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Inspecting cross-border macro-financial mechanisms ☆

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ABSTRACT

We model structural time-varying macro-financial linkages between the U.S. and euro area using a large dataset for each region. We extract both real and financial cycles and identify shocks, using a factor model with drifting parameters. To interpret the mechanisms that drive the empirical results, we contextualize our estimates using a two-country financial accelerator model. Our evidence speaks clearly of an asymmetric cross-border transmission between U.S. and euro area, especially in the financial domain. This is confirmed by our theoretical complement, which shows a strong transmission of U.S. TFP shocks. Moreover, the U.S. is a more leveraged economy, which accentuates the financial accelerator effect.

1. Introduction

The eagerness to understand macro-financial linkages has been brisk and unprecedented over the past decade and a half. Much of this has been driven by the desire to comprehend the forces that led to the Great Recession, including the deep and long-lasting consequences from the financial downturn that began in 2007. In particular, recent research on macro-finance has focused on the role of the financial sector as a generator of shocks, which are transferred to the overall economy via macro-financial linkages. Less (albeit some) effort has been put in understanding cross-border transmissions of real and financial shocks. The euro area and the U.S. have the largest bilateral trade and investment relationship, and enjoy the most integrated economic relationship globally (European

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Commission, 2023).[1] Thus, disentangling the mechanisms behind shock transmission between the U.S. and euro area is crucial to promote global macro and financial stability.

Macro-financial interactions between these two economies are complex, and potentially subject to fundamental changes over time. The aim of this paper is to provide a robust assessment of these interactions by taking into account all the underlying dimensions to the problem. The first part of the issue involves defining what the macroeconomic and financial cycles are. Yet, in the empirical literature there is still a wide debate on the exact definition of a real cycle and how different and more complete it is from the standard business cycle. For the financial counterpart, there is even less consensus on what constitutes a financial cycle, its statistical characterization, and how similar it is to the real cycle. The existing definitions, usually, tend to be narrow, exogenously predetermined, or based on short time series samples.

Recognizing the above short-comings, this paper attempts to provide a comprehensive definition of real and financial cycles using dynamic factor models. Unlike previous studies, our empirical framework allows for an endogenous and time-varying selection of variables in the construction of each of the latent cycles, selecting from a large dataset of real activity and financial indicators, for each economy.[2] In addition, to give it structural anchoring, we reproduce the empirical relationships with a stylized two-country Iacoviello-type model.

The second part of the problem consists of measuring the intensity of the evolving macro-financial interactions. To quantify the degree of time variation and profundity in linkages, the cycles are allowed to endogenously evolve according to a structural VAR model with drifting coefficients.[3] To the best of our knowledge, this is the first study of macro-financial spillovers between the U.S. and the euro area, each as single economic units, both from an empirical and theoretical point of view. Moreover, the study covers a longer sample than previous studies, starting in the 1980s.[4]

Our empirical results point to an important asymmetric cross-border transmission of U.S. shocks, which had intensified over time. First, the (mutual) impact of U.S. shocks is much larger than those from the euro area. Real as well as financial shocks originating from the U.S. have statistically and economically significant impact on euro area macroeconomic and financial cycles. Conversely, shocks from the euro area tend to produce either small or short-lasting effects, or even negative on the U.S economy. Furthermore, we see a cross-border 'substitution effect', akin to flight-to-safety. Second, we observe a heavy dynamic evolution in responses. The intensity in the transmission of shocks increases over time, at least until the Great Recession. The introduction of the Euro did not manage to alter the hegemony of the U.S. in the bilateral relations. Third, since the Great Recession, the transmission of U.S. shocks has weakened, meanwhile the negative transmission of euro area shocks has dampened. This can be interpreted as a small change in the global role of the U.S., whereby the weakening of its economy and the protectionism that followed has reduced its' international exposure and role as originator of cross-border shocks. This is confirmed by our theoretical complement, which shows that the transmission of U.S. TFP shocks is significantly larger and more persistent than any alternative shock specifications. This creates a distinction in responses across economies, even in a symmetric real shock scenario. Moreover, the U.S. is a more leveraged economy, which accentuates the financial accelerator effect. That is why we find a heftier (relative to euro area) transmission of financial shocks to U.S. real activity in our empirical estimates.

Our work relates to several strands of the literature. On the empirical side, there are studies that have focused on the measurement of the cycles. Most of these studies find that financial cycles are longer in length and larger in amplitude than business cycles, but with an increasing synchronization over time (Drehmann et al. (2012), Aikman et al. (2015), Gerba (2015), Schuler et al. (2017) and Gerba et al. (2018a)). Moreover, Borio (2014) and Borio et al. (2017) show that financial activity matters for characterizing the business cycle, since including financial information improves the estimation of the output gap. Moreover, information contained in financial cycles has important predictive implications for economic downturns. Nevertheless, our aim here is not to estimate the output gap, as in Borio et al. (2017), or to test the predictive power of financial variables for economic recessions/swings. We instead focus on bidirectional transmission of structural shocks, making our framework more structural in interpretation, and supported by the theoretical framework to narrowed down the sources of these shocks.

Other studies have focused on the transmission of shocks from a vector autoregressions (VARs) perspective. Balke (2000) and Calza and Sousa (2006) use Threshold VAR models to measure the effect of credit shocks on real activity, for the U.S. and euro area, respectively. Both studies show evidence of a stronger impact occurring under low credit growth regimes. For similar purposes, Davig and Haikko (2010), Hubrich and Tetlow (2015), and Nasson and Tallman (2015) use Markov-switching VAR models to study the relationship between financial stress and U.S. economic activity.[5] All these studies agree in that the propagation of financial shocks to the real economy is different during high financial stress regime in comparison to normal times.

The two strands of the empirical literature described above have been somehow disconnected. The present paper intends to unify them by extracting both macroeconomic and financial cycles from a large set of information with Kalman filtering techniques,

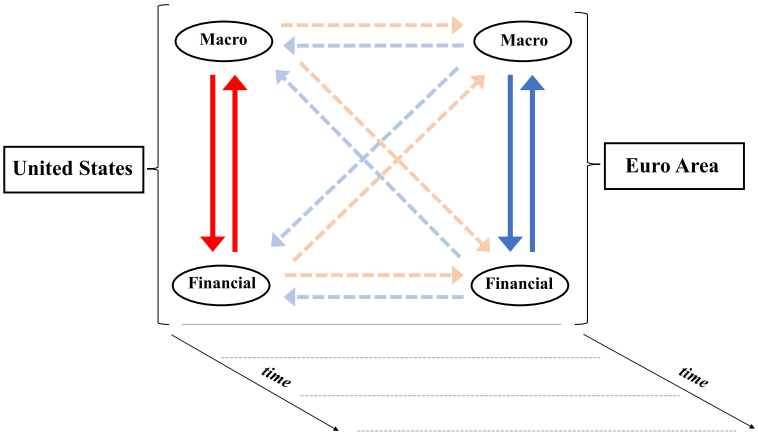
[1] See 'EU trade relations with the United States: Facts, figures and latest developments.' https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/united-states for further details.

[2] These variables include information about output, employment, production, consumption, etc., on the real side, and information regarding balance sheets, credit, foreign financial activity, etc., on the financial side of the economy. The motivation for including this feature in our modeling strategy relies on the need for robustness in the determination of the most relevant variables driving the financial cycle over time, given the lack of consensus about its definition.

[3] Also, in order to provide robust assessments, the identification of real and financial shocks is based on a wide range of schemes that assume exclusion, sign and timing restrictions on the impulse response functions.

[4] In particular, the sample starts in 1981:II for the case of the euro area, which is considerably longer than the sample analyzed in the previous studies that focus on macro-financial linkages in this region. Due to better data availability, for the U.S. we can go as far back as 1960:I.

[5] Kaufmann and Valderrama (2010) apply a similar framework to also assess the case of the euro area.



Note: Solid red (blue) arrows denote the domestic macro-financial interactions for the U.S. (euro area). Dashed red arrows make reference to the spillovers from the U.S. to the euro area. Dashed blue arrows denote the spillovers from the euro area to the US.

Fig. 1. International Macro-Financial Dynamic Interactions. (For interpretation of the colors in the figure(s), the reader is referred to the web version of this article.)

and simultaneously, casts those extracted cycles into a structural VAR model with time-varying parameters to assess changes in the propagation of their shocks. We also incorporate an international dimension to our analysis by looking at cross-border spillovers between the U.S. and the euro area, both within the sectors, and across. In this regard, most of the studies have looked at the U.S. outward spillover, finding that U.S. financial and real shocks matter significantly for the rest of the world. Using a structural VAR model for pre-2008 data, Bayoumi and Trung Bui (2011) find that international business cycles are largely driven by U.S. financial shocks, with minor role for shocks from other advanced economies. Miranda-Agrippino and Rey (2018) equally find that there are large financial spillovers from the U.S. to the rest of the world.

Our framework is more extensive than previous studies since it allows to identify outward as well as inward spillovers in the U.S. and the euro area, both within the sector as well as across them. Moreover, we allow the degree of spillover effects between the two regions to exhibit potential changes over time.[6]

On the theoretical side, the paper is akin to DSGE models with cross-border mechanisms. Guerrieri et al. (2013), Quint and Rabanal (2014), Rubio (2014) have DSGE models for the euro area in which macroeconomic and financial linkages in a monetary union are studied. They find that financial and housing markets matter for cross-country spill-overs in business cycles within the euro area. However, none of these papers have considered US-euro area spill-overs.

