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The International Propagation of News Shocks

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Abstract

We address the question of business cycle co-movements within and between countries. Considering the U.S. and Canada, as well as Germany and Austria, we show that a stock market innovation in the large country, that does not affect Total Factor Productivity in the short run, does indeed explain much of Total Factor Productivity changes in the long run. We therefore label such a shock a news about Total Factor Productivity of the large country. This shock is shown to act as a demand shock in the data, creating a boom in the large country as well as in the small one. Second, we propose a two-country-two-sector model that is shown to give realistic quantitative predictions. The model builds on the closed economy model of Beaudry and Portier [2004], in which there are limited possibilities to reallocate factors between investment and consumption good sectors. We also show that a canonical Real Business Cycle two-country model cannot account for those responses to technological news shocks we have identified in the data.

Key Words : Business Cycles, Expectations, International Fluctuations, News

JEL Classification : E32 – F41

Introduction

Since A.C. Pigou and J.M Keynes, the macroeconomic literature has emphasized the role of expectations in affecting business cycles. The newest embodiment of the literature stresses on the role of expectations regarding future productivity growth in creating fluctuations. Beaudry and Portier [2005, 2006] and Haertel and Lucke [2007] have shown that Total Factor Productivity permanent improvements can be spotted in stock prices fluctuations before they actually increase TFP. The effects of those news shocks on economic activity have been investigated in a set of recent papers (Beaudry and Portier [2004], Christiano, Motto, and Rostagno [2005], Jaimovich and Rebelo [2006], Beaudry, Collard, and Portier [2006], Den Haan and Kaltenbrunner [2007])

In this paper, we first show that the data supports the existence news-driven international business cycles. We find evidence of such news shocks and find that they do generate domestic booms that are exported to close trade partners. We then propose a two-country-two-sector model that is shown to give realistic quantitative predictions. The model builds on the closed economy model of Beaudry and Portier [2004], in which there are limited possibilities to reallocate factors between investment and consumption good sectors. We also show that a canonical Real Business Cycle two-country model cannot account for those responses to technological news shocks we have identified in the data.

In a first section, we document that news about future increases in TFP are creating international business cycles. More precisely, we show that innovations in the U.S. stock price that are orthogonal to current U.S. TFP are increasing U.S. TFP in the long run, are associated with an increase in output, consumption, investment and hours in the U.S. and in one of the closest U.S. trade partner, Canada. We repeat the same exercise with German stock price innovations and show that they create German business cycle, but also Austrian one. We also show that German news impact positively on French and Italian business cycle. In a second section, we propose a quantitative assessment of the international propagation of news shock in a two-country extension of Beaudry and Portier [2004] closed economy model. We show that the model responses to a local technological news shocks display an aggregate boom at home, and that this boom is also transmitted to the foreign country. The key insight is that, because news shocks are common knowledge, they act as a common shock although the news is about a technological improvement in one country only. We also show that a quantitative "international real business cycle" model *à la* Backus, Kehoe, and Kydland [1994] fails reproducing the conditional response to technological news shocks.

1   Facts on the International Propagation of News Shocks

In this section, we assess the empirical propagation of news shocks across countries. Namely, we compute the impact of U.S. TFP news on Canadian business cycle and the impact of German TFP news on the Austrian, French and Italian business cycles.

1.1 Identification of News Shocks in a Bivariate Setup

Beaudry and Portier [2006] identify news shock to productivity estimating a bivariate VAR[1] on the log of Total Factor Productivity corrected for capacity utilization (TFP) and a stock price index (SP):

$$A(L) \begin{pmatrix} \Delta TFP_t \\ \Delta SP_t \end{pmatrix} = \begin{pmatrix} u_{1,t} \\ u_{2,t} \end{pmatrix} \tag{1}$$

with $A(L) = I + \sum_{i=1}^{\infty} A_i L^i$. u_1 and u_2 are two white noise residuals with covariance matrix Ω. From this VAR, they recover the following Wold representation:

$$\begin{pmatrix} \Delta TFP_t \\ \Delta SP_t \end{pmatrix} = B(L) \begin{pmatrix} u_{1,t} \\ u_{2,t} \end{pmatrix}. \tag{2}$$

with $B(L) = I + \sum_{i=1}^{\infty} B_i L^i$.

Identification amounts at choosing a matrix C_0 that maps "reduced-form" residuals u into "structural" ones ε: $u_t = C_0 \varepsilon_t$. Imposing that the covariance matrix of ε is identity, the matrix C_0 shall verify $C_0 C_0' = \Omega$, which imposes 3 constraints on the four elements of C_0. One extra restriction is therefore needed to uncover the following "structural" representation:

$$\begin{pmatrix} \Delta TFP_t \\ \Delta SP_t \end{pmatrix} = C(L) \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix} \tag{3}$$

with $C(L) = \sum_{i=0}^{\infty} C_i L^i$ and $C_i = B_i C_0$ for $i > 0$.

Beaudry and Portier [2006] successively impose a long run and a short run restriction to identify *(i)* a short–run TFP shock and *(ii)* a long–run TFP shock. They show that the shock which is orthogonal to the short–run TFP shock is almost perfectly correlated with the long–run TFP shock. In other words, a stock price innovation which has no instantaneous impact on TFP explains virtually 100% of its long–run variance. This shock is interpreted as a news on future TFP improvements which shows up instantaneously in stock market capitalization but only affects measured TFP with a delay.

In what follows, we denote ε_1 the stock price innovation (the shock that is orthogonal to contemporaneous TFP), and recover it by imposing the identifying constraint $C_0(1,1) = 0$. Figure 1 displays the response of U.S. TFP to the ε_1 shock (left panel) together with the share of the forecast error variance of TFP associated to this shock (right panel). Two features emerge. First, the news shock has a significant long–run effect on TFP and explains a large share of the forecast error. Second, it has almost no impact on TFP during the first five years. This favors an interpretation of ε_1 as a news about future U.S. TFP.

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[1] For simplicity, we assume away constants and cointegration in this presentation, although we do consider those issues in the estimation.

Figure 1: Identification of the U.S. News Shock in a Bivariate Setup
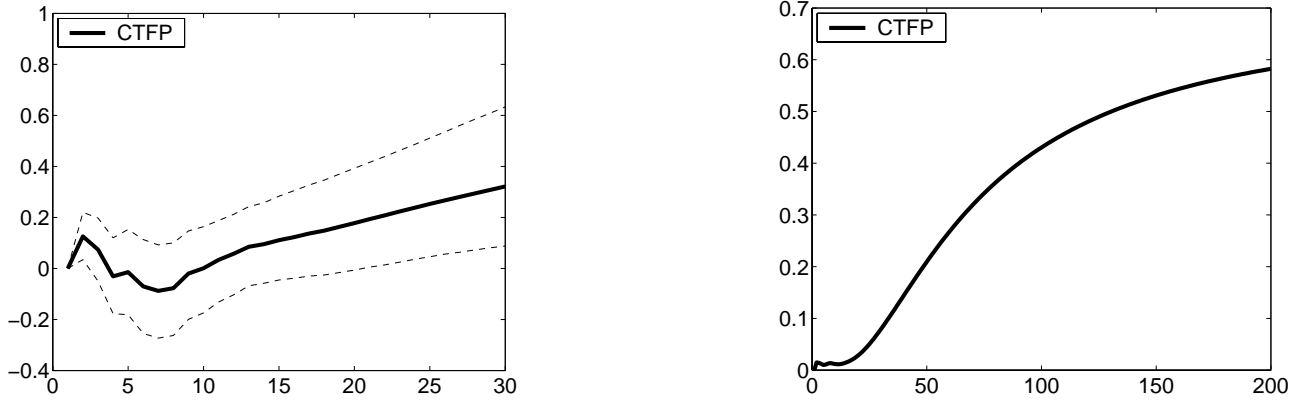
This Figure displays the Impulse Response Functions of TFP corrected for capacity utilization to a news shock (left panel) as well as the share of the variance of forecast errors (right panel) obtained from a (Corrected TFP, SP) VECM with 5 lags. Sample: 1960Q1 to 2000Q4.

1.2 Identification in a Trivariate Setup

We want to build on the empirical identification presented above to recover the responses of different macroeconomic aggregates in country J to a news about total factor productivity in country I. Let X be any macroeconomic variable, in log. We consider trivariate structural processes of the type:

$$\begin{pmatrix} \Delta TFP_{I,t} \\ \Delta SP_{I,t} \\ \Delta X_{J,t} \end{pmatrix} = C(L) \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{pmatrix} = \left[\sum_{k=0}^{\infty} C_k L^k \right] \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{pmatrix}. \tag{4}$$

Here, $\varepsilon_{1,t}$ denotes the news shock, while $\varepsilon_{2,t}$ and $\varepsilon_{3,t}$ denote the two remaining shocks. Those three shocks are independent, have zero mean and unit variance. Three additional restrictions are required to recover the structural representation from the reduced–form residuals.

We adopt the following short–run identification. The news shock ε_1 has no instantaneous impact on TFP, $C_0(1,1) = 0$, but may affect stock prices or the third variable. Shock ε_2 has no instantaneous impact neither on TFP nor on the stock market capitalization, $C_0(1,2) = C_0(2,2) = 0$. It may be interpreted as a shock specific to variable X. Finally, the third shock ε_3 can affect any of the three variables instantaneously, as would a TFP surprise typically do.

The precise specification of the estimated VECM is set as follows. We impose a lag structure on the system in level, say k lags. We test the number of cointegration relationship in this system using Johansen's test procedure. If no cointegration relationship is detected, we estimate the VAR underlying (4) in first–differences with $k-1$ lags. If we detect three cointegration relationships, we estimate the VAR in level with k lags. With one or two cointegration relationships, we estimate the

system in first–difference with one or two error correction terms and $k-1$ lags. At this stage, we compute standard information criteria (AIC, BIC and Hannan–Quin). We iterate on the number of lags and finally choose the specification that maximizes the information criteria.

We now present the results based on actual data.

1.3 News on U.S. TFP and Their Impact on U.S. and Canadian Business Cycle

To quantify the impact of U.S. TFP news on U.S. and Canadian business cycle, we estimate model (4) on quarterly U.S. and Canadian data.[2] Being U.S. main trade partner, Canada is a natural candidate to assess the international propagation of a U.S. news shocks. Furthermore, the U.S. economy being approximately five times as large as the Canadian one, U.S. shocks are likely to have sizeable consequences in Canada.

We see on Figure 2 that a positive U.S. news shock (*i.e.* a positive increase in market capitalization independent of any current TFP increase but which forecasts a future TFP increase) triggers a domestic expansion. Output, employment, consumption and investment exhibit significant increases after the shock.[3] This expansion is an episode of expectation–driven national business cycle.

Figure 2: Response to a U.S. News Shock, USA
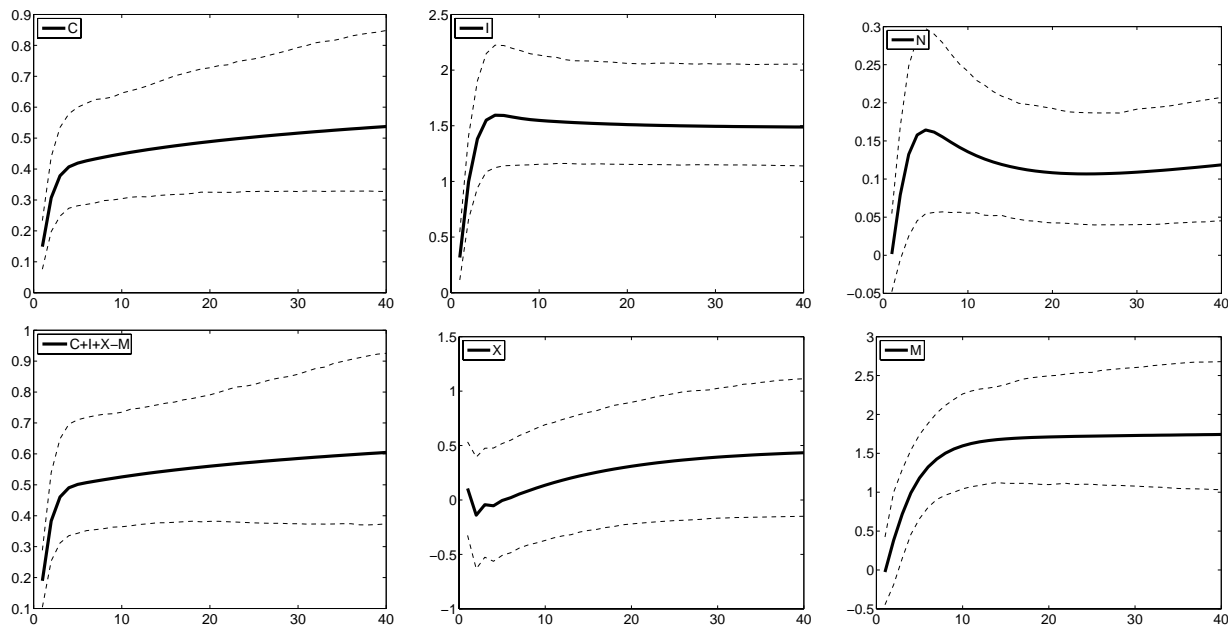
This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM. Sample: 1960Q1 to 2000Q4.

