News Shocks and International Business Cycles

Daniele Siena *

Banque de France

PRELIMINARY

June 2015

Abstract

The role of news shocks for international business cycle is first evaluated using a structural factor-augmented VAR model. This allows us to solve the non-fundamentalness problem and to recover the correct spillovers of news shocks across countries. Then, using a two-country, two-good real business cycle model with complete financial markets, we match the evidence including news shocks. In fact, the increased synchronization of the United States and the European Union business cycles with the rest of the world and the experienced increase in the international financial market integration motivates the search for a solution of the IRBC puzzles that does not rely only on the incompleteness of financial markets. Anticipated productivity shocks, in a standard IRBC model, featuring weak short-run wealth effects on the labor supply and investment adjustment costs, can match the evidence.

Keywords: International Business Cycles, Anticipated Shocks, Structural VARs

JEL Classification: 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.

The views expressed in this paper are those of the author alone and do not reflect those of the Banque de France.

1 Introduction

[The non-fundamentalness analysis using a structural factor-augmented VAR is not yet in the paper but it is going to be added soon]

The stochastic growth model developed by Backus *et al.* (1992), in particular the two good extension proposed by Backus, Kehoe and Kydland (1994 and 1995, henceforth BKK or standard IRBC model), has been used extensively in the literature to understand international business cycle properties. The original formulation with complete financial markets has been used successfully to explain the short run counter-cyclicality of the net export and the S-shaped cross-correlation of the trade balance and the terms of trade.[1] However, it is a well documented fact that the model fails to match the empirical positive cross-country correlations of output, employment and investment and that it cannot account for some important properties of the real exchange rate.[2]

Different studies have tried to understand what modifications of the model would help to solve those puzzles. Typically this literature assumes that financial markets are incomplete and the reason is straight forward: the existence of a full set of state-contingent assets implies perfect distribution of risks among domestic and foreign agents and determines the efficient allocation of resources; therefore, country specific shocks are spread internationally generating an almost perfect cross-country correlation of consumption and opposite cross-country reaction of investment and employment (wealth effect).

From the first quarter of 1961 to the first quarter of 2000 the United States and the European Union business cycles have become less synchronized with the cycle in the rest of the world. Heathcote and Perri (2003) explain that this fact can be seen as a transition from a less to a more financial integrated world. We are now interested in understanding how the business cycle correlations have evolved in the past decade, as the international financial integration process continued (Lane and Milesi-Ferretti (2007), Coordinated Investment Portfolio Survey, CIPS).

We update the sample of Heathcote and Perri (2003) up to the first quarter of 2012 for

[1] See Backus *et al.* (1994).

[2] Section 2.1 lists all the puzzles related to the standard IRBC model.

the United States (USA) and the European Union (EU, 15 countries). We use a broader and a narrower measure for the rest of the world to check how the USA and the EU business cycles co-move with respect to the rest of the world. Surprisingly, after the first documented decrease in the international business cycle synchronization (1960-2000), the past decade has been characterized by a strong increase in the cross-country correlation of business cycles. In the time span 1994:1-2012:1 the international correlation of output, consumption and employment reached levels well above the values registered in 1963:1-1979:4.

Therefore, we want to understand how the standard international business cycle model can account for a high international business cycle synchronization in a world in which the assumption of complete financial markets is less counterfactual. We propose anticipated shocks as the solution.

The existence of complete international financial markets implies full international risk sharing and efficient allocation of resources across-countries. Full insurance implies that shocks are spread among countries through the value of the financial assets while the efficient allocation implies that capitals are always invested in the more productive country. Understanding why these two implications restrain unanticipated but not anticipated shocks to generate cross-country co-movement is the main contribution of the paper.

We start by introducing anticipated shocks in the two-country, two-good real business cycle model with complete financial markets and we compare the results with the implications of the baseline model specification of Backus *et al.* (1994). We show that the model with anticipated shocks can generate the positive cross-country correlation of output, investment and hours worked that the baseline model fails to reproduce. The intuition for why unanticipated shocks in world with complete financial market cannot generate international co-movements is well known in the IRBC literature, and is as follows.