The rest of the paper is organized as follows. Section 2 describes the empirical framework. Section 3 analyzes the results from the two-economy model. In section 4, we dig into the theoretical results. As robustness, we analyze the one-economy case in section 5. Section 6 concludes.

2. Empirical framework

This section describes the econometric framework used to jointly (i) extract macroeconomic and financial cycles from large datasets and (ii) assess the evolving interdependence between these cycles across regions. Our aim is to provide a framework that allows for a flexible selection of variables driving both cycles over time, and that also accounts for potential changes in the propagation of real and financial shocks.

The full empirical model can be stylistically represented by Fig. 1. Each economy in the figure has two sectors, macroeconomic and financial. Domestic spillovers between the sectors in the U.S. (euro area) are denoted by red (blue) solid arrows. In parallel, cross-border interactions between the sectors are denoted with dashed arrows. The dashed arrows are central to our cross-border analysis. Moreover, all these relationships may be subject to fundamental changes over time, catering for a dynamic dimension to the model.

To model the dynamics of the two economies, we rely on a dynamic factor model with drifting loadings, where the factors evolve according to a VAR model with time-varying coefficients. We are interested in providing a deep and accurate understanding of their corresponding macro-financial linkages, as well as identifying potential changes in the cross-border spillovers between the two economies. In particular, we intend to estimate the time-varying effect of (i) financial shocks in the U.S. to the financial cycle in the euro area, (ii) real shocks in the U.S. to the real cycle in the euro area, (iii) financial shocks in the U.S. to the real cycle in the euro area, (iv) real shocks in the U.S. to the financial cycle in the euro area, (v) financial shocks in the euro area to the financial cycle in the U.S., (vi) real shocks in the euro area to the real cycle in the U.S., (vii) financial shocks in the euro area to the real cycle in the

[6] For instance, Gravelle et al. (2006) find evidence of shift-contagion across currency markets, but not bond markets. Dungey et al. (2010) find that the degree of shift-contagion depends on the crisis, with higher levels during subprime U.S. 2007 crises or the 1998 Russian/LTCM crisis.

Table 1
Sign and Exclusion Restrictions for the Two-economy model.

	Fin. Shock E.A.	Real Shock E.A.	Fin. Shock U.S.	Real Shock U.S.
Financial Cycle E.A.	+	+	*	+
Real Cycle E.A.	+	+	0	+
Financial Cycle U.S.	*	0	+	+
Real Cycle U.S.	0	0	+	+

Note: The symbol * indicates that no restriction is imposed in the corresponding relationship. E.A. refers to euro area.

U.S., and (viii) real shocks in the euro area to the financial cycle in the U.S. This information corresponds to the dashed arrows in Fig. 1, red for spillovers from U.S. to the euro area, and blue for spillovers from euro area to U.S.

To correctly model all these dimensions, we propose a joint model that is flexible enough to be reduced to a one-country system for individual economies. Accordingly, consider the following US-euro area dynamic factor model:

$$\begin{bmatrix} \mathbf{F}_t^{US} \\ \mathbf{R}_t^{US} \\ \mathbf{F}_t^{EA} \\ \mathbf{R}_t^{EA} \end{bmatrix} = \begin{bmatrix} \mathbf{\Lambda}_{f,t}^{US} & 0 & 0 & 0 \\ 0 & \mathbf{\Lambda}_{r,t}^{US} & 0 & 0 \\ 0 & 0 & \mathbf{\Lambda}_{f,t}^{EA} & 0 \\ 0 & 0 & 0 & \mathbf{\Lambda}_{r,t}^{EA} \end{bmatrix} \begin{bmatrix} f_t^{US} \\ r_t^{US} \\ f_t^{EA} \\ r_t^{EA} \end{bmatrix} + \begin{bmatrix} \mathbf{v}_{f,t}^{US} \\ \mathbf{v}_{r,t}^{US} \\ \mathbf{v}_{f,t}^{EA} \\ \mathbf{v}_{r,t}^{EA} \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} f_t^{US} \\ r_t^{US} \\ f_t^{EA} \\ r_t^{EA} \end{bmatrix} = \mathbf{\Psi}_{1,t} \begin{bmatrix} f_{t-1}^{US} \\ r_{t-1}^{US} \\ f_{t-1}^{EA} \\ r_{t-1}^{EA} \end{bmatrix} + \cdots + \mathbf{\Psi}_{k,t} \begin{bmatrix} f_{t-k}^{US} \\ r_{t-k}^{US} \\ f_{t-k}^{EA} \\ r_{t-k}^{EA} \end{bmatrix} + \begin{bmatrix} u_{f,t}^{US} \\ u_{r,t}^{US} \\ u_{f,t}^{EA} \\ u_{r,t}^{EA} \end{bmatrix} \tag{2}$$

where $\mathbf{F}_t^{US}$ and $\mathbf{R}_t^{US}$ denote the set of information on financial and real activity, respectively, for the U.S. economy. Similarly, $\mathbf{F}_t^{EA}$ and $\mathbf{R}_t^{EA}$ denote the same set of information but for the euro area economy. Notice that, consequently, this joint model would extract four latent common factors associated to the financial and real cycles for the U.S. (f_t^{US} and r_t^{US}) and for the euro area (f_t^{EA} and r_t^{EA}). The idiosyncratic innovations, $\mathbf{v}_t = (\mathbf{v}_{f,t}^{US}, \mathbf{v}_{r,t}^{US}, \mathbf{v}_{f,t}^{EA}, \mathbf{v}_{r,t}^{EA})'$, are assumed to be orthogonal and normally distributed, $\mathbf{v}_t \sim N(0, diag(\mathbf{\Omega}))$.

The main advantage of this joint model is that we allow for the four latent factor to be endogenously interrelated in a VAR fashion.[7] The reduced form innovations from the VAR, $\mathbf{u}_t = (u_{f,t}^{US}, u_{r,t}^{US}, u_{f,t}^{EA}, u_{r,t}^{EA})'$, are also assumed to be normally distributed, $\mathbf{u}_t \sim N(0, \mathbf{\Sigma})$. To be able to assess the propagation of real and financial shocks, we let $\mathbf{u}_t = \mathbf{A}^{-1}\boldsymbol{\varepsilon}_t$, where the vector $\boldsymbol{\varepsilon}_t = (\varepsilon_{f,t}^{US}, \varepsilon_{r,t}^{US}, \varepsilon_{f,t}^{EA}, \varepsilon_{r,t}^{EA})'$, denotes the underlying structural shocks, such that $E(\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_t^{'}) = I$, and $E(\boldsymbol{\varepsilon}_t \boldsymbol{\varepsilon}_{t-k}^{'}) = 0$, $\forall k$, and $\mathbf{A}$ denotes the impact multiplier matrix.[8]

The main challenge associated to the joint model arises when defining the restrictions to identify cross-border spill-overs. As noticed in Prieto et al. (2016), structural (DSGE) models are still not available in a form to derive meaningful and widely accepted sign restrictions to disentangle real and financial shocks (see Eickmeier and Ng (2011) for a discussion). However, we take advantage of the fact that the model incorporates two economies instead of only one in order to define a set of restrictions that help us to identify the underlying structural shocks. In particular, we assume that, within each region, there is a positive and contemporaneous response of real activity and financial conditions to both real and financial shocks. Next, we assume that euro area developments, in general, have no contemporaneous impact on U.S. developments, with only one exception. We allow for the possibility that the financial conditions in the U.S. and euro area contemporaneously influence each other. Finally, we assume that positive U.S. real shocks are favorable for both real and financial conditions in the euro area. However, a positive financial shock in the U.S. would take at least one period to build up an influence the euro area macroeconomic conditions. This set of restrictions can be summarized in Table 1.

To allow for changes over time in the information contained in the cycles and in the propagation of shocks between real and financial cycles, we let both the autoregressive coefficients $\boldsymbol{\psi}_t = vec(\mathbf{\Psi}_t)$, where $\mathbf{\Psi}_t = [\mathbf{\Psi}_{1,t}, ..., \mathbf{\Psi}_{k,t}]$, and the factor loadings $\boldsymbol{\lambda}_t = vec(\mathbf{\Lambda}_t)$, where $\mathbf{\Lambda}_t = [\mathbf{\Lambda}_{f,t}^{US}, \mathbf{\Lambda}_{r,t}^{US}, \mathbf{\Lambda}_{f,t}^{EA}, \mathbf{\Lambda}_{r,t}^{EA}]'$, to be time-varying by following random walk dynamics,

$$\boldsymbol{\psi}_t = \boldsymbol{\psi}_{t-1} + \boldsymbol{w}_t, \tag{3}$$

$$\boldsymbol{\lambda}_t = \boldsymbol{\lambda}_{t-1} + \boldsymbol{\omega}_t. \tag{4}$$

[7] In the empirical applications, we assume $k = 2$.

[8] We recognize that there might be effects (between these two economies) stemming from relations with third-party countries. Our general empirical identification allows us to capture some of that. Moreover, the general equilibrium model in the final section includes second-order effects, which capture these transmissions via third party countries.

