundamentalness test of domestic FAVAR with domestic and US factors

Domestic FAVAR h-domestic factors h-foreign factors	Domestic Principal components (from h + 1 to j)								
	2	3	4	5	6	7	8	9	10
1	0,11	0,05	0,00	0,01	0,01	0,01	0,02	0,03	0,04
	0,00	0,00	0,01	0,02	0,03	0,06	0,05	0,03	0,06
2		0,55	0,69	0,60	0,38	0,42	0,52	0,48	0,10
		0,29	0,12	0,21	0,22	0,17	0,26	0,32	0,38
3			0,54	0,09	0,09	0,16	0,18	0,24	0,28
			0,40	0,57	0,03	0,00	0,00	0,00	0,00
4				0,64	0,62	0,70	0,79	0,89	0,92
				0,70	0,93	0,88	0,83	0,85	0,71
5					0,45	0,65	0,77	0,89	0,95
					0,89	0,83	0,76	0,74	0,64
6						0,75	0,84	0,95	0,97
						0,09	0,17	0,31	0,25
7							0,82	0,84	0,67
							0,47	0,70	0,73
8								0,53	0,35
								0,71	0,93
9									0,18
									0,88

Note:

Second, on the contrary, Canada and Euro Area news shocks identified with only domestic information are non-fundamental. Past US information can help forecast Canadian and EA news shocks even after having included the necessary information to select domestic fundamental shocks. As can be seen in Table 3 and 4, the domestic criteria would select respectively 2 and 5 principal components for Canada and EA. These are however insufficient to guarantee fundamentalness with respect to past foreign information. This can be seen in the red p-values of Table 3 and 4.[9] Anticipated cycles in Canada and EA are not isolated from the rest of the world.

Considering this, we proceed to identify Canadian and EA news shocks including in the

[9]In Table 3 foreign information corresponds to US information while in Tab 4 is summarized by the first principal components extracted from a large dataset including US and Canada.

Table 4: EA Fundamentalness test of domestic FAVAR with domestic and foreign factors

Domestic FAVAR h-domestic factors h-foreign factors	Domestic Principal components (from h + 1 to j)								
	2	3	4	5	6	7	8	9	10
1	0,42	0,25	0,40	0,01	0,02	0,04	0,05	0,07	0,01
	0,10	0,01	0,02	0,03	0,02	0,03	0,03	0,05	0,07
2		0,11	0,14	0,00	0,00	0,00	0,00	0,00	0,00
		0,76	0,63	0,32	0,02	0,04	0,00	0,00	0,00
3			0,30	0,00	0,00	0,00	0,00	0,00	0,00
			0,34	0,63	0,05	0,08	0,01	0,02	0,00
4				0,00	0,00	0,00	0,00	0,00	0,00
				0,98	0,50	0,26	0,01	0,01	0,00
5					0,26	0,50	0,41	0,51	0,66
					0,62	0,43	0,27	0,07	0,13
6						0,80	0,25	0,37	0,52
						0,28	0,22	0,08	0,13
7							0,76	0,95	0,77
							0,09	0,01	0,03
8								0,97	0,76
								0,02	0,08
9									0,36
									0,85

Note:

FAVAR model international information. This can be done using principal components extracted not from a domestic but from a global dataset composed by macroeconomic variables of all countries, condensing both the global and local information. The minimum number of principal components necessary to guarantee the orthogonality of the estimated domestic news shocks from past domestic and international information is then included. In practice, we perform the orthogonality test of a FAVAR, with an increasing number of world principal component, with respect to all areas of the world separately and we stop at the minimum that satisfy joint orthogonality. Table 5 shows the test for the EA on the sample 1995q1-2014q4.

Table 5 shows that 6 global principal components should be included in the estimation. Performing the same test for Canada in 1981q1-2014q4 sample (Tables available in the appendix), we select 3 global principal components. The selected number of global principal components is included in our baseline VAR with TFP and real stock prices (proposed by Beaudry and Portier (2006)) and news shocks are identified as those (i) do not move TFP on impact but can move real stock prices and (ii) have maximal impact on TFP at the 40 quarters horizon. From the FAVAR model we then extract the identified domestic news

Table 5: EA Fundamentalness test of international FAVAR with domestic and foreign factors

International FAVAR h-domestic factors h-US factors h-CA factors	Domestic Principal components (from h + 1 to j)								
	2	3	4	5	6	7	8	9	10
	0,33	0,19	0,34	0,37	0,28	0,32	0,18	0,12	0,16
1	0,65	0,55	0,72	0,85	0,58	0,71	0,11	0,16	0,09
	0,29	0,25	0,27	0,42	0,47	0,60	0,61	0,71	0,70
		0,09	0,17	0,32	0,48	0,60	0,73	0,75	0,35
2		0,31	0,06	0,09	0,00	0,00	0,00	0,00	0,00
		0,09	0,10	0,14	0,03	0,06	0,08	0,02	0,00
			0,79	0,66	0,47	0,56	0,63	0,67	0,32
3			0,03	0,01	0,00	0,00	0,00	0,00	0,00
			0,93	0,65	0,01	0,02	0,02	0,01	0,00
				0,42	0,23	0,30	0,29	0,43	0,27
4				0,00	0,00	0,00	0,00	0,00	0,00
				0,38	0,00	0,01	0,01	0,01	0,00
					0,42	0,48	0,57	0,58	0,48
5					0,03	0,09	0,19	0,26	0,16
					0,14	0,34	0,54	0,33	0,29
						0,51	0,19	0,27	0,32
6						0,92	0,97	0,99	0,92
						0,34	0,53	0,41	0,55
							0,29	0,57	0,63
7							0,54	0,65	0,83
							0,24	0,37	0,53
								0,58	0,54
8								0,12	0,30
								0,45	0,71
									0,80
9									0,88
									0,99

the p-value of the F-test in a regression of the news shock estimated using specifications

shocks.

In order to evaluate the relevance and potential synchronizing force of news shocks we estimate a 7 domestic variables VAR-X model in which we include foreign news shocks, identified as explained above, as exogenous variables. Following the literature we include as domestic variables TFP, real stock prices, real consumption, hours worked, real output, real investment and expected business conditions from surveys and inflation. We then proceed in two steps. First we compute the corresponding dynamic multipliers of news shocks on domestic macroeconomic variables. This allows us to test if foreign news shocks are indeed a synchronizing or de-synchronizing force. Second we perform an historical decomposition to check the relevance of these shocks for IRBC.

Figure 2 shows the effect of a US news shock on the the US (green line - IRF from FAVAR) and on Canada (blue line - dynamic multipliers from VAR-X). As it can be see, US news shocks are a synchronizing force across countries. This holds also for the EA.

