Finance and Synchronization*

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August 19, 2018

Abstract

In the workhorse model of international real business cycles, financial integration exacerbates the cycle asymmetry created by country-specific supply shocks. The prediction is identical in response to purely common shocks in the same model augmented with simple country heterogeneity (e.g., where depreciation rates or factor shares are different across countries). This happens because common shocks have heterogeneous consequences on the marginal products of capital across countries, which triggers international investment. In the data, filtering out common shocks requires therefore allowing for country-specific loadings. We show that finance and synchronization correlate negatively in response to such common shocks, consistent with previous findings. But finance and synchronization correlate non-negatively, almost always positively, in response to purely country-specific shocks.

Keywords: Financial linkages, Business cycles synchronization, Contagion, Common Shocks, Idiosyncratic Shocks.

JEL Codes: E32, F15, F36, G21, G28.

*For useful comments, we would like to thank the Editor, Charles Engel, two referees, as well as Michael Binder, Giancarlo Corsetti, Richard Harrison, Sujit Kapadia, Robert Kollmann, Eric Monnet, Franck Portier, Daniele Siena, Konstantinos Theodoridis, and Gregory Thwaites. We are also grateful for comments from attendants to the 10th Annual Workshop on "The Macroeconomics of Global Interdependence" in Dublin, the IAAE 2016 Annual Meetings, the "Workshop on International Business Cycles" at Banque de France, and seminar participants at the ECB and the Bank of England. Financial support from the Chaire Banque de France at the Paris School of Economics is gratefully acknowledged. An online appendix with additional results can be found on the authors' websites. The views expressed in this paper are solely those of the authors and should not be taken to represent those of the Bank of England.

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1 Introduction

Understanding how disturbances propagate across countries is of first-order importance. Openness in general is often singled out as a plausible and significant propagation channel. Historically openness to goods trade came first, and there is robust evidence that trade partners display correlated business cycles.[1] The global consequences of the 2007-2008 recession have contributed to shifting the focus on the importance of financial linkages. While it was always important to assess how financial integration affects the international synchronization of business cycles, the question has become of paramount importance since 2008, for policy-makers and researchers alike.

In the canonical two-country real business cycles model with country-specific productivity shocks (Backus et al., 1992, BKK henceforth) capital flows to wherever returns are higher. Therefore, greater financial linkages lower the international synchronization of business cycles in response to country-specific shocks. But in a similar two-country model, augmented with credit or collateral constraints, a country-specific shock that makes the constraint binding at home is contagious abroad as domestic agents recall foreign assets to meet the constraint.[2] There is no reason for the constraint to become binding in response to a specific kind of shock: demand, supply, or even financial shocks may all create a binding constraint, and so trigger contagion. Here, therefore, greater financial linkages can increase synchronization in response to country-specific shocks. The common feature of these models is that they analyze the consequences of purely idiosyncratic, country-specific shocks, with ambiguous predictions.

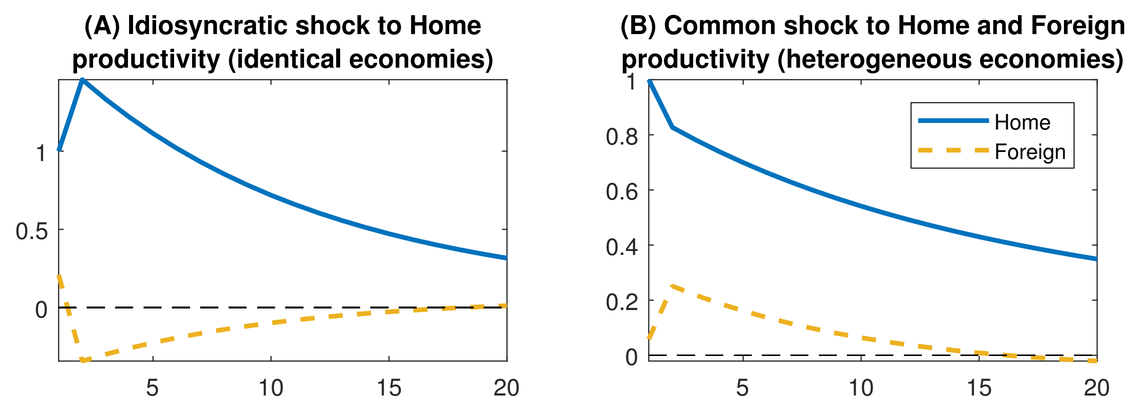
It is not difficult to see that similar predictions arise from the canonical international RBC model in response to common shocks, provided that some mild heterogeneity exists across countries. For instance, countries with different depreciation rates or different capital

[1] Among many others, see Frankel and Rose (1998) or Baxter and Kouparitsas (2005).

[2] Devereux and Yetman (2010), Dedola and Lombardo (2012), Kalemli-Ozcan et al. (2013), or Allen and Gale (2000) offer different versions of the mechanism, where constraints are at bank or firm level.

shares react to the same technology shock with different magnitudes, driving a gap between the marginal products of capital on impact. As a result, international investment rises, and the international synchronization of cycles falls. In fact, the predictions of BKK with homogeneous countries and idiosyncratic shocks are observationally equivalent to its predictions with heterogeneous countries and common shocks, for plausible parametrization of heterogeneity.

Figure 1 Impulse Response Functions in Variants of BKK



Note. Panel (A) reports the impulse response functions to a productivity shock in the Home country in the case where the Home and Foreign economies are identical. The chart reports the response of Output in the Home (solid line) and Foreign (dashed line) economies. Panel (B) reports the same impulse response functions for a common shock (i.e., a shock that raises productivity by the same amount in the Home and Foreign economy) when the two economies are heterogeneous. The source of heterogeneity is the share of capital in the production function (θ). Panel A sets $\theta = 0.36$ for both the H and F economy, Panel B uses $\theta_H = 0.44$ and $\theta_F = 0.32$. All remaining parameters are identical to BKK (except time to build, set to 1). The size of the shock has been normalized so that it increases Home output by 1 percent.

Figure 1 plots the responses of output to a technology shock as implied by two versions of BKK. Panel (A) reproduces the well known results in BKK in response to a shock to productivity in the Home country, under the conventional symmetric calibration. Panel (B) introduces a version of BKK that deviates from the original in two dimensions: (i) the productivity shock is common, i.e. perfectly synchronized across countries; and (ii) the share of capital is heterogeneous across countries, taking values of 0.44 in the Home country, and 0.32 in the Foreign country.[3] Both panels imply responses of output that are negatively

[3] This dispersion is consistent with the values for Portugal and Japan reported in the Penn World Tables

correlated across countries on impact.[4]

To investigate the ambiguous link between finance and synchronization in response to country-specific shocks, it is therefore important to control for common shocks that are allowed to have different effects across countries. The conventional approach consists in including time effects or trends in an estimation whose dependent variable measures the synchronization of cycles between countries i and j. This does eliminate the effects of those shocks that by construction have identical effects on both economies. But it does not eliminate common shocks with heterogeneous effects that are likely to exist in a world where countries display fundamental differences. To eliminate common shocks with heterogeneous effects, alternatives are necessary. This paper follows the simplest possible approach: the shocks are identified by the principal components that are common to at least two countries, where the loadings on each principal component are allowed to be country-specific. In the main text, the loadings are assumed constant, but for robustness we also repeat the analysis estimating a factor model that allows for time-varying loadings using Bayesian techniques.[5] Both decompositions have the advantage of simplicity and an established place in the literature.[6] There are of course many alternatives, which we leave for further work. However, we also provide analytically a general intuition for the results of the paper, which is not conditioned on one specific way to isolate common shocks with heterogeneous effects.

Conditional on common shocks (with heterogeneous effects), we confirm that finance and synchronization correlate negatively. The result supports Kalemli-Ozcan et al. (2013) (KPP henceforth), who show that an increase in financial integration causes a fall in business cycle

(version 8.1). In our sample of countries, the average capital share is 0.35, with a standard deviation of 0.05.

[4]This result generalizes to other forms of heterogeneity. In Appendix A, we present the analogues of Figure 1 with heterogeneous depreciation rates, different discount rates, or different inventory to output ratios, parametrized with σ in Backus et al. (1992). The intuition is general: with heterogeneity, common shocks drive a wedge between the marginal products of capital in the Home and Foreign economies.

[5]This is left for an online appendix. We find very little time variation in the estimated loadings.

[6]That common shocks can have heterogeneous effects is in fact a key premise of the literature on Global VAR (GVARs) pioneered by Pesaran et al. (2004). Heterogeneous responses at country, sector, or regional levels have been documented repeatedly in this literature. For example, using a large heterogeneous panel VAR, Cesa-Bianchi et al. (2017) document heterogeneous responses to global credit supply shocks across countries.

synchronization in 18 OECD countries. But our interpretation differs from theirs. According to KPP, the data support the view that financial flows are efficient in their quest for high returns, behaving exactly as the canonical international RBC model predicts in response to idiosyncratic shocks. We conclude instead that the finding arises at least in part in response to common shocks with heterogeneous effects.

Now these effects are given parametrically: they represent the response of country i to a common shock, which differs from the response of country j because, say, the countries have different capital shares. The difference in responses is therefore a constant, given by the differences in deep parameters of the model. Empirically, the response of a given country's GDP to the common shock is given by the factor loading in the principal component estimation; we call it the country's "elasticity of GDP" to the common shock. We show that capital tends to flow from countries with inelastic GDP to countries with elastic GDP in response to a positive common shock, and vice versa for negative shocks. An interpretation is that on average countries with elastic GDP should be net recipients of international capital in years of global boom, but net contributors in years of global recession. We document this correlation in OECD data.

In contrast, there is no systematic time pattern in the response of international investment to purely country-specific shocks: source and destination countries change depending on the realization of the shocks, as in BKK. Interestingly, increases in financial linkages are almost always associated with *more* synchronized business cycles in response to well identified country-specific shocks. The coefficient estimates are never negative, and significantly positive in virtually all the specifications we consider.[7] This stands in contrast with common shocks, and suggests financial links can in fact foster the contagious propagation of *country-specific* shocks across borders. In theory, this result supports the existence of (endogenously binding) constraints: in response to country-specific shocks, financial flows may serve to al-

[7] The two non significant estimates arise when synchronization is measured by Pearson correlation coefficients, which are known to be problematic when the variance of the underlying shocks is varying over time. See Forbes and Rigobon (2002).

leviate collateral or balance sheet constraints, rather than to take advantage of attractive differentials between returns across countries.