The innovations $\boldsymbol{w}_t$ and $\boldsymbol{\omega}_t$ are white noise Gaussian processes with zero mean and constant covariances, $\boldsymbol{\Theta}_w$ and $\boldsymbol{\Theta}_\omega$, respectively. Appendix A provides details regarding the Bayesian procedure employed to estimate the model.[9]

The overall output retrieved by this empirical framework provides a comprehensive analysis of macro-financial interactions along the following dimensions: (i) within sectors of a given economy (ii) across sectors within a given economy, (iii) across sectors and across economies, and (iv) over the time dimension. Moreover, we provide a series of additional exercises for robustness purposes. First, we shut off the international dimension and contrast our findings in the one-economy version to those including a cross-border dimension. Next, we employ a number of alternative estimation approaches: we alter the estimation method of the latent cycles, the identification of structural shocks, and potential changes in the volatility of macroeconomic and financial cycles. In sum, given the high complexity of measuring macro-financial linkages at the international level, we adopt a series of alternative exercises with the only aim of gathering main messages that describe, from a robust and meaningful way, how macroeconomic and financial shocks propagate across borders.

3. International macro-financial linkages

This section provides a comprehensive overview of the time-varying interactions between macroeconomic and financial sectors, for the U.S. and euro area, and across borders. In doing so, we provide different pieces of information designed to study these interactions from various perspectives. The first layer assesses the evolving strength of commonalities within each of the two sectors, that is, macroeconomic and financial. This is done by jointly characterizing the underlying cycles and inferring the segments of the real and financial sectors that are most important for driving those cycles over time. The second layer characterizes the joint propagation of macroeconomic and financial shocks. This is performed by examining the time-varying correlation between the cycles, and analyzing information contained in impulse responses. We aim to provide a discussion that is comparative in nature, consequently, the description of the results is structured per type of features, and not per economy. The third layer, the most important in our study, disentangles the complex cross-border transmission, both within and across (macroeconomic and financial) sectors.

Notice that in the analysis, we use the terms *linkages* and *interactions* interchangeably, treating them as synonyms for deep and dynamically evolving relations between the two sectors. This is in contrast to the commonly used word *nexus* or *link* that we interpret as not profoundly changing over time.

3.1. Data

The data has been gathered from a variety of existing sources, where particularly the series for the euro area have been constructed by previous studies. The description of the variables for the U.S. economy is reported in Table 2, they were retrieved from the St. Louis Fed database. The available sample spans from 1960:I to 2017:IV, covering four very distinct episodes in U.S. contemporaneous economic history including the Golden Age, stagflation and oil shocks, Great Moderation, and the Great Recession. The list of variables used in the analysis of the euro area is reported in Table 3. The data spans the period between 1980:I and 2014:IV, covering the pre-Single Market episode, as well as the Single Market and the monetary union era. The data is gathered from the work of Gerba et al. (2018a), in turn collected from a variety of international sources.[10] For the pre-EMU period, the series have been backward extrapolated using weights from euro area-12, and then adjusted as the new members joined the monetary union. Thus, the country weights for the pre-euro area period reflect the relative economic strength of the member states in the union around the time of the introduction of the physical euro coins in 2002.

All variables, except for ratios and spreads are expressed in growth rates in our model. Financial ratios and spreads are expressed in levels. Our data sample is extensive and wide-ranging enough to encompass many aspects of the financial and real sectors. On the financial side, we have included price as well as quantity variables. Price variables include corporate financing spreads, financial ratios of firms, and stock market indices. Quantities include assets and liabilities of banks (including their subcomponents), assets and liabilities of households and firms (along with their subcomponents), credit, monetary system net foreign assets and liabilities, monetary aggregates, and velocity of money. On the real side, our sample comprises of aggregate as well as disaggregate macroeconomic measures. Included are GDP, labor market indicators, and variables capturing productivity and the supply side of the economy such as real output per hour, unit labor costs, and compensation to employees.

Since the set of information used for each economic region is not exactly the same due to their idiosyncrasies and availability, our intention here is to be empirically as broad and comprehensive as possible in order to capture the multi-faceted nature of the contemporary financial sector and the macroeconomy. In addition, because of frictions and imperfections, fluctuations and alterations in quantities may not always show up in prices. Equally, fluctuations and alterations in the banking system may not always result in

[9] Alternative approaches, such as global VAR model with time-varying parameters (Crespo Cuaresma et al., 2019), can be also used to infer the propagation of shocks over time. Although, we depart from the assumption that there is no single indicator that solely captures the financial or business cycle, but instead many indicators can influence these cycles, with potentially different intensities over time. This assumption leads us to handle with a large set information, where the dimensionality reduction represents a key feature for the tractability of the problem at hand. Hence, we believe that a factor model is the most appropriate setting for assessing the propagation of financial and business cycle shocks, when measurements of both cycles are not predetermined and need to be simultaneously inferred.

[10] One set of variables comes from the ECB's euro area Wide Model including variables F1-F3, F9-F11, R1-R5 in Table 3. Variables F4-F7 come from Datastream, while F8 and R6-R7 come from OECD World Economic outlook. The remaining variables are retrieved from two BIS sources: F12-F19 and R8 from BIS Market data, and F20-F21 from BIS International Financial Statistics database.

Table 2
List of variables for the U.S.

ID	Trans.	Description
F1	2	Nonfinancial Corporate Business; Net Worth, Billions of Dollars
F2	2	Nonfinancial Corporate Business: Profits After Tax (without IVA and CCAdj), Billions of Dollars
F3	2	Private Residential Fixed Investment, Billions of Dollars
F4	2	Households and Nonprofit Organizations; Net Worth, Billions of Dollars
F5	2	Nonfinancial Corporate Business; Credit Market Instruments; Liability, Billions of Dollars
F6	2	Households and Nonprofit Organizations; Credit Market Instruments; Liability, Billions of Dollars
F7	2	Households and Nonprofit Organizations; Home Mortgages; Liability, Billions of Dollars
F8	2	All Sectors; Commercial Mortgages; Asset, Billions of Dollars
F9	2	Households and Nonprofit Organizations; Total Time and Savings Deposits; Asset, Level, Billions of Dollars
F10	2	Households and nonprofit organizations; corporate equities; asset, Level, Billions of Dollars
F11	2	Federal Government; Credit Market Instruments; Liability, Level, Billions of Dollars
F12	2	S&P500
F13	2	M1 Money Stock, Billions of Dollars
F14	2	Velocity of M1 Money Stock, Ratio
F15	2	Velocity of M2 Money Stock, Ratio
F16	2	M2-M1 Money Stock, Billions of Dollars
F17	2	Velocity of MZM Money Stock, Ratio
F18	1	AAA-spread
F19	1	BAA-spread
F20	1	Corporate risk spread
F21	1	10-Year Treasury Constant Maturity Rate, Percent
F22	2	Total Consumer Credit Owned and Securitized, Outstanding, Billions of Dollars
F23	2	Households and Nonprofit Organizations; Consumer Credit; Liability, Billions of Dollars
R1	2	Real Gross Domestic Product, Billions of Chained 2009 Dollars
R2	2	Real Personal Consumption Expenditures, Billions of Chained 2009 Dollars
R3	2	Nonfarm Business Sector: Real Compensation Per Hour, Index 2009 = 100
R4	2	Real Gross Private Domestic Investment, Billions of Chained 2009 Dollars
R5	2	Real Disposable Personal Income, Billions of Chained 2009 Dollars
R6	2	Average Weekly Hours of Production and Nonsupervisory Employees: Manufacturing, Hours
R7	2	All Employees: Manufacturing, Thousands of Persons
R8	2	Nonfarm Business Sector: Real Output Per Hour of All Persons, Index 2009 = 100
R9	2	Gross Fixed Capital Formation in United States, Billions of United States Dollars

Note. The column "Trans." of the table indicates the transformation made to the corresponding variable prior to include it in the model. "Trans. = 1" indicates that the variable is expressed in levels. "Trans. = 2" indicates that the variable is expressed in growth rates.

corresponding movements in the private sector, even if it is the counterparty. That is why we require a sufficient and diverse set of indicators to capture these complexities. For that reason, on the financial side we have expanded on the usual credit- and asset price variables to include indicators of other entries in the balance sheets of private sector and banks (including but not only securities, liabilities, net worth, profits after tax, savings), monetary system, corporate financial ratios and different corporate (default) spreads. In a similar manner, we expand our macroeconomic side to include information beyond the usual business cycle (or GDP). That is why we include detailed information on consumption capacity, labor market, firm inputs, productivity, and the supply side in general. As a result, we expect to have a more comprehensive account of the multi-layered character of macro-financial linkages across all segments of the contemporary advanced economies.

3.2. Strength of commonalities within sectors

The estimated real and financial cycles of the U.S. and euro area for the period 1980:I-2014:IV are plotted in Fig. 2. In both economies, the financial cycle lasts much longer than the macroeconomic one. In other words, the frequency of the financial cycle is lower. Volatility of the financial cycle is, in both economies, smaller, making it look smoother. Also, while financial activity underwent two larger contractions during our sample period (1992 and 2008), macroeconomic activity experienced more (albeit shorter) downturns. The first corresponds to the global economic downturn in the Western world in the early 1990's, including the U.S. savings & loan crisis and a restrictive monetary policy. The second date corresponds to the onset of the Great Recession.[11] Moreover, the financial cycle experienced a profound change in frequency around 1990. While the average length of a financial

[11] Compared to alternative composite measures of financial activity in the US, such as the National Financial Conditions Index (NFCI) of Brave and Butters (2012), or the non-financial and credit-to-GDP cycles, we find similarity to the non-financial leverage cycle (see Fig. B-1 of Appendix B). The long cycles and the long build-ups in particular since the 1990s are visible in both. However, the reversals are sharper in our financial cycle, and the flexibility in our framework allows for parallel long-term movement in the trend. In addition, like the leverage cycle, our financial cycle is a good lead indicator and could serve as an early warning signal for financial stress. The swings in the cycle anticipate those of credit-to-GDP and the business cycle (see Fig. B-2 of Appendix B). In comparison to the adjusted NFCI, the information contained in our financial cycle is more informative on the particular phase of the cycle and the probability and severity of a subsequent reversal. The NFCI, on the other hand, is better suited for risk monitoring and analysis of risk build-up.