Dynamic Multiplier of a US news shock on Canada

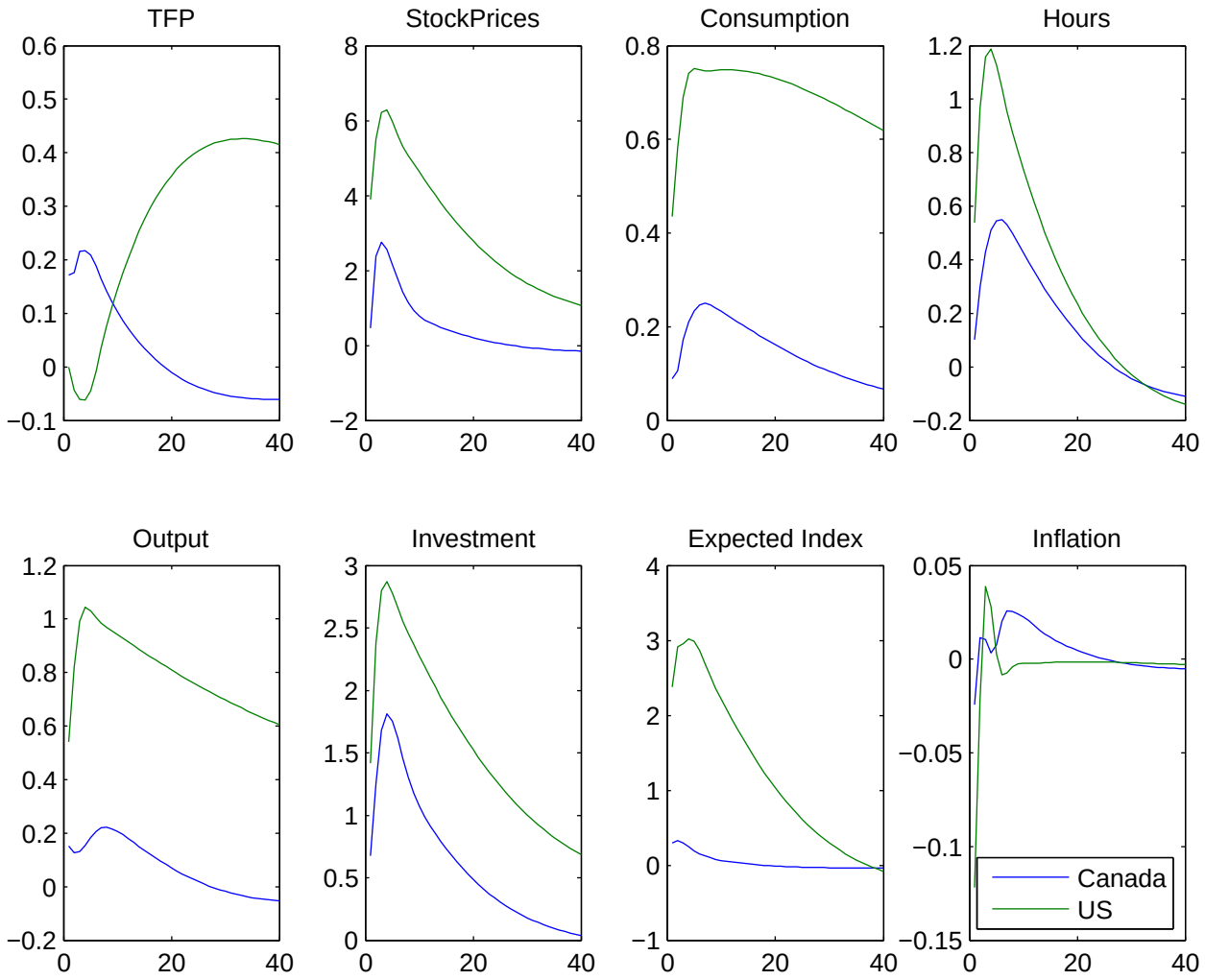
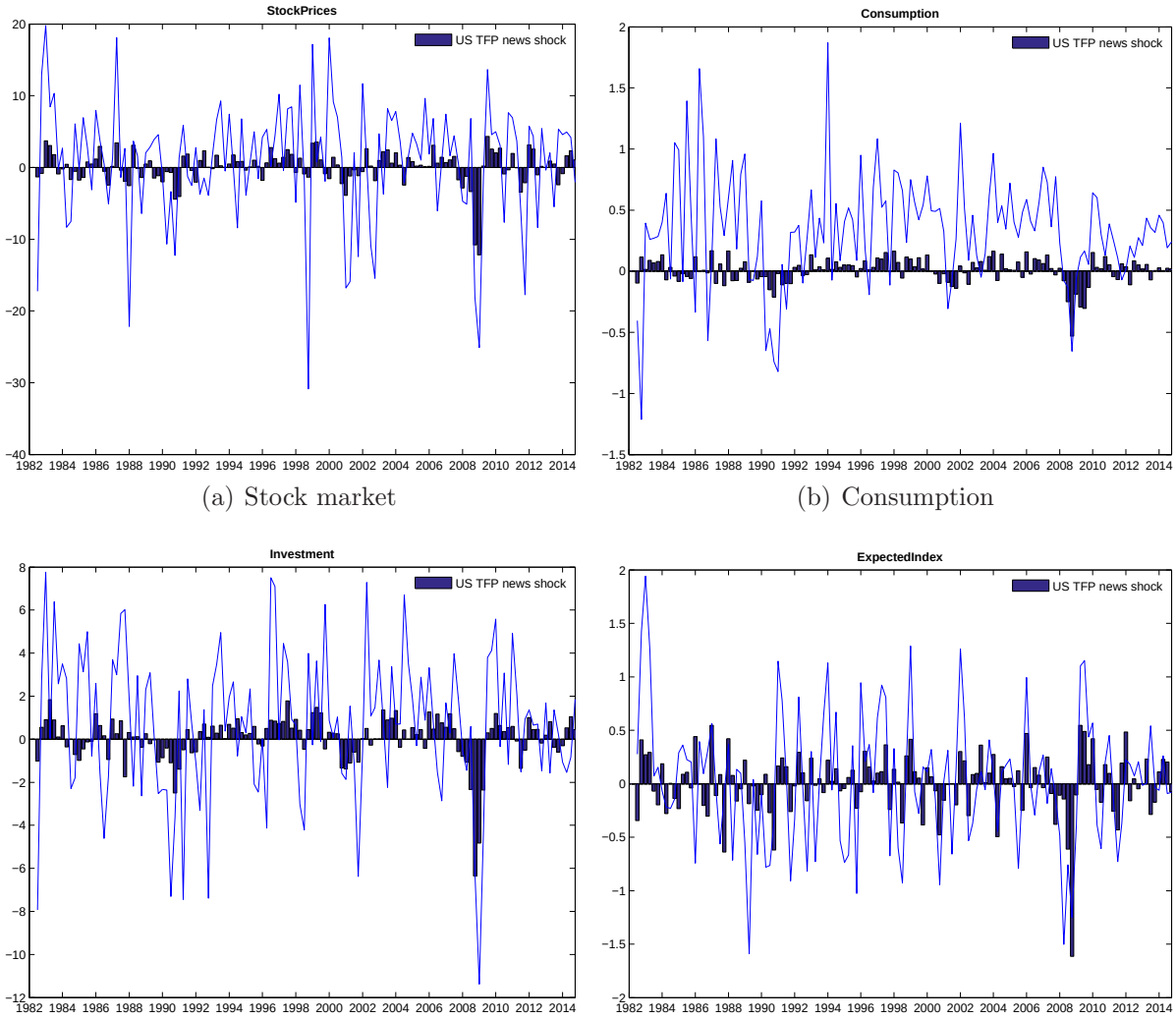


Figure 2

Then, to evaluate the relevance of news shocks for domestic and foreign business cycle fluctuations we compute both a variance decomposition for the role of news shocks on domestic variables and an historical decomposition for the role of foreign shocks in the realized cycle. Figure 3 shows the role of US news shocks for Canadian stock prices, consumption, investment and business expectations between 1982q1 to 2014q4.