Can we easily interpret common and idiosyncratic shocks in terms of changes in technology, in demand, or in financial health? This is an important question in light of the Great Recession of 2008, often understood as a financial shock that was fundamentally different from the preceding history. For instance, Kalemli-Ozcan et al. (2013) construct a simple model that implies financial contagion via financial shocks, and show empirically that finance and synchronization moved in the same direction during the Great Recession. They interpret the shock in 2008 as fundamentally different from the preceding history during which finance and synchronization went in opposite directions. We emphasize that our decomposition is just a generalization of the conventional empirical approach that control for common shocks using year effects: our common shocks are more general, and of course they nest the special case of common shocks with similar effects across countries. What we identify as "idiosyncratic shocks" is merely a subset of the shocks considered, among others, in Kalemli-Ozcan et al. (2013), one that controls for common shocks with heterogeneous effects. There is neither more nor less reason to call these shocks "demand", "supply" or "financial" in this paper than there is elsewhere in this literature. We argue it is only idiosyncratic shocks that have ambiguous consequences on the link between finance and synchronization, not common ones. The claim is true irrespective whether these shocks are to the supply, the demand, or the financial side of the economy.

Recent Literature. Unsurprisingly, the recent years have witnessed a plethora of models where financial integration results in contagion. Early contributions include Devereux and Yetman (2010) where contagion is triggered by leverage-constrained investors. As portfolios are modified in response to a shock, the leverage constraint becomes binding elsewhere, with contagious consequences. Devereux and Yu (2014) extend the model to investigate the welfare consequences of financial integration. Dedola and Lombardo (2012) emphasize the importance of globally correlated borrowing costs in creating contagion. The common feature of these theories is the presence of financial frictions, which result in country-specific shocks that are contagious through endogenously binding constraints.

The empirical literature is equally replete with analyses of whether financial linkages are contagious or not. In an early contribution, Morgan et al. (2004) investigate how bank ownership across US states affect fluctuations in Gross State Products. They find the lifting of branching regulations between 1976 and 1994 resulted in synchronized states' business cycles. Imbs (2006) finds a similar result in a cross-section of countries, using alternative measures of international financial integration. Kalemli-Ozcan et al. (2013) argue the finding is driven by permanent features of country pairs, which result in both synchronized cycles and financial linkages. In 18 OECD countries, they show the link between finance and synchronization becomes negative once country-pair specific intercepts are accounted for. The results are confirmed by Duval et al. (2016) in 63 advanced and emerging countries between 1995 and 2013. Monnet and Puy (2016) show that the share of the variance of GDP explained by global shocks is lowest during periods of financial integration, which suggests idiosyncratic shocks are more prevalent in those periods.

It is well known that the bulk of the volatility in GDP across countries can be explained by common shocks. In a series of influential papers, Kose et al. (2003, 2008), Crucini et al. (2011), or Hirata et al. (2013) identify the contribution of common shocks (global or regional) to individual countries' business cycles. A key result is that shocks common to two or more countries constitute the main driver of business cycles in both the developed and developing worlds. The details of the decompositions depend on the sample of countries and time coverage; but common shocks rarely explain less than half of GDP growth volatility, and often more than 75 percent.

The possibility that common shocks have heterogeneous loadings is an old tradition in empirical macroeconomics. Forni and Reichlin (1998) identify sector-level effects of aggregate shocks in the US. Bernanke et al. (2005) augment standard Vector Auto-Regressions with unobserved factors to identify their potentially heterogeneous consequences on economic activity. Mumtaz et al. (2011) extend the approach to an international context. Peersman and Smets (2005) identify heterogeneous effects of monetary shocks at sector level. Kilian (2008) shows the consequences of exogenous oil shocks are heterogeneous across G7 countries. Giannone and Lenza (2010) show that the high correlation between domestic savings and investment, also known as the Feldstein-Horioka puzzle, can be rationalized with global shocks that are allowed to have heterogeneous effects on saving and investment at country level.

The rest of the paper is structured as followed. Section 2 presents the conventional estimation of the effects of finance on synchronization. Common shocks are discussed in terms of their theoretical impact on the correlation between finance and synchronization. Section 3 introduces the data, and discusses the relevance of common vs. idiosyncratic shocks in GDP and in financial data. The decomposition is then used to discuss the effects of finance on synchronization. Section 4 discusses some extensions. Section 5 concludes.

2 Finance and Synchronization: Why Common Shocks Matter

This Section first discusses the consequences of common shocks on business cycle synchronization, and then turns to the consequences of common shocks on the estimated effect of finance on synchronization.

2.1 Synchronization

It has become standard to measure the synchronization between two economies i and j on the basis of the absolute differential in GDP growth $\mathcal{S}_{ij,t}$ given by:

$$\mathcal{S}_{ij,t} = -\left|y_{i,t} - y_{j,t}\right|, \tag{1}$$

where $y_{i,t}$ and $y_{j,t}$ are the growth rates of GDP in country i and j at time t. The definition is such that $\mathcal{S}_{ij,t}$ increases with the degree of synchronization, with negative values close to zero between synchronized countries.

The variable $S_{ij,t}$ presents two key advantages. First, it is readily observable at high frequencies, yearly or quarterly. Second, unlike the Pearson correlation coefficient, it is invariant to the volatility of the underlying shock (see Forbes and Rigobon, 2002, Corsetti et al., 2005). However, its properties are ambivalent. Even if two countries respond in the same direction to a shock, i.e., co-movement is high, $S_{ij,t}$ can fall if the magnitude of the responses is different across countries. In other words, $S_{ij,t}$ conflates a measure of co-movement and a measure of dispersion. The same is of course not true of the more conventional Pearson correlation coefficient.[8]

The measure in equation (1) is now used widely, for example by Giannone et al. (2010), Kalemli-Ozcan et al. (2013), Kalemli-Ozcan et al. (2013), or IMF (2013) among others. Morgan et al. (2004), Kalemli-Ozcan et al. (2013), or Kalemli-Ozcan et al. (2013) introduce an alternative that controls for common shocks, given by:

$$\mathcal{S}^{e}_{ij,t} = -\left|e_{i,t} - e_{j,t}\right|, \tag{2}$$

[8] Nor is it of the quasi-correlation coefficient in Duval et al. (2016).

where $e_{i,t}$ is a residual of a panel growth regression:

$$y_{i,t} = \alpha_i + \gamma_t + e_{i,t}. \tag{3}$$

As is clear, $\mathcal{S}^e_{ij,t}$ controls for shocks that are common across the panel of GDP growth rates, but that are constrained to have homogeneous effects across countries.

This paper argues the existence of common shocks with country-specific effects alters the interpretation of $\mathcal{S}_{ij,t}$ (or $\mathcal{S}^e_{ij,t}$). To see this, assume the true model for GDP growth involves a vector of common shocks $\mathcal{F}^y_t$ with heterogeneous country loadings, i.e.:

$$y_{i,t} = a^y_i + b^y_i \mathcal{F}^y_t + \varepsilon^y_{i,t}. \tag{4}$$

where a^y_i is the average growth of GDP in country i, $\varepsilon^y_{i,t}$ denotes the response of GDP growth to an idiosyncratic shock, and b^y_i is the vector of country i's loadings (or 'elasticities') on a $f \times 1$ vector of common (to at least two countries) factors $\mathcal{F}^y_t$. By definition, the synchronization measure in equation (1) can be re-written as:

$$\mathcal{S}_{ij,t} = -\left| a^y_i - a^y_j + \left(b^y_i - b^y_j\right) \mathcal{F}^y_t + \varepsilon^y_{i,t} - \varepsilon^y_{j,t} \right|. \tag{5}$$

The equilibrium response of synchronization to idiosyncratic shocks is given by:

$$\mathcal{S}^\varepsilon_{ij,t} = -\left| \varepsilon^y_{i,t} - \varepsilon^y_{j,t} \right|, \tag{6}$$

which differs from $\mathcal{S}_{ij,t}$ because of the equilibrium response of GDP in both countries to the common shocks summarized in $\mathcal{F}^y_t$. Denote the guilty term by:

$$\mathcal{S}^{\mathcal{F}}_{ij,t} = -\left| \left(b^y_i - b^y_j\right) \mathcal{F}^y_t \right|. \tag{7}$$

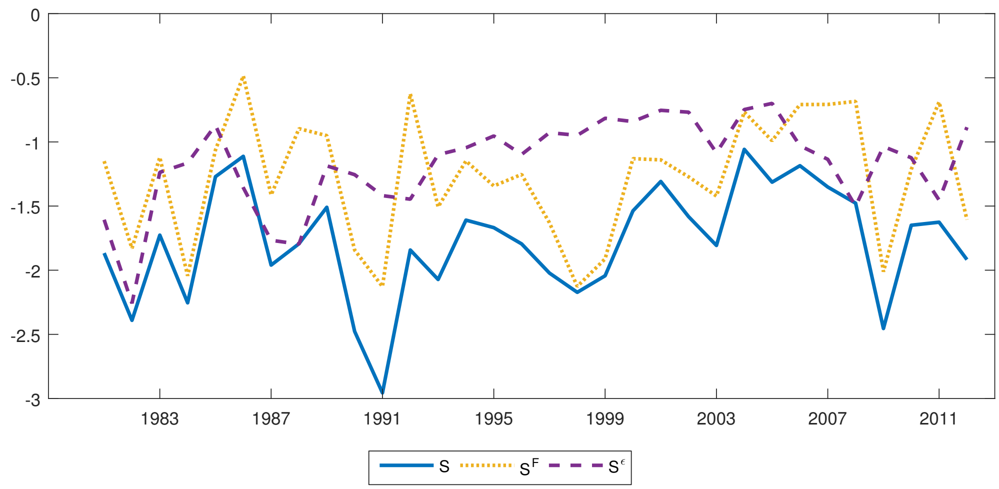
By definition, $\mathcal{S}^{\mathcal{F}}_{ij,t}$ varies with both dimensions of the panel, and so has the potential to affect the behavior of $\mathcal{S}_{ij,t}$ meaningfully, even in a regression controlling for country-pair fixed and for year effects.[9]

Figure 2 reports the behavior of the synchronization measure $\mathcal{S}_{ij,t}$ (solid line) in the cross-section of 18 advanced economies from 1980 to 2012, together with its decomposition into $\mathcal{S}^{\mathcal{F}}_{ij,t}$ (dotted line) and $\mathcal{S}^{\varepsilon}_{ij,t}$ (dashed line). The recessions of 1991 and 2008 are associated with large falls in $S_{ij,t}$, a somewhat counter-intuitive feature of a synchronization measure. We conjecture this results from the heterogeneous responses of different countries to common shocks, and thus reflects the fact that $S_{ij,t}$ is a measure of dispersion rather than co-movement. Even though most countries were moving in the same direction (for instance during the global recession of 2008-09), $\mathcal{S}_{ij,t}$ fell as the pace of the contraction in GDP was heterogeneous across countries. For instance, US annual GDP growth went from about -0.3 in 2008 to about -2.8 percent in 2009, whereas UK GDP growth went from -0.3 to -4.3 percent. Even though both growth rates fell, $\mathcal{S}_{ij,t}$ fell from 0 to -1.5, and thus implied that the UK and the US became less synchronized.