Table 3
List of variables for the euro area.

ID	Trans.	Description
F1	1	Firm price-book ratio
F2	2	Savings rate hshlds
F3	1	Firm dividend yield
F4	1	Price-earning ratio of non-financial firms EMU
F5	1	Price-earning ratio of financial firms EMU
F6	1	Price-earning ratio of non-financial firms US
F7	1	Price-earning ratio of financial firms US
F8	1	Current account balance
F9	1	Price-book ratio financial firms
F10	1	Price-book ratio non-financials
F11	1	Firms price-cash flow ratio
F12	2	Depository corp. excl. CB, assets, loans to non-banks, M-end
F13	2	OMFI, assets, credit to non fin. corporations, total, M-end
F14	2	Banks (MFI), loans to non-financial corporations (MU), M-end - outstanding amount at the end of period
F15	2	Claims of monetary syst. on non-govt. sect., loans (MU11-17), M-end
F16	2	Depository corp. excl. CB, assets, loans to non-banks, M-end
F17	1	Bank liabs, non-monetary, LT (MU11-17), total, M-end
F18	2	Monetary system net foreign assets, assets (MU11-17), M-end
F19	2	Monetary system net foreign assets, liabs. (MU11-17), M-end
F20	2	Money stock m2 (MU11-17), M-end
F21	2	Money stock m3 (MU11-17), M-end
R1	2	Real GDP
R2	2	Private consumption
R3	2	Government consumption
R4	2	Gross investment
R5	2	Labor force
R6	2	Total employment
R7	2	Unit labor cost
R8	2	Compensation to employees

Note. The column "Trans." of the table indicates the transformation made to the corresponding variable prior to include it in the model. "Trans. = 1" indicates that the variable is expressed in levels. "Trans. = 2" indicates that the variable is expressed in growth rates.

cycle was 5-7 years in the pre-1990 sample, it increased to 7-10 years in the subsequent period. The macroeconomic cycle, on the other hand, had an average length of 2-5 years throughout the entire sample period.

Comparing the two economies, there are some differences with respect to the U.S. While in the first half of the sample (1980-1996), the financial cycle is largely below the trend, the real cycle had completed a full phase by that time. Also, while the first boom phase in the financial cycle lasted for around 7 years (1996-2003), that of the macroeconomy was 2 years shorter. It is also important to notice that there is a stronger co-movement between both cycles starting from mid-1990's, with boom and bust phases roughly coinciding, albeit the timing and magnitude is not entirely identical.

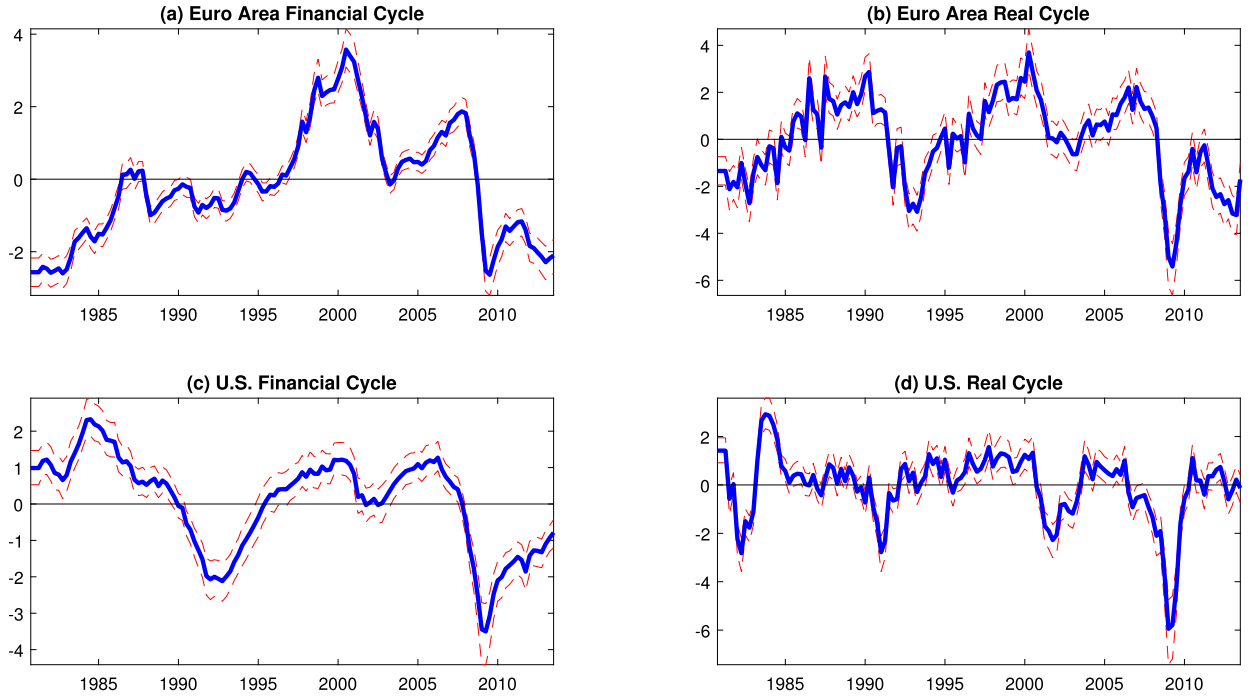
On the whole, there are significant differences in the nature of the two cycles. Financial cycles are longer and smoother, in particular since 1990's, while real cycles have lower amplitude and are more erratic. Also, it seems that higher and longer build-ups in the financial sector have resulted in higher peaks, while more frequent reversals in the real economy have resulted in deeper troughs for the macroeconomic cycle, relatively speaking. Additionally, there seems to be a significant co-movement between the two cycles, in particular for the euro area. The next section explores this feature in further detail.[12]

We also examine the durability in commonalities within each sector, defined as the contemporaneous relationship between real and financial indicators with its corresponding cycle (or factor). This evolving relationship is measured by the time-varying factor loadings. This information is useful to identify potential changes in the composition of both cycles, and therefore, to interpret them in a more accurate manner.

For the U.S. case, we find that the composition of U.S. real and financial cycles has remained, in general, relatively unchanged as the degree of variability over time in the factor loadings has remained relatively stable. The case of the euro area is somewhat different. The results indicate a clear change in the composition of the euro area financial cycle. On the one hand, indicators containing information about credit and balance sheet variables have increased their correlation with the financial cycle over time.[13]

[12] For robustness purposes, we also compute the underlying cycles, independently for each economy, using principal components (PC) and plot them in Figs. B-3 and B-4 of the Appendix B. Although PC provides consistent estimation of the factors, this method is not able to endogenously assess potential instabilities in factor loadings. The results show that the factors estimated by PC follow a similar pattern to the factors estimated with Bayesian methods, with the later exhibiting smoother and more stable dynamics, confirming our inferences on the two cycles.

[13] This includes variables such as loans to non banks by deposit institutions, loans to non governmental sector and monetary aggregates, but also others such as net foreign assets and net foreign liabilities.



Note: The figures plot the estimated real and financial cycles for the U.S. and euro area obtained with the (joint) two-economy model. The solid blue lines make reference to the median of the posterior distribution, while the dashed red lines indicate the percentile 16 and 84 of the posterior distribution.

Fig. 2. Factors of the U.S. and euro area.

Conversely, other set of financial indicators have exhibited a decreasing correlation with the financial cycle over time.[14] Regarding the real sector, commonalities have remained relatively steady.[15]

3.3. Depth of linkages across sectors

We now turn to measuring the evolving interaction between macroeconomic and financial cycles. We do so from different perspectives in order to provide robust assessments. We start by computing the time-varying contemporaneous correlation between the two cycles for each economy.[16] Later, we will examine the cross-sectoral transmissions to financial and real shocks through impulse response functions (IRFs).

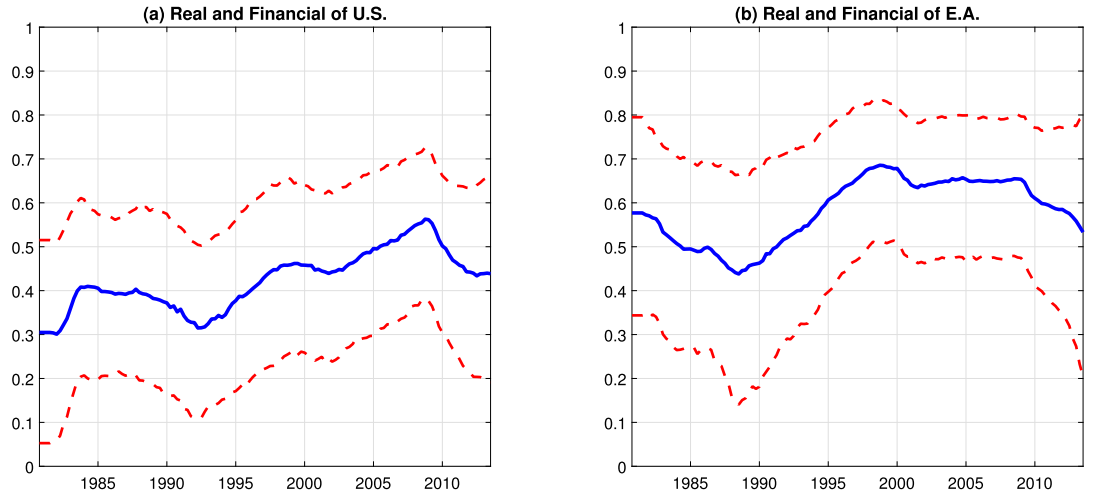
Overall, the correlation has been larger in the case of the euro area. Although the contemporaneous co-movement between the two cycles has been high, it is considerably tighter in euro area. One potential reason for that difference is that, by being a bank-based financial system, the macro-financial transmissions are tighter, which intensifies the comovement between the two cycles.