Consider an unanticipated positive productivity shock in the home country, which is for simplicity internationally uncorrelated. In the home country, the raise in productivity increases the present discounted value of future income and then the value of the domestic assets in the portfolio.[3] As the household wealth increase, where the wealth is given by the

[3]Notice that through out the paper a positive/negative productivity shock, anticipated or unanticipated, will always increase/decrease the present value of future income resulting in an increase/decrease in the value of the financial assets. Henceforth we refer to these as changes in the wealth, implying that the lifetime

value of the portfolio, agents want to consume more and have more leisure (both normal goods), increasing consumption and decreasing the labor supply. On the other hand, as the increase in productivity makes capital and labor more productive, firms increase the demand of capital and labor pushing up their prices. In reaction, households increase investment and the amount hours worked.[4] In the home country, the reaction to a positive unanticipated productivity shock is an increase in output, consumption, hours worked and investment. What happens to the foreign economy? As the value of the domestic assets increases,[5] the value of the portfolio held by foreign agents raises, increasing the wealth of foreign households. The increase in wealth pushes up the demand for consumption and leisure, resulting in an increase in consumption and a decrease in the labor supply. Differently from the home country, the firms demand of labor and capital remains unchanged, given the unchanged productivity. The result is a lower amount of hours worked, for a higher wages, that implies lower output. Given the contemporaneous increase in consumption and decrease in output, investment has to be reduced. Therefore, in the foreign economy, the reaction is an increase in consumption but a decrease in output, hours worked and investment. So far, we have shown the mechanism that is responsible for the failure of unanticipated productivity shocks to generate positive international co-movements of output, employment and investment in a model with complete financial markets.

How is it possible that the same model can generate positive co-movements when the shocks are the same but anticipated? The intuition is straight forward and is as follows. The only difference between unanticipated and anticipated shocks is the period which separates the announcement from the actual realization of the shock. During this periods, the values of the assets change but the real side of the economy is unaffected. The change in the value of the assets affects the wealth of the domestic and foreign economy in the same way, due to full risk sharing assumption. The equivalent movement in wealth in the two countries implies a symmetric response which generates a positive co-movement of economic variables. When

wealth of agents is determined by the value of assets that they hold.

[4]Notice that the shift in the labor demand generates an increase in wages such that the new equilibrium in the labor market, where both the demand and supply curve shifted, is characterized by higher number of hours worked and higher wages.

[5]Notice that we didn't assume any bias in the portfolio holdings that implies that both domestic and foreign household have the same amount of domestic and foreign assets.

the shock realizes we are back to the mechanism presented in the unanticipated shock case. To summarize, anticipated shocks are able to generate positive co-movement in the period between the announcement and the actual realization of the shock thanks to the symmetric reaction of the wealth effect. Another way of interpreting the role of the anticipated shock is that, in the lag between the announcement and the actual realization, it generates a symmetric cross-country demand shock. Longer is the period of the announcement, stronger will be the co-movement generated by the model.

Next, with the help of the impulse response functions, we learn that, although we are able to match the IRBC cycle properties, we fail to match the closed economy business cycle regularities: macroeconomics aggregate should increase in response to a positive anticipated productivity shock. In fact, while consumption goes up, output, investment and employment fall in both countries as a reaction to a positive anticipated shock.[6] The reason is the well known[7] failure of standard neoclassical models to generate the correct domestic business cycle dynamics in response to persistent anticipated shocks. The increase in the wealth, coming from the the positive anticipated shock, generates a decrease in the labor supply that pushes investment and output down: output, investment and hours worked fall in the country that is hit by the news shock. As a consequence of perfect risk sharing across countries, the positive wealth effect spreads to the foreign economy causing a decrease in the labor supply that generates a drop in investment and output also in the other economy. International business cycle properties are satisfied at the cost of failing to reproduce the domestic business cycle dynamics: output, employment and investment fall in both countries in response to positive anticipated shocks.

Therefore, we include in the model two features that have been proved to be important in order to match the business cycle dynamics in response to anticipated productivity shocks: preferences featuring weak short-run wealth effects and sluggishness in the adjustment of investments. Such a framework can now generate the correct international and domestic business cycle dynamics. The contribution of these two new features of the model is straight forward. As before, anticipated positive productivity shocks increase the wealth in both coun-

[6]The inability of the standard BKK model to generate the correct domestic business cycle dynamics in response to a country specific anticipated shock has been proved also by Beaudry *et al.* (2011).