The plots of $\mathcal{S}^{\mathcal{F}}_{ij,t}$ and $\mathcal{S}^{\varepsilon}_{ij,t}$ in Figure 2 confirm this conjecture, showing that the decline in $\mathcal{S}_{ij,t}$ observed during the 1991 or 2008 recessions is clearly associated with common shocks and their heterogeneous impact, as $\mathcal{S}^{\mathcal{F}}_{ij,t}$ drops substantially in both cases. We emphasize this does not have to be the case: $\mathcal{S}_{ij,t}$ does not have to systematically take low values during recessions. The facts that it does in OECD data, and that $\mathcal{S}_{ij,t}$ is highly positively correlated with $\mathcal{S}^{\mathcal{F}}_{ij,t}$ both suggest that common shocks with heterogeneous effects are relevant in the sample at hand. In contrast, $\mathcal{S}^{\varepsilon}_{ij,t}$ increases in 2008, and does not fall in 1991. In fact, $\mathcal{S}^{\varepsilon}_{ij,t}$ reflects what is expected of an average of idiosyncratic shocks: low volatility over the period, with average values much closer to zero than $\mathcal{S}_{ij,t}$ or $\mathcal{S}^{\mathcal{F}}_{ij,t}$, and no systematic association with

[9] The same argument holds for $\mathcal{S}^{e}_{ij,t}$. To see why, define $\gamma_t = \bar{b}\mathcal{F}_t$ since by construction a time effect constrains a common shock to homogeneity in the cross section. It is easy to see that $\mathcal{S}^{e}_{ij,t} = -\left|(b_i - b_j)\,\mathcal{F}^y_t + \varepsilon_{it} - \varepsilon_{jt}\right|$ since $e_{it} = b^y_i \mathcal{F}^y_t - \bar{b}\mathcal{F}_t + \varepsilon^y_{i,t}$. Therefore $\mathcal{S}^{e}_{ij,t}$ continues to be polluted by common shocks. The time effect only controls for one specific kind of common shock, with homogeneous effects.

Figure 2 THE EVOLUTION OF SYNCHRONIZATION (AND OF ITS IDIOSYNCRATIC AND COMMON COMPONENTS)



NOTE. The solid line plots the evolution over time of the average value of $\mathcal{S}_{ij,t}$ for the 1980-2012 period. The average is computed across 153 country pairs for each year. The chart also reports the cross-sectional averages of the idiosyncratic component (dashed line) and the common component (dotted line) of $\mathcal{S}_{ij,t}$. $\mathcal{F}_t$ has been proxied by the first 3 principal components on the full panel of GDP growth rates (see details below).

a specific episode or a specific kind of shock (financial, oil, or monetary).

The measure $\mathcal{S}_{ij,t}$ conflates two mechanisms: the international propagation of idiosyncratic shocks, $\mathcal{S}^{\varepsilon}_{ij,t}$, and the international equilibrium response to common shocks, $\mathcal{S}^{\mathcal{F}}_{ij,t}$. The former is a measure of synchronization in response to country-specific shocks; the latter is a measure of the dispersion in GDP growth rates in response to common shocks. This distinction complicates the estimated effect of financial integration on synchronization.

2.2 Specification

The conventional panel regression that investigates the impact of financial integration on synchronization is due to KPP. It writes:

$$\mathcal{S}_{ij,t} = \alpha_{ij} + \gamma_t + \beta \cdot K_{ij,t} + \delta \cdot Z_{ij,t} + \eta_{ij,t}, \tag{8}$$

where $K_{ij,t}$ measures bilateral financial linkages between i and j, and $Z_{ij,t}$ denotes a vector of controls, for instance bilateral goods trade. The year effects γ_t account for global shocks that affect all countries homogeneously. The country-pair specific effect α_{ij} ensures β is estimated over time, in deviations from country-pair averages, which constitutes a substantial improvement relative to earlier estimations typically obtained in cross-section. See for instance Frankel and Rose (1998), Doyle and Faust (2005), Imbs (2006) or Baxter and Kouparitsas (2005), among many others. While estimates of β are positive and significant in cross-section regressions, KPP show they switch signs and become significantly negative within country-pairs. Since the theory that underpins equation (8) models the propagation of shocks over time, the estimation should include country-pair fixed effects. The resulting negative estimates of β are suggestive that financial integration exacerbates the asymmetry caused by country-specific shocks. This is the interpretation espoused by KPP.

This paper argues the existence of common shocks in equation (8) can affect the estimates of β. The previous section argues common shocks are mechanically embedded in $\mathcal{S}_{ij,t}$, provided they have country-specific effects. Consider now the possibility that common shocks also affect bilateral capital linkages. This is a well charted area. For instance Forbes and Warnock (2012) document that a key driving force of gross capital flows are changes in global risk. Rey (2013) argues capital flows worldwide obey global factors. Bruno and Shin (2014) document that changes in the VIX affect the cyclicality in capital flows worldwide. For simplicity, we posit a straightforward relation between capital cross-holdings and (common or idiosyncratic) shocks, i.e.:

$$K_{ij,t} = a_{ij}^K + b_{ij}^K \mathcal{F}_t^K + \varepsilon_{ij,t}^K. \tag{9}$$

This specification allows for permanent differences in capital cross-holdings, a_{ij}^K, for idiosyncratic shocks to bilateral capital $\varepsilon_{ij,t}^K$, and for a vector of common shocks $\mathcal{F}_t^K$. Common shocks can have heterogeneous consequences across country pairs, captured by b_{ij}^K. The specification is general, in that it can account for global cycles in financial integration, or for a potential trend in $K_{ij,t}$. If gross financial flows are procyclical in response to global shocks, as in Rey (2013) or Broner et al. (2013), we should have $b_{ij}^K \geq 0$. If $K_{ij,t}$ displays an upward trend, $\mathcal{F}_t^K$ takes positive and rising values in t.

In the presence of common shocks with heterogeneous loadings, negative estimates of β can arise because of a systematic correlation between factor loadings. For example, a correlation can exist between the factor loadings on output, $\left(b_i^y - b_j^y\right)$, and the factor loadings on capital, b_{ij}^K. If such were the case, one would expect negative estimates of β to arise when cycle synchronization is measured with $\mathcal{S}_{ij,t}$ or with $\mathcal{S}_{ij,t}^{\mathcal{F}}$, but not with $\mathcal{S}_{ij,t}^{\varepsilon}$. The first two are polluted by common shocks with heterogeneous effects, and thus embed time-invariant factor loadings, whereas the latter is clear of any common shock. If this is indeed the reason why estimates of β are negative, the results are driven by *permanent* features of GDP growth and of capital flows, that prevail systematically in response to common shocks. They reflect the fact that permanent differences exist across countries in terms of how GDP growth and capital flows respond to common shocks. But they are silent on the response of financial flows to country-specific developments, and on its consequence on synchronization.

3 The Effects of Finance on Synchronization

This Section first introduces the various data sources that have become standard in this literature. It then moves to a description of the paper's key results.

3.1 Data

Annual data on GDP at constant prices are collected from the OECD National Accounts. GDP is measured using the expenditure approach, and deflated with each country's GDP deflator. Bilateral financial linkages are obtained from the "International Locational Banking Statistics" released by the Bank of International Settlements (BIS).[10] The data collect information on international financial claims and liabilities of banks resident in a BIS reporting country, vis-a-vis counter-party countries. The data are in USD, and deflated using the US GDP deflator. They focus on bank linkages, and are therefore of somewhat limited scope. But few alternatives exist that measure bilateral financial linkages over time for other classes of assets.

Data coverage is best for reporting countries, which include most developed economies. It is much more incomplete for counter-party countries that include many developing economies, where a lot of data points are missing. The practice has been to combine information about claims and liabilities in both directions. For instance, information on liabilities due by counter-party country j towards country i is completed by data on claims held by reporting country i in country j. In addition, given the recent globalization in financial flows, the data are normalized, by population or GDP. In particular, consider two measures for $K_{ij,t}$:

$$K_{ij,t}^{pop} = \frac{1}{4}\left[\ln\left(\frac{A_{ij,t}}{P_{i,t}+P_{j,t}}\right) + \ln\left(\frac{L_{ij,t}}{P_{i,t}+P_{j,t}}\right) + \ln\left(\frac{A_{ji,t}}{P_{i,t}+P_{j,t}}\right) + \ln\left(\frac{L_{ji,t}}{P_{i,t}+P_{j,t}}\right)\right], \tag{10}$$