In the case of the U.S., the correlation has varied significantly over time, as it is shown in Fig. 3. It almost doubled in less than 30 years, finishing at almost 0.6 by the eve of the Global Financial Crisis. Although there were some minor corrections in that positive slope during the 1980:I-2014:IV sample, from early 1990's, the intensification in correlation just continued (almost) uninterruptedly until 2008. This particular period was characterized by heavy deregulation in the U.S. financial system, both across activities/segments and geographically. Also during this time, an intense financial deepening involving many of the known financial innovations occurred during this period. As a result, competition between financial institutions intensified. The U.S. financial system opened up heavily during this period and attracted a lot of foreign capital. That capital fueled two market bubbles: first in the corporate financing market (dot-com boom), and then in the housing market (subprime). On the real side, during this time inflation was significantly reduced and there was seemingly stable and moderate growth. Apart from a very brief downturn in early 90's and early 2000's, the rest of these two decades was characterized by a solid expansion. The increased liquidity in the system also leads to increased consumption and investment, and solid employment and productivity figures. These changes potentially explain the rapid increase in correlation between the two cycles over this period. Only during the Great Recession has it receded.

[14] These variables contain information about the financial position of firms, such as, price-earning ratios of non financial firms or price-book ratio of financial firms.

[15] Figs. B-5 to B-8, located in Appendix B for the sake of space, plot the factor loadings dynamics.

[16] Since the cycles, proxied by the factors, evolving according to a vector autoregression, we compute the unconditional variance-covariance matrix of the elements in the VAR, i.e. f_t and r_t, and not of its innovations. Next, we compute the corresponding correlation coefficient. Since this measure is a function of the parameters of the VAR, the same procedure is applied for each period of time to obtain the time-varying correlation.



Note: The figure plots the estimated time-varying correlation between the macroeconomic and financial cycles associated to a given economy. The solid blue line makes reference to the median of the posterior distribution, while the dashed red lines indicate the percentile 16 and 84 of the posterior distribution.

Fig. 3. Correlations between real and financial cycles: two-economy model.

Qualitatively, we see something similar in the euro area in Fig. 3, but at a higher level.[17] Estimates move around 0.5 and 0.7, which is around 20% higher than those of the US. After the Single European Act in 1987, the correlation started to steadily grow, reaching close to 0.7 by the new millennium. Notice that the collapse of the European Stability Mechanism in 1992 did not interrupt this long-term trend of macro-financial deepening. In general, since the formal adoption of the Euro, the correlation has grown slower compared to the previous growth phase. These results indicate that the establishment of the Economic and Monetary Union (EMU) and the adoption of the currency is associated with long-lasting stronger interactions between the financial sector and the real economy. As in the case of the U.S., we see a sharp correlation reversal following the Great Recession.

Altogether, the correlation between the macroeconomic and financial cycles has grown and is high in both economies, albeit at a generally higher level in the euro area.

Next, we turn to potential changes over time in the propagation of real and financial shocks for both economies. The left chart column of Fig. 4 plots the response of real activity to a financial shock in a three-dimensional graph, while the right chart column plots the response of financial conditions to a real shock. The top half depicts the U.S. responses, and the bottom euro area responses. The results show a couple of salient asymmetric patterns.

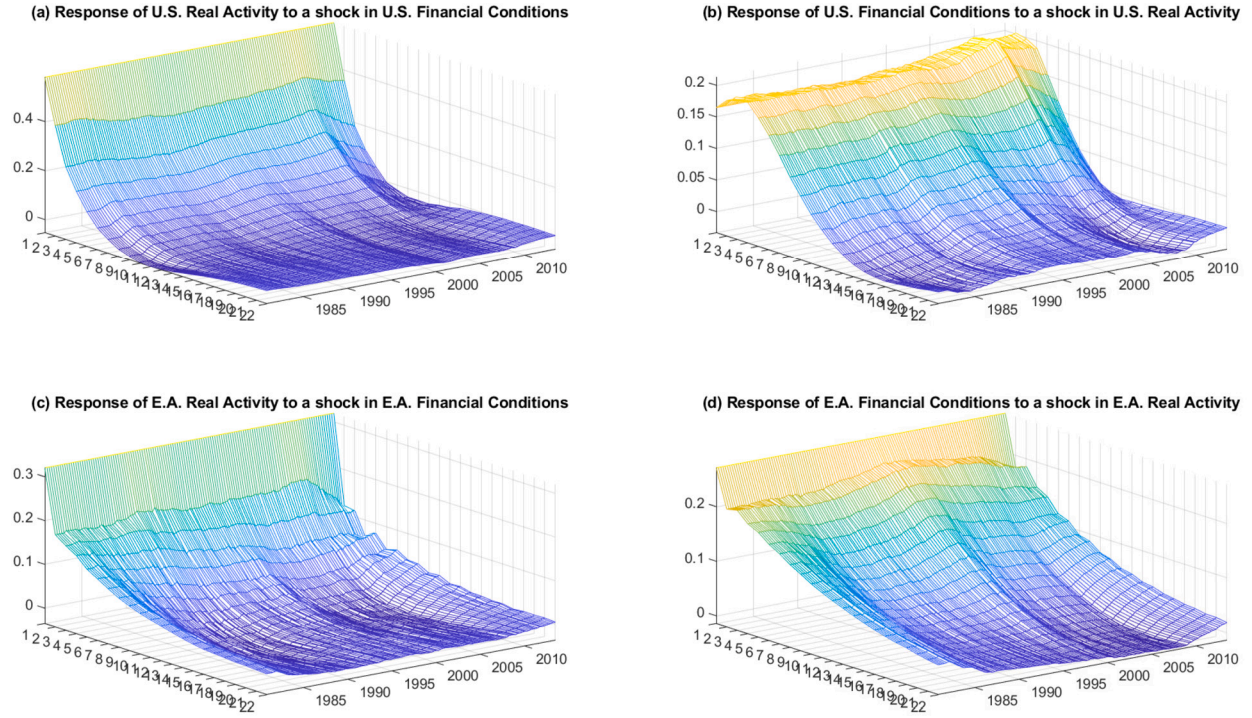
We see opposite relative sizes in responses to shocks across economies. While for real activity, the responses in the U.S. are larger, for financial conditions, it is for the euro area. Financial shocks cause a larger macroeconomic response in the U.S., reflecting a higher overall leverage of that economy. Yet, the persistence in responses of real activity over time is larger in euro area. That could be indicative of inertia in real economy adjustments to financial factors. Conversely, we observe both larger and more persistent response in financial conditions to shocks on the real side in the euro area. That is indicative of higher elasticity of financial conditions to economic states. Meanwhile, we note that financial conditions are, relatively speaking in cumulative terms, more elastic compared to real activity. This emphasizes the larger adjustments or swings in the financial sector to unexpected disturbances, and why it can be a source of overall volatility or (in)stability, through second-order effects.

Turning to the dynamics, there is not much variation over time in the propagation of macro and financial shocks **within** regions. Later, we will show that this is not the case when we look at the propagation of shocks **across** regions, since we see sizable changes in those IRFs over time.

3.4. International spillovers

We proceed with the third layer in our analysis, to examine the intensity of cross-border transmissions or spillovers between the two economies, both across the sectors and in-between them, which are described by the dashed arrows in Fig. 1. In doing so, we first compute the cross-border and cross-sector time-varying correlations, and report them in Fig. 5. The figure shows clear patterns associated with strong and sustained increases in the correlation between (i) U.S. and euro area financial activity, (ii) U.S. and euro area real activity, and (iii) U.S. financial and euro area real activity. Such an increasing interdependence pattern persisted until the eve of the Great Recession, followed by a slight declined afterwards. The only exception is the correlation between the U.S. real and euro area financial activity, which has remained fairly stable over time. This is solid evidence of the strong bilateral relations

[17] One potential explanation for this might be that euro area is a bank-based financial system. In a bank-based financial system, the linkages between financial flows and macroeconomic variables are tighter because of credit. Banks have a crucial function in maturity transforming financial liabilities into assets and put those at disposal of economic agents. Those agents use credit for decisions, affecting directly real variables (consumption, investment, contracting of labor, etc.).



Note: The figure plots the estimated time-varying impulse responses, for different horizons, to a unit shock in the factors structural innovation. The surface makes reference to the median of the corresponding posterior distribution. The estimates are obtained by using sign and exclusion restrictions in the impact multiplier matrix to identify the structural shocks in Table 1.