Historical decomposition of the role of US news shocks on Canadian business cycle



(a) Stock market

(b) Consumption

(c) Investment

(d) Expectation Index

Figure 3:

Table 6 quantifies the role of US news shocks on Canada and the Euro Area. The coefficient is calculated using the historical decomposition performed using the VAR-X. In fact, given the impossibility of using the standard forecast error variance decomposition to assess the role of the exogenous shocks we compute a proxy by the ratio of the averaged square of the contribution of foreign news shocks (to the historical decomposition) to the Mean Squared Error.

On one hand, US news shock are a non neglibile driver of International Real Business Cycle in Canada but not as much in the Euro Area. In fact, by looking at the percentage of

Table 6: Average percentage contribution of US-news shocks in Canada/Euro Area fluctuations

Country	Period	TFP	Stock Prices	Consumption	Hours	Output	Investment	Expectation Index	Inflation
Canada	1982:2014	7,13	7,41	5,05	10,23	2,09	10,59	26,83	4,73
Euro Area	1995:2014	2,85	2,03	2,45	3,34	2,74	5,40	8,19	4,50

Using the historical decomposition from the VAR-X, values are indicating the relative importance of US-news shocks computed as the ratio of the averaged square of the contribution of each structural shock (to the historical decomposition) to the Mean Squared Error, in percentage.

the explained variance of news shocks, US anticipated shocks explain an important fraction of the fluctuations of those variables more sensitive to changes in expectation: 7% of stock prices fluctuations, 10% of Investment fluctuations and 27% of the consumer survey expected indicators are due to news shocks in the US. AS shown clearly by Figure 3, US news shocks played an important contractionary role during the Great Recession. As for Europe, US news shock are accounted to be less relevant, effecting only up to 2% stock market flucutations and 8% expectations of consumers. Due to the strict identification of news shocks and the VAR-X exogeneity assumption, we claim that this numbers are indeed lower bounds estimates.

Table 7: Variance decomposition to domestic news shocks in Canada and Euro Area

			Horizons					
Country	Period	Variables	0	4	8	16	24	40
Canada	1982:2014	TFP	0,00	3,24	7,01	12,83	17,65	24,76
		Stock Prices	17,45	6,49	8,45	11,46	13,92	17,66
		Consumption	18,20	6,08	4,68	7,33	12,43	22,29
		Hours	6,83	5,98	12,81	20,08	24,46	29,21
		Output	11,44	17,93	21,42	27,32	31,95	38,69
		Investment	29,91	11,71	9,65	9,23	11,13	17,29
		Exp Index	7,86	3,36	6,62	10,08	12,08	13,42
		Inflation	74,68	67,89	67,42	65,50	63,29	61,32
Euro Area	1995:2014	TFP	0,00	7,58	16,94	20,33	19,50	24,29
		Stock Prices	9,15	6,92	12,27	13,16	14,16	20,52
		Consumption	15,02	4,55	11,04	24,46	27,24	27,35
		Hours	10,59	3,87	11,90	31,01	35,57	32,62
		Output	2,86	3,61	10,08	13,94	13,27	19,00
		Investment	17,23	3,77	10,33	22,43	25,18	25,00
		Exp Index	9,69	13,71	20,59	19,86	20,27	24,65
		Inflation	15,20	13,02	12,98	13,87	15,88	16,89

FAVAR Variance decomposition to a domestic news shocks identified in Canada with 3 global principal components and in the EA with 6 global principal components

On the other hand, news shocks are computed to be not marginal driver of domestic

business cycle fluctuations. For the domestic impact of domestic news shocks we can perform a standard variance decomposition of the forecast error at different horizons using our FAVAR model, where news shocks are identified as explained above with the previously selected number of global principal components. Table 7 shows the result, which are in line with the number computed by Forni *et al.* (2014) for the US.

3 The Model

We now rely on a theoretical framework to explain how and why, domestic news shocks can act as a synchronizing force across the cycle. The modeling framework has been proposed by Backus *et al.* (1994). The world is characterized by two countries inhabited by the same number of identical infinitely lived households. The two countries produce a differentiated tradable good respectively with domestic labor and capital. Factors of production are internationally immobile but international financial markets are complete.

Productivity shocks are the only source of fluctuations in the model. For those shocks we include an anticipated component: agents learn about the shock exactly a year before the actual realization of it. We follow the exposition of the model developed by Heathcote and Perri (2002).

3.1 Baseline Model

The two countries $i \in \{H, F\}$ produce respectively a differentiated good $j \in \{a, b\}$ which is traded internationally. We denote with S the set of all possible events and with $s_t \in S$ the particular event experienced in time t. s^t denotes the history of events up to and including date t. We attach a probability $\pi(s^t)$ to each history of events. A variable $X(s^t, s_{t+1})$ will depend on the history up to time t and will be related to the specific event s_{t+1}.

The infinitely lived representative household, in country i, enjoys consumption of a final good $C_i(s^t)$ and leisure $(1 - L_i(s^t))$:

$$U\left(C_i(s^t), 1 - L_i(s^t)\right) = \frac{1}{1-\sigma}\left[C_i^{\mu}(s^t)\left(1 - L_i(s^t)\right)^{1-\mu}\right]^{\sigma} \tag{1}$$

Households, in each country i, supply labor and rent the owned capital stocks, K_i, to

perfectly competitive intermediate-good firms that produce good j for wage W_i and interest rate R_i^k. Labor and capital are internationally immobile but international asset markets are complete, providing a full set of Arrow securities. Let $B_i(s^t, s_{t+1})$ denote the quantity of bonds purchased by household, in country i, after history s^t, that pays one unit of j good in period $t+1$, if the state realized is s_{t+1}. $Q_i\left(s^t, s_{t+1}\right)$ denotes the price of the bond in units of the domestically produced good. The budget constraint of household in country i can be written as:

$$\begin{aligned} & C_i(s^t) + I_i(s^t) + q_i^j(s^t) \sum_{s_{t+1}} Q_i\left(s^t, s_{t+1}\right) B_i(s^t, s_{t+1}) = q_i^j(s^t) B_i(s^{t-1}, s_t) + \\ & + q_i^j(s^t)\left[R_i^k(s^t) K_i(s^t) + W_i(s^t) L_i(s^t)\right] \\ & \quad \text{for} \quad \{i = H, j = a\} \text{ and } \{i = F, j = b\} \end{aligned} \tag{2}$$

where q^j is the price of intermediate good a and b in terms of the final good F_i respectively in country H and F. Consumption, C_i and investment, I_i, are denoted in final good units. Investment augments the capital stock following the law of motion:

$$K_i(s^t) = (1-\delta) K_i(s^{t-1}) + I_i(s^t)^{10} \tag{3}$$

The major difference between our baseline specification and the original paper by Backus *et al.* (1993) is that we remove the assumption that capital needs time to accumulate. We will introduce an equivalent assumption later making clear why it is worth to investigate the role of friction in the accumulation of capital separately.