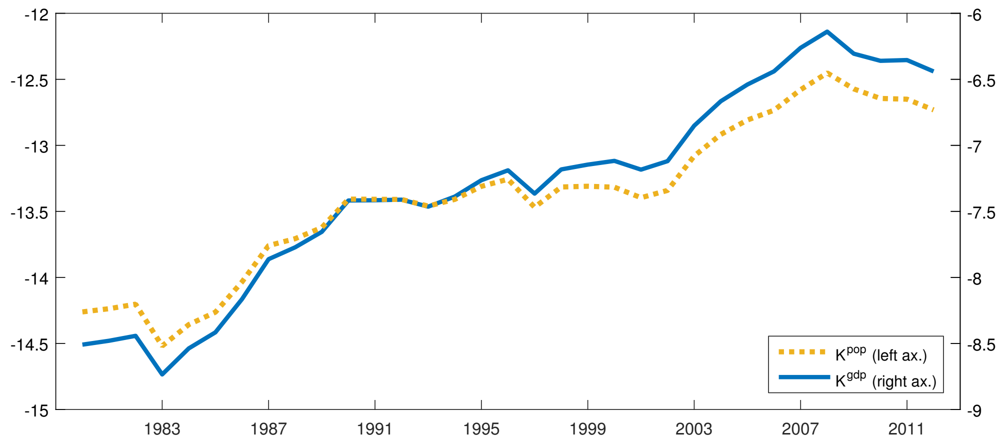
and:

$$K_{ij,t}^{gdp} = \frac{1}{4}\left[\ln\left(\frac{A_{ij,t}}{Y_{i,t}+Y_{j,t}}\right) + \ln\left(\frac{L_{ij,t}}{Y_{i,t}+Y_{j,t}}\right) + \ln\left(\frac{A_{ji,t}}{Y_{i,t}+Y_{j,t}}\right) + \ln\left(\frac{L_{ji,t}}{Y_{i,t}+Y_{j,t}}\right)\right], \tag{11}$$

where $A_{ij,t}$ ($L_{ij,t}$) denotes the claims (liabilities) on country j held by banks located in country i, $Y_{i,t}$ is GDP in country i and time t, and $P_{i,t}$ is population in country i at time t. Both measures are bilateral; they contain no information on the direction of capital holdings. Figure 3 reports the average value of $K_{ij,t}^{pop}$ and $K_{ij,t}^{gdp}$ across country pairs. Even though both variables are normalized, an upward trend clearly survives in both measures.

[10] A non-negligible proportion of the BIS data that we use are not publicly available: they are restricted series, accessible by anyone affiliated with a participating central bank through DBS Online. The BIS also agrees to grant access to the data to anyone wishing to replicate the results upon physically arriving at the BIS and conducting analysis on the premises. The non-confidential data, along with replication files are available from the authors' websites, at: http://www.jeanimbs.com/papers2_files/Replication.zip, or https://sites.google.com/site/ambropo/CIS_FinanceSynch_Replication.zip

Figure 3 THE EVOLUTION OF BANKING INTEGRATION



NOTE. The solid and dotted lines plot the evolution over time of the average value of $K_{ij,t}^{pop}$ and $K_{ij,t}^{gdp}$ for the 1980-2012 period. The average is computed across 153 country pairs for each year.

Bilateral goods trade data are collected from the IMF's Direction of Trade. The data are expressed in USD, and deflated using the US GDP deflator. Trade intensity is measured as the ratio of bilateral exports and imports, as a proportion of total trade in each country, following Frankel and Rose (1998) among many others. As in KPP, data are limited to 18 developed economies, in order to minimize structural differences in the cross section.[11] The sample is initially focused on the recent period with data until 2012, but later restricted to the "tranquil" times that preceded 2006.

The key argument of the paper rests on the identification of shocks to GDP that are common across countries. The decomposition is performed in as simple a manner as possible, using simple factor analysis. In particular, we estimate:

$$y_{i,t} = a_i^y + b_{1,i}^y \mathcal{F}_{1,t}^y + ... + b_{n,i}^y \mathcal{F}_{n,t}^y + \nu_{it}^y, \tag{12}$$

[11]The 18 countries are: Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, the UK, Ireland, Italy, Japan, the Netherlands, Portugal, Sweden, and the US. Duval et al. (2016) examine a data set including 63 advanced and emerging countries between 1995 and 2013, focusing on the role of (value added) trade in synchronizing business cycles.

where n is the number of countries in the sample.[12] The vector of n factors provides an exact decomposition of the variance in the dependent variable, but since each loading is estimated with error, an estimation residual ν_{it}^{y} appears in the regression. Denoting fitted values with a hat, the decomposition can be rewritten as:

$$y_{it} = \hat{a}_i + \hat{b}_{1,i}^{y}\hat{\mathcal{F}}_{1,t}^{y} + ... + \hat{b}_{n,i}^{y}\hat{\mathcal{F}}_{n,t}^{y}. \tag{13}$$

The decomposition defines factors that may or may not be common to two or more countries. A conventional approach to distinguish common from idiosyncratic factors is to consider the eigenvalues associated with each factor: idiosyncratic shocks display eigenvalues strictly below one, while they are above one for shocks that affect two countries or more. Since by construction, the eigenvalues associated with $\hat{\mathcal{F}}_{n,t}^{y}$ (with $n = 1, 2, ..., N$) decrease in n, this provides a decomposition of factors into ones that are common to two countries or more, and ones that are specific to one single economy.

Table 1 provides a summary of the factor estimates for GDP growth rates y_{it}. Two factors are enough to explain more than 70 percent of the variance in GDP growth. This is not surprising: it is simply a reformulation of well known facts in the framework of a simple factor analysis, established for instance by Kose et al. (2003) for GDP growth rates.

Table 1 Factor Estimates for GDP Growth

	Eigenvalues	Share of variance	Cum. share of variance
$\mathcal{F}_1$	10.67	59.3%	59.3%
$\mathcal{F}_2$	2.21	12.3%	71.5%
$\mathcal{F}_3$	1.02	5.7%	77.2%
$\mathcal{F}_4$	0.89	4.9%	82.2%
$\mathcal{F}_5$	0.83	4.6%	86.8%

Note. Principal components are computed on the panel of 18 GDP growth series (y_{it}) over the sample period 1980–2012.

[12] A large literature studies adequate estimation strategy in the presence of interactive fixed effects akin to equation (12). Examples include Bai (2009) or Su et al. (2015).

Table 1 also implies a decomposition of y_{it} into common vs. country-specific shocks, according to the estimated eigenvalues associated with each factor. Using Section 2's notation, the first column of Table 1 implies the following decomposition:

$$y_{it} = \hat{a}_i + \hat{b}^y_{1,i}\hat{\mathcal{F}}^y_{1,t} + \hat{b}^y_{2,i}\hat{\mathcal{F}}^y_{2,t} + \hat{b}^y_{3,i}\hat{\mathcal{F}}^y_{3,t} + \hat{\varepsilon}^y_{i,t}, \tag{14}$$

The first three principal components are common to two countries or more.[13]

3.2 Estimation results

Equation (8) is the paper's key panel regression. We use the principal component decomposition just described to run three versions of the estimation. The first simply reproduces known results, where the dependent variable is given by $\mathcal{S}_{ij,t}$ that embeds both common and idiosyncratic shocks. The two alternative specifications condition the estimation on one kind of shock only: on common shocks only, with $\mathcal{S}^{\mathcal{F}}_{ij,t}$ as the dependent variable, and on idiosyncratic shocks only, with $\mathcal{S}^{\varepsilon}_{ij,t}$ as the dependent variable. All three estimations are performed for the two variants of $K_{ij,t}$, normalized by population or by GDP.

Table 2 reports the panel estimates of equation (8); Table 3 includes a control for the intensity of bilateral trade. In both tables, columns (1) and (4) reproduce the significantly negative estimates of β within country pair, as in KPP.[14]

However, as this paper has argued, $\mathcal{S}_{ij,t}$ embeds the heterogeneous responses of GDP to common shocks. Inasmuch as common shocks also affect $K_{ij,t}$, negative estimates of β in columns (1) and (4) could still arise because of features specific to each country pair: The responses of $\mathcal{S}_{ij,t}$ and $K_{ij,t}$ to common shocks. Columns (2) and (5) in both tables confirm that negative estimates of β arise when synchronization is conditioned on common shocks

[13] See Appendix B for a summary description of the estimated common factors.

[14] Estimates of β continue to be significantly negative if the dependent variable is $\mathcal{S}^{\mathcal{F}}_{ij,t} + \mathcal{S}^{\varepsilon}_{ij,t}$ instead of $\mathcal{S}_{ij,t}$. These results are available upon request.

Table 2 BANKING INTEGRATION AND BUSINESS CYCLE SYNCHRONIZATION: PANEL ("WITHIN") ESTIMATES

	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\varepsilon}$	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\varepsilon}$
	(1)	(2)	(3)	(4)	(5)	(6)
Banking / Pop. (K^{pop})	-0.144	-0.154	0.075			
	(0.040)	(0.030)	(0.021)			
	[-3.63]	[-5.05]	[3.54]			
Banking / GDP (K^{gdp})				-0.148	-0.159	0.072
				(0.042)	(0.032)	(0.022)
				[-3.56]	[-4.98]	[3.28]
Observations	4863	4863	4863	4863	4863	4863
R^2	0.099	0.222	0.133	0.099	0.222	0.133
Country Pairs	153	153	153	153	153	153

NOTE. All regression specifications include a vector of country-pair fixed effects and a vector of year fixed effects. Estimation is performed over the 1980-2012 period. Standard errors are adjusted for country-pair-level heteroskedasticity and autocorrelation.

Table 3 BANKING INTEGRATION AND BUSINESS CYCLE SYNCHRONIZATION: PANEL ("WITHIN") ESTIMATES WITH CONTROLS

	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\varepsilon}$	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\varepsilon}$
	(1)	(2)	(3)	(4)	(5)	(6)
Banking / Pop. (K^{pop})	-0.102	-0.132	0.060			
	(0.040)	(0.028)	(0.024)			
	[-2.57]	[-4.71]	[2.55]			
Banking / GDP (K^{gdp})				-0.106	-0.137	0.056
				(0.041)	(0.029)	(0.024)
				[-2.55]	[-4.65]	[2.32]
Trade	-0.382	-0.198	0.132	-0.386	-0.203	0.141
	(0.134)	(0.114)	(0.078)	(0.133)	(0.113)	(0.078)
	[-2.86]	[-1.75]	[1.69]	[-2.90]	[-1.79]	[1.81]
Observations	4859	4859	4859	4859	4859	4859
R^2	0.103	0.224	0.134	0.103	0.225	0.134
Country Pairs	153	153	153	153	153	153

NOTE. All regression specifications include a vector of country-pair fixed effects and a vector of year fixed effects. Estimation is performed over the 1980-2012 period. Standard errors are adjusted for country-pair-level heteroskedasticity and autocorrelation.

only. As argued in Section 2, this result could be driven by a systematic correlation between $b_i^y - b_j^y$ and b_{ij}^K.