[7] Jaimovich and Rebelo (2009), Lorenzoni (2011) and Schmitt-Grohé and Uribe (2012)

tries. However, the reduced wealth elasticity of the labor supply guarantees now that labor does not fall in response to the increase in wealth: investment and output do not decrease. On the other hand, investment adjustment costs ensure that the reaction of investment, as soon as the shock realizes, is smoother in the two countries. Depending on the size of the cost, we will have that the adjustment of the amount of capital starts in both countries as soon as the news is received and this avoids the opposite instantaneous adjustment we would have in a world without frictions at the time in which the shock realizes.

Our conclusion is that in a world with complete financial markets, anticipated shocks could play a major role in international business cycle synchronization. From a theoretical experiment we see that anticipated productivity shock, in a world with low labor supply wealth elasticity and investment adjustment costs, can generate a positive cross-country correlation of output, consumption, investment and hours worked.

It is worth noting that an alternative explanation for the increase in the synchronization could be derived from the study by Davis (2012). He shows empirically that, depending on the type of the financial integration experienced, 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 with respect to the baseline model. Otherwise we could have an increase in the cross-country correlations if the balance sheet effect dominates.[8]

The paper is organized as follows. Section 2 introduces the major puzzles and the solutions proposed in the open-macroeconomic literature. In section 4 we look at the data in order to assess what the IRBC values are today, with a particular interest in understanding the evolution of the cross-country correlations. Section 5 illustrates the set-up of the baseline model and it introduces the structure of anticipated shocks. We present the results for the baseline and extended model in section 6. Section 7 concludes.

[8]For a full descriptions of the empirical analysis and the theoretical mechanism behind the wealth and the balance effects we cross-refer to Davis (2012). 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 The Puzzles and the Solutions

The international real business cycle literature (IRBC) is a field in which a lot of puzzles are still open or only partially solved. Before analysing the role of anticipated shocks in international co-movements, we summarize the major miss-matches between the theoretical and the empirical findings which are relevant for our analysis.[9] We then briefly try to summarize the main contribution and mechanism behind some of the relevant studies that have been addressing those puzzles.

2.1 The Puzzles

With the help of Obstfeld and Rogoff (2001) we briefly list the major puzzles that are relevant for our analysis of the international real business cycles:

- Cross-country correlation of consumption is much higher in the model than in the data;
- Cross-country correlation of output is much higher in the data than in the model. Empirical international output correlation is higher than consumption;
- Cross country correlation of employment and investment is found to be negative in the model while it is positive in the data;
- The real exchange rate is negatively correlated with the ratio of domestic and foreign consumption while it is positive and almost equal to one in the model (Backus-Smith puzzle).

2.2 Literature Review - Possible Solutions

Many of the open economy puzzles come from a particular mechanism generated by the standard international real business cycle model. The assumptions of complete financial markets, equivalent to perfect international risk sharing, and constant relative risk aversion utility function imply that the real exchange rate is determined by the ratio between domestic and foreign consumptions. This generates a strong correlation between consumption across

[9] In section 4 we will check if they are still valid in today's data

countries and a low volatility of the real exchange rate. The complete market assumption implies also that the two countries' output reacts in a different way when one of the two economies is hit by a shock. The reason, which we will see later in detail, is that the investment and the labor supply will increase in the most productive country but will decrease in the other country.

An important fraction of the open macroeconomic literature, after the construction of the standard IRBC model by Backus *et al.* (1992), explored different models aiming at reconciling the empirical findings with the results of the model. Most of those studies focus on relaxing the strong assumption of complete financial markets and can be clustered in two groups: models limiting the type/number of assets available and models limiting the functioning of the market.