At period 0, the representative household, in country i, maximizes his/her expected lifetime utility subject to the budget constraint (2) combined with the law of motion of capital (3):

$$\begin{aligned} & \max_{C_i(s^t), L_i(s^t), K_i(s^t)} E_0 \sum_{t=0}^{\infty} \sum_{s^t} \pi(s^t) \beta^t \frac{1}{1-\sigma} \left[C_i^{\mu}(s^t)\left(1 - L_i(s^t)\right)^{1-\mu}\right]^{\sigma} \\ & \text{s.t. } C_i(s^t) + K_i(s^t) - (1-\delta) K_i(s^{t-1}) + q_i^j(s^t) \sum_{s_{t+1}} Q_i\left(s^t, s_{t+1}\right) B_i(s^t, s_{t+1}) = \\ & \qquad = q_i^j(s^t)\left[R_i^k(s^t) K_i(s^t) + W_i(s^t) L_i(s^t)\right] + q_i^j(s^t) B_i(s^{t-1}, s_t) \end{aligned}$$

where $\beta < 1$ is the discount factor which, for simplicity, is assumed to be constant.

Domestic intermediate firms produce only good a and foreign intermediate firms produce only good b. The output is carried with country specific technology using labor and capital

[10] In the original version of the model, proposed by Backus *et al.* (1994), the investment technology requires time to build new capital. We will introduce in section 4.1 an isomorphic way to model adjustment costs.

combined in a Cobb-Douglas production function. Firms, in country i, maximize profits:

$$\begin{aligned} &\max_{L_i(s^t),K_i(s^t)} Y_i(s^t) - W_i(s^t)L_i(s^t) - R_i^k(s^t)K_i(s^t) \\ &\text{subject to } Y_i(s^t) = Z_i(s^t)K_i(s^t)^\theta L_i(s^t)^{1-\theta},\ K_i(s^t), L_i(s^t) \geq 0 \end{aligned} \tag{4}$$

As in the budget constraint, $W_i(s^t)$ and $R_i^k(s^t)$ are the wage and the price of capital expressed in terms of the intermediate good produced.

The intermediate goods are used by the final good firms to produce F_i, which is formed by domestically and foreign produced goods. Those firms are perfectly competitive and have a constant return to scale technology available (Armington aggregator):

$$F_i(a_i(s^t), b_i(s^t)) = \begin{cases} \left[\gamma^{\frac{1}{\epsilon}} a_i(s^t)^{\frac{\epsilon-1}{\epsilon}} + (1-\gamma)^{\frac{1}{\epsilon}} b_i(s^t)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}, & \text{for } i = H \\ \left[(1-\gamma)^{\frac{1}{\epsilon}} a_i(s^t)^{\frac{\epsilon-1}{\epsilon}} + \gamma^{\frac{1}{\epsilon}} b_i(s^t)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}, & \text{for } i = F \end{cases} \tag{5}$$

where γ sets the preferences for the home produced goods and ϵ is the elasticity of substitution between the domestic and foreign good. We set $\gamma \geq 0$ allowing for home bias in consumption. Final good firms maximize profits choosing the optimal demand for good a and b solving the following maximization:

$$\begin{aligned} &\max_{a_i(s^t),b_i(s^t)} F_i(s^t) - q_i^a(s^t)a_i(s^t) - q_i^b(s^t)b_i(s^t) \\ &\text{subject to } a_i(s^t), b_i(s^t) \geq 0 \text{ and equation (5).} \end{aligned} \tag{6}$$

Market clearing for intermediate and final goods requires that:

$$a_H(s^t) + a_F(s^t) = Y_H(s^t), \tag{7}$$

$$C_H(s^t) + I_H(s^t) + G_H(s^t) = F_H(s^t); \tag{8}$$

$$b_H(s^t) + b_F(s^t) = Y_F(s^t), \tag{9}$$

$$C_F(s^t) + I_F(s^t) + G_F(s^t) = F_F(s^t). \tag{10}$$

The law of one price holds throughout the world, for both goods, and asset market clears:

$$B_H(s^t, s_{t+1}) + B_F(s^t, s_{t+1}) = 0, \qquad \forall s_{t+1} \in S. \tag{11}$$

Before defining the competitive equilibrium, we present the definition of three important international variables. The terms of trade, from a domestic perspective, is defined as the price of imports with respect to exports: $TOT_H(s^t) = \frac{q_H^b(s^t)}{q_H^a(s^t)}$. The real exchange rate, given the assumption of complete markets is given by the risk sharing condition and is defined as the price of the foreign final good with respect to the domestic final good: $RER_H(s^t) = \frac{q_H^a(s^t)}{q_F^a(s^t)}$. Finally we define the net export, $NX_H(s^t)$, as the ratio between the value of the exported goods minus the value of the imported goods to output:

$$NX_H(s^t) = \frac{a_F(s^t) - TOT_H(s^t) b_H(s^t)}{Y_H(s^t)} \tag{12}$$

As a source of fluctuations we include only productivity. The two exogenous sources of fluctuations, country i technologies (Z_H, Z_F), follow these processes:

$$\begin{bmatrix} \widehat{z}_H(s^t) \\ \widehat{z}_F(s^t) \end{bmatrix} = \begin{bmatrix} \rho_z & \rho_{zz} \\ \rho_{zz} & \rho_z \end{bmatrix} \begin{bmatrix} \widehat{z}_H(s^{t-1}) \\ \widehat{z}_F(s^{t-1}) \end{bmatrix} + \begin{bmatrix} \epsilon_H^Z(s^t) \\ \epsilon_F^Z(s^t) \end{bmatrix} \tag{13}$$

$$\text{with} \quad \begin{bmatrix} \epsilon_H^Z(s^t) \\ \epsilon_F^Z(s^t) \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_{\epsilon_H^Z} & \sigma_{\epsilon_H^Z \epsilon_F^Z} \\ \sigma_{\epsilon_H^Z \epsilon_F^Z} & \sigma^2_{\epsilon_F^Z} \end{bmatrix} \right) \tag{14}$$

where $\widehat{z}_H$ and $\widehat{z}_F$ represent the log deviation from steady state of those variables.