[2]See Appendix A for an extensive description of the data.

[3]The increase is employment is slightly delayed, giving rise to the usual productivity cycle.

Interestingly, U.S. imports respond positively to the U.S. news shock, while U.S. exports are left unaffected. These findings are in line with the demand–side interpretation of news shocks: the expectations of future technology improvements, the intuition goes, lead households to increase consumption and firms to start building–up capital right away (provided that some frictions prevent households from eating capital). Part of this increased demand is met by foreign producers. As long as technology remains unchanged, home exports are not stimulated, so that net exports are countercyclical.

The rise in U.S. imports provides a channel for the transmission of the U.S. boom to its trade partners. Figure 3 displays the response of Canadian aggregates to the U.S. news shock. It shows that Canadian investment instantaneously rise, while consumption and output remain unchanged on impact. After a couple of periods, consumption, investment, output and employment do increase in Canada as well as in the U.S., and the orders of magnitude of these responses are the same in Canada and the U.S..

Notice that the U.S. news shock stimulates Canadian exports, as opposed to U.S. ones. The boom in exports is obviously consistent with the increase in U.S. imports. Overall, the U.S. news shock rapidly triggers an expansion in Canada, which is an episode of expectation–driven international business cycle.

Figure 3: Response of Canadian Aggregates to a News on U.S. TFP
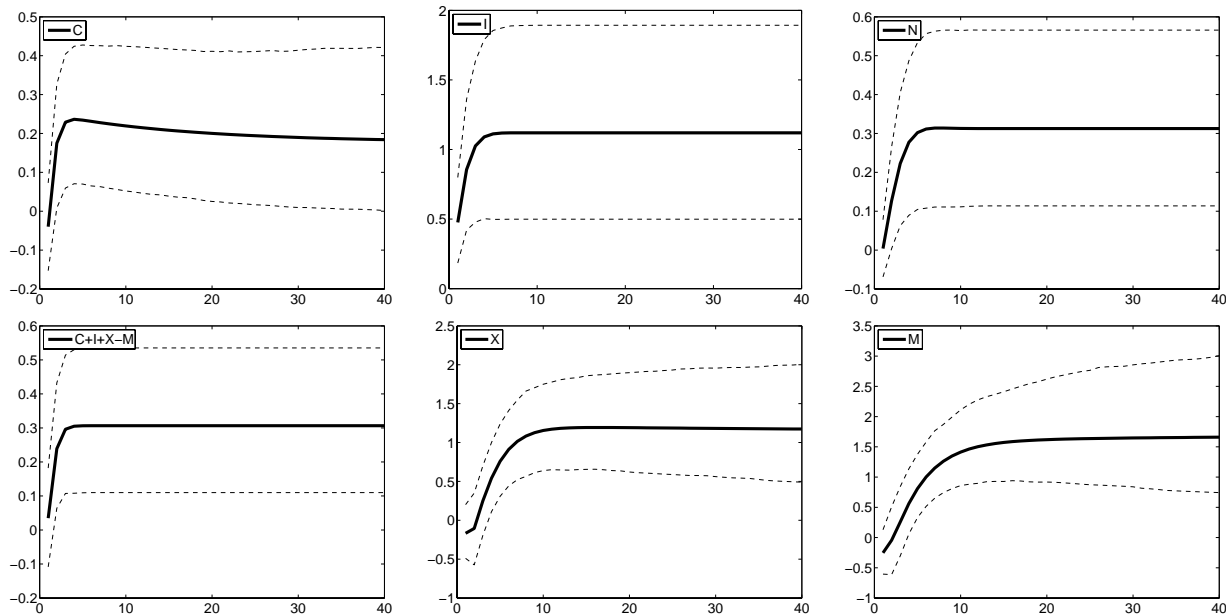
This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected U.S. TFP, U.S. SP, Canadian macro aggregate) VECM. Sample: 1965Q1 to 2000Q4.

A possible interpretation of the shock we have identified is that it is a Canadian TFP surprise, orthogonal to U.S. TFP, but having an effect on U.S. stock prices. We dismiss this interpretation for two reasons. First, Canada being a small country compared to the U.S. (this is why we chose it), it is quite unlikely that Canadian TFP could explain a lot of the short run variablility of U.S. stock prices, and almost all the long run variability of U.S. TFP. Second, we estimate the response of Canadian TFP by including it as the third variable in the three-variables VECM[4]. Figure 4 displays the IRF and variance decomposition of the Canadian Solow residual to our estimated U.S. news shock. This shock has no significant impact on Canadian factor productivity and only explains slightly more than 1% of its variance after one hundred years. The shock that we identify is therefore not a Canadian TFP surprise.

Figure 4: Response of Canadian TFP to a News on U.S. TFP
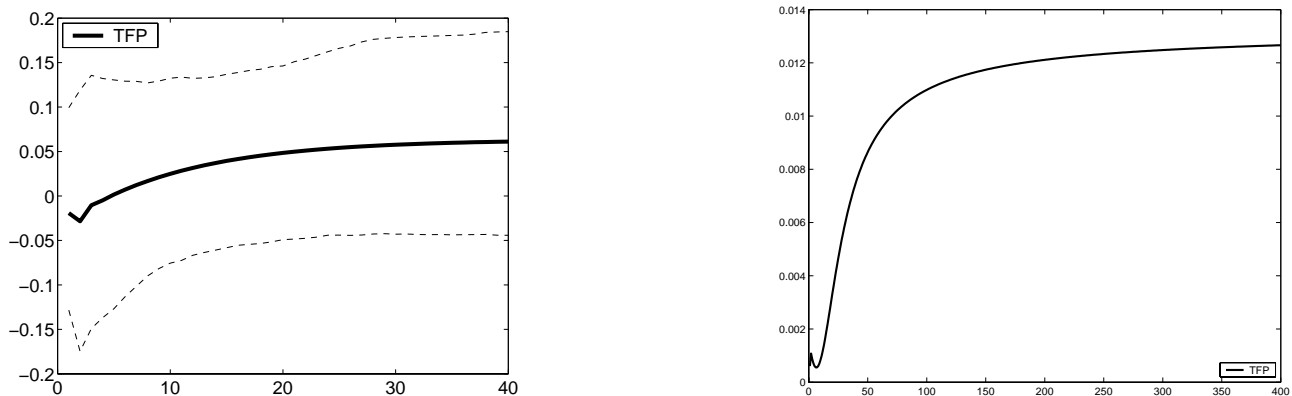
This Figure displays the Impulse Response Functions of the Canadian TFP to a U.S. news shock (left panel) as well as the share of the variance of forecast errors (right panel), obtained from a (Corrected TFP, SP, Canadian TFP) VECM. Sample: 1966Q1 to 2000Q4.

Our preferred interpretation of these findings is that permanent U.S. TFP improvements diffuse slowly, while they are immediately incorporated in agents expectations in both countries. Such news create an aggregate boom at home, but also in economies in close trade partnership with the U.S..

1.4 News on German TFP and Their Impact on German and Austrian Business Cycle

We extend our previous result to a second pair of countries with similar characteristics, namely Germany and Austria. As for the U.S.A.-Canada pair, Austrian GDP is about one fifth of the German one, and Germany is Austria's main trade partner. We identify a news shock to German TFP using

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[4]We thank Stephen Murchison from the Bank of Canada for providing us with a TFP series.

Haertel and Lucke [2007]'s data and estimate its dynamic impact on German and Austrian aggregates. In this dataset as well, TFP is corrected for capacity utilization.

Figure 5: Identification of the German News Shock in a Bivariate Setup
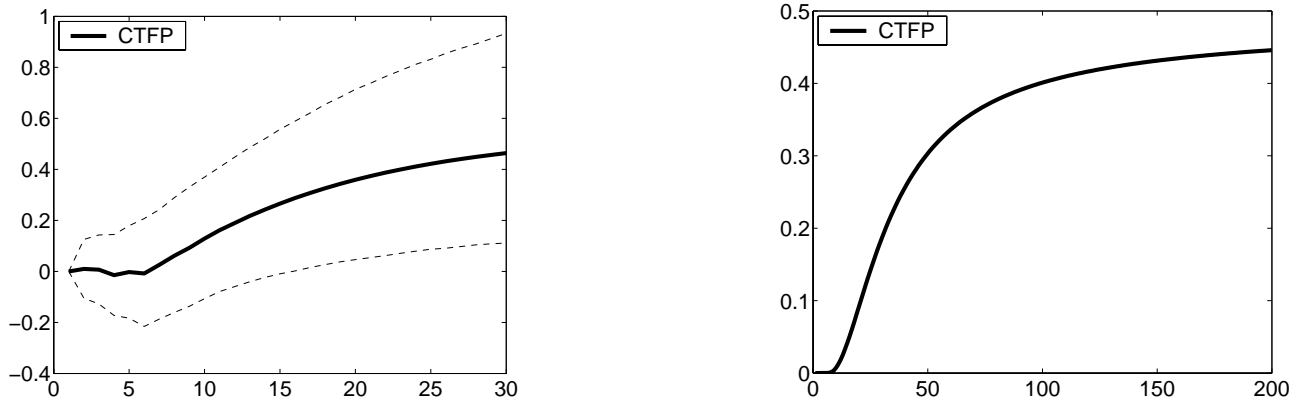
This Figure displays the Impulse Response Functions of TFP corrected for capacity utilization to a news shock (left panel) as well as the share of the variance of forecast errors (right panel) obtained from a (Corrected TFP, SP) VECM with 5 lags. Sample: 1970Q1 to 2004Q3.

Figure 5 displays the IRF of TFP to the news shock (left panel) and the forecast–error variance decomposition (right panel) obtained with a bivariate VECM. Results are similar to the U.S. ones. The impact on TFP remains insignificant for more than fifteen quarters and a large part of the long–run forecast–error variance is attributable to the shock with no instantaneous impact on corrected TFP.

We then compute the dynamic responses of several German macroeconomic aggregates in a three–variables setup. The results of these estimations are reported in Figure 6. German consumption, investment and output rise in the quarters following a news shock, while employment does not change. The news shock stimulates German imports; on the contrary, German exports exhibit no significant change. As in the U.S., the aggregate boom is likely to propagate to Germany's trade partners through the rise in imports.

Figure 7 displays the IRF of Austrian aggregates to the German news shock. Consumption, investment and output rise in response to the German news shock. These three variables as well as employment exhibit non–monotonic responses. Finally, Austrian exports significantly increase after the news shock hitting its trade partner, as did Canadian exports.

We replicate the exercise on French and Italian data. The responses of French and Italian aggregates to the German news, in Appendix D, provide further evidence of an international propagation of the German news shock.