Fig. 4. National macro-financial spillovers over time: two-economy model.

between the two economies, that also illustrates the importance of accounting for changes over time in the source and intensity of cross-border macro-financial cycles.

Although correlation measures are useful to address the overall strength of bilateral cross-border macro-financial relationships, they remain silent about the asymmetric effects between sectors and economies. There are eight possible ways to consider cross-border interactions in macro-finance, as illustrated by the dashed arrows in Fig. 1. Therefore, we proceed to evaluate the impulse response functions retrieved from the two-economy model. Chart A of Fig. 6 shows the effect that shocks generated in the U.S. economy have on the euro area, while Chart B of the same figure shows how shocks generated in the euro area could affect the U.S. economy. The shocks are identified by relying on the combination of sign, exclusion and timing restrictions reported in Table 1.

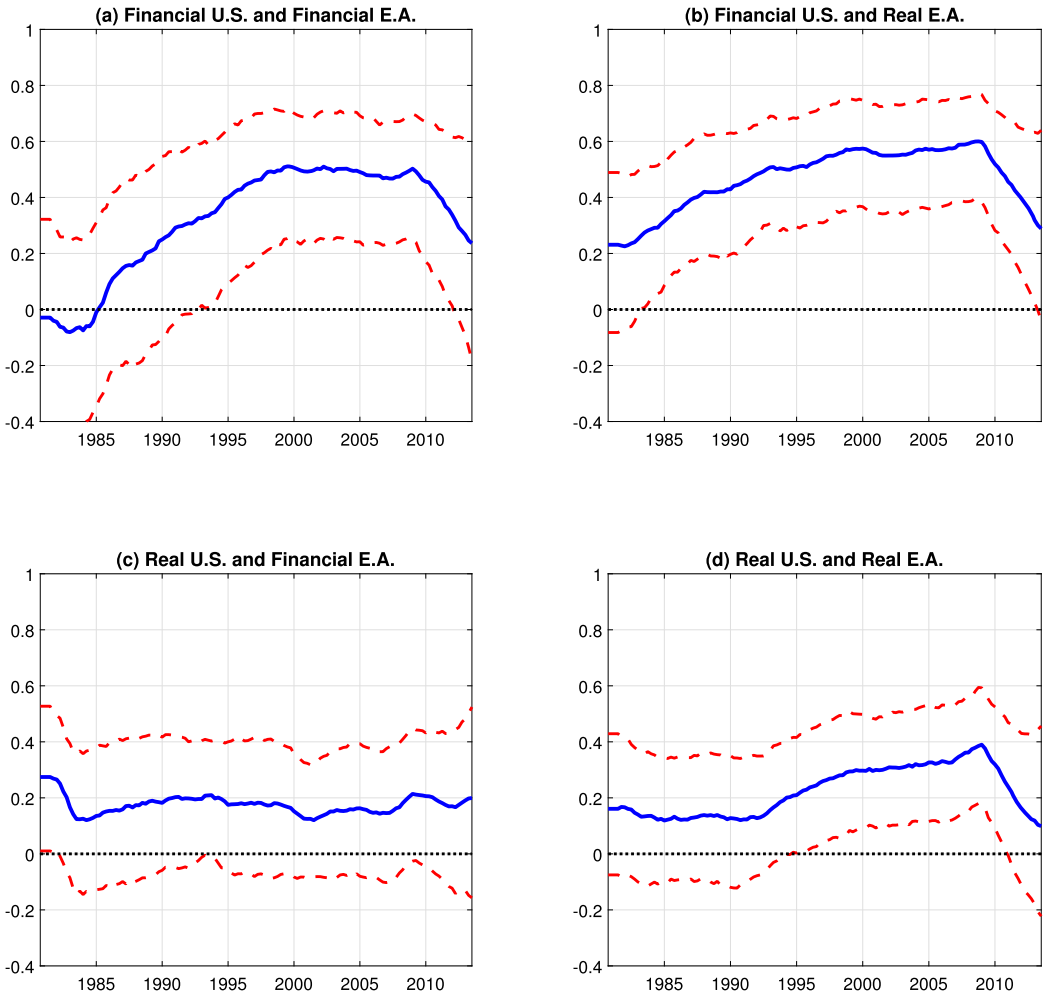
A clear pattern emerges from the estimated IRFs. The (mutual) impact of U.S. shocks is much larger than those from the euro area. Real as well as financial shocks originating from the U.S. have statistically and economically significant impact on euro area macroeconomic and financial cycles.[18] Conversely, shocks from the euro area tend to produce either small short-lasting effects, or even negative on the U.S economy (in line with Jansen (2019)). Furthermore, we see a cross-border 'substitution effect', akin to flight-to-safety, that is, when the financial or real conditions deteriorate (improve) in the euro area, the financial conditions in the U.S. improve (deteriorate).[19]

Moreover, we see a strong dynamic evolution in responses. The intensity in the transmission of shocks increases over time, at least until the Great Recession. This is consistent with the increasing correlation pattern between the factors across sector and regions, shown in Fig. 5. Also, there seems to be no evidence of an intensification in transmission of euro area shocks to the U.S. since the formal introduction of the Euro, at least not as a clearly visible change in pattern since 2000. These results suggest that the hegemony of the U.S. in the international monetary and financial system has remained (and even increased over time). The introduction of the Euro did not manage to alter it (in line with the discussion in Gourinchas et al. (2019)).

There is however a subtle but important change in the transmission to euro area financial conditions over 2000's. In particular, after around 2002, transmission of shocks arriving from the U.S. seems to weaken somewhat, having persistently risen previously. Even if it is not enough evidence to establish a causal relation, this coincides with the full introduction of the euro on 1 January 2002.

[18] This finding is in line with the findings of Berg and Vu (2019) and Kose et al. (2017), who find economically and statistically significant effects on the world economy from U.S. financial volatility. Georgiadis (2016) find similar results for U.S. conventional and unconventional monetary policy.

[19] Although, there is a substantial amount of uncertainty associated with these negative responses. Figs. B-9 and B-10 of Appendix B plot the cumulative IRFs for selected horizons along with the corresponding credible sets.



Note: The figures plot the estimated time-varying correlation between the real and financial cycle associated to the U.S. and euro area. The solid blue line makes reference to the median of the posterior distribution, while the dashed red lines indicate the percentile 16 and 84 of the posterior distribution.

Fig. 5. Correlation between real and financial cycles of U.S. and euro area: two-economy model.

Hence, although the monetary union may not have resulted in an increase in cross-border spillovers of real or financial shocks, it seems to have somewhat weakened the transmission of U.S. shocks by creating a tighter net and core, at least in the financial sphere.

Another relevant finding is that since the Great Recession, the transmission of U.S. shocks has weakened, meanwhile the negative transmission of euro area shocks has also been reduced. This can be interpreted as a small change in the global role of the U.S., whereby the weakening of its economy and the protectionism that followed has reduced its international exposure and role as originator of cross-border shocks. Crespo Cuaresma et al. (2019) also find that the transmission of U.S. monetary policy shocks has weakened in the aftermath of the global financial crisis in a Global VAR framework.

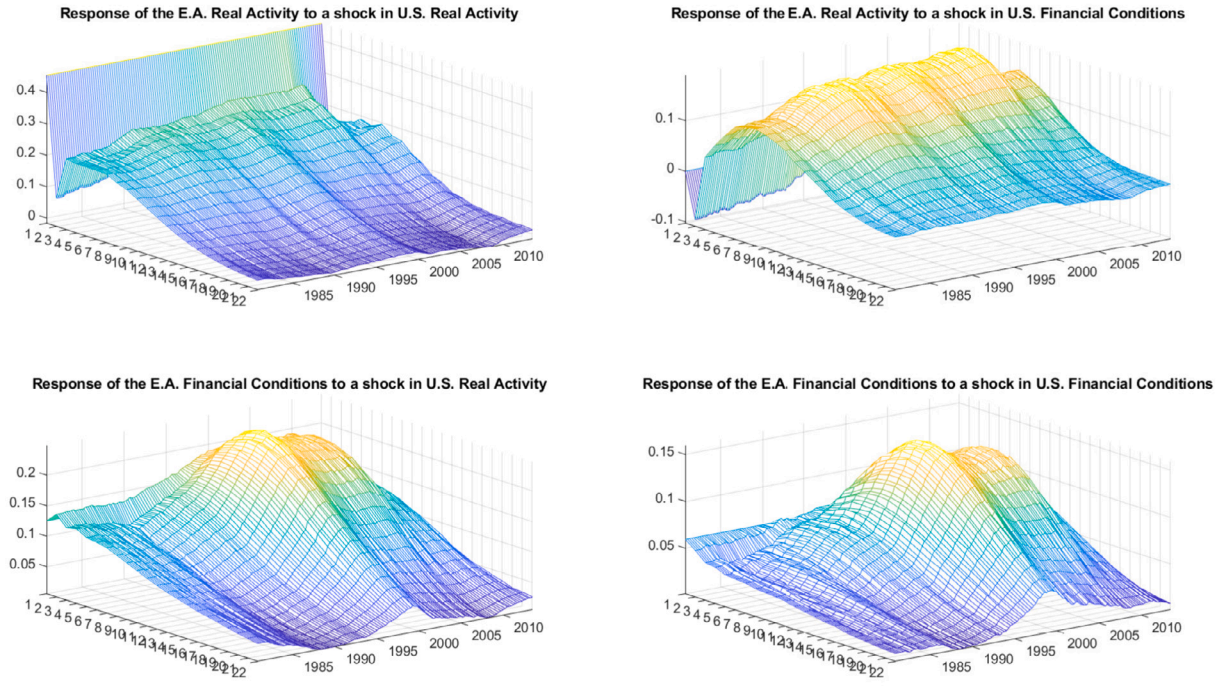
Our empirical results point to an important asymmetric cross-border transmission of U.S. shocks, which had intensified over time. In the next section, we attempt to decompose those shocks, and understand the structural sources of those using a two-country DSGE model. By aligning the theoretical framework to the empirical model, we aim to contextualize our empirical findings to a theoretical setting.