For each shock we introduce an unanticipated but also an anticipated component. Following Schmitt-Grohé and Uribe (2012) notation, if $x_t = \rho_x x_{t-1} + \epsilon_t^x$ identifies a general exogenous process, we assume that the error terms follows the structure:

$$\epsilon_t^x = \epsilon_{0,t}^x + \epsilon_{4,t-4}^x \tag{15}$$

where $\epsilon_{4,t-4}^x$ is today's realization of a shock that was acknowledged a year before. For a full and detailed exposition of this method of introducing anticipated shocks we cross-refer

Table 8: Calibrated Parameteres - Baseline Model

Par	Value	Description
β	0.99	Discount Factor
μ	0.34	Consumption Share
σ	2	Risk Aversion
δ	0.025	Depreciation of capital
θ	0.36	Capital's share of output
γ	0.7208	Calibrated using import share = 0.15
ϵ	1.5	Trade elasticity
Technology process		
$\begin{bmatrix} \rho_z & \rho_{zz} \\ \rho_{zz} & \rho_z \end{bmatrix} = \begin{bmatrix} 0.906 & 0.088 \\ 0.088 & 0.906 \end{bmatrix}$		
$VAR\epsilon_H^Z = VAR\epsilon_F^Z = 0.00852^2$		
$Corr(\epsilon_H^Z, \epsilon_F^Z) = 0.258$		
$g_t = 0$		

to section 3 of Schmitt-Grohé and Uribe (2012). We will follow this assumption, of having both an unanticipated and anticipated shock component in every specification of the model that we will see from now on.

Let $s_t = \{Z\}$, where $Z = \{Z_H, Z_F\}$. The competitive equilibrium is a set of home and foreign representative household decision rules $C_i(s_t)$, $L_i(s_t)$, $K_i(s_t)$ and $B_i(s_t)$; a set of domestic and foreign intermediate good firms decision rules $K_i(s_t)$ and $L_i(s_t)$; A set of domestic and foreign final good firms decision rules $a_i(s_t)$ and $b_i(s_t)$. A set of pricing functions $q_i^a(s_t)$, $q_i^b(s_t)$, $R_i^k(s_t)$, $W_i(s_t)$, $Q_i(s_t)$ such that they satisfy: 1. the household problem; 2. the intermediate and final firms problem; 3. the market clearing conditions.

Table 8 summarizes the values of the benchmark paramenters. We treat the United States as the domestic country and the rest of the world as the foreign country. We make this choice for two reasons: first, it allows us to better compare the results from the model with the empirical evidence presented in section 2; second, considering just a single country as a foreign economy will imply focusing on a really small fraction of the international flow of goods of the USA (see Heathcote and Perri (2002)). The benchmark parameters are taken from Backus *et al.* (1994). The discount factor is set equal to 0.99, the consumption share to 0.34 and the risk aversion to 2. Looking at the production side, capital share of output is 0.36, the depreciation rate of capital is 10 percent per year and the import share is set equal to 0.15. The most important parameter, ϵ, which determines the elasticity of substitution between domestic and foreign goods, is set equal to 1.5 (Heathcote and Perri (2002) and

Backus *et al.* (1994)). For the technology process we follow exactly the specification proposed by Backus *et al.* (1994).

After having shown the implication of anticipated shocks in the IRBC baseline framework, section 4.1 assesses the importance of anticipated shocks in a model with little short run wealth effects on the labor supply and investment adjustment costs.[11]

4 Results

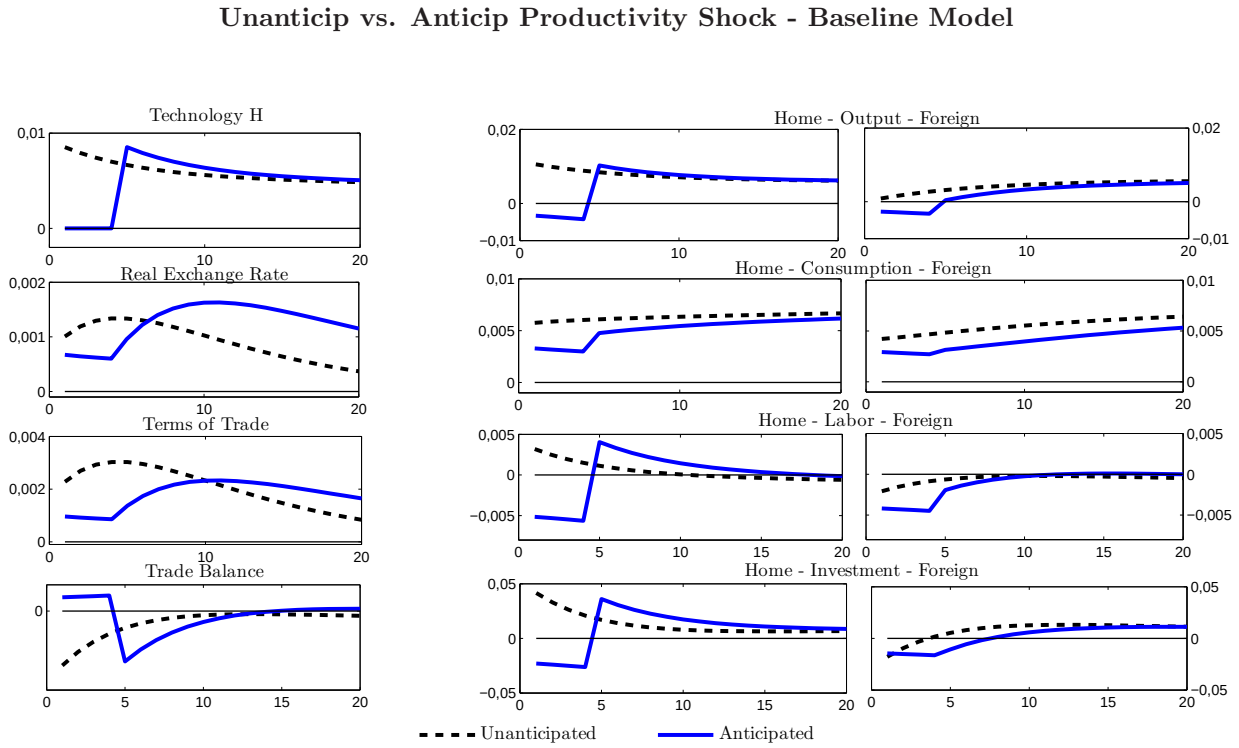


Figure 4: Impulse-responses to a positive unanticipated and anticipated technology shock (baseline model).

Figure 4 depicts the impulse-responses of the baseline model to both an unanticipated and an anticipated positive productivity shock in the domestic economy. Focusing first on the more standard unanticipated shock, the dotted line, we see clearly how the model is unable to generate international co-movement of some variables.