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Figure 6: Response of German aggregates to a German News Shock
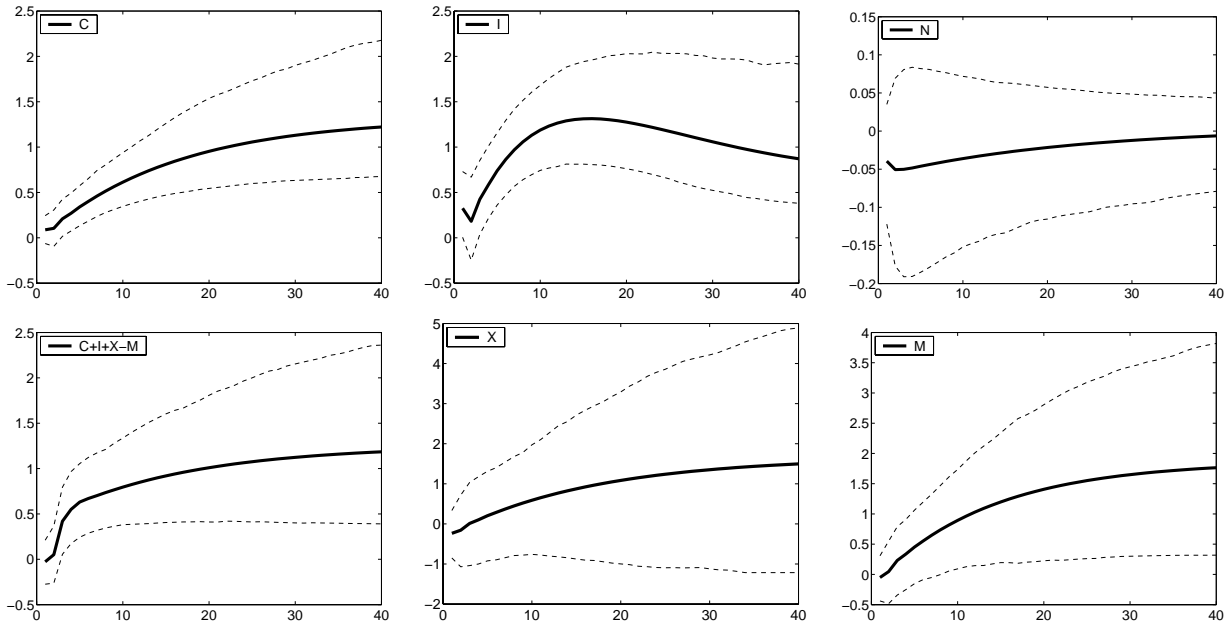
This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM. Sample: 1970Q1 to 2004Q3.

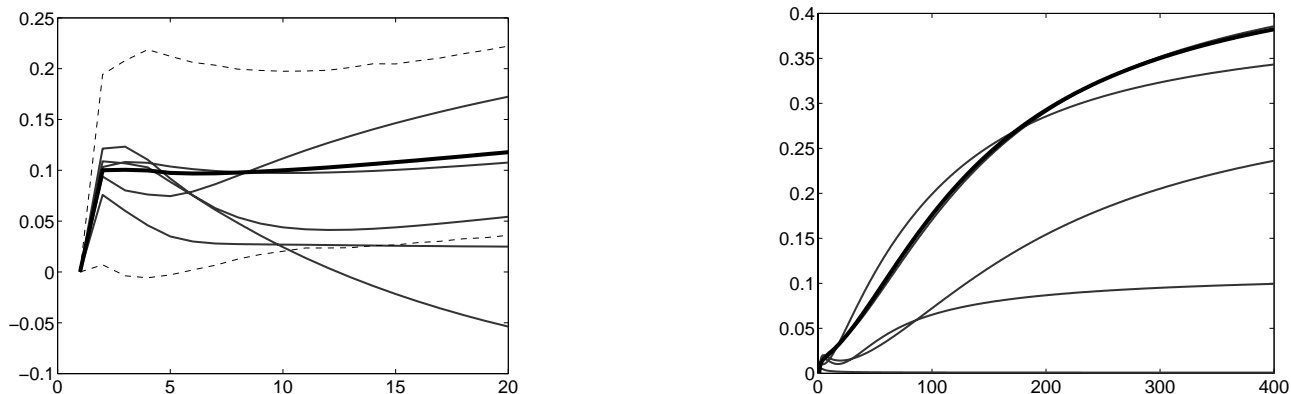Figure 7: Response of Austrian aggregates to a German News Shock
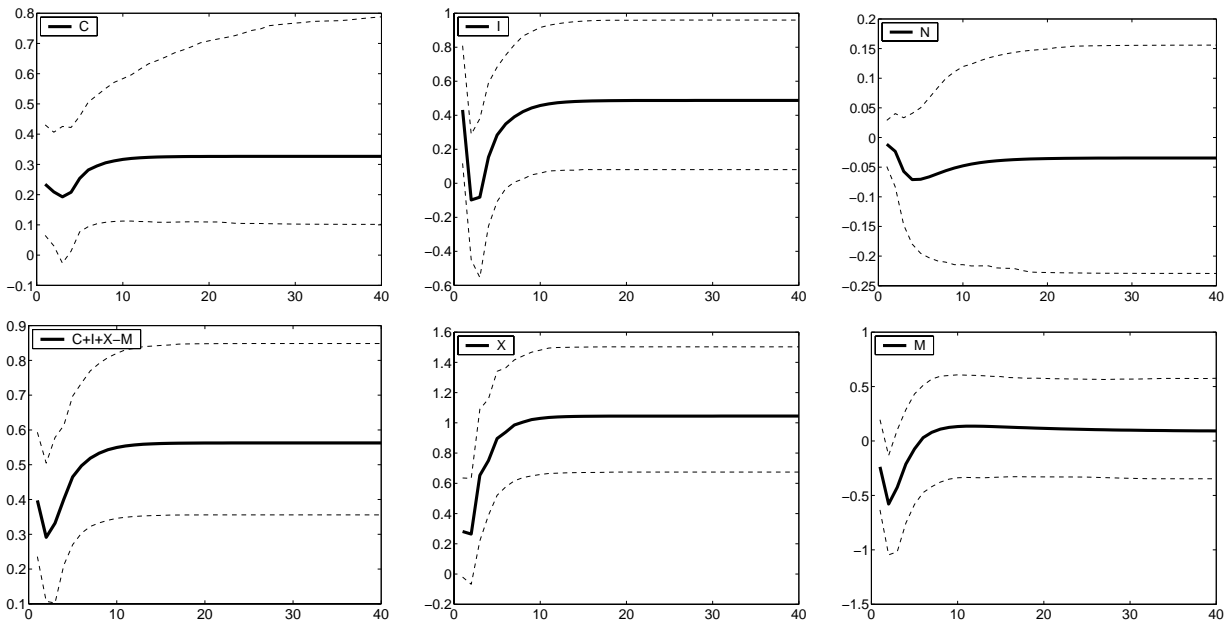
This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM. Sample: 1969Q1 to 2004Q3.

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1.5 Robustness in a Two–Step Approach

A shortcoming of the previous approach is that the estimated realizations of the news shock, $\{\widehat{\varepsilon}_{1,t}\}$ are not identical across trivariate VECM estimations. Two reasons explain such differences. First, samples differ across countries.[5] Second, the estimated values of the VECM coefficients (including the estimated cointegration vector) depend on the third variable $X_{J,t}$.

We first show that estimates are indeed quite similar. Figure 8 displays the responses of U.S. TFP (left panel) together with the shares of the forecast error variance of TFP (right panel) for each of the trivariate systems. We use the VAR with output (specifically, $C + I + X - M$) as the benchmark thick black lines. The thick black line on the left panel of Figure 8 is therefore the response of U.S. TFP to a news shock when the third variable in the VECM is output, whereas the five other lines are the response of U.S. TFP to a news shock when the third variable in the VECM is U.S. consumption, investment, hours, imports and exports. The IRFs of TFP show that four out of five experiments lie within the confidence interval of the benchmark. The share of the variance of the forecast error attributable to the news shock is also fairly similar across experiments. The only quite different estimates are obtained when hours appear as the third variable. Similar results are obtained with Germany, as shown on Figure 9.

Figure 8: Identification of the U.S. News Shock in a Trivariate Setup

This Figure displays the Impulse Response Functions of TFP corrected for capacity utilization to a news shock (left panel) as well as the share of the variance of forecast errors (right panel) obtained from a (Corrected TFP, SP, third variable) VECM. The thick black line and confidence interval represents the (Corrected TFP, SP, C+I+X-M) VECM.

Another route to address this issue of comparability is to impose identity of the news shocks

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[5]U.S. aggregate data are available from 1960Q1 on, while Canadian data begin in 1965Q1. Some German aggregates are available from 1970Q1 on, as compared to 1969Q1 for Austria.

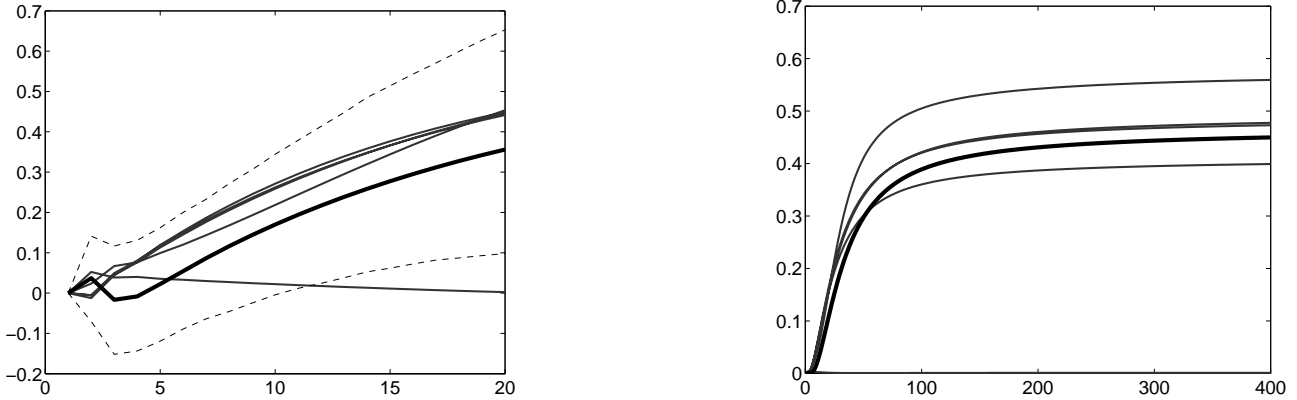Figure 9: Identification of the German News Shock in a Trivariate Setup

This Figure displays the Impulse Response Functions of TFP corrected for capacity utilization to a news shock (left panel) as well as the share of the variance of forecast errors (right panel) obtained from a (Corrected TFP, SP, third variable) VECM. The thick black line and confidence interval represents the (Corrected TFP, SP, C+I+X-M) VECM.

in all the estimated VECM, using a two-step approach. This approach encompasses Beaudry and Portier [2006]'s bivariate estimation in a three–variables vector error–correction model. Specifically, we estimate model (4) under the following set of additional restrictions:[6] (1) lagged values of the third variable have no effect on TFP and stock prices, namely $C_k(1,3) = C_k(2,3) = 0 \,\forall k$; (2) a unique cointegration relationship links TFP and stock prices, but not the third variable; (3) the number of lags equals 5.

This approach ensures that the news shocks identified in this three–variables system are exactly identical to those identified in Beaudry and Portier [2006]'s two–variables system. Furthermore, the news shock does not depend any longer on the third variable of the system. Hence, the impulse response functions and variance decompositions describe the responses of different aggregates to the very same object, making comparisons relevant.

The results obtained with this methodology, displayed in appendices B and C, are very similar to those we have previously obtained. In the two country-pairs, the news shock creates an expansion in the domestic country as well as in its neighbor. The main difference between the results of this approach and those of the unconstrained VECM is that U.S. exports rise following a news shock. However, this increase is less pronounced than the increase in U.S. imports.

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[6] This constrained VAR equation is estimated using a Seemingly Unrelated Regression (see Zellner [1962]).