Columns (3) and (6) of Tables 2 and 3 show that the estimates of β are significantly positive when synchronization is measured by $\mathcal{S}^{\varepsilon}_{ij,t}$ defined in equation (6). The synchronization measure captures the equilibrium response of GDP in countries i and j to a country-specific shock: this is the object that models of the international business cycle have ambiguous predictions about. The contagious consequences of finance mirrored by positive estimates of β are consistent with models where financial flows serve to alleviate binding constraints, rather than to chase high returns.

The panel of GDP growth rates used until now include the Great Recession years, until 2012. Arguably, the most recent period includes years when financial linkages may have been especially contagious. For instance Kalemli-Ozcan et al. (2013) show that estimates of β become less negative if the crisis years are included. They explain the instability in coefficient estimates with the prevalence of credit shocks during the Great Recession. Given the magnitude and globality of the Great Recession, it is likely to affect estimates of common shocks, and thus the estimated elasticities of GDP and capital to common shocks.

Table 4 repeats the previous three estimations, but on a sample that now stops in 2006.[15] Estimates of β continue to be negative when the dependent variable is $\mathcal{S}_{ij,t}$ or $\mathcal{S}^{\mathcal{F}}_{ij,t}$; and to be positive when it is $\mathcal{S}^{\varepsilon}_{ij,t}$, consistent with the prevalence of contagious shocks and credit constraints in the years preceding the Great Recession.

Endogeneity is an obvious concern for OLS estimates of equation (8). There is every reason to expect that financial linkages, especially bank linkages, are governed by a diversification motive. Then $K_{ij,t}$ tends to take high values between countries that are out of sync, i.e., where $\mathcal{S}_{ij,t}$ takes large negative values. This endogeneity bias results in estimates of β that are biased downwards: (negative) OLS estimates in columns (1)-(2) and (3)-(5) are biased away from zero, and (positive) OLS estimates in columns (3) and (6) are biased towards zero.

[15]The principal component analysis on the 1980-2006 also implies that the first three principal components are common to two countries or more (with eigenvalues of 5.3, 2.6, and 1.09, respectively).

Table 4 Banking Integration and Business Cycle Synchronization: Panel ("Within") Estimates Excluding the Great Recession

	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\varepsilon}$	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\varepsilon}$
	(1)	(2)	(3)	(4)	(5)	(6)
Banking / Pop. (K^{pop})	-0.280	-0.314	0.091			
	(0.063)	(0.052)	(0.028)			
	[-4.46]	[-6.04]	[3.22]			
Banking / GDP (K^{gdp})				-0.284	-0.321	0.085
				(0.066)	(0.054)	(0.029)
				[-4.33]	[-5.91]	[2.91]
Observations	3945	3945	3945	3945	3945	3945
R^2	0.118	0.183	0.102	0.118	0.181	0.102
Country Pairs	153	153	153	153	153	153

Note. All regression specifications include a vector of country-pair fixed effects and a vector of year fixed effects. Estimation is performed over the 1980-2006 period. Standard errors are adjusted for country-pair-level heteroskedasticity and autocorrelation.

An important contribution of KPP is the introduction of an instrument for $K_{ij,t}$ that is time-varying and country pair specific. The instrument builds from the existence of European directives, issued by the European Commission at a certain date, and implemented later in member countries, with lags that vary with each country. KPP focus on the 27 directives that pertain to financial regulation, as part of the Financial Services Action Plan launched in 1998 to remove barriers across Europe. At each point in time, and for each country pair the instrument, $FSAP_{ij,t}$, considers the overlap in directives that happen to be implemented in both countries i and j. They argue implementation dates are exogenous to current economic conditions, so that the instrument satisfies standard excludability constraints. The index constitutes a novel and powerful instrument for financial integration $K_{ij,t}$.[16]

Table 5 presents Instrumental Variable estimations of equation (8), once again for the three considered measures of cycle synchronization, $\mathcal{S}_{ij,t}$, $\mathcal{S}^{\mathcal{F}}_{ij,t}$, and $\mathcal{S}^{\varepsilon}_{ij,t}$. Estimates of β are still significantly negative for the measures of synchronization that embed common shocks, $\mathcal{S}_{ij,t}$ and $\mathcal{S}^{\mathcal{F}}_{ij,t}$. As in Table 4, when synchronization focuses on idiosyncratic shocks (i.e.,

[16]Following KPP, the instrument takes value zero for non EU member countries, and for all years before 1998.

Table 5 BANKING INTEGRATION AND BUSINESS CYCLE SYNCHRONIZATION: PANEL ("WITHIN") IV ESTIMATES EXCLUDING THE GREAT RECESSION

	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\varepsilon}$	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\varepsilon}$
	(1)	(2)	(3)	(4)	(5)	(6)
Banking / Pop. (K^{pop})	-0.487	-0.367	0.237			
	(0.132)	(0.084)	(0.089)			
	[-3.69]	[-4.35]	[2.66]			
Banking / GDP (K^{gdp})				-0.519	-0.391	0.253
				(0.141)	(0.090)	(0.095)
				[-3.69]	[-4.35]	[2.66]
Observations	3951	3951	3951	3951	3951	3951
R^2	0.112	0.188	0.054	0.110	0.185	0.046
Country Pairs	153	153	153	153	153	153

NOTE. All regression specifications include a vector of country-pair fixed effects and a vector of year fixed effects. Estimation is performed over the 1980-2006 period. Standard errors are adjusted for country-pair-level heteroskedasticity and autocorrelation.

when using $\mathcal{S}^{\varepsilon}_{ij,t}$ as a dependent variable) estimates of β are positive and significant.

3.3 Discussion

There are two key results in this paper. Firstly, in response to well identified idiosyncratic shocks financial integration and cycle synchronization move hand in hand. This is an important result, which runs counter to the current state of knowledge on this question. Secondly, in response to common shocks that are allowed to have country-specific effects financial integration and cycle synchronization move in opposite directions. This Section discusses the latter result, and especially to what extent it differs from KPP.

The negative correlation between $\mathcal{S}^{\mathcal{F}}_{ij,t}$ and $K_{ij,t}$ could in fact just be a reformulation of the main result in KPP. Common shocks are estimated in annual data, which means the set of common shocks could contain country-specific disturbances that propagate across countries within a year. In that case, our result that $\mathcal{S}^{\mathcal{F}}_{ij,t}$ and $K_{ij,t}$ correlate negatively could simply reflect the propagation of shocks as modeled in BKK: a technology shock increases the marginal product of capital in a country, capital flows there (within a year), and cycles become less synchronized. We emphasize that, even under this interpretation, the mismeasurement issue pertains to $\mathcal{S}^{\mathcal{F}}_{ij,t}$, and not to $\mathcal{S}^{\varepsilon}_{ij,t}$. The positive correlation between $\mathcal{S}^{\varepsilon}_{ij,t}$ and $K_{ij,t}$ continues to exist, and it points to contagious consequences of financial integration — with a propagation mechanism that is potentially slow (above one year).

This interpretation of the negative correlation between $\mathcal{S}^{\mathcal{F}}_{ij,t}$ and $K_{ij,t}$ has a direct implication: it must be associated with values of the factor loadings b^y_i and b^y_j that have opposite signs. The intuition is straightforward: as a productivity shock increases the return to investing in one country, its economy attracts capital, just as GDPs in countries i and j move in opposite directions. This motivates a decomposition of $\mathcal{S}^{\mathcal{F}}_{ij,t}$ into two parts: $\mathcal{S}^{\mathcal{F}+}_{ij,t}$, constituted of common shocks with symmetric effects across countries (i.e., $b^y_i \cdot b^y_j > 0$), and $\mathcal{S}^{\mathcal{F}-}_{ij,t}$ constituted of shocks that have opposite effects across countries ($b^y_i \cdot b^y_j < 0$).[17] If our finding is but a reformulation of the result in KPP, we expect that $\mathcal{S}^{\mathcal{F}-}_{ij,t}$ correlates negatively with $K_{ij,t}$, but $\mathcal{S}^{\mathcal{F}+}_{ij,t}$ does not.

Table 6 presents the results. Interestingly, we confirm that $\mathcal{S}^{\mathcal{F}-}_{ij,t}$ and $K_{ij,t}$ correlate negatively: it is possible there are some idiosyncratic shocks embedded in $\mathcal{F}^y_t$ that propagate within one year via capital flows, and have asymmetric effects on countries' GDP as BKK would predict. But the table shows that $\mathcal{S}^{\mathcal{F}+}_{ij,t}$ and $K_{ij,t}$ also correlate negatively. In other words, the negative correlation we find between $\mathcal{S}^{\mathcal{F}}_{ij,t}$ and K_{ijt} cannot be solely explained by the mechanism proposed in BKK.

Where does this result come from then? To gain intuition consider a version of equation (8) conditioned on the first factor: the dependent variable becomes $\mathcal{S}^{\mathcal{F}1}_{ij,t} = -\left|\left(b^y_{1,i} - b^y_{1,j}\right)\mathcal{F}^y_{1,t}\right|$, and the key regressor becomes $a^K_{ij} + b^K_{ij}\mathcal{F}^K_{1,t} + \varepsilon^K_{ij,t}$. A useful property of $\mathcal{S}^{\mathcal{F}1}_{ij,t}$ is that all loadings

[17] On the basis of the results in Section 3.2 where three common factors are estimated, $\mathcal{S}^{\mathcal{F}+}_{ij,t}$ is computed as $-\left|\left(b^y_{1,i} - b^y_{1,j}\right)\mathcal{F}^y_{1,t} + \left(b^y_{2,i} - b^y_{2,j}\right)\mathcal{F}^y_{2,t} + \left(b^y_{3,i} - b^y_{3,j}\right)\mathcal{F}^y_{3,t}\right|$, for all i, j such that $b^y_{s,i} \cdot b^y_{s,j} > 0$, $s = 1, 2, 3$. And $\mathcal{S}^{\mathcal{F}-}_{ij,t}$ is computed with the remaining pairs. Each component corresponds approximately to half of all cases.