In response to an unanticipated productivity shock consumption increases almost equally

[11] To simulate the model with use Dynare. For the details see Adjemian *et al.* (2011)

in both countries while output increases a lot more in the country hit by the shock. As explained in **??**, this is a consequence of the full risk sharing assumption. Hours worked and investment have opposite reactions in the two countries. Marginal products of factors increase in the economy hit by the shock pushing up investment and labor, as the labor supply wealth effect is smaller than the substitution effect due to the increase in wages. Instead, in the foreign economy, the opposite happens as a result of the positive wealth effect, spread into the country through the value of the international assets. This leads to a reduction of hours worked and investment in the foreign economy: capitals will be invested more in the relative more productive country. Net export, therefore, decreases despite the gained international competitiveness of the terms of trade and the real exchange rate.

The mis-match between the model implications and the empirical findings is importantly reduced when we consider anticipated shocks. As can be seen in figure 4, the model can now generate positive international cross-correlation of output, employment and investment. Notice, in table 9, that the model is able to reduce some important IRBC puzzles: output has a positive cross correlation of 0.32; consumption international co-movement is reduced; investment and labor do not have opposite reactions.

The ability of anticipated productivity shock to synchronize the IRBC comes from the symmetric effect that news have on both economies in the periods preceding the realization of the shock. In fact, through the value of the internationally asset portfolio, the wealth effect of the anticipated shock is spread among the countries in a symmetric way. Another way of interpreting the role of the anticipated shock is that, in the periods preceding the actual change in productivity, it generates a symmetric cross-country demand shock.

However, notice that the ability of the BKK model with anticipated shocks to match the IRBC properties is illusory. It is a well documented fact that a persistent anticipated shock, in a frictionless neo-classical framework, generates the wrong behavior our output, consumption and employment. A positive persistent productivity shock is transmitted to both countries as an increase in wealth that leads agents to increase the demand for both normal goods: consumption and leisure. This generates a decrease in the labor supply. Productivity, until the shock realizes, is constant and capital is inherited from the previous period. Therefore output, and then investment, fall in both economies. This generates positive international

co-movement but fails to match the domestic business cycle properties: output, consumption and employment response positively to an increase in expected productivity.

The results we have just presented were derived assuming the Backus *et al.* (1994) calibration. Changes in productivity were transmitted in-between countries through two channels. First, we allowed some degree of international spill-over, $\rho_{zz} = 0.088$, generated by the fact that the productivity of one country is partially influenced by the past productivity of the other country (equation 14); second, following Backus *et al.* (1994), we have assumed that shocks are correlated across countries $\sigma_{\epsilon_H^Z \epsilon_F^Z} = 0.258$.

We are now interested in understanding how the anticipated shocks would improve the cross-correlation of international business cycle variables when we assume that shocks are not correlated and there is no spill-over effect. We first assume a zero correlation between shocks leaving the spill-over effect and then we assume that there is no relationship in the productivity processes of the two economies. In table 9 we present the results. Anticipated shocks can still reduce the distance with the empirical evidence, even when we exclude possible spill-over effects, but, as we can see, the improvement is reduced. In fact, the model, without assuming any correlation between shocks, is unable to generate a positive co-movement of investment across countries just as a reaction to anticipated productivity shock.

4.1 Jaimovich-Rebelo preferences and adjustment costs of investment

We have just shown how international business cycle features are better matched when anticipated shocks are introduced in the standard international business cycle model. However, while the model performs better in terms of international cross-correlation, it performs worse in terms of domestic business cycle regularities: output, consumption and hours worked should move in the same direction of the anticipated technology shocks. The persistency of the shock in addition to the frictionless neo-classical framework generates an equilibrium in which the labor market dynamics doesn't allow to have an increase in all the variables in response to an anticipated shock (figure 4). The reason comes from the strong positive wealth effect caused by the future expected increase in productivity. Given that capital is

Table 9: International Business Cycle Statistics (HP filtered)

		Correlation				
Economy		(y_H, y_F)	(c_H, c_F)	(I_H, I_F)	(L_H, L_F)	$(\frac{\lambda_H}{\lambda_F}, RER)$
Data		0.72	0.55	0.65	0.42	-0.09
Base Model	Non-Antic. TFP	-0.06	0.91	-0.81	-0.93	0.95
	Antic. TFP	0.32	0.80	0.10	0.49	0.83
Base Model	Non-Antic. TFP	-0.32	0.85	-0.96	-0.88	0.95
(no corr)	Antic. TFP	0.07	0.69	-0.17	0.26	0.83
Base Model	Non-Antic. TFP	-0.32	0.55	-0.46	0.03	0.97
(no corr/no spill-over)	Antic. TFP	0.01	0.26	-0.30	0.05	0.83
Invest. Adj Cost	Non-Antic. TFP	-0.17	0.85	-0.01	-0.37	1
(no corr)	Antic. TFP	-0.07	0.16	0.62	0.25	1
Jaimovich-Rebelo pref.	Non-Antic. TFP	0.13	0.98	-0.90	0.30	0.89
(no corr)	Antic. TFP	0.04	0.95	-0.47	0.12	0.72
JR + Inv Adj Cost	Non-Antic. TFP	0.34	0.97	-0.04	0.68	1
(no corr)	Antic. TFP	0.24	0.95	0.65	0.60	0.99
Incomplete Markets						
Base Model	Non-Antic. TFP	0.23	0.37	-0.76	-0.72	0.45
	Antic. TFP	0.42	0.53	-0.30	0.52	0.31
Base Model	Non-Antic. TFP	-0.03	0.13	-0.84	-0.83	0.45
(no corr)	Antic. TFP	0.18	0.32	-0.51	0.31	0.31

Output, consumption, investment and employment cross-country theoretical correlations compared with the data from 1960-2012 for the USA. The last column shows the correlation between the relative domestic and foreign consumption and the real exchange rate. All the variables, in the data and in the model, are hp-filtered. (no corr) stands for a parametrization in which shocks are not correlated across countries. (no spill-over) indicates $\rho_{zz} = 0$.

inherited from the previous period and productivity will not change until the shock actually realizes, the only force that can generate an increase in output is labor. However, the demand of labor from the firm size does not change while the supply of labor, driven by the positive wealth effect, shifts down. The result is a decrease in hours worked and a decrease also of GDP and investment. A different specification of preferences, different information structures, nominal and real rigidities have been introduced in models featuring anticipated shocks to avoid this well known problem. Lorenzoni (2011) provides a comprehensive review of the different solutions proposed and their mechanism.

In order to exploit the ability of anticipated shocks to synchronize IRBC fluctuations, we need to introduce a new specification of the model that does not suffer from the wrong domestic business cycle behavior of the frictionless neo-classical model. From previous literature we learned that the combination of preferences that can control the degree of the labor wealth effect and frictions in the adjustment of capital is sufficient for anticipated produc-

tivity shocks to generate the proper co-movements. Therefore we introduce the preferences specification proposed by Jaimovich and Rebelo (2009) and investment adjustment cost in the model. Starting from the investment adjustment cost we introduce the two features in the model, one at the time, in order to properly understand the role played by each modification.

Lucca (2007) proved that adjustment costs associated with changes in the rate of investment are isomorphic to the time-to-build models used by Backus *et al.* (1994). In addition, Jaimovich and Rebelo (2009) showed how investment adjustment costs can be important for anticipated shocks: an increase in the cost makes it more convenient for agents to adjust sooner the stock of capital generating a smoother adjustment; capitals, if the cost is sufficiently large, will start to increase at the time of the news shock generating positive complementarities on the demand side of labor.