We start by presenting the first group of models. Baxter and Crucini (1995) and later Kollmann (1996) and Arvanitis and Mikkola (1996) assume that there are only non-contingent bonds available in the economy. Whenever shocks are strongly persistent or do not get transmitted internationally through other mechanisms, the incompleteness of the financial market has important implications for the international transmission of business cycles: the cross-country output correlation becomes positive as in the data. In the same stream of literature Heathcote and Perri (2002) show that a model with financial autarky can explain, at the same time, the volatility of the terms of trade and the cross country correlation of output, consumption, investment and employment. Corsetti *et al.* (2008) and Benigno and Thoenissen (2008) focus more on the dynamics of the real exchange rate, but using incomplete financial market as an important mechansim, and show that the negative correlation between domestic and foreign consumption with the real exchange rate can be reconciled with standard open-economy models.

Behind this first block of models there is the idea that the increasing financial integration decreases the international cross-country correlation of the output, as a consequence of the wealth effect. The mechanism through which the wealth effect works, abstracting from the trade channel, is the following. Country 1 is hit by a negative productivity shock and will experience a decrease in investment due to the decrease in the marginal productivity of capital. With no financial market, country 2 would be completely unaffected: we would experience a

decrease in output in country 1 and a constant output in country 2. Differently, remembering that a complete financial market is equivalent to having an asset for every possible realization of shocks, the effects change when there is perfect risk sharing across countries. Now, if a negative shock hits country 1, the wealth of country 2 will also be decreased. This decrease in wealth in country 2 would push savings and investments up increasing the output.[10]

The second group of models focuses on the functioning of the financial markets. Kehoe and Perri (2002) introduce the idea that international loans are imperfectly enforceable. This assumption can generate a positive correlation of cross-country output and succeeds in making employment and investment co-move positively. Using a similar market incompleteness, Bodenstein (2008) addresses the Backus-Smith puzzle through a two country model with complete asset markets but also with a limited enforcement of international financial contracts. At the cost of high real exchange rate volatility, this model performs better than the incomplete, single international bond, financial market used by Baxter and Crucini (1995).

3 Empirical estimation

Assume a world in which the only sources of business cycle fluctuations are productivity shocks. Those shocks can be either surprises or anticipated some period in advance. In an international macro environment (two country model), we see that countries' business cycles are not orthogonal. We claim that two are the sources of correlation in the cycle. The first comes from the fact that, in a world with complete financial markets and in which information are freely spread around the world, country specific anticipated shocks generate wealth effects that are anyway spread contemporaneously across countries. In addition there are international anticipated shocks which are affecting contemporaneously the future evolution of TFP (e.g. standardization). These shocks, additionally to a correlated wealth effect will generate a co-movement of TFP when the shock will realize (assuming that anticipation has the same time-lag across countries) which will synchronize the cycle. TFP will therefore not be correlated because of TFP surprise shocks are correlated but because of news shocks that

[10]For simplicity, in the exposition of the wealth effect, we excluded the mechanism that works through trade. When we consider also the trade effect, the results are even starker, as now trade flows are also affected by the decrease in wealth.

are correlated. Therefore, looking at news shocks only in the domestic environment can be miss-leading and still subject to the non-fundamentalness problem. In fact, not having the information coming from the other country can lead to the inability of recalling the correct anticipated shock in a domestic environment. We propose here a solution to overcome the non-fundamentalness problem. Following the approach of Forni *et al.* (2014) we enlarge their analysis by including in a large FVAR also international variables.

around the world are not Now, considering international linkages it is safe to assume that information are spread across countries. where information

4 Data - Business Cycle Synchronization

We are interested in measuring the levels and the evolutions of the international real business cycle correlations. We focus on the United States and the European Union with respect to the rest of the world in the quarters from 1960:1 to 2012:1. Heathcote and Perri (2003) showed that the United States business cycle, between the first quarter of 1960 and the second quarter of 2002, had become less synchronized with the cycle of the rest of the world. The international correlation of output, consumption, investment and employment decreased in the period from 1981:2 to 2000:1.

We consider data on GDP, consumption, gross fixed capital formation and employment.[11] We start by treating the USA as the home country and then we see if and how the level of the cross country correlation changes when we consider the European Union as the main country. For the foreign economy, the rest of the world, we provide two different measures: first, as in Heathcote and Perri (2003), we use the sum of the European Union (15 countries) and Japan; second, we propose 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.

From 1960 to 2000, both the US and the EU business cycles have become less synchronized with the cycle in the rest of the world. This result holds independently on the narrower or broader definition of the rest of the world. However, it is interesting to notice that starting

[11] We subtract the government consumption from the GDP to avoid that episodes of wars could bias the results.