Table 6 BANKING INTEGRATION AND BUSINESS CYCLE SYNCHRONIZATION ("WITHIN" ESTIMATES): $\mathcal{S}^{\mathcal{F}}_{ij,t}$, $\mathcal{S}^{\mathcal{F}+}_{ij,t}$, AND $\mathcal{S}^{\mathcal{F}-}_{ij,t}$ CONTROLLING FOR TRADE

	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\mathcal{F}+}$	$\mathcal{S}^{\mathcal{F}-}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\mathcal{F}+}$	$\mathcal{S}^{\mathcal{F}-}$
	(1)	(2)	(3)	(4)	(5)	(6)
Banking / Pop. (K^{pop})	-0.132	-0.041	-0.066			
	(0.028)	(0.013)	(0.022)			
	[-4.71]	[-3.24]	[-2.98]			
Banking / GDP (K^{gdp})				-0.137	-0.041	-0.068
				(0.029)	(0.013)	(0.023)
				[-4.65]	[-3.07]	[-3.00]
Trade	-0.198	0.072	-0.095	-0.203	0.068	-0.098
	(0.114)	(0.038)	(0.091)	(0.113)	(0.038)	(0.090)
	[-1.75]	[1.89]	[-1.04]	[-1.79]	[1.80]	[-1.09]
Observations	4859	4859	3811	4859	4859	3811
R^2	0.224	0.339	0.406	0.225	0.339	0.406
Country Pairs	153	153	153	153	153	153

NOTE. All regression specifications include a vector of country-pair fixed effects and a vector of year fixed effects. Estimation is performed over the 1980-2006 period. Standard errors are adjusted for country-pair-level heteroskedasticity and autocorrelation.

are positive, $b^y_{1,i} > 0$ for all i.[18] Equation (8) becomes:

$$- |b^y_{1,i} - b^y_{1,j}| \cdot |\mathcal{F}^y_{1,t}| = \alpha_{ij} + \gamma_t + \beta^{\mathcal{F}1} \cdot \left[a^K_{ij} + b^K_{ij}\mathcal{F}^K_{1,t} + \varepsilon^K_{ij,t}\right] + \delta \cdot Z_{ij,t} + \eta^{\mathcal{F}}_{ij,t}, \tag{15}$$

where we used the fact that:

$$\left|\left(b^y_{1,i} - b^y_{1,j}\right)\mathcal{F}^y_{1,t}\right| = \left|b^y_{1,i} - b^y_{1,j}\right| \cdot \left|\mathcal{F}^y_{1,t}\right|. \tag{16}$$

Clearly, the sign of $\beta^{\mathcal{F}1}$ is given by:

$$Cov\left[-|b^y_{1,i} - b^y_{1,j}| \cdot |\mathcal{F}^y_{1,t}|,\ b^K_{ij}\mathcal{F}^K_{1,t}\right] = -|b^y_{1,i} - b^y_{1,j}| \cdot b^K_{ij}\ Cov\left[\left|\mathcal{F}^y_{1,t}\right|, \mathcal{F}^K_{1,t}\right]. \tag{17}$$

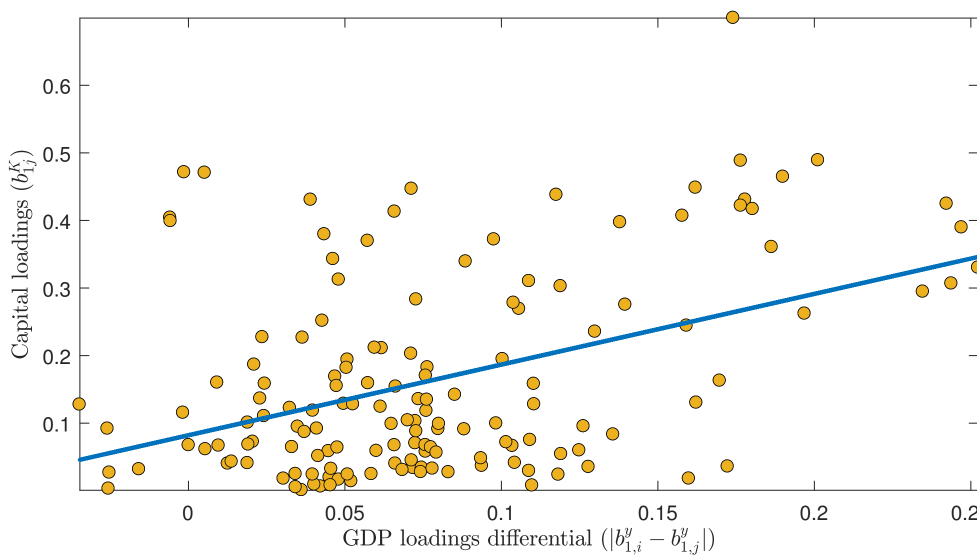
where $Cov[\cdot]$ denotes the covariance operator. According to equation (17), a negative esti-

[18]This is not surprising or novel, as the first factor is typically the global economic cycle, with which most countries —especially developed ones— correlate positively.

mate of $\beta^{\mathcal{F}1}$ requires, for example, a positive covariance between $|b^y_{1,i} - b^y_{1,j}|$ and b^K_{1j} and a positive covariance between $\left|\mathcal{F}^y_{1,t}\right|$ and $\mathcal{F}^K_{1,t}$.

These are in fact the signs that prevail in our data, which we take to explain why $\mathcal{S}^{\mathcal{F}1}_{ij,t}$ and $K_{ij,t}$ move in opposite directions, and by extension why the same is true of $\mathcal{S}^{\mathcal{F}+}_{ij,t}$ and $K_{ij,t}$. The correlation between $|b^y_{1,i} - b^y_{1,j}|$ and b^K_{1j} is 0.43 in the cross section formed by 153 country pairs, with a t-statistic of 5.64. Figure 4 shows the corresponding scatter plot, and confirms the finding is not driven by outliers.

Figure 4 Correlation Between Factor Loadings on GDP and Capital



Note. Each dot represents a country pair. The horizontal axis reports the pairwise difference in the loadings on the first GDP factor in absolute value ($|b^y_{1,i} - b^y_{1,j}|$). The vertical axis reports the loading on the first capital factor ($\hat{b}^K_{1,i}$). The slope of the fitted line implies a correlation of 0.43 in the cross section formed by 153 country pairs, with a t-statistic of 5.64.

The correlation between $\left|\mathcal{F}^y_{1,t}\right|$ and $\mathcal{F}^K_{1,t}$ is 0.20. (Note that it would be zero if the two factors were perfectly correlated). These results mean that the responses of capital and GDP to common shocks happen to be similar: countries with elastic GDP are also the systematic destination of capital flows during global (or regional) booms, but their source in global (or regional) recessions.

4 Extensions and Robustness

This Section discusses extensions to our baseline specification. We consider an alternative measure of synchronization, the Pearson correlation coefficient. We augment the regression with a measure of similarity in the specialization of production, a prominent candidate variable that could have potential effects on both financial integration and cycle synchronization. Finally, we investigate the robustness of our results in sub-samples.[19]

4.1 Correlation Coefficients

Most of the literature until recently uses the Pearson correlation coefficient as a measure of cycle synchronization. It is problematic in panel regressions, because it is measured with error and because it responds to changes in the variance of the underlying shocks. Still, KPP show that the negative estimates in equation (8) survive this alternative measurement of synchronization.

Consider the consequences of equation (4) on the Pearson correlation ρ_{ij} between the GDP growth rates of countries i and j. By definition:

$$\rho_{ij} = \left(w_i^{\mathcal{F}}\right)^{\frac{1}{2}} \left(w_j^{\mathcal{F}}\right)^{\frac{1}{2}} + \left(1 - w_i^{\mathcal{F}}\right)^{\frac{1}{2}} \left(1 - w_j^{\mathcal{F}}\right)^{\frac{1}{2}} \rho_{ij}^{\varepsilon}, \tag{18}$$

where $w_i^{\mathcal{F}} = b_i^2 V(\mathcal{F}_t^y)/V(y_{i,t})$ is the share of the variance of GDP growth in country i that corresponds to common shocks, and ρ_{ij}^{ϵ} is the Pearson correlation coefficient that captures cycle synchronization conditional on idiosyncratic shocks. As is evident, in the presence of common shocks, the Pearson correlation between GDP growth is an imperfect measure of the actual correlation coefficient implied by country-specific shocks, even if underlying risk is held constant. A corrective term drives a wedge between the two coefficients. Its magnitude

[19] In an online appendix we compute time-varying factor loadings and show our key results survive this generalization.

depends on the share of the variance in GDP growth that can be explained by common shocks in both countries i and j.

Correlation coefficients were traditionally used in cross-section, since they are computed in the time dimension. But it is also possible to compute them over successive sub-periods, and use the resulting panel as the dependent variable in equation (8). Then the corrective term in equation (18) involving $w_i^{\mathcal{F}}$ and $w_j^{\mathcal{F}}$ can also be time-varying. With an intuition that is analogous to Forbes and Rigobon (2002), changes in the variance of the underlying shocks affect the panel properties of ρ_{ij}. The empirical question posed by this possibility is whether the estimates of β in equation (8) depend on how synchronization is measured, by ρ_{ij} or by ρ_{ij}^{ε}.

Table 7 BANKING INTEGRATION AND BUSINESS CYCLE SYNCHRONIZATION ("WITHIN" ESTIMATES): PEARSON CORRELATION COEFFICIENT

	ρ	$\rho^{\mathcal{F}}$	ρ^{ε}	ρ	$\rho^{\mathcal{F}}$	ρ^{ε}
	(1)	(2)	(3)	(4)	(5)	(6)
Banking / Pop. (K^{pop})	0.003	-0.031	-0.017			
	(0.181)	(0.015)	(0.020)			
	[0.19]	[-2.07]	[-0.83]			
Banking / GDP (K^{gdp})				0.005	-0.033	-0.018
				(0.019)	(0.016)	(0.021)
				[0.26]	[-2.11]	[-0.85]
Observations	915	915	915	915	915	915
R^2	0.240	0.259	0.001	0.240	0.260	0.001
Country Pairs	153	153	153	153	153	153

NOTE. All regression specifications include a vector of country-pair fixed effects and a vector of year fixed effects. Estimation is performed over the 1980-2012 period. Standard errors are adjusted for country-pair-level heteroskedasticity and autocorrelation.