2   Modeling

We have established in the previous section that the data are supporting a news view of international business cycles, in which news about future TFP improvements in one country are creating booms home and abroad. In this section, we aim at replicating those facts in a two-country dynamic general equilibrium model. Let us think of a news shock as the news, in period 0, that productivity will increase in period T in country A. Replicating the observed conditional responses to this shock is a challenging task for at least two reasons that we now illustrate with a simple one-good-complete-markets-two-country (A and B) BKK benchmark model. A formal exposition of the claims presented here is given in Appendix E.

First, as a direct extension of a result shown in Beaudry and Portier [2007] for closed economies, news shocks will move consumption on the one hand and investment and hours on the other hand in opposite directions during the interim period (from 0 to T). Following a good news about future technology in country A, the representative agent of both economies is wealthier, as one of the asset in her portfolio (capital located in A) will serve higher return in the future. The two representative agents therefore consume more of all normal goods, typically consumption and leisure. As technology has not yet improved, productivity of labor is not higher, and therefore no substitution effect pushes labor supply upwards. As a result, worked hours fall and consumption rises in both countries. The only way to finance this consumption boom is therefore a drop in investment in both countries.

Second, when the local technological improvement occurs (in period T), it is well-known that models have trouble in reproducing the cross-country correlation of inputs (the so-called "input anomaly"). There are strong incentives to use productive inputs more intensively in the country benefiting from a positive productivity differential. This leads to negative cross-correlations of output, investment and labor input.

Here we propose a two-country version of a model introduced by Beaudry and Portier [2004]. We show that the qualitative properties of the model are in line with our empirical facts.

2.1   A Two-Country Pigou Model

There are four building blocks in that multi–country model. First, there are two sectors for final use goods in each country, one producing the local consumption good and one producing the local investment good. The multi-good structure has been shown to be needed for news-driven business cycles, but also to help solving the input anomaly. Second, there are static gains to trade in the model. There are in each country two sectors of intermediate goods, one consumption–oriented (meaning that

this intermediate good will enter in the production of consumption) and one investment–oriented (meaning that this intermediate good will enter in the production of investment). Consumption and investment are then produced in each country with a CES aggregator of home and foreign intermediate goods. This assumption is helpful to deal with the input anomaly. Third, capital and labor are complementary in the consumption–oriented intermediate good sector. This implies that investment is needed to take advantage of a good news in the interim period and increasing consumption. Capital–labor complementarity creates an incentive to increase both investment and consumption. Fourth, we assume that reallocation of inputs between the consumption and investment good sector is costly, so that increasing consumption in the interim period cannot be done easily by shifting resources away from the investment good sector. Formally, we assume that labor is the only variable factor in the production of the investment-oriented intermediate good. This last assumption, by preventing capital reallocation in the business cycle, helps creating the positive response of all macroeconomic aggregates to news shocks. A less extreme assumption would be to introduce adjustment cost of capital reallocation but this would further increase the model dimension.

Those four building blocks allow us to generate news-driven international co-movements. We now expose in more details the structure of the economy. We consider a stylized economy composed of two countries, A and B, which are symmetrical, with respective population N_A and N_B.

Final goods. There are two final-use sectors: a consumption goods sector and an investment one. The consumption good sector of country A combines two intermediate goods, Z_{AA} which is produced home and Z_{BA} which is imported from country B[7], to produce the consumption good, according to the following constant returns CES aggregator:

$$C_{A,t} = \left[b_C Z_{AA,t}^{\nu_C} + (1 - b_C) Z_{BA,t}^{\nu_C} \right]^{\frac{1}{\nu_C}}, \ 0 < b_C < 1. \tag{5}$$

The analogue consumption bundle for country B writes

$$C_{B,t} = \left[(1 - b_C) Z_{AB,t}^{\nu_C} + b_C Z_{BB,t}^{\nu_C} \right]^{\frac{1}{\nu_C}}. \tag{6}$$

Similarly, the final investment good in country A is produced by combining two intermediate goods, X_{AA} which is produced home and X_{BA} which is imported from country B, according to

$$I_{A,t} = \left[b_I X_{AA,t}^{\nu_I} + (1 - b_I) X_{BA,t}^{\nu_I} \right]^{\frac{1}{\nu_I}}, \ 0 < b_I < 1.$$

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[7]We adopt here the following notation: Z_{IJ} means good Z produced in I and used in J.

Investment in each country is then used to increment the domestic stock of capital:

$$K_{A,t+1} = (1 - \delta) K_{A,t} + I_{A,t} = (1 - \delta) K_{A,t} + \left[b_I X_{AA,t}^{\nu_I} + (1 - b_I) X_{BA,t}^{\nu_I} \right]^{\frac{1}{\nu_I}} \tag{7}$$

and

$$K_{B,t+1} = (1 - \delta) K_{B,t} + I_{B,t} = (1 - \delta) K_{B,t} + \left[(1 - b_I) X_{BA,t}^{\nu_I} + b_I X_{BB,t}^{\nu_I} \right]^{\frac{1}{\nu_I}} . \tag{8}$$

Intermediate goods. Country A produces a consumption-oriented intermediate good Z_A using capital and labor H_A according to the following CES technology:

$$Z_{A,t} = \left[a \left(\theta_{A,t} \overline{H}_{A,Z}^{1-\varphi} H_{A,t}^{\varphi} \right)^{\nu} + (1 - a) K_{A,t}^{\nu} \right]^{\frac{1}{\nu}} . \tag{9}$$

$\theta_{A,t}$ denotes the technology index which will serve as the exogenous driving force, $\overline{H}_{A,Z}$ represents some fixed labor required in the production of the consumption-oriented intermediate good. We will restrict attention to cases where the elasticity of substitution between K and labor in the final goods sector is no greater that one. This intermediate good is then either used at home (Z_{AA}) or exported (Z_{AB}).

Country A also produces a investment-oriented intermediate good X_A using variable labor $\widetilde{H}_A$ according to the following technology:

$$X_{A,t} = \widetilde{\theta}_{A,t} \overline{K}_A^{1-\alpha_X - \beta_X} \overline{H}_{A,X}^{\beta_X} \widetilde{H}_{A,t}^{\alpha_X} . \tag{10}$$

$\widetilde{\theta}_{A,t}$ denotes the technology index in the investment-oriented intermediate good sector. We assume that some labor $\overline{H}_{A,X}$ and all the capital used in this sector $\overline{K}_A$ are in fixed quantity. As we explained, the absence of possibility of reallocating capital between the two-sectors is crucial to obtain news-driven business cycles.

In country B, the analogue consumption-oriented and investment-oriented intermediate goods write respectively

$$Z_{B,t} = \left[a \left(\theta_{B,t} \overline{H}_{B,Z}^{1-\varphi} H_{B,t}^{\varphi} \right)^{\nu} + K_{B,t}^{\nu} \right]^{\frac{1}{\nu}} \tag{11}$$

and

$$X_{B,t} = \widetilde{\theta}_{B,t} \overline{K}_B^{1-\alpha_X - \beta_X} \overline{H}_{B,X}^{\beta_X} \widetilde{H}_{B,t}^{\alpha_X} . \tag{12}$$

Preferences. The representative household of country A has preferences over individual consumption and hours worked at all periods, discounts period utility at rate β and we assume that the period felicity is of the Hansen-Rogerson type:

$$\mathcal{U}_A \left(c_{A,t}, h_{A,t}, \widetilde{h}_{A,t} \right) = \left[\ln c_{A,t} - \chi \left(h_{A,t} + \widetilde{h}_{A,t} + \overline{h}_A \right) \right]$$

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The country B agent preferences are similar to country A ones.

2.2 Equilibrium Allocations

The two welfare theorems apply in this setup and we solve for an optimal allocation. The Social Planner chooses $\left\{ c_{J,t},\ h_{J,t},\ \widetilde{h}_{J,t},\ I_{J,t},\ K_{J,t+1},\ Z_{IJ} \right\}_{J=A,B}$ in order to

$$\max E_0 \sum_{t=0}^{+\infty} \beta^t \left[N_A \left(\ln c_{A,t} - \chi \left(h_{A,t} + \widetilde{h}_{A,t} + \overline{h}_A \right) \right) + N_B \left(\ln c_{B,t} - \chi \left(h_{B,t} + \widetilde{h}_{B,t} + \overline{h}_B \right) \right) \right]$$

subject to conditions (5) to (12) and the following resource conditions

$$
\begin{cases}
C_{A,t} & = & N_A c_{A,t} \\
C_{B,t} & = & N_B c_{B,t} \\
H_{A,t} & = & N_A h_{A,t} \\
H_{B,t} & = & N_B h_{B,t} \\
\widetilde{H}_{A,t} & = & N_A \widetilde{h}_{A,t} \\
\widetilde{H}_{B,t} & = & N_B \widetilde{h}_{B,t} \\
Z_{A,t} & \geq & Z_{AA,t} + Z_{AB,t} \\
Z_{B,t} & \geq & Z_{BA,t} + Z_{BB,t} \\
X_{A,t} & \geq & X_{AA,t} + X_{AB,t} \\
X_{B,t} & \geq & X_{BA,t} + X_{BB,t} \\
N_A \overline{h}_A & \geq & \overline{H}_{A,X} + \overline{H}_{A,Z} \\
N_B \overline{h}_B & \geq & \overline{H}_{B,X} + \overline{H}_{B,Z} \\
K_{A,0} & = & K_{B,0} \ \text{ given,}
\end{cases}
$$

where small letters denote per capita variables.

Once this social optimum problem solved, one can backup prices and National Income and Product Accounts. We assume that the consumption good in country A is the numéraire. For $I \in \{A, B\}$, q_I will denote the price of the investment good, p_I the price of the consumption good (with $p_A = 1$) and w_I the wage rate. We define nominal GDP of country I as $p_I C_I + q_I I_I$. Period 0, in which the economy is at the steady-state, is chosen as the base period. Using a subscript S for steady state values, real GDP in any period will be computed as $p_I^S C_I + q_I^S I_I$. Baskets of imports and of exports are computed in the same way, using period 0 as the base period for prices. Finally, Total Factor Productivity will be measured as if the model was a one-sector Cobb-Douglas economy

$$TFP_{I,t} = \frac{p_I^S C_I + q_I^S I_I}{K_{I,t}^{1-sh}(H_{I,t} + \widetilde{H}_{I,t})^{sh}}$$

where sh is the steady state labor income share.

Because the model has no analytical solution, we turn to numerical analysis.

2.3 Numerical Response to a News

In this section, we propose a numerical analysis of the model allocations following a news shock on productivity in one country. The period is one quarter. We assume that the two countries have the same size, normalize productivity θ_I to 1 and set β to .984. Parameters $\widetilde{\theta}$, a, χ, b and δ are set to match the following steady-state values: consumption to GDP ratio is .7, labor income is 2/3 of GDP, imports and exports represent 25% of GDP each and capital to annual GDP ratio is 1.25.

For the elasticity of substitution between domestic and foreign intermediate goods, we choose a value of 0.4, meaning that the two intermediate goods are complementary. This level of elasticity is at the bottom end what is generally chosen in the literature. As we do not allow for any common component in shocks, relatively strong complementarities are needed for local technological shocks to generate positive comovements when implemented. On the contrary, complementarity is not needed for the response to news as during the interim period: the two countries comove positively regardless of the degree of complementarity. Finally, capital and labor are assumed to be complementary in the production of the consumption-oriented intermediate goods, with elasticity 0.2. This elasticity is the one estimated by Beaudry and Portier [2004]. α_X, β_X and ϕ are also taken from Beaudry and Portier [2004].

We study the response of the economy to a non–expected permanent technological shock in the consumption-oriented intermediate good sector of country A, $\theta_{A,t}$. Other technological parameters are maintained constant. In order to replicate the diffusion process observed in the data, we assume that $\theta_{A,t}$ follows:

$$\theta_{A,t} = 1 + \frac{u_{A,t}}{100} \tag{13}$$

$$u_{A,t} = u_{A,t-1} + \rho\left(u_{A,t-1} \times (1 - u_{A,t-1})\right) + \varepsilon_{A,t-t} \tag{14}$$

with $\rho = .8$. The economy is supposed to be at steady state before period 0, with $u_{A,0} = 0$ and $\theta_{A,0} = 0$. The economy is hit in period 0 by a shock $\varepsilon_{A,0} = 1\%$. The shock does not affect productivity for the first T periods, although it is observed in period 0 by the agent. After implementation, u_t slowly increases and asymptotically reaches 1, so that $\theta_{A,t}$ permanently increases by 1%. We assume $t = 4$. The evolution of θ as well as the response of measured TFP are displayed on Figure 10. Notice that before period 10, θ_A is not larger than .1 %. Also notice that measured aggregate TFP is contaminated, and slightly decrease in country B. This comes from the fact that, due to fixed factors, returns are slightly decreasing in the economy.