3.5. The cross-border effect

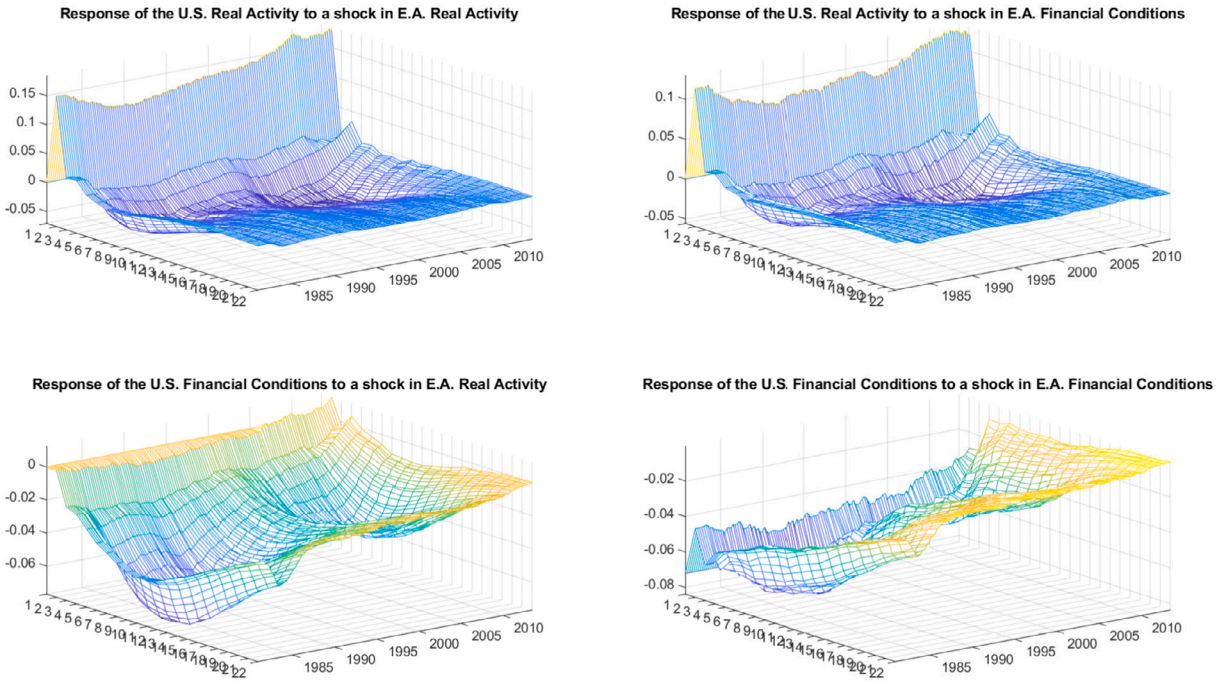
Next, we evaluate the role that cross-border links play in shaping the respective macro-financial linkages. To accomplish this, we shut off the cross-border dimension, and only focus on the solid lines in Fig. 1. Strictly speaking, we do not allow for an international transmission of shocks, and therefore estimate the model for the two economies separately. More details on the one-economy model can be found in Appendix E.

In order to identify real and financial shocks in a one-economy model, we propose an alternative identification scheme. First, we assume that real activity and financial conditions are persistent processes by assuming positive signs in the off-diagonal entries

(a) From the U.S. to the euro area



(b) From the euro area to the U.S.



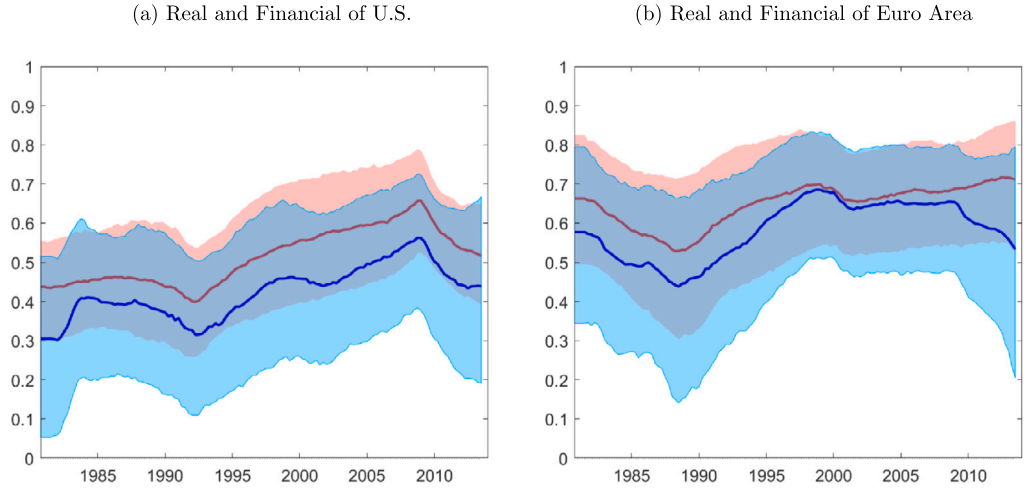
Note: The figure plots the estimated time-varying impulse responses, for different horizons, to a unit shock in the factors structural innovation. The surface makes reference to the median of the corresponding posterior distribution. The estimates are obtained by using sign and exclusion restrictions in the impact multiplier matrix to identify the structural shocks in Table 1.

Fig. 6. International macro-financial spillovers over time: two-economy model.

Table 4
Sign, Exclusion and Timing Restrictions for the one-economy model.

	Financial Shock	Real Shock
h = 0		
Financial Cycle	+	+
Real Cycle	0	+
h = 1		
Financial Cycle	*	*
Real Cycle	+	*

Note: The symbol * indicates that no restriction is imposed in the corresponding relationship, and "h" denotes the horizon of the impulse response.



Note: The figures plot the estimated time-varying correlation between the real and financial cycle. The red (blue) area makes reference to the densities of the estimates obtained with the one-economy (two-economy) model. The densities indicate the credible set based on the 16 and 84 of the posterior distribution, while the solid lines make reference to the posterior median.

Fig. 7. Correlations between real and financial cycles: comparison between one-economy and two-economy model.

of the impact multiplier matrix. Second, we assume that positive real activity shocks have positive contemporaneous effect on financial conditions, but that a shock in financial conditions does not have a contemporaneous effect on real activity. As noticed in Prieto et al. (2016) (and many other studies), this assumption implies that macroeconomic variables react with a delay to financial shocks, possibly because of wealth effects and other effects which involve financial intermediaries that take time to materialize. Third, consequently, we assume that it would take at least one period for real activity to react to a shock in financial conditions. Therefore, we postulate that a positive unexpected change in the financial cycle positively affects the real cycle with a one period lag. Note that, in the two-economy model described in the previous section, the restriction on the non-contemporaneous effect of financial on macroeconomic conditions is relaxed and financial shocks are allowed to contemporaneously influence real activity.[20] The restrictions employed in the one-economy model are summarized in Table 4.

By shutting off the cross-border dimension, we find that the dynamic contemporaneous correlations between the two sectors increase overall, as shown in Chart A, for U.S., and Chart B, for the euro area, of Fig. 7. Also, the correlation in the U.S. is less oscillating and that of the euro area much more accumulative over time than in the one obtained with the two-economy model.[21] This exercise suggests that by not taking into account the cross-border effects in the measurement of macro-financial linkages, one may end up overestimating those relationships.

We also compare the impulse responses between the one-economy and two-economy models. Fig. B-12, in Appendix B reports the IRFs for the one-economy U.S. model, and Fig. B-13 the same for the euro area. There are some important differences. We find important cross-country heterogeneities. In the euro area, the interactions have increased in both directions, from financial to real, and vice versa, but in the U.S., they have increased in only one direction, from **financial to real**. Also, the financial sector of the U.S. presents a sensitivity to macroeconomic shocks that is of higher magnitude and of shorter duration than in the euro area.

[20] This is in no way restrictive, as restrictions only last for one quarter, and we tested for alternative schemes, without a substantial impact on the results.

[21] Also, the uncertainty associated with the one-economy model estimates is smaller than that of the two-economy model due to the larger number of parameters involved in the latter one.

Table 5
Recursive Identification for the Two-economy model.

	Fin. Shock E.A.	Real Shock E.A.	Fin. Shock U.S.	Real Shock US
Financial Cycle E.A.	∗	∗	∗	∗
Real Cycle E.A.	0	∗	∗	∗
Financial Cycle US	0	0	∗	∗
Real Cycle US	0	0	0	∗

Note: The symbol ∗ indicates that no restriction is imposed in the corresponding relationship. E.A. refers to euro area.

Table 6
Alternative Sign and Exclusion Restrictions for the Two-economy model.