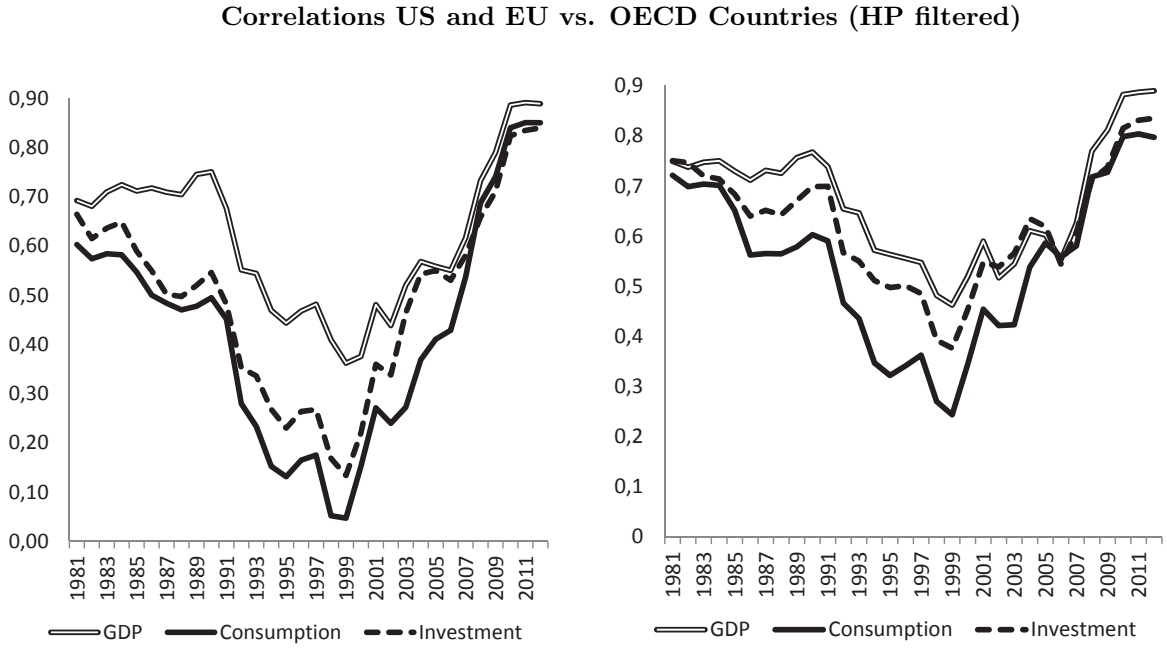
Table 1: Cross-country correlations (HP filtered)

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 or the European Union (15 member countries); Foreign country: Rest of the world measured both as the sum of the European Union 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. Appendix 8.1 provides the details on the data used.

in 2000 the international business cycle synchronization picked up again. This result is not just a consequence of the great Recession and it is not due to the particular choice of the sample. To prove it, in figure 1, we show the cross-country correlation of output, consumption and investment for the USA and the European Union in successive 17 year windows, from 1963:1-1979:4 to 1994:1-2012:1. It is clear that there was a decline of home and foreign cross country correlations up to 2000 but then, they have started to increase again reaching, at the beginning of 2012, values above the average between 1963 and 1974. The same cycle applies to all the series considered, not only for GDP or consumption.

Two more results from table 1 are worth to be noticed. First, when we take into consideration the IRBC correlations of the USA using the broader definition of the rest of world (all OECD countries and not only Japan and EU15), the synchronization, for all the series and all the time period considered, increases. This could be due either to the fact that we are including countries, like for example Canada, which are strongly related to the USA or to the stronger influence of the US economy to smaller OECD countries. The second fact is that, not surprisingly, also the European Union is strongly synchronized with the rest of



(a) USA (b) EU

Figure 1: Output, consumption and investment international correlations for a rolling window from 1963:1-1981:1 to 1994:1-2012 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. For example, 1981 will be the reference for the value of the cross-country correlation of GDP, consumption and investment from 1963 to 1981.

the world cycle. What is not obvious is that the synchronization of the EU with respect to the other OECD countries is stronger than the one of the USA. Some more analysis is necessary to better understand these two points but it is interesting to keep in mind that the synchronization of the IRBC could be even stronger than what it is perceived and that the European Union co-movement is stronger than the one experienced in the USA.