Figure 11 displays the response of the economy to this shock. Let us first consider the first ten

Table 1: Two-country Pigou and BKK Models Parameters Values

		Pigou Model	BKK Model
N_a, N_b	:	1	1
a	:	.01	-
b_C	:	.94	-
b_I	:	.94	-
b	:	-	.83
ϕ	:	.6	-
ν	:	-3.78	-
ν_C, ν_I	:	-.5	-
ν	:	-.5	-
α_X	:	.97	-
β_X	:	0	-
α	:	-	1/3
χ	:	.1225	1
δ	:	.06	.06
β	:	.984	.984
θ	:	1	1
$\widetilde{\theta}$	:	3	-
ρ	:	.8	.8
N	:	4	4

Figure 10: Pigou Model, Technological News in Country A
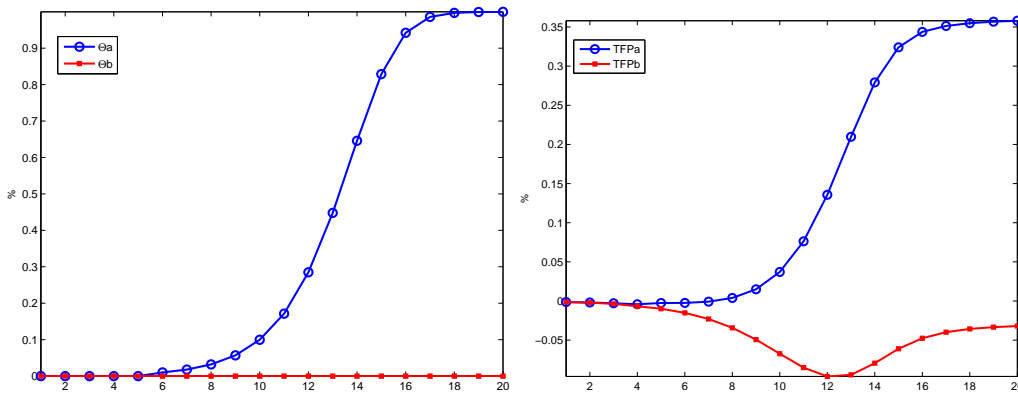
In this Figure, we display the time path of technology in the consumption-oriented intermediate good sector θ (left panel) as well as the response of measure TFP in the two countries. In period 1, agents learn that technology of country A will start diffusing in period 5 and eventually increase by one percent. All variables are expressed in percentage deviation from their steady-state level. The parameters values are the ones of Table 1.

periods. Absent of any changes on current fundamentals (the first four periods), or with virtually no technological change (periods 5 to 10), the two economies experience an aggregate boom: GDP, consumption, investment and hours increase in both countries, more so in country A that in country B. Note that imports increase more than exports in country A, while the opposite happens in country B: the news shocks act as a demand shock in country A, that runs a trade balance deficit. When the technological improvement is partially implemented (say 15 period after the news), work hours start decreasing in country A, but stay above their steady state level, while investment is also decreasing in country B (but again stays above steady state), as capital gets reallocated to country A. At this point, country A net exports become larger but stay negative. This set of responses shares a lot with the estimated responses as obtained from the empirical analysis of section 1. We only focus here on the conditional response to news shocks. The computation of cyclical unconditional moments in models including various shocks is left for future research.

2.4 International Transmission of News Shocks in More Standard Settings

Is the (relatively) non-standard setup of the Pigou model necessary? Although we do not claim that this is the unique way of obtaining news-driven international business cycles[8], we have outlined above (and we show in Appendix E) that regular models cannot replicate the facts. Here we illustrate quantitatively this claim with the most well accepted flex-price and complete market model, that is inspired from the seminal work of Backus, Kehoe, and Kydland [1994]. Let us briefly expose the building blocks of the model.

Final goods. There is one final good per country, that is used for both consumption and investment purposes. This good is obtained by combining intermediate goods produced home and abroad. Therefore, countries final good resource constraints are given by:

$$
\begin{aligned}
C_{A,t} + I_{A,t} &= \left[b Z_{AA,t}^{\nu} + (1 - b_C) Z_{BA,t}^{\nu} \right]^{\frac{1}{\nu}} \\
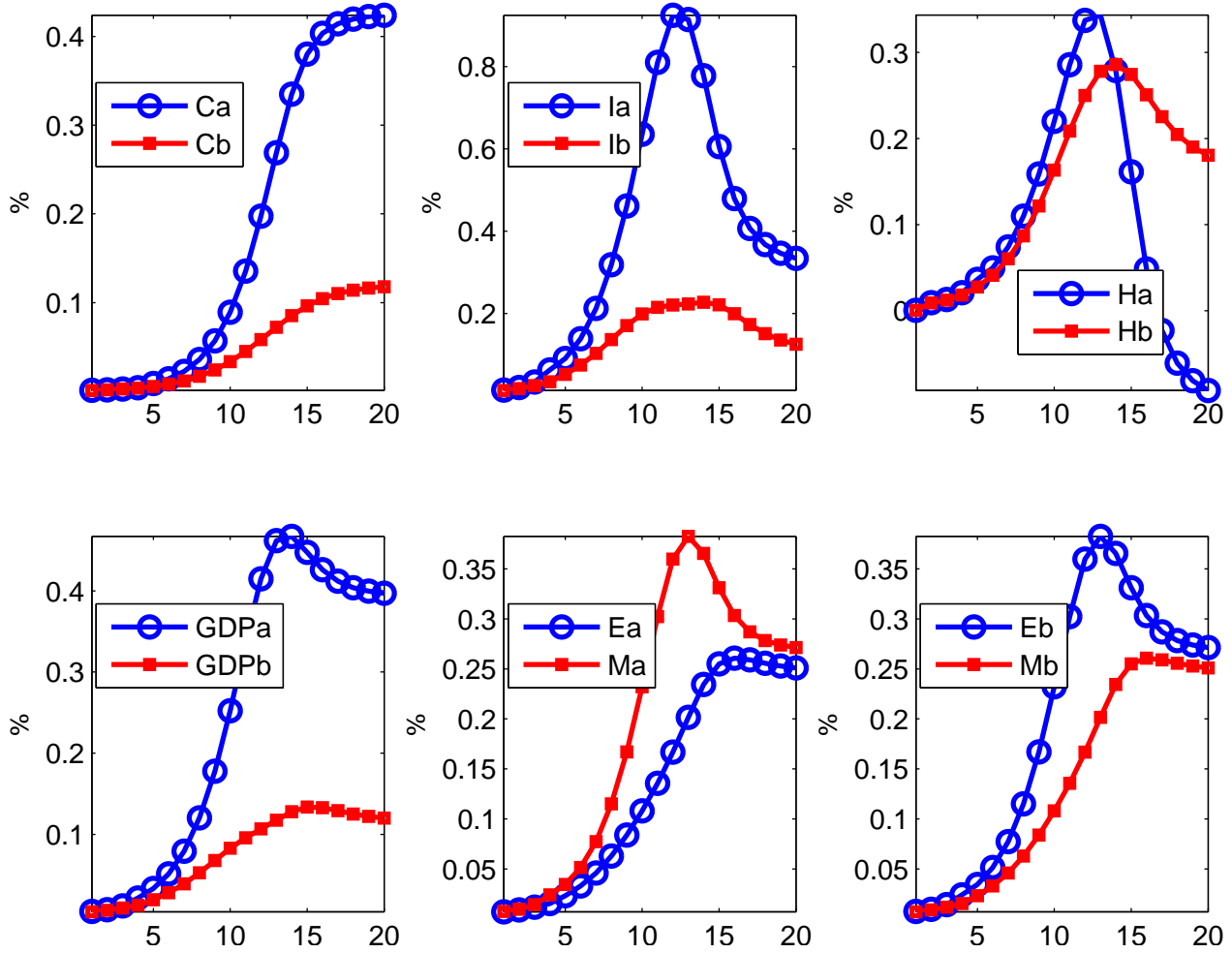C_{B,t} + I_{B,t} &= \left[(1 - b) Z_{AB,t}^{\nu} + b Z_{BB,t}^{\nu} \right]^{\frac{1}{\nu}}
\end{aligned}
$$

Investment in each country is then used to increment the domestic stock of capital:

$$
K_{A,t+1} = (1 - \delta) K_{A,t} + I_{A,t}
$$

$$
K_{B,t+1} = (1 - \delta) K_{B,t} + I_{B,t}
$$

---

[8]See for example the model of Jaimovich and Rebelo [2006] and the small open-economy extension they propose in Jaimovich and Rebelo [2007].

Figure 11: Pigou Model, Technological News in Country A

In this Figure, we display the response to a technological news that is specific to country A. In period 1, agents learn that technology will start diffusing in period 5 and eventually increase by one percent in country A. All variables are expressed in percentage deviation from their steady-state level. The parameters values are the ones of Table 1.

Intermediate goods. Each country A produces an country-specific intermediate good that is used domestically and exported:

$$
\begin{aligned}
Z_{AA,t} + Z_{AB,t} &= \Theta_{A,t} K_{A,t}^{\alpha} H_{A,t}^{1-\alpha_X} \\
Z_{BA,t} + Z_{BB,t} &= \Theta_{B,t} K_{B,t}^{\alpha} H_{B,t}^{1-\alpha_X}
\end{aligned}
$$

Preferences. The representative household of each country has preferences over individual consumption and hours worked at all periods. We keep the Hansen-Rogerson functional form:

$$
\begin{aligned}
U_A &= \sum_{t=0}^{\infty} \beta^t \left[\ln c_{A,t} - \chi h_{A,t} \right] \\
U_B &= \sum_{t=0}^{\infty} \beta^t \left[\ln c_{B,t} - \chi h_{B,t} \right]
\end{aligned}
$$

Numerical Response to a News Shock. The model is calibrated to match the same steady state properties than previously: consumption to GDP ratio is .7, labor income is 2/3 of GDP, imports and exports represent 25% of GDP each and capital to annual GDP ratio is 1.25. As previously, we assume strong complementarity between home and foreing goods (elasticity of substitution equal to 0.2).

The response of the economy to a local (country A) technology shock similar to the one shown on Figure 10 is displayed on Figure 12. The model dramatically fails in producing a home expansion: consumption increases in both countries, but investment and employment fall during the first ten periods, before effective implementation of the technological improvement. Investment and hours recession is exported abroad during the first ten periods, and international trade collapses. When the technology actually improves (after period ten), one observes a boom in both countries, country A's boom being exported because home and foreign goods are complementary in the production function. The model therefore fails in reproducing the responses estimated in the first section of the paper.