Table 7 shows that it does: the estimates of β are essentially zero in columns (1) and (4), when the dependent variable in equation (8) is given by $\rho_{ij,t}$, computed over five-year windows. It becomes strongly negative and significant when the correlation coefficient is computed on common shocks only, in columns (2) and (5). But it is again essentially zero when the dependent variable is replaced by $\rho_{ij,t}^{\varepsilon}$. We note that Pearson correlation coefficients are estimated over five-year windows in Table 7, and constitute therefore measures of synchronization that are estimated with considerable error. We note furthermore that changes over time in both $\rho_{ij,t}$ and $\rho^{\varepsilon}_{ij,t}$ continue to be affected by changes in the variances of the underlying shocks. While it is reassuring that the Pearson correlation coefficient conditioned on common shocks continues to be negatively related with financial integration, it is not overly worrisome that the relation between $\rho^{\varepsilon}_{ij,t}$ and financial integration is essentially zero: there are many well known reasons why this may happen.

4.2 Similarity in Production

We examine whether the association between output synchronization and banking integration documented so far is driven by other factors. In particular, we control for the possibility that the relation we estimate between synchronization ($\mathcal{S}_{ij,t}$, $\mathcal{S}^{\mathcal{F}}_{ij,t}$, and $\mathcal{S}^{\varepsilon}_{ij,t}$) and financial integration ($K_{ij,t}$) is driven by the fact that countries with similar sectors tend to display both synchronized cycles and strong bank linkages. Sectorial similarities have been shown to figure prominently on the list of the determinants of cycles synchronization (see Imbs (2004, 2006)).

To control for this possibility we augment the baseline specification with a measure of sectorial dissimilarities, given by

$$SPEC_{ij,t} = \sum_{s=1}^{S} \left| \frac{y_{s,it}}{\mathrm{Y}_{it}} - \frac{y_{s,jt}}{\mathrm{Y}_{jt}} \right|$$

where $y_{s,it}/Y_{it}$ denotes the share of sector's $s = 1, ..., S$ Gross Value Added (GVA) in total GVA. The measure is conventional in the literature, see KPP or Imbs (2006). We compute $SPEC_{ij,t}$ using the EU and World KLEMS tables, with two-digit sector-level data covering 16 countries between 1980 and 2012.[20] Table 8 reproduces our key specifications, augmented

[20]The country coverage is reduced from 18 to 16 countries because World KLEMS do not have any information on Switzerland and Australia. We have verified the paper's main findings hold in this reduced

to include controls for sector-level similarities measured in logarithms, as is standard. The inclusion of $SPEC_{ij,t}$ affects drastically the coefficients of interest on banking integration, which all become insignificant. Evidently, countries with similar sectors tend to have strong bank linkages, as would happen for instance if international banks were expert at lending in specific sectors. Because of this collinearity, it is difficult to ascertain if banking integration has any direct consequence on synchronization, other than one reflecting sectorial specialization.

Table 8 Banking Integration and Business Cycle Synchronization ("Within" Estimates): Controlling for Similarity in Production

	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\epsilon}$	$\mathcal{S}$	$\mathcal{S}^{\mathcal{F}}$	$\mathcal{S}^{\epsilon}$
	(1)	(2)	(3)	(4)	(5)	(6)
Banking / Pop. (K^{pop})	-0.069	-0.019	-0.023			
	(0.066)	(0.047)	(0.033)			
	[-1.06]	[-0.40]	[-0.69]			
Banking / GDP (K^{gdp})				-0.079	-0.024	-0.024
				(0.067)	(0.048)	(0.034)
				[-1.18]	[-0.49]	[-0.71]
ln($SPEC$)	-2.167	-1.620	-0.238	-2.174	-1.624	-0.237
	(0.367)	(0.279)	(0.120)	(0.367)	(0.279)	(0.120)
	[-5.90]	[-5.80]	[-1.98]	[-5.93]	[-5.82]	[-1.98]
Observations	3006	3006	3006	3006	3006	3006
R^2	0.185	0.336	0.170	0.185	0.336	0.170
Country Pairs	120	120	120	120	120	120

Note. All regression specifications include a vector of country-pair fixed effects and a vector of year fixed effects. Estimation is performed over the 1980-2012 period. Standard errors are adjusted for country-pair-level heteroskedasticity and autocorrelation.

The instrument $FSAP_{ij,t}$ introduced in KPP could in principle help address this conundrum. After all, financial deregulation could be expected to isolate the exogenous component of banking integration, and tell us whether it matters for synchronization independently of sectorial similarities. But that will only be meaningful is $FSAP_{ij,t}$ is uncorrelated with $SPEC_{ij,t}$, or if their correlation is exclusively driven by banking integration. In the data,

sample.

the raw correlation between (log) $SPEC_{ij,t}$ and $FSAP_{ij,t}$ is -0.12, and a regression of (log) $SPEC_{ij,t}$ on the instrument, including year effects and pair-specific intercepts, yields a coefficient of -0.055, significant at the one percent confidence level with a t-statistic of -9.27.[21]

The existence of this strong relation between $SPEC_{ij,t}$ and $FSAP_{ij,t}$ is potentially problematic for the use of financial deregulation as an instrument. For example, financial deregulation could correlate systematically with sectorial similarities because countries specialized in similar activities tend to adopt similar European directives at the same time.[22] If that were the case, then instrumenting bank linkages with $FSAP_{ij,t}$ cannot be conclusive, because $FSAP_{ij,t}$ itself embeds some of the explanatory power of $SPEC_{ij,t}$ for cycle synchronization: The coefficient on (instrumented) banking integration is partly driven by sectorial similarities. In fact, this instrumentation would be problematic whether $SPEC_{ij,t}$ is included in the specification or not, as the coefficient on $K_{ij,t}$ conflates the putative effect of banking integration, and the well known effect of $SPEC_{ij,t}$ on synchronization.

On the other hand, it is of course possible that the observed correlation between $SPEC_{ij,t}$ and $FSAP_{ij,t}$ is working exclusively *via* banking integration. For example, financial deregulation favors banking integration, which renders integrating economies similar in terms of their production at sector level.[23] In that case, $FSAP_{ij,t}$ is a perfectly legitimate instrument.

So where does this leave us? We will not know for sure the magnitude of the channels that link $K_{ij,t}$, $SPEC_{ij,t}$, and synchronization until separate instruments become available for banking integration and for sectorial specialization. With such an expanded set of instruments, it will be possible to identify *separately* how much banking linkages and production similarities affect synchronization. By the same token, it will be possible to ascertain the

[21] If we include $BANKINT_{ij,t}$ in this regression, the coefficient on $FSAP_{ij,t}$ becomes -0.024 with a t-statistic of -4.15. Of course these regressions are both silent about causality.

[22] For example, countries with a specialization in financial services (Ireland, the Netherlands, the United Kingdom, and Austria) display on average 0.6 more directives in common than others. Also, changes in $FSAP_{ij,t}$ in those countries are more correlated than elsewhere, with an average correlation coefficient of 0.91 vs. 0.80.

[23] This is the mechanism that would be implied by Kalemli-Ozcan et al. (2003).

legitimacy of $FSAP_{ij,t}$ as an instrument for banking integration in these regressions. We leave this endeavor for further research.

4.3 Sub-Samples

The magnitude of shocks, the nature of economic integration, or the channels of propagation could have changed fundamentally over the estimation period 1980-2012. It is of independent interest to investigate whether our conclusions are modified over specific sub-periods. Table 9 presents such an analysis, where the starting date of the sample used for the estimation is modified by increments of four years. Specifically, each column of Table 9 reports coefficients estimated over different sample periods, with the results for $\mathcal{S}_{ij,t}$, $\mathcal{S}^{\mathcal{F}}_{ij,t}$, and $\mathcal{S}^{\varepsilon}_{ij,t}$ reported in the top, middle, and bottom panel, respectively.

Table 9 shows that our main result is robust to different estimation samples, with the coefficient on $\mathcal{S}^{\epsilon}_{ij,t}$ being positive and significant in five out the six sub-periods considered (see bottom panel). On the other hand, the upper panels of the table show that the coefficient on $\mathcal{S}_{ij,t}$ turns from negative to positive when considering more recent sample periods. This might be due to the period of the global financial crisis, during which the coefficient of $K_{ij,t}$ on $\mathcal{S}_{ij,t}$ turned positive (see Kalemli-Ozcan et al. (2013)).

Table 9 Banking Integration and Business Cycle Synchronization ("Within" Estimates): Sub-Samples

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:			$\mathcal{S}$			
Sample starts in year:	1980	1984	1988	1992	1996	2000
Banking / Pop. (K^{pop})	-0.144	-0.068	-0.010	0.170	0.183	0.169
	(0.040)	(0.040)	(0.047)	(0.062)	(0.088)	(0.074)
	[-3.63]	[-1.69]	[-0.21]	[2.73]	[2.08]	[2.29]
Observations	4863	4271	3663	3055	2447	1836
R^2	0.099	0.100	0.100	0.083	0.097	0.105
Country Pairs	153	153	153	153	153	153
Dependent variable:			$\mathcal{S}^{\mathcal{F}}$			
Sample starts in year:	1980	1984	1988	1992	1996	2000
Banking / Pop. (K^{pop})	-0.154	-0.049	-0.043	0.097	0.188	0.148
	(0.030)	(0.023)	(0.031)	(0.048)	(0.082)	(0.065)
	[-5.05]	[-2.12]	[-1.40]	[2.01]	[2.29]	[2.27]
Observations	4863	4271	3663	3055	2447	1836
R^2	0.222	0.223	0.215	0.203	0.237	0.215
Country Pairs	153	153	153	153	153	153
Dependent variable:			$\mathcal{S}^{\epsilon}$			
Sample starts in year:	1980	1984	1988	1992	1996	2000
Banking / Pop. (K^{pop})	0.075	0.081	0.026	0.048	0.052	0.071
	(0.021)	(0.023)	(0.022)	(0.022)	(0.026)	(0.036)
	[3.54]	[3.47]	[1.16]	[2.17]	[1.99]	[1.97]
Observations	4863	4271	3663	3055	2447	1836
R^2	0.133	0.108	0.076	0.078	0.094	0.107
Country Pairs	153	153	153	153	153	153

Note. All regression specifications include a vector of country-pair fixed effects and a vector of year fixed effects. Estimation is performed over increasingly small sample periods, ending in 2012 and starting in the year indicated at the top of each column. Standard errors are adjusted for country-pair-level heteroskedasticity and autocorrelation.