Capital accumulation, in equation 3, is substituted by this new formulation:

$$K_i(s^t) = (1-\delta)K_i(s^{t-1}) + I_i(s^t)\left[1 - \phi\left(\frac{I_t}{I_{t-1}}\right)\right], \tag{16}$$

where the function ϕ represent the adjustment costs to be paid when the level of investment changes over time. We assume that $\phi(1) = \phi'(1) = 0$ and $\phi''(1) = \eta_k > 0$. As in Jaimovich and Rebelo (2008) we set $\eta_k = 1.3$.

Table 9 shows the results for the cross country correlation in response to both unanticipated and anticipated positive productivity shock in the domestic economy. Not surprisingly the model, for both shocks, works better in terms of the investment dynamics generating a positive cross-country correlation. Anticipated shocks improve in the matching of all the co-movements but, as before, the ability of generating a positive correlation between the domestic and the foreign labor market is driven by the decrease in the labor supply in the domestic economy hit by a positive anticipated shock.

To solve the problem of the miss-behavior of the labor market in response to anticipated shocks, we introduce a preference specification that allows us to control, through a parameter, the degree of the wealth elasticity of the labor supply. We follow Jaimovich and Rebelo (2009) formulation:

$$U(C_t, L_t) = \frac{\left\{C_t - \psi^L L_t^{1+\nu} X_t\right\}^{1-\sigma} - 1}{1-\sigma}, \tag{17}$$

where

$$X_t = C_t^{\mu} X_{t-1}^{1-\mu}. \tag{18}$$

Utility depends on consumption at time t, C_t, and hours worked L_t. X_t controls the wealth effect on labor supply through the parameter $\mu \in [0, 1]$. By changing μ we can account for two important classes of utility functions used in the business cycle literature: King *et al.* (1988) types of preferences (KPR henceforth) when $\mu = 1$ and Greenwood *et al.* (1988) when $\mu = 0$ (GHH henceforth). As in Jaimovich and Rebelo (2009), we impose $\mu > 0$, in order to put some weight on the KPR preferences which are growth consistent. We set the parameter $\mu = 0.0001$ in order to decrease the degree of the wealth effect on the labor supply consistently.

In order to isolate the results coming from the new utility specification, we first present the results assuming that the investment sector does not have any adjustment cost. Afterwards we combine the two new features in the baseline model to understand the role of anticipated shocks for the IRBC, when also the correct closed economy business cycle properties are satisfied.

Comparing the results between this new specification and the baseline framework, in table 9, we see how controlling the role of the wealth effect on the labor dynamics allows us to improve significantly in two aspects of the IRBC. Both for the unanticipated and anticipated shocks, the labor cross-country correlation becomes really close to the empirical findings and the output becomes positively correlated across country. We can conclude that the simple introduction of GHH preferences solves for both unanticipated and anticipated productivity shocks the puzzle related to the employment negative cross-country international dynamics of the standard IRBC model.

However, by just changing the preferences, we cannot match the proper dynamics of investment and by just using the investment adjustment costs we cannot match the correct labor dynamics (hours worked decrease in the country which experienced the anticipated

productivity shock). We then add both features to the model contemporaneously and we check what happens. With the exception of the puzzles related to consumption (Backus-Smith and consumption correlation puzzle) the model matches the international business cycle regularities quite well with anticipated shocks. Anticipated shocks, now consistent also with the proper closed business cycle economy properties, can really overturn some of the major puzzles in the international business cycle literature.

In order to understand how well anticipated shocks do in improving the ability of the standard BKK model to match the IRBC characteristics, we compare the results with the most used modification of the model in which financial markets are incomplete. Following Heathcote and Perri (2002) we assume that there is only one non contingent bond available in the economy.[12] All the other assumptions are back to the baseline framework: separable utility function and no investment adjustment costs. As previously found in the literature, the model with incomplete risk sharing, is now able to reduce the cross-correlation of consumption and, in particular, performs much better in terms of the correlation between relative consumption and the real exchange rate (table 9). This should not come as a surprise given that we break the tight relation between consumption and the real exchange rate. However two things are worth noticing. First, the model performs poorly with respect to the cross-correlation between labor and investment in the two countries. In fact it generates a strong negative correlation as opposed to the positive correlation seen in the data. Second, the positive international co-movement of output holds only as long as we keep the two shocks being correlated. In the last line of table 4 we see how the model performs poorly when we assume zero correlation between the shocks. Anticipated shocks, even in the incomplete financial market setup, perform better in terms of IRBC properties.[13]

We conclude that just by adding anticipated shocks in the standard international real business cycle model and being careful in controlling both the positive wealth effect on the labor supply and the speed of capital adjustment, we can improve the performance of the model significantly, without the need of assuming incomplete markets. The reason why we

[12]For a description of the framework we use, see Heathcote and Perri (2002), Enders and Muller (2009) and Opazo (2006). As in Enders and Muller (2009), we use endogenous discount factor to close the model and ensure stationarity and uniqueness of the steady state

[13]For a deeper analysis of anticipated socks in this framework we cross-refer to Opazo (2006)

are careful in assuming that markets are incomplete is the evidence shown in figure 1(b) by which we see that the cross-country correlation of consumption is increasing to levels similar to the ones implied by the models with complete financial markets.

5 Conclusion

We have examined the importance of anticipated shocks in a standard two-country, two-good real business cycle model with complete financial markets. The increased synchronization of the United States and the European Union business cycles with the rest of the world found in the data and the evidence that the international financial integration process is increasing (Lane and Milesi-Ferretti, 2007) motivated us to find a source of international co-movements that works without the need of assuming imperfect risk sharing across countries.

From the empirical analysis we have found that international business cycle synchronization has been strongly increasing from the beginning of the year 2000. After the strong decrease in the synchronization, found by Heathcote and Perri (2003) and attributed to the wealth effect generated by the increasing financial integration, we now face a world in which the international-business cycle co-movements are particularly strong and the financial market is increasingly internationally integrated with respect to previous years. Explaining open-economy puzzles by just assuming financial market incompleteness could be puzzling in itself given that the data tell us that consumption cross-country correlation has almost reaching the values implied by models with complete financial markets.

We have found that anticipated shocks are an important source of international real business cycle movements in a world in which financial markets are complete. Once we have controlled for the positive wealth effect of the labor supply and we have introduced a mechanism by which capitals adjust smoothly, the otherwise standard IRBC model can account for the majority of the puzzles by just introducing some anticipated component in the productivity shocks. An anticipated technology shock generates a positive cross-country correlation of output, consumption, investment and hours worked. However, notice that the model cannot solve the Backus-Smith puzzle. That should not come as a surprise given that in the model we do not break the mechanism by which relative consumption is strongly

correlated to the real exchange rate. A possible solution that we leave for future research is to understand if the model with complete financial market could solve the Backus-Smith puzzle by introducing anticipated shocks and limited international enforcement of contracts.