Conclusion

In this paper, we have addressed the question of business cycle co-movements within and between countries. First, we have documented the fact that news about future technological improvements home create a boom home and abroad. This has been shown using U.S. and Canadian data as well as with German and Austrian ones. We have then proposed a two-country-two-sector model that allows for news shocks to propagate as they do in the data, and showed that the model is giving realistic quantitative predictions. We have also shown that the canonical two-country RBC model was not

Figure 12: BKK Model, Technological News in Country A
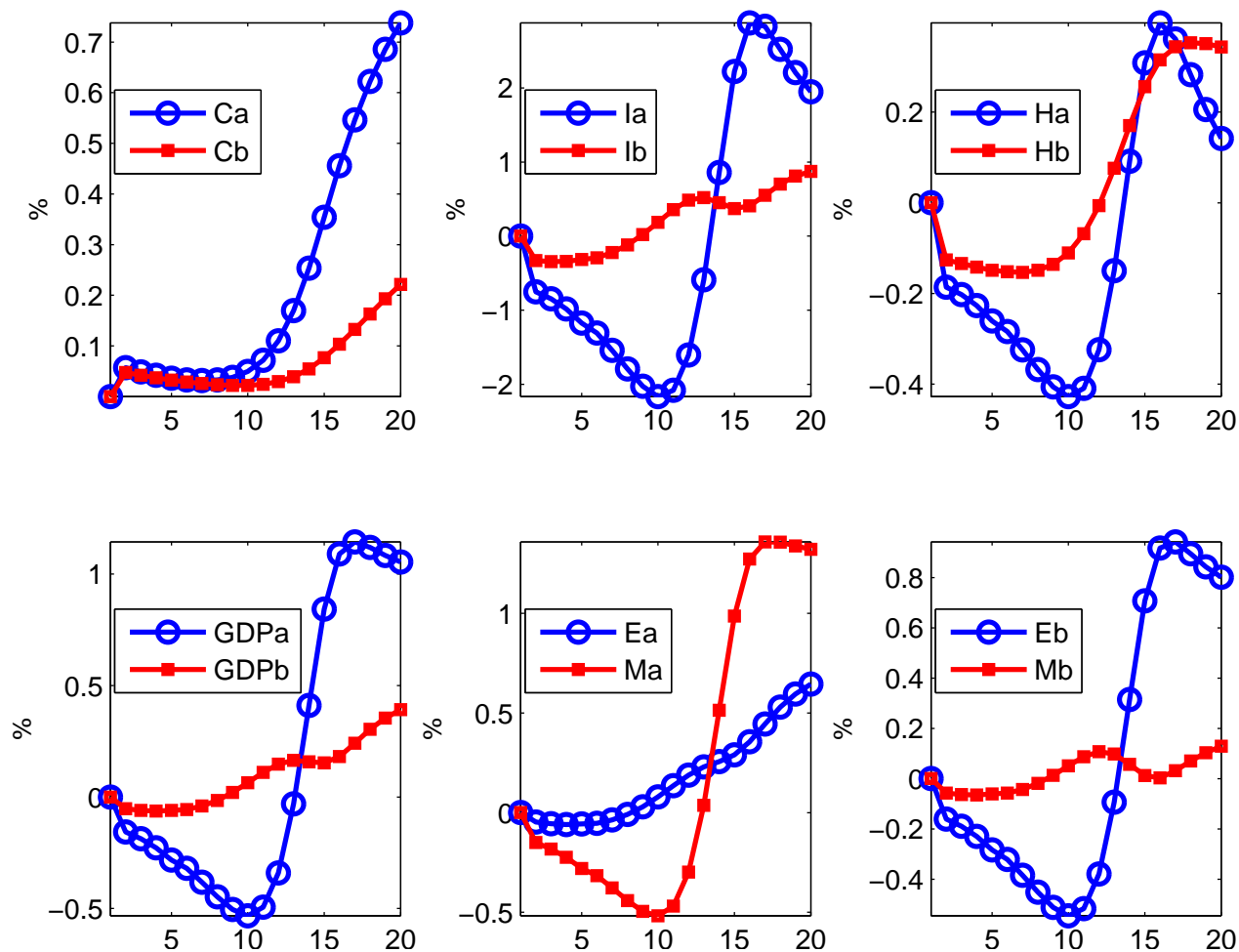
In this Figure, we display the response to a technological news that is specific to country A. In period 1, agents learn that technology will start diffusing in period 5 and eventually increase by one percent in country A. All variables are expressed in percentage deviation from their steady-state level. The parameters values are the ones of Table 1.

able to reproduce the facts and to account for news-driven national and international business cycles. Future work should tell us whether a model along the lines presented here also replicates unconditional moments of international business cycles when some other shocks are introduced in the analysis.

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A Data appendix

A.1 TFP and Stock Market Capitalization

We use existing data from the previous study of Beaudry and Portier [2006] and Haertel and Lucke [2007].

A.2 Macroeconomic Aggregates

Nominal GDP, private consumption, investment (gross fixed capital formation), exports and imports of goods and service – as well as their deflators – are from OECD's Quarterly National Accounts dataset. We use Civilian Employment data from OECD's Labor Force Statistics. Finally, all variables are expressed per capita using the population aged 15 to 64.

The following computations were performed:

Austria

The dataset with benchmark year 2000 is available from 1988Q1 on. From 1964Q1 to 1987Q4, Quarterly National Accounts were retropolated from data in base 1983, after X-11 seasonal adjustment.

Quarterly National Accounts were retropolated from data in base 1980.

Germany

German macroeconomic aggregates refer to West Germany (BRD) from 1970Q1 to 1990Q4, and to unified Germany from 1991Q1 onwards. The benchmark year for West German deflator is 1991, while that for unified German deflator is 2000.

Italy

The dataset with benchmark year 2000 is available from 1980Q1 (or 1980Q4) on. From 1970Q1 to 1979Q4 (or 1980Q3), Quarterly National Accounts were retropolated from data in base 1995.
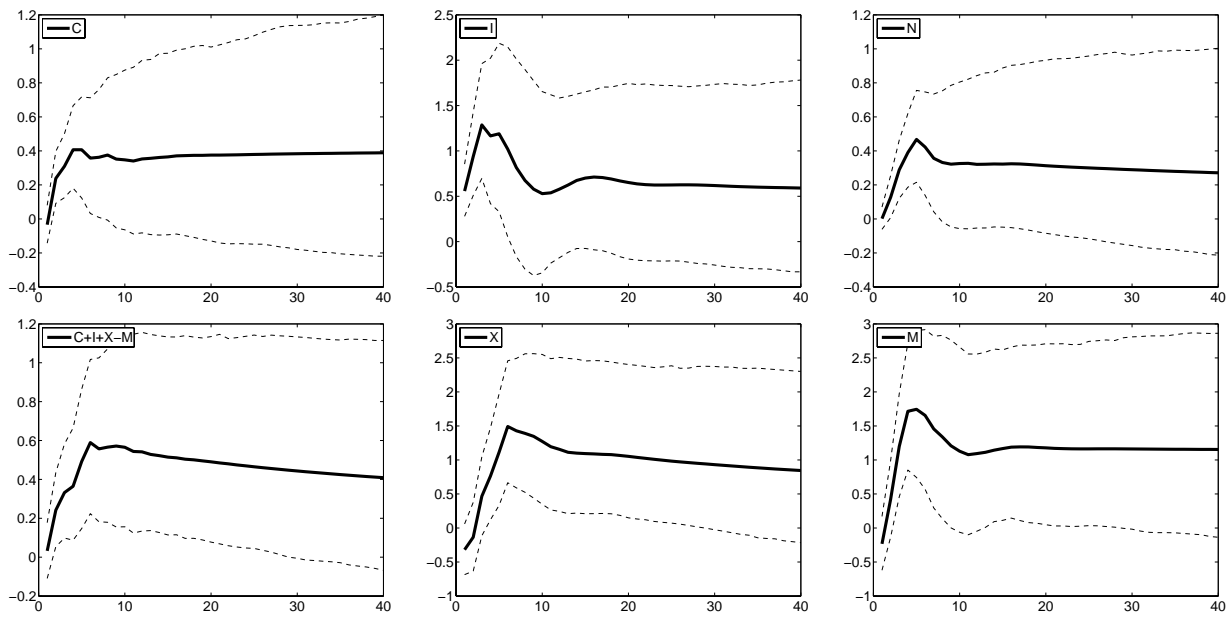
B   Responses of Canadian Aggregates to a U.S. News Shock in the Two–Step Approach

Figure 13: Response of U.S. and Canadian Aggregates to a U.S. News Shock, Two-Step Approach
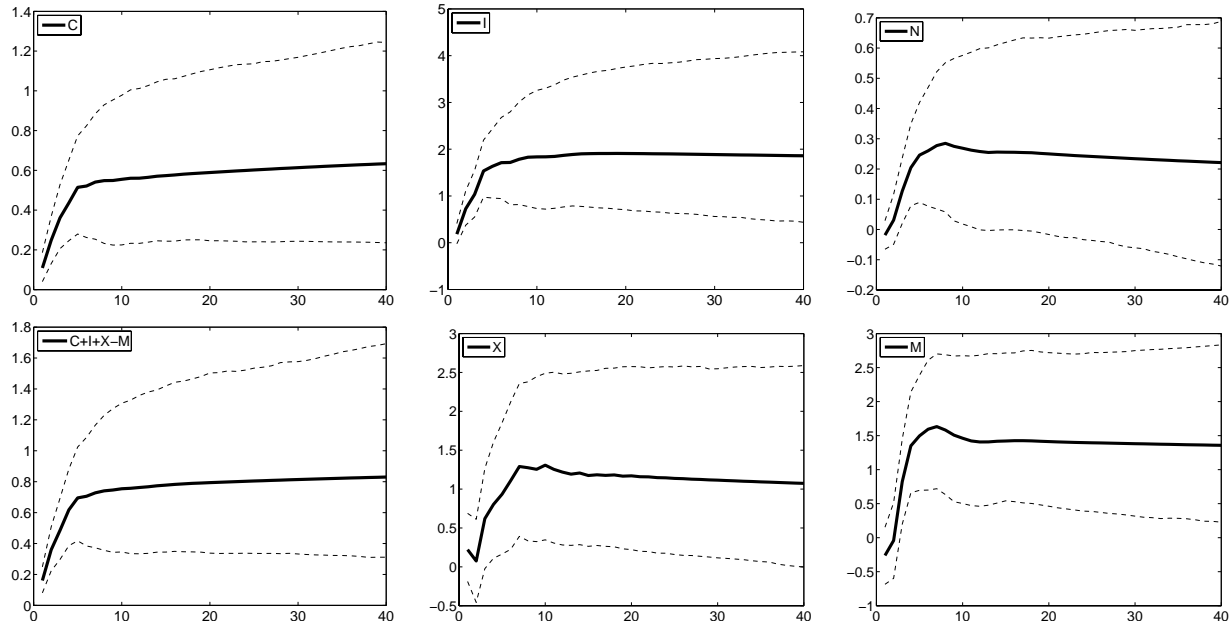
This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM under the set of restrictions explained in the main text. Sample: 1960Q1 to 2000Q4.
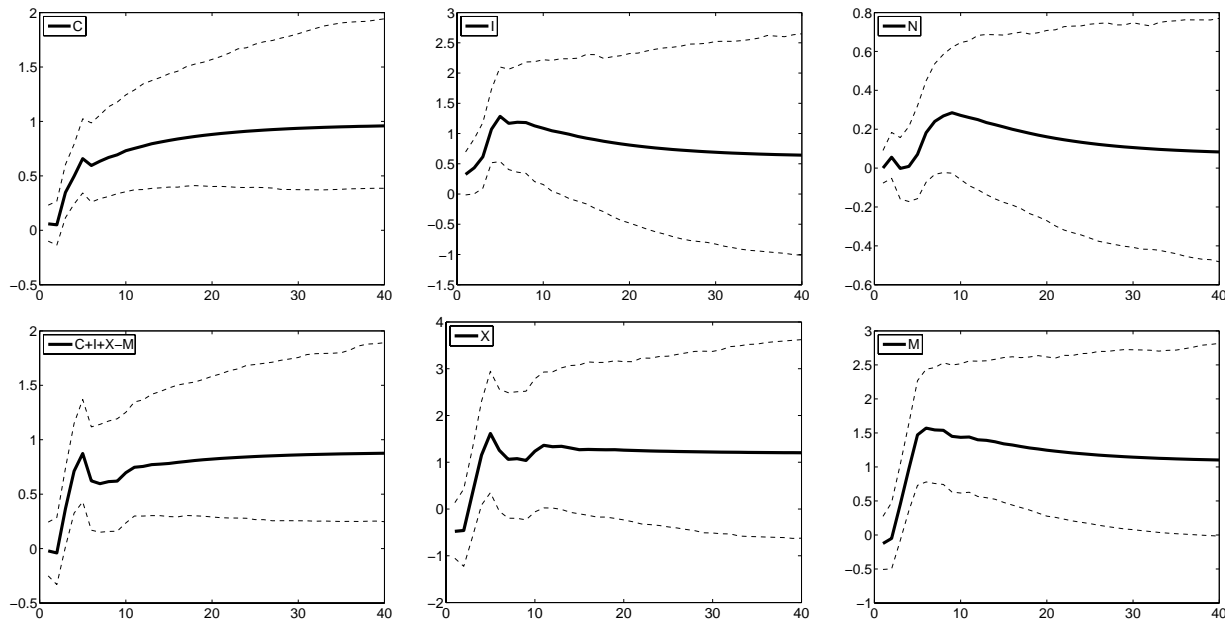
Figure 14: Response of Canadian Aggregates to a U.S. News Shock, Two-Step Approach