The last line of table 1 shows that the Backus-Smith puzzle is still consistent with the data. 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.

We proved, using the most recent available data, that those empirical regularities that were in contrast with the standard IRBC model are still important: consumption is far from being perfectly correlated, even if we consider only the period of highest correlation. GDP is constantly more cross correlated than consumption; GDP, investment and employment are strongly correlated across industrialized countries and it is even more so in the last ten years.

5 The Model

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).

5.1 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:

$$K_i(s^t) = (1-\delta)K_i(s^{t-1}) + I_i(s^t)^{12} \tag{3}$$

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

[12] 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 6.1 an isomorphic way to model adjustment costs.

(3):

$$\max_{C_i(s^t),L_i(s^t),K_i(s^t)} E_0 \sum_{t=0}^{\infty} \sum_{s^t} \pi(s^t)\beta^t \frac{1}{1-\sigma} \left[C_i^{\mu}(s^t)\left(1-L_i(s^t)\right)^{1-\mu}\right]^{\sigma}$$

$$\text{s.t. } C_i(s^t) + K_i(s^t) - (1-\delta)K_i(s^{t-1}) + q_i^j(s^t) \sum_{s_{t+1}} Q_i\left(s^t, s_{t+1}\right) B_i(s^t, s_{t+1}) =$$

$$= q_i^j(s^t)\left[R_i^k(s^t)K_i(s^t) + W_i(s^t)L_i(s^t)\right] + q_i^j(s^t)B_i(s^{t-1}, s_t)$$

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

$$\max_{L_i(s^t),K_i(s^t)} Y_i(s^t) - W_i(s^t)L_i(s^t) - R_i^k(s^t)K_i(s^t)$$

$$\text{subject to } Y_i(s^t) = Z_i(s^t)K_i(s^t)^{\theta}L_i(s^t)^{1-\theta},\ K_i(s^t), L_i(s^t) \geq 0 \tag{4}$$

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:

$$\max_{a_i(s^t),b_i(s^t)} F_i(s^t) - q_i^a(s^t)a_i(s^t) - q_i^b(s^t)b_i(s^t)$$

$$\text{subject to } a_i(s^t), b_i(s^t) \geq 0 \text{ and equation (5).} \tag{6}$$

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.

Table 2: 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		
$\begin{bmatrix} \rho_z & \rho_{zz} \\ \rho_{zz} & \rho_z \end{bmatrix} = \begin{bmatrix} 0.906 & 0.088 \\ 0.088 & 0.906 \end{bmatrix}$		
$VAR\epsilon_H^Z = VAR\epsilon_F^Z = 0.00852^2$		
$Corr(\epsilon_H^Z, \epsilon_F^Z) = 0.258$		
$g_t = 0$		

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 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 2 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 4; 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 6.1 assesses the importance of anticipated shocks in a model with little short run wealth effects on the labor supply and investment adjustment costs.[13]

6 Results

Figure 2 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 in both countries while output increases a lot more in the country hit by the shock. As explained in 2.2, 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