5 Conclusion

In the workhorse model of international real business cycles with complete markets, financial flows exacerbate asymmetries in business cycles as they relocate efficiently to the country with highest marginal product of capital. Under mild heterogeneity (e.g., in factor shares) the same model has observationally equivalent predictions in response to a common shock: while productivity changes are identical in both countries, the marginal products of capital respond differently, and so do GDP growth rates. The key difference is interpretation: with common shocks, capital flows respond to countries' fundamental heterogeneity, rather than an efficient quest for high returns.

To establish whether international capital flows are fundamentally efficient, it is therefore imperative to control for common shocks of a specific kind: those that are allowed to have heterogeneous effects across countries. Conditional on such common shocks, we find that financial linkages tend to result in less synchronized business cycles in 18 OECD countries. We show this finding is driven by the permanent features of cross-country heterogeneity, rather than by random, country-specific shocks. In contrast, conditional on well identified idiosyncratic, country-specific shocks we show that financial flows result in more synchronized business cycles in the vast majority of specifications. This finding provides support for the possibility that international financial flows serve to alleviate binding financial constraints, thus fostering contagion.

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Appendix

A Heterogeneity in Backus et al. (1992)

We investigate in detail the role of heterogeneous structural parameters using the model developed by Backus et al. (1992) (BKK). Capital flows where the marginal product of capital is higher, creating an asymmetric response of output across countries: the country with the relatively high marginal product of capital experiences an inflow of capital and a relative increase in production. In terms of our main variable of interest, any shock that opens a wedge between the marginal products of capital in H and F, will lead to a fall in synchronization, as measured by:

$$\mathcal{S}_{ij,t} = -\left|y_{i,t} - y_{j,t}\right|. \tag{A.1}$$

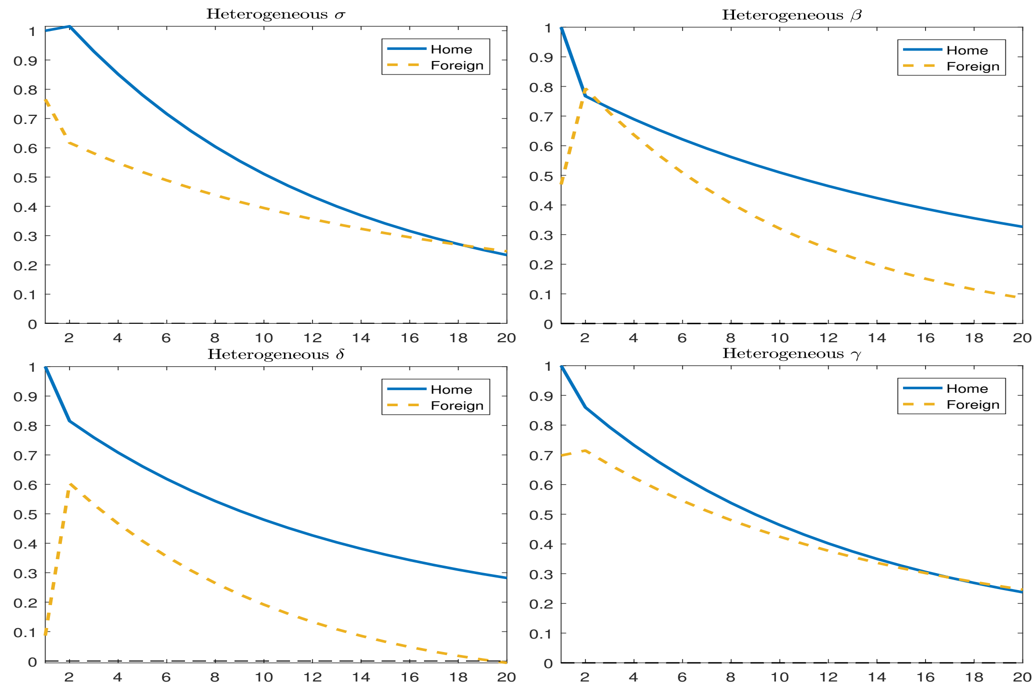
Consider the expression of the MPK (y_t^k) in BKK:

$$y_t^k \equiv \frac{\partial y_t}{\partial k_t} = -\frac{1}{\upsilon}\left[\left(\lambda_t k_t^{\theta} n_t^{1-\theta}\right)^{-\upsilon} + \sigma z_t^{-\upsilon}\right]^{-\frac{1}{\upsilon}-1} \times -\upsilon\left(\lambda_t k_t^{\theta} n_t^{1-\theta}\right)^{-\upsilon-1} \times \theta\lambda k_t^{\theta} n_t^{-\theta} \tag{A.2}$$

The response of the MPK to a productivity shock ($\partial y_t^k/\partial\lambda_t$) directly depends on some structural parameters of the economy (e.g., the capital share in production (θ), the elasticity of substitution between inventories and the capital-labor aggregate (υ), the parameter governing the inventory to output ratio (σ)). But it also depends indirectly on all other parameters of the model via the response of capital (k_t), labor (n_t), and output (y_t) to the common shock, such as the risk aversion coefficient (γ), or the subjective discount factor (β).

Equation (A.2) therefore shows that *any difference* in the structural parameters between H and F would lead to an asymmetric response of GDPs and, hence, to a fall in measured synchronization $\mathcal{S}_{ij,t}$. To show this, we report below the impulse response functions from four different experiments, where we set: (a) the parameter governing the inventory to output ratio to $\sigma^H = 0.01$ and $\sigma^F = 5$; (b) the subjective discount factor to $\beta^H = 0.995$ and $\beta^F = 0.975$; (c) the depreciation rate to $\delta^H = 0.01$ and $\delta^F = 0.06$; and (d) the coefficient of relative risk aversion to $\gamma^H = 1$ and $\gamma^F = 3$. Figure A.1 reports the results: in all cases there is an asymmetric response of output in the H and F economy to the common productivity shock.

Figure A.1 IMPULSE RESPONSE FUNCTIONS IN VARIANTS OF BKK



NOTE. The charts report the response of Output in the Home (solid line) and Foreign (dashed line) economies to a common productivity shock (i.e., a shock that raises productivity by the same amount in the Home and Foreign economy) when the two economies are heterogeneous. The sources of heterogeneity are the parameter governing the inventory to output ratio σ; the rate of time preference β; the depreciation rate δ; and the coefficient of relative risk aversion γ. See text for more details. All remaining parameters are identical to BKK (except for the time to build which is set to 1). The size of the shock has been normalized so that it increases Home output by 1 percent.

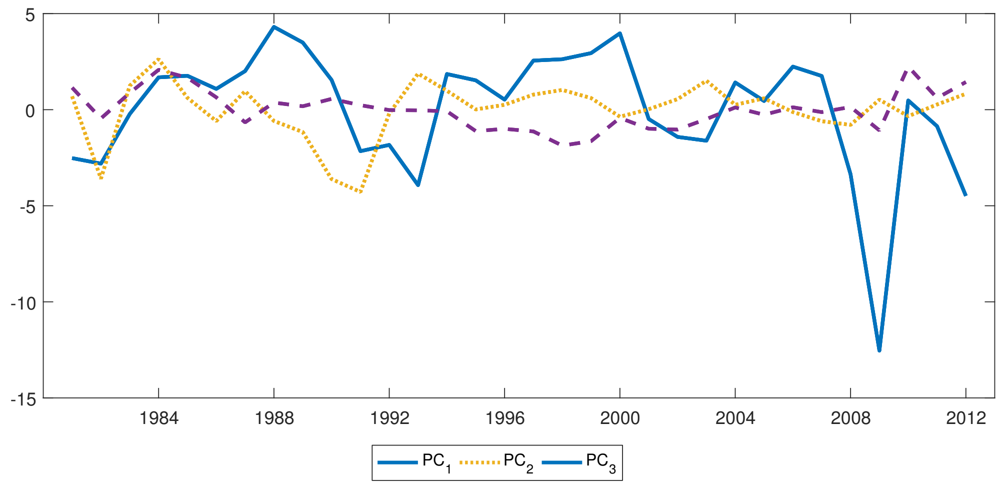
B Principal components

We compute principal components using the `pca` command in Stata on the panel of GDP growth rates for the 18 countries in our sample. We standardize the GDP growth data, so that we can interpret all principal components with an associated eigenvalue that is greater than 1 as common to at least two countries. Figure B.1 reports the estimated first three principal components (from the panel of GDP growth rates y_{it}) that are common to 2 or more countries.

It is well known that interpreting principal components is a hard task, as the approach is purely statistical and the principal components are identified only up to a rotation matrix. While a structural interpretation of the factors is beyond the scope of this paper, we provide some evidence that they are all economically relevant as they are all related with some 'global' observable variables.

Table B.1 reports the correlation coefficients between the first three principal components and annual world GDP growth (Δy_t^W), the annual growth rate in the world GDP deflator

Figure B.1 Estimated Principal Components



Note. Principal components are computed on the panel of 18 GDP growth series (y_{it}).

(π_t^W), the price of oil (oil_t), the Vix index (Vix_t), the changes in the Federal Funds rate (ff_t^{US}) and the annual return on an index of global equity prices (eq_t^W).

Table B.1 Correlation Between Factors and Global Variables

	$\mathcal{F}_1$	$\mathcal{F}_2$	$\mathcal{F}_3$
World GDP (Δy_t^W)	0.7***	0.2	0.4**
World Inflation (π_t^W)	0.1	-0.2	0.3*
Oil (oil_t)	-0.4**	0.0	0.4**
Vix Index (Vix_t)	-0.3*	-0.1	-0.1
Federal Funds (ff_t^{US})	0.4**	0.3*	0.1
World Equity (eq_t^W)	0.6***	0.1	0.2

Note. Statistical significance at the 1, 5, and 10 percent is denoted with *, **, and *** respectively.

Table B.1 shows that $\mathcal{F}_1$ is positively correlated not only with world growth, but also with the Vix Index and global equity returns. $\mathcal{F}_3$ is also correlated with world growth, but more weakly. $\mathcal{F}_1$ correlates positively with both world inflation and oil prices. Finally, $\mathcal{F}_2$ is correlated with changes in the Federal Funds rate, a proxy for monetary conditions at the center of the global financial system.