This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM under the set of restrictions explained in the main text. Sample: 1965Q1 to 2000Q4.
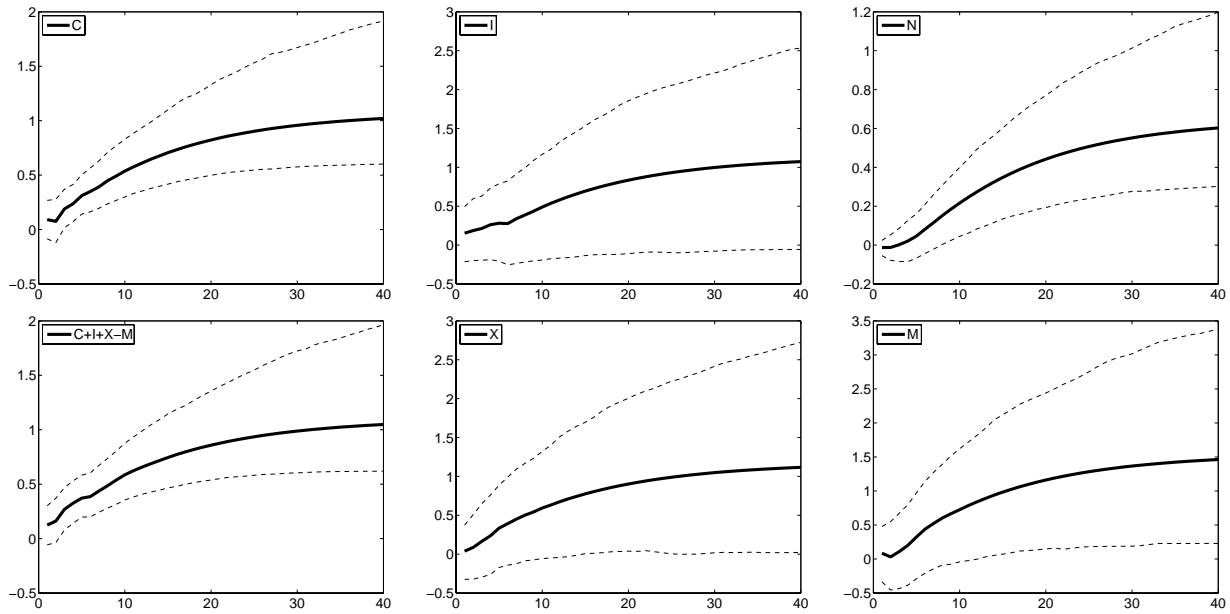
C   Responses of Austrian Aggregates to a German News Shock in the Two–Step Approach

Figure 15: Response of German Aggregates to a German News Shock, Two-Step Approach

This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM under the set of restrictions explained in the main text. Sample: 1970Q1 to 2004Q3.
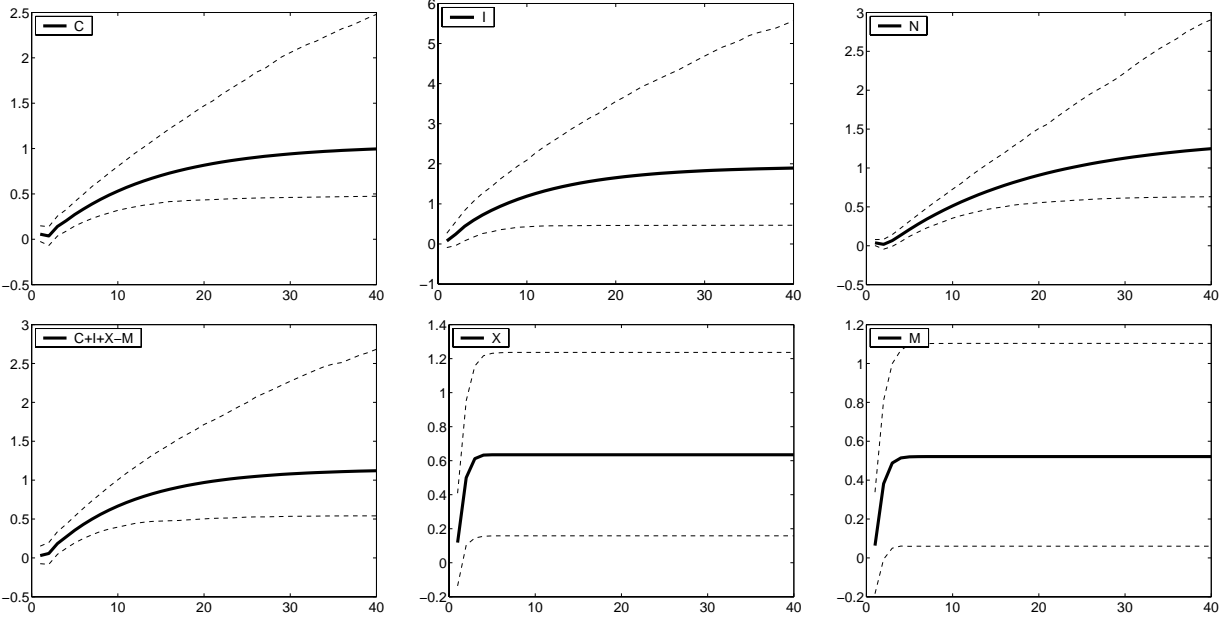
Figure 16: Response of Austrian Aggregates to a German News Shock, Two-Step Approach

This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM under the set of restrictions explained in the main text. Sample: 1969Q1 to 2004Q3.
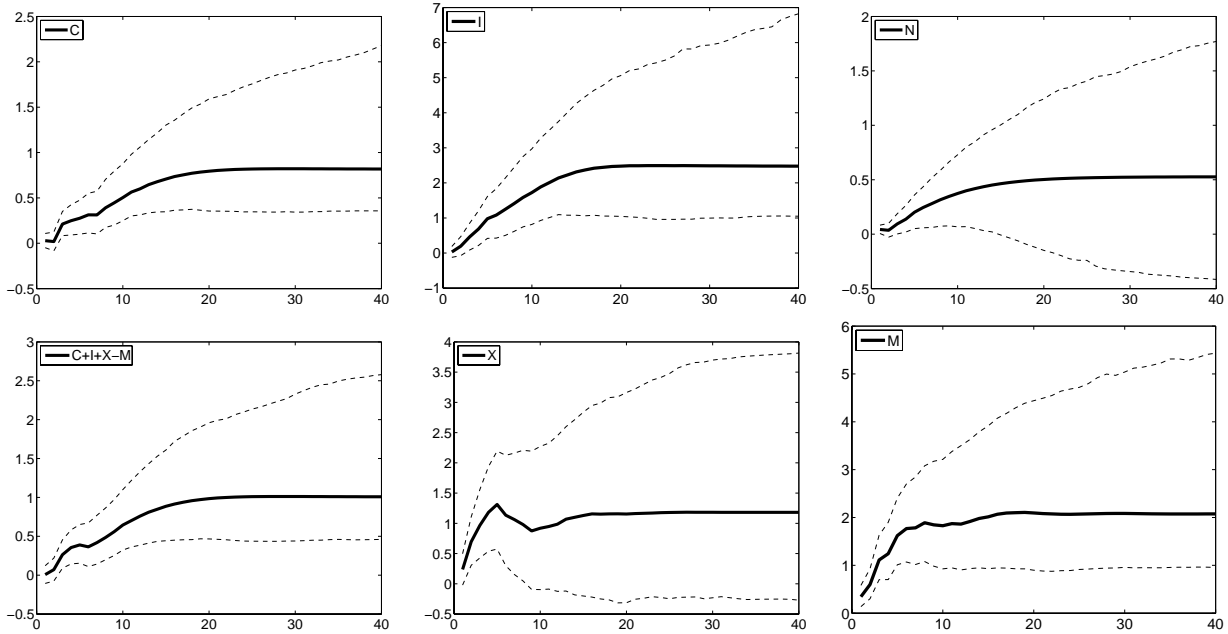
D Responses of French and Italian Aggregates to a German News Shock

Figure 17: Response of French aggregates to a German News Shock

This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM. Sample: 1978Q1 to 2004Q3.

Figure 18: Response of French aggregates to a German News Shock – two–step approach

This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM under the set of restrictions explained in the main text. Sample: 1978Q1 to 2004Q3.

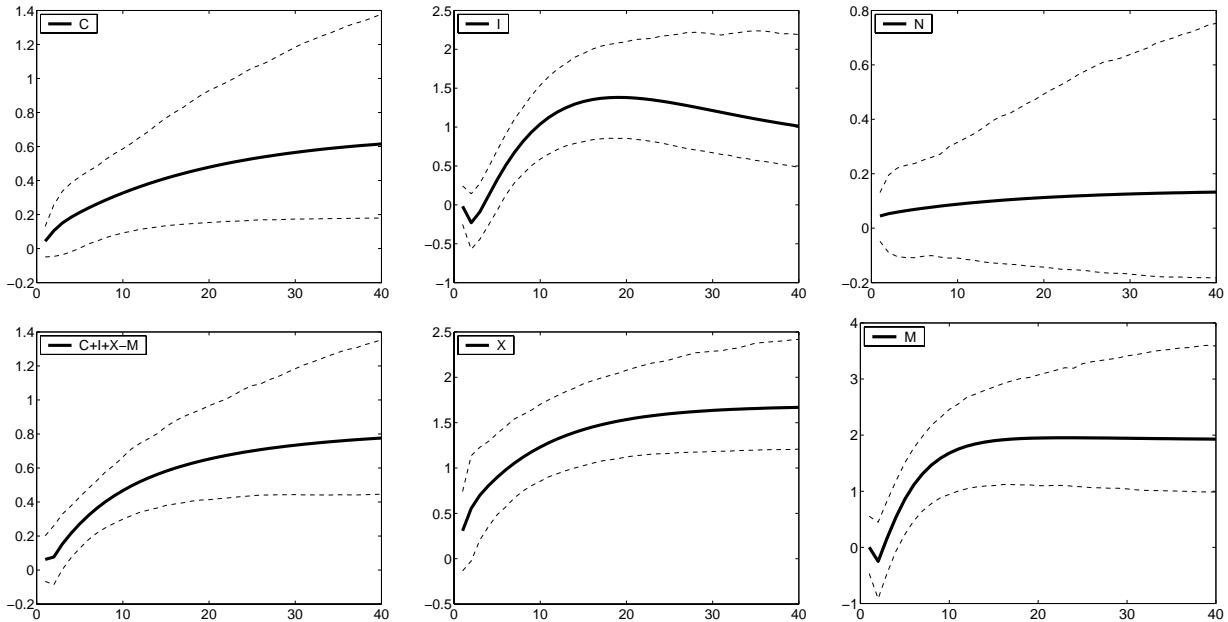Figure 19: Response of Italian aggregates to a German News Shock

This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM. Sample: 1970Q1 to 2004Q3.