We conclude that anticipated shocks are an important source of international synchronization in a world in which financial markets are more and more integrated.

References

Adjemian, Stphane, Houtan Bastani, Frderic Karam, Michel Juillard, Junior Maih *et al.* (2011): Dynare: Reference Manual Version 4. Dynare Working Papers 1, CEPREMAP.

Backus, David, Patrick J. Kehoe and Finn E. Kydland (1993): International Business Cycles: Theory and Evidence. NBER Working Papers 4493, National Bureau of Economic Research, Inc.

Backus, David K, Patrick J Kehoe and Finn E Kydland (1994): Dynamics of the Trade Balance and the Terms of Trade: The J-Curve? *American Economic Review*, 84(1), pp. 84–103.

Barsky, Robert B. and Eric R. Sims (2011): News shocks and business cycles. *Journal of Monetary Economics*, 58(3), pp. 273 – 289.

Beaudry, Paul, Martial Dupaigne and Franck Portier (2011): Modeling News-Driven International Business Cycles. *Review of Economic Dynamics*, 14(1), pp. 72–91.

Beaudry, Paul, Patrick Fve, Alain Guay and Franck Portier (2015): When is Nonfundamentalness in VARs A Real Problem? An Application to News Shocks. CEPR Discussion Papers 10763, C.E.P.R. Discussion Papers.

Beaudry, Paul and Franck Portier (2006): Stock Prices, News, and Economic Fluctuations. *American Economic Review*, 96(4), pp. 1293–1307.

Davis, J. Scott (2014): Financial integration and international business cycle co-movement. *Journal of Monetary Economics*, 64(C), pp. 99–111.

Enders, Zeno and Gernot J. Muller (2009): On the international transmission of technology shocks. *Journal of International Economics*, 78(1), pp. 45–59.

Fève, Patrick, Julien Matheron and Jean-Guillaume Sahuc (2009): On the dynamic implications of news shocks. *Economics Letters*, 102(2), pp. 96–98.

Forni, Mario and Luca Gambetti (2010): Fiscal Foresight and the Effects of Goverment Spending. CEPR Discussion Papers 7840, C.E.P.R. Discussion Papers.

Forni, Mario and Luca Gambetti (2014): Sufficient information in structural {VARs}. *Journal of Monetary Economics*, 66, pp. 124 – 136.

Forni, Mario, Luca Gambetti and Luca Sala (2014): No News in Business Cycles. *Economic Journal*, 124(581), pp. 1168–1191.

Forni, Mario, Luca Gambetti and Luca Sala (2016): VAR Information and the Empirical Validation of DSGE Models. Center for Economic Research (RECent) 119, University of Modena and Reggio E., Dept. of Economics "Marco Biagi".

Forni, Mario, Domenico Giannone, Marco Lippi and Lucrezia Reichlin (2009): Opening The Black Box: Structural Factor Models With Large Cross Sections. *Econometric Theory*, 25(05), pp. 1319–1347.

Greenwood, Jeremy, Zvi Hercowitz and Gregory W Huffman (1988): Investment, Capacity Utilization, and the Real Business Cycle. *American Economic Review*, 78(3), pp. 402–17.

Heathcote, Jonathan and Fabrizio Perri (2002): Financial autarky and international business cycles. *Journal of Monetary Economics*, 49(3), pp. 601–627.

Heathcote, Jonathan and Fabrizio Perri (2003): Why Has the U.S. Economy Become Less Correlated with the Rest of the World? *American Economic Review*, 93(2), pp. 63–69.

Jaimovich, Nir and Sergio Rebelo (2008): News and Business Cycles in Open Economies. *Journal of Money, Credit and Banking*, 40(8), pp. 1699–1711.

Jaimovich, Nir and Sergio Rebelo (2009): Can News about the Future Drive the Business Cycle? *American Economic Review*, 99(4), pp. 1097–1118.

King, Robert G., Charles I. Plosser and Sergio T. Rebelo (1988): Production, growth and business cycles : I. The basic neoclassical model. *Journal of Monetary Economics*, 21(2-3), pp. 195–232.

Lambrias, Kyriacos (2013): News Shocks, Real Exchange Rates and International Co-Movements. BCL working papers 83, Central Bank of Luxembourg.

Lane, Philip R. and Gian Maria Milesi-Ferretti (2007): The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities, 1970-2004. *Journal of International Economics*, 73(2), pp. 223–250.

Leeper, Eric M., Todd B. Walker and Shu-Chun Susan Yang (2008): Fiscal Foresight: Analytics and Econometrics. NBER Working Papers 14028, National Bureau of Economic Research, Inc.

Levchenko, Andrei A. and Nitya Pandalai-Nayar (2015): TFP, News, and "Sentiments:'" The International Transmission of Business Cycles. NBER Working Papers 21010, National Bureau of Economic Research, Inc.

Lorenzoni, Guido (2011): News and Aggregate Demand Shocks. *Annual Review of Economics*, 3(1), pp. 537–557.

Lucca, David O (2007): Resuscitating Time-to-Build. Unpublished manuscript, Fed. Reserve Bank, New York.

Opazo, Luis (2006): The Backus-Smith Puzzle: The Role of Expectations. Working Papers Central Bank of Chile 395, Central Bank of Chile.

Sakane, Kosaka Michiru (2013): News-driven international business cycles. *The B.E. Journal of Macroeconomics*, 13(1), p. 43.

Schmitt-Grohé, Stephanie and Martín Uribe (2012): What's News in Business Cycles. *Econometrica*, 80(6), pp. 2733–2764.

6 Appendix

6.1 Data Sources

We list here the data used for the empirical analysis:

1. Gross Domestic Product - expenditure approach, OECD Quarterly National Account, Millions of US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted [for USA, EUROPEAN UNION 15, JAPAN, TOTAL OECD].

2. Private Final Consumption Expenditure , OECD Quarterly National Account, Millions of US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted [for USA, EUROPEAN UNION 15, JAPAN, TOTAL OECD].

3. Central Government Final Consumption Expenditure, OECD Quarterly National Account, Millions of US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted [for USA, EUROPEAN UNION 15, JAPAN, TOTAL OECD].

4. Gross Fixed Capital Formation, OECD Quarterly National Account, Millions of US dollars, volume estimates, fixed PPPs, OECD reference year, annual levels, seasonally adjusted [for USA, EUROPEAN UNION 15, JAPAN, TOTAL OECD].

5. Real Effective Exchange Rate - Price-adjusted Major Currencies Dollar Index, Foreign Exchange Rates - H.10, Board of the Governors of the Federal Reserve System [for USA]; Eurostat, Industrial countries' effective exchange rates including new Member States - quarterly data (ert_eff_ic_q) [for EUROPEAN UNION 15].

6. Weekly Hours, Establishment Survey, BLS [USA and EUROPEAN UNION 15] and ILO - montlhy data [JAPAN]

7. Real GDP, net of government consumption = (1) - (3)