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

Unanticip vs. Anticip Productivity Shock - Baseline Model

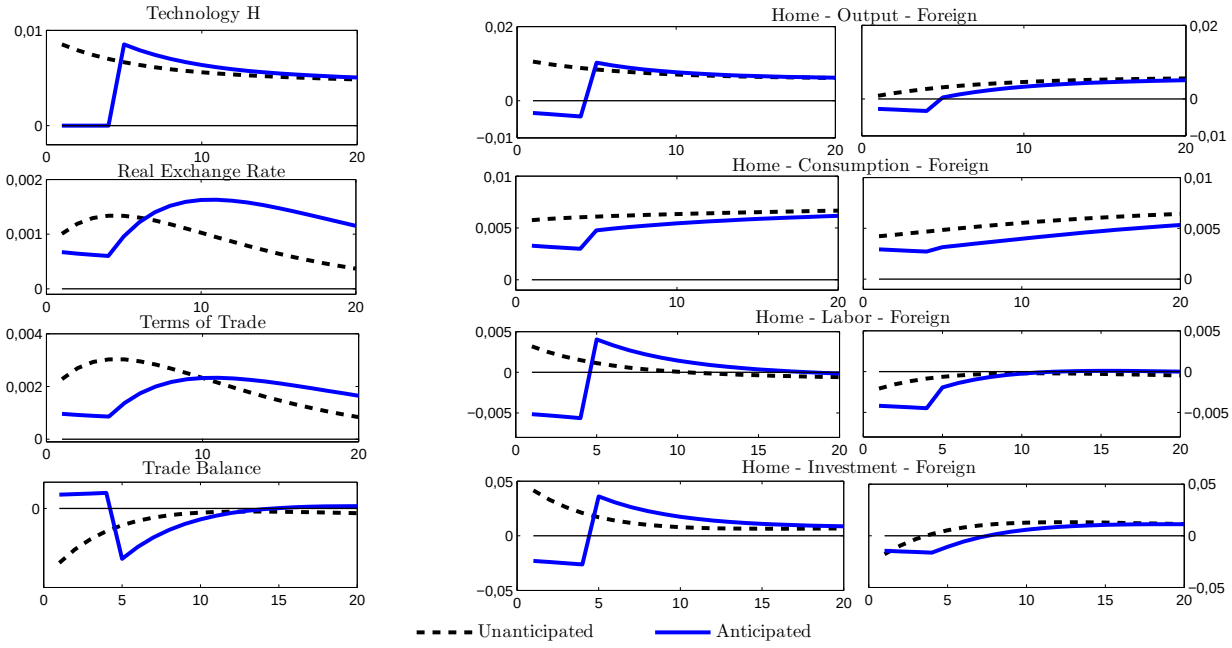


Figure 2: Impulse-responses to a positive unanticipated and anticipated technology shock (baseline model).

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 2, the model can now generate positive international cross-correlation of output, employment and investment. Notice, in table 3, 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

Table 3: 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 $\rho_{zz} = 0$.

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 3 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.

6.1 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 2). The reason comes from the strong positive wealth effect caused by the future expected increase in productivity. Given that capital is 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 productivity 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 3 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 3, 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.[14] 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 3). 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 6 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.[15]

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 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.

7 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

[14]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

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

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.

Arvanitis, Athanasios V and Anne Mikkola (1996): Asset-Market Structure and International Trade Dynamics. *American Economic Review*, 86(2), pp. 67–70.

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 (1992): International Real Business Cycles. *Journal of Political Economy*, 100(4), pp. 745–75.

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.

Baxter, Marianne and Mario J Crucini (1995): Business Cycles and the Asset Structure of Foreign Trade. *International Economic Review*, 36(4), pp. 821–54.

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

Benigno, Gianluca and Christoph Thoenissen (2008): Consumption and real exchange rates with incomplete markets and non-traded goods. *Journal of International Money and Finance*, 27(6), pp. 926–948.

Bodenstein, Martin (2008): International Asset Markets and Real Exchange Rate Volatility. *Review of Economic Dynamics*, 11(3), pp. 688–705.

Corsetti, Giancarlo, Luca Dedola and Sylvain Leduc (2008): International Risk Sharing and the Transmission of Productivity Shocks. *Review of Economic Studies*, 75(2), pp. 443–473.

Davis, Scott (2012): Financial integration and international business cycle co-movement: the role of balance sheets. Globalization and Monetary Policy Institute Working Paper 89, Federal Reserve Bank of Dallas.

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

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

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.

Kehoe, Patrick J. and Fabrizio Perri (2002): International Business Cycles with Endogenous Incomplete Markets. *Econometrica*, 70(3), pp. 907–928.

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.

Kollmann, Robert (1996): Incomplete asset markets and the cross-country consumption correlation puzzle. *Journal of Economic Dynamics and Control*, 20(5), pp. 945–961.

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.

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.

Obstfeld, Maurice and Kenneth Rogoff (2001): The Six Major Puzzles in International Macroeconomics: Is There a Common Cause? In: *NBER Macroeconomics Annual 2000, Volume 15*, NBER Chapters, pp. 339–412. National Bureau of Economic Research, Inc.

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

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

8 Appendix

8.1 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)