Figure 20: Response of Italian aggregates to a German News Shock – two–step approach
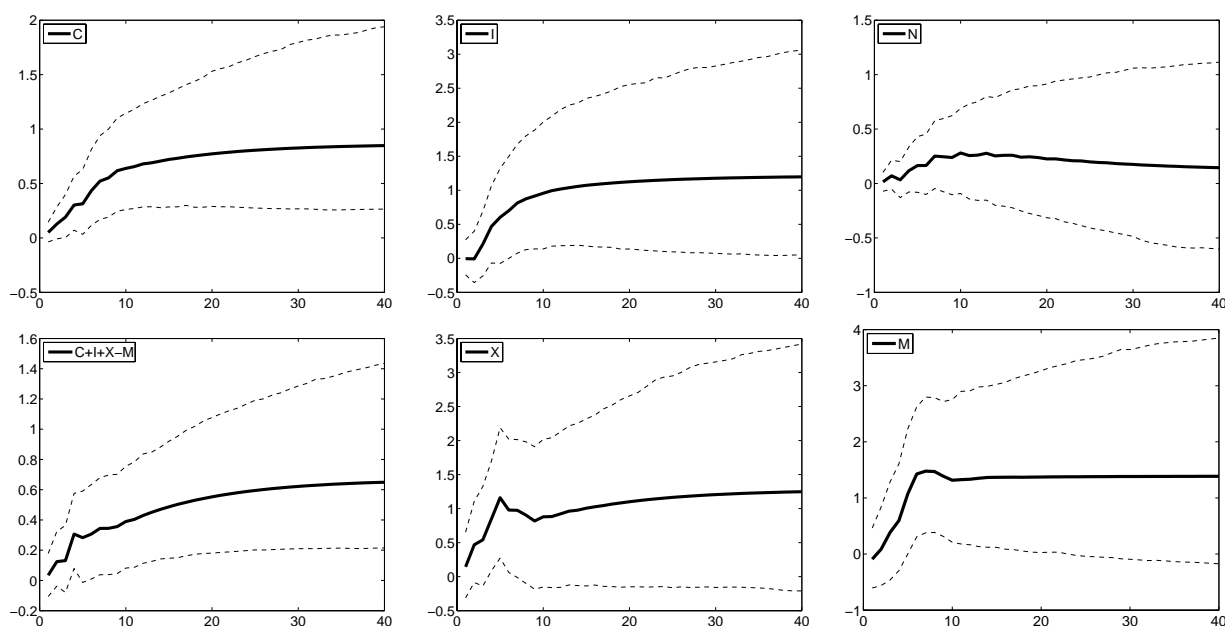

This Figure displays the Impulse Response Functions of selected aggregates to a news shock obtained from a (Corrected TFP, SP, macroeconomic aggregate) VECM under the set of restrictions explained in the main text. Sample: 1970Q1 to 2004Q3.

E News Shocks in a Simple Two-Country RBC Model

In this section of the appendix, we formally show that in a Simple Two-Country RBC Model, news shocks synchronize macroeconomic aggregates across countries but create opposite movements of consumption, investment and hours, while technological surprises desynchronize investment and worked hours.

E.1 The Model

Consider a general two-country, one final good economy. In period t, the final good Y is produced in quantities $Y_{A,t}$ in country A and $Y_{B,t}$ in country B, using capital ($K_{A,t}$ and $K_{B,t}$) and labor services ($H_{A,t}$ and $H_{B,t}$). The good can be then consumed or invested, either in country A ($C_{A,t}$ and $I_{A,t}$) or B ($C_{B,t}$ and $I_{B,t}$). The economy is hit by technology shocks $\theta_{A,t}$ and $\theta_{B,t}$. Capital quantity and location are predetermined.

A benevolent planner assigning equal weights to country A and B maximizes the objective function

$$\max_{\left\{C_{J,t}, H_{J,t}, I_{J,t}, K_{J,t+1}\right\}_{J=A,B}} E_0 \sum_{t=0}^{+\infty} \beta^t \left[U\left(C_{A,t}, 1 - H_{A,t}\right) + U\left(C_{B,t}, 1 - H_{B,t}\right)\right]$$

subject to the following constraints

$$\begin{cases} K_{A,t+1} & \leq & (1-\delta)\,K_{A,t} + I_{A,t} & (\eta_{A,t} \geq 0) \\ K_{B,t+1} & \leq & (1-\delta)\,K_{B,t} + I_{B,t} & (\eta_{B,t} \geq 0) \\ C_{A,t} + C_{B,t} + I_{A,t} + I_{B,t} & \leq & F\left(K_{A,t}, H_{A,t}; \theta_{A,t}\right) + F\left(K_{B,t}, H_{B,t}; \theta_{B,t}\right) & (\lambda_t \geq 0)\,. \end{cases}$$

Functions U and F fulfill all the usual assumptions (convexity of preferences, normality of both consumption and leisure, concavity and homogeneity of degree one for technology). We make the further simplifying assumption that preferences are separable in consumption and leisure ($U_{12} = 0$). The separability between consumption and leisure delivers clear–cut results. Without loss of generality, we assume symmetric initial endowments: $K_{A,t} = K_{B,t} > 0$.

The first-order conditions of this program imply:

$$U_1\left(C_{A,t}, 1 - H_{A,t}\right) = U_1\left(C_{B,t}, 1 - H_{B,t}\right) \tag{E-1}$$

$$U_2\left(C_{A,t}, 1 - H_{A,t}\right) = U_1\left(C_{A,t}, 1 - H_{A,t}\right) \cdot F_2\left(K_{A,t}, H_{A,t}; \theta_{A,t}\right) \tag{E-2}$$

$$U_2\left(C_{B,t}, 1 - H_{B,t}\right) = U_1\left(C_{B,t}, 1 - H_{B,t}\right) \cdot F_2\left(K_{B,t}, H_{B,t}\right) \tag{E-3}$$

$$U_1\left(C_{A,t}, 1 - H_{A,t}\right) = \beta E_t \Bigg\{ \left[1 - \delta + F_1\left(K_{A,t+1}, H_{A,t+1}; \theta_{A,t+1}\right)\right]$$

$$\times U_1\left(C_{A,t+1}, 1 - H_{A,t+1}\right) \Bigg\} \tag{E-4}$$

$$U_1\left(C_{B,t}, 1 - H_{B,t}\right) \;\; = \;\; \beta E_t \Bigg\{ \left[1 - \delta + F_1\left(K_{B,t+1}, H_{B,t+1}; \theta_{B,t+1}\right)\right]$$

$$\times U_1\left(C_{B,t+1}, 1 - H_{B,t+1}\right) \Bigg\} \tag{E-5}$$

$$C_{A,t} + C_{B,t} + I_{A,t} + I_{B,t} \;\; = \;\; F\left(K_{A,t}, H_{A,t}; \theta_{A,t}\right) + F\left(K_{B,t}, H_{B,t}; \theta_{B,t}\right) \tag{E-6}$$

$$K_{A,t+1} \;\; = \;\; \left(1 - \delta\right) K_{A,t} + I_{A,t} \tag{E-7}$$

$$K_{B,t+1} \;\; = \;\; \left(1 - \delta\right) K_{B,t} + I_{B,t}. \tag{E-8}$$

together with the usual transversality conditions.

E.2 Equilibrium Allocations Properties

RESULT 1 *(**Local Technological Surprise**) If technology shocks are local and surprises (i.e. $d\theta_{A,t} > 0$, $d\theta_{B,t} = 0$ for some t), then hours worked are not perfectly correlated across countries. For realistic settings, hours and investments are negatively correlated.*

PROOF AND DISCUSSION OF RESULT 1 (**Local Technological Surprises**) :

We consider small deviations from the symmetric steady-state of the economy. Assume $\theta_{A,t} = \overline{\theta} + d\theta_{A,t} \neq \theta_{B,t} = \overline{\theta}$.

From equation (E-1), we know that perfect risk-sharing requires consumption in both countries to be perfectly correlated.

Differentiation of equation (E-2) and (E-3) implies

$$[U_1\left(\cdot\right) \, F_{22}\left(\cdot\right) + U_{22}\left(\cdot\right)]\left(dH_A - dH_B\right)$$

$$= \;\; -U_{11}\left(\cdot\right) \, F_2\left(\cdot\right) \left(dC_A - dC_B\right) - [U_1\left(\cdot\right) \, F_{23}\left(\cdot\right)] d\theta_A$$

$$= \;\; - [U_1\left(\cdot\right) \, F_{23}\left(\cdot\right)] d\theta_A$$

Finally,

$$\frac{dH_A - dH_B}{d\theta_A} = \frac{U_1\left(\cdot\right) \, F_{23}\left(\cdot\right)}{-U_1\left(\cdot\right) \, F_{22}\left(\cdot\right) - U_{22}\left(\cdot\right)} \;\; > 0.$$

We see from this last equation that hours worked are not perfectly correlated. In country A, they increase more than in country B following a technological surprise in A, therefore amplifying productivity differentials and breaking the perfect correlation of outputs. It is hard to obtain more unambiguous analytical results. Results from calibrated examples show that for standard calibration, hours actually move in opposite direction, creating a negative correlation between output on impact. As investments are also negatively correlated, the negative correlation between output persists. □

RESULT 2 *(Technological News)* *If technology shocks are announced T periods in advance, then allocations are symmetrical in the $T - 1$ first periods of the interim period, for both world and local news. In the interim period, consumption and hours always move in opposite directions.*

PROOF AND DISCUSSION OF RESULT 2 **(Technological News)** :

When the economy is hit by a news shock, no current fundamental is affected, so that allocations $(C_A, C_B, H_A, H_B, I_A, I_B)$ are moving along the hyper surface defined by equations (E-1), (E-2), (E-3) and (E-6), for given expectations. From (E-1), we know that consumptions allocations will be symmetrical. The conditions defining the set of temporary equilibria write

$$U_2\left(C_t, 1 - H_{A,t}\right) = U_1\left(C_t, 1 - H_{A,t}\right) \cdot F_2\left(K_t, H_{A,t}; \overline{\theta}\right) \tag{E-9}$$

$$U_2\left(C_t, 1 - H_{B,t}\right) = U_1\left(C_t, 1 - H_{B,t}\right) \cdot F_2\left(K_t, H_{B,t}; \overline{\theta}\right) \tag{E-10}$$

$$2\,C_t + I_{A,t} + I_{B,t} = F\left(K_t, H_{A,t}; \overline{\theta}\right) + F\left(K_t, H_{B,t}; \overline{\theta}\right) \tag{E-11}$$

$$K_{A,t+1} = (1 - \delta)\,K_t + I_{A,t} \tag{E-12}$$

$$K_{B,t+1} = (1 - \delta)\,K_t + I_{B,t}. \tag{E-13}$$

Full differentiation of (E-9) and (E-10) implies

$$\left[\underbrace{U_1\left(\cdot\right)}_{>0}\underbrace{F_{22}\left(\cdot\right)}_{<0} + \underbrace{U_{22}\left(\cdot\right)}_{<0}\right](dH_A - dH_B) = 0.$$

Hence, $dH_A = dH_B$.

A priori, condition (E-11) does not determine the breakout of investment at the temporary equilibrium. However, if expectations regarding future technology and preference are common to both countries, the Euler equations write:

$$U_1\left(C_t, 1 - H_t\right) = \beta E_t\left\{ \left[1 - \delta + F_1\left(K_{A,t+1}, H_{t+1}; \theta_{t+1}\right)\right] \times U_1\left(C_{t+1}, 1 - H_{t+1}\right)\right\}$$

$$U_1\left(C_t, 1 - H_t\right) = \beta E_t\left\{ \left[1 - \delta + F_1\left(K_{B,t+1}, H_{t+1}; \theta_{t+1}\right)\right] \times U_1\left(C_{t+1}, 1 - H_{t+1}\right)\right\}.$$

If $T > 1$ and $t < T - 1$, technology does not change in $t + 1$. Therefore $K_{A,t+1} = K_{B,t+1}$, hence $I_{A,t} = I_{B,t}$. All variables are therefore equal in both countries: expectations-driven business cycles embed strong cross-country synchronizing forces.

We now show that such news shocks do not create business cycle movements for consumption, investment and hours. We concentrate on country A. Fully differentiating (E-9), by normality of consumption and leisure, one can show that dC_A and dH_A are of opposite signs. As allocations are

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symmetrical, it is also true for dC_B and dH_B. Then, using (E-6), one obtains that dI_A and dI_B are of the same sign that dH_A. $\qquad\square$