	Fin. Shock E.A.	Real Shock E.A.	Fin. Shock U.S.	Real Shock US
Financial Cycle E.A.	+	+	∗	∗
Real Cycle E.A.	0	+	∗	∗
Financial Cycle US	0	0	+	+
Real Cycle US	0	0	0	+

Note: The symbol ∗ indicates that no restriction is imposed in the corresponding relationship.

3.6. Robustness

For robustness purposes, we additionally estimate the two-economy model by assuming an alternative shock identification strategy, which consists of a Cholesky factorization described in Table 5. We order first the U.S. real cycle, followed by the U.S. financial cycle, and by the real cycle of the euro area, leaving at the end the financial cycle of the euro area. Notice that this order implies that (i) financial shocks take at least one period to affect macroeconomic conditions, and (ii) U.S. developments could affect contemporaneously euro area developments, but not vice versa.

For further validation purposes, we re-estimate the model using a mixture of recursive and sign-restrictions as outlined in Table 6. It consists of three parts: (i) recursive restrictions within each block; (ii) euro area shocks do not contemporaneously impact the US; (iii) leave unrestricted the effects that U.S. shocks have on euro area. This is an alternative scheme that is sufficiently broad to incorporate the empirical results contained in the current international macro-financial literature.

Figs. B-14-B-15, and B-16-B-17, located in Appendix B, plot the impulse response patterns associated to the (i) recursive and (ii) alternative sign restrictions identification schemes, respectively. Notice that in both cases the impulse responses are qualitatively similar to the ones obtained with the benchmark identification scheme. The only difference in magnitude we find is that with these alternative identifications, transmission of U.S. financial and euro area real shocks is more intense, while those of U.S. real are of slightly smaller magnitude. Moreover, the negative effects of euro area shocks on U.S. financial conditions are also somewhat stronger in these alternative specifications. One could say that adverse (favorable) shocks in euro area developments could be beneficial (damaging) for the U.S. financial conditions. An explanation for this pattern is that the U.S. may act as a hub that attracts investments and (financial) capital when conditions are adverse in Europe. Since the financial deregulation in early 1980's and geographical liberalization in financial services, the flow of capital to U.S. has continuously increased. However, this positive trend broke with the near financial meltdown in 2008 and the deep contraction in the U.S. financial sector. That could explain why the negative transmission from euro area to U.S. financial system has debilitated.

Our international analysis reveals a number of important facts regarding the relation between the euro area and the U.S. since the financial liberalization and trade integration in 1980's. First and most firmly, we find that the transmission of macro and financial shocks across borders is largely asymmetric, going from the U.S. to the euro area. Previous literature hints towards this asymmetry, but does not fully model the bidirectional spillovers, or does it for only one policy or aspect. For instance, Jarocisnki (2019) show using a SVAR that Fed monetary policy has much stronger effects on ECB's monetary policy, while euro area's has negligible impact on the U.S. Second, we find that the intensity of transmissions across borders increased over time. However, since the Great Recession, this positive trend has been reversed, and transmission of U.S. shocks has been weakened. This could be the result of the weakened dominance of the U.S. economy globally, or because of the protectionism that followed the financial crisis of 2007-08. Third, we find a negative relation in transmission between EA shocks and U.S. financial conditions. One could say that adverse (favorable) shocks in euro area developments could be beneficial (damaging) for the U.S. financial conditions. However, this pattern has dampened following the near financial meltdown in the U.S. in 2008. Previous papers (Berg and Vu (2019), Gourinchas et al. (2019), Jarocisnki (2019), Georgiadis (2016)) have advocated for a dominant position of the U.S. in the international financial, monetary, or macroeconomic sphere. However, as far as we are aware, this is the first study to formally establish it in a structural empirical model with (i) full bidirectional spillovers between two of the largest global economies, (ii) along macroeconomic and financial dimensions simultaneously, and (iii) covering a relatively large time span that allows for long-term interpretations.

4. Theoretical framework

To contextualize our empirical findings, we nest the two sectors in a two-country version of the model in Iacoviello (2005). The model includes infinite-horizon, two-country economy with a flexible exchange rate regime. The two countries represent the U.S.

(big open economy) and the euro area (medium open economy), and are denoted by US and EA, respectively. Households consume, work and demand real estate. Each country produces one differentiated good but households consume goods from both countries. For simplicity, housing is a non-traded good. We assume that labor is immobile across countries. Firms follow a standard Calvo problem. In this economy, both final and intermediate goods are produced. Prices are sticky in the intermediate goods sector. The central bank in each country sets the interest rate to respond to domestic inflation. We can then use the model to explore how shocks are transmitted across countries. To do so, we calibrate the model to realistically reflect the characteristic of both countries. In line with the literature, the weight of the U.S. is calibrated higher than that of the euro area, in order to reflect the larger importance of one economy vis-a-vis the other.[22]

Impulse response functions derived from the theoretical model help us interpret the mechanisms underlying our empirical findings. The shocks in the theoretical version have a micro-founded rationale, which allows us to interpret the empirical results in a more rigorous way. To disentangle the various layers of asymmetry in the cross-border transmission, we first examine a symmetric shock scenario, followed by an asymmetric one. The first scenario allows us to understand the nature of the cross-border transmission arising from distinct economic structures. All impulse responses are reported in Appendix D, for the sake of space.

Similar to the empirical findings, a symmetric real shock (TFP shock) generates a higher impact on financial conditions (bonds/credit) in the US compared to the EA, and just marginally higher than in the real sector (consumption). Following our benchmark calibration, the US is a more leveraged economy, which accentuates the financial accelerator effect. This creates a distinction in responses across economies, even in a symmetric real shock scenario.[23] By the same token, a recessionary macroeconomic shock (oil price shock) leads to a stronger response in financial conditions (credit) in the US compared to the EA. At the same time, the response of real variables is also stronger in the US, as confirmed by the data.[24]

For the sake of completeness, we also consider a pure financial shock, namely a symmetric LTV shock. We find that a symmetric financial (LTV) shock generates a significantly higher response in the macroeconomic cycle (consumption, GDP, labor) in the US compared to EA. The response is also more persistent in the US. In this case, financial conditions have a stronger effect on the more leveraged economy, transmitting also more strongly to the real side.[25]

Next, we consider asymmetric shocks, which, by definition should be transmitted differently across countries, independently of calibration. For instance, an asymmetric productivity shock (1 in the US, 0 in the EA) renders similar responses in financial and real variables in the EA. However, there is a somewhat stronger reaction in EA real activity. Domestically, the response of financial conditions is persistent, as in the data.

Similarly, an asymmetric productivity shock (0 in US, 1 in the EA) renders weak response in the US, much weaker than in the opposite case.[26] Moreover, it causes a negative response of US real activity and in the medium run, in financial conditions. This is strongly in line with the empirical model IRFs, which indicates that the macro shock in the empirical model could be largely driven by a TFP shock.[27]

When the asymmetric shock comes from the financial side of the economy (LTV shock), we find the following. An asymmetric financial shock (1 in US, 0 in EA) renders higher financial conditions responses in the EA than real activity. Moreover, they are more persistent. Domestically, the response of real activity to a financial shock is very persistent. The persistence parameter is higher than in the data. If the same shock originates in the EA (0 US, 1 EA), we find an analogous response in the US real and financial activity. Compared to the opposite case, financial conditions in the US respond more persistently. Domestically, the response of real activity is similar to that of the US.

Our empirical and theoretical findings are closely aligned. In particular, for real shocks we find that the interaction between macro and financial variables is highly matched. However, our financial shock is more specific compared to the data. Our empirical and theoretical results show some divergence with respect to the financial shock. The reason for that is that the theoretical model only zooms in on a particular type of shock, which had greater importance in the 2000's. That is not representative of the whole sample used in the empirical estimation.

5. Conclusions

This paper analyzes the macro-financial interactions within a structural time-varying framework using a large dataset for two of the largest global economies. Our study includes three dimensions: macro-financial linkages, cross-border spillovers and theoretical underpinnings.

Our evidence speaks clearly of an asymmetric cross-border transmission between US and EA, especially in the financial domain. This is confirmed by our theoretical complement, which shows that the transmission of US TFP shocks is significantly larger and more persistent than any alternative shock specifications. Moreover, the US is a more leveraged economy, which accentuates the financial accelerator effect. This creates a distinction in responses across economies, even in a symmetric real shock scenario.

[22] Full details on the theoretical model and exact calibrated parameters are described in Appendix C.

[23] In terms of correlation between credit and consumption, we find that it is high and positive in both economies, confirming our previous empirical findings.

[24] Both correlations between credit and consumption continue to be high and positive, although slightly lower than in the previous case, as indicated by the data.

[25] The correlation between credit and consumption is again high and positive although slightly lower in the EA than in the US.

[26] The responses are overall smaller for US to a shock in EA than in the EA to a shock in the US.

[27] This is the advantage of this approach, as we can extrapolate the TFP shock using an endogenous estimation procedure with a large dataset. Pure TFP shocks are normally very hard to estimate empirically.

Over time, cross-border spill-overs from US financial to EA real has intensified. At the same time, spill-overs from EA real to US real have also strengthened. However, in spite of that, we find clear evidence of a US hegemony in the cross-border relations, especially on the financial side.

These results shed important light on the structure in the transatlantic cross-border transmissions of both the financial and macroeconomic sectors. They are indeed very useful and relevant for policy practitioners all over the world.

CRediT authorship contribution statement

Eddie Gerba: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Danilo Leiva-León:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Margarita Rubio:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

Appendix A. Supplementary material

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jimonfin.2024.103094.

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