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The role of the United States in the global economy and its evolution over time

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Abstract This article aims at assessing the role of the United States in the global economy and its evolution over time. Based on a Global VAR modeling approach, this article shows first that countries with a large trade exposure with the U.S. economy have a relatively larger sensitivity to U.S. developments. However, even for countries that do not trade so much with the U.S., they are largely influenced by its dominance through other partners' trade. Moreover, while no clear trend seems to emerge, it seems that the role of the U.S. in the global economy has changed over time. Overall, for most countries—the latest recession excluded—a change in U.S. GDP had weaker impacts—though more persistent—for most recent periods. The latest recession, however, led to some renewed increase in the sensitivity of the economies to U.S. developments.

Keywords International transmission of shocks · Business cycle · Global VAR (GVAR)

JEL Classification E32 · E37 · F41

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1 Introduction

The U.S. economy is very often seen as "the engine" of the world economy. As a result, any sign of slowdown in the United States rises concerns about harmful spillovers to the other economies. As the recent global economic recession has shown, the history of past U.S. recessions usually coincides with significant reductions in global growth. Figure 1 shows the relatively strong correlation of U.S. real GDP growth and that of the rest of the world. In addition to a large correlation (45%), it seems that in some periods, the U.S. cycle tends to lead the rest of the world one. Indeed, the correlation between the U.S. and the rest of the world growth rates lagged by one or two quarters increases to 49%.

While this topic has been widely studied in the literature,[1] it has received renewed attention recently. The increasing economic integration at the world level and the resulting emergence of large economic players, like China, is likely to have weakened the role of the U.S. economy as a driver of global growth. For instance, Dees and Vansteenkiste (2007) note that while the U.S. business cycle still leads the world's, Asia, where China's rise is helping the region to establish business cycles largely independent of its main trading partners, is a notable exception. Hence, when the United States entered into recession at the end of 2007, one has questioned the ability of the global economy to "decouple" from U.S. cyclical developments. While there were some signs of decoupling in the first quarters following the U.S. downturn, they disappeared rapidly toward the end of 2008, when the crisis became more global and the economic cycles turned out to be more synchronous across the world. Overall, the U.S.'s influence on other countries' economies remains larger than direct trade ties would suggest, owing to third-market effects together with increased financial integration that tends to foster the international transmission of cyclical developments.

Estimating the source and the size of spillovers across industrialized countries, Bayoumi and Swiston (2009) show that the U.S. shocks generate significant spillovers, while those from the euro area and Japan are small. They also show that financial effects tend to dominate the international spillovers. Analyzing the results for two subperiods (1970–1987 and 1988–2006), they finally show the importance of the great moderation in U.S. output fluctuations and associated financial stability in lowering output volatility elsewhere.

As the study over two subperiods might hide recent changes, this article aims at showing the evolution over time of the role of the United States in the global economy. Based on a Global VAR (GVAR) modeling approach, this article shows first that the economies with a large trade exposure with the U.S. economy have a relatively larger sensitivity to U.S. developments. However, even for countries that do not trade so much with the U.S., they are largely influenced by its dominance through other partners' trade. Moreover, while no clear trend seems to emerge, it seems that the role of the U.S. in the global economy has changed over time. Overall, for most countries—the latest recession excluded—a change in U.S. GDP had weaker impacts—though

[1] See for instance Canova and Marriman (1998), Kose et al. (2003), Osborn et al. (2005), Stock and Watson (2005), and Yamagata (1998)

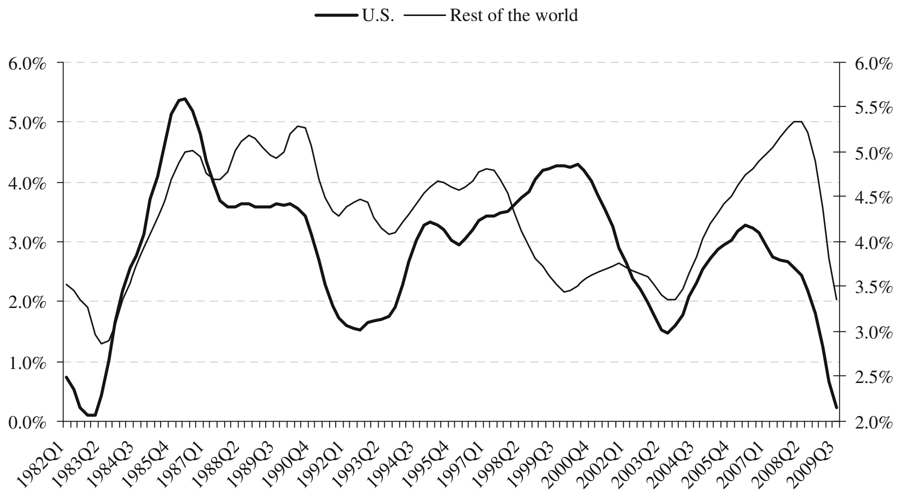

Fig. 1 U.S. and rest of the world real GDP growth rates (Year-on-year growth rates – 3 year moving average). *Source*: Authors' computation. *Note*: The rest of the world real GDP is obtained by aggregating the data of 32 economies (excl. the U.S.) using PPP GDP weights

more persistent—for most recent periods. The latest recession, however, led to some renewed increase in the sensitivity of the economies to U.S. developments.

Section 2 presents the modeling strategy chosen to study the international transmission of changes in U.S. economic activity. Section 3 shows the empirical results by distinguishing an analysis over the sample 1979–2009 and a time-varying analysis to identify any change in the degree of transmission over time. Section 4 concludes.

2 Modeling the international transmission of changes in U.S. economic activity

As in Bayoumi and Swiston (2009), we use a VAR modeling to study the international transmission of changes in U.S. economic growth. However, to avoid restricting the VAR to too few countries, we apply the global vector autoregressive (GVAR) modeling approach originated in Pesaran et al. (2004). The innovation of the GVAR approach is the construction of weakly exogenous country-specific foreign variables for each of the separate country models. By treating the foreign variables as weakly exogenous, this approach enables country-specific models to be estimated separately and be combined thereafter without facing the problem of estimating a large number of parameters (the so called curse of dimensionality problem) typically associated with large-scale models. Once solved, the GVAR model can be used for forecasting or generalized impulse response (GIR) analysis in the usual manner. In order to apply the GVAR modeling approach on a time-varying dimension, the size of the model needs to be not too large. We, therefore, restrict the variables of interest to real GDP and study the transmission of changes in U.S. economic activity to the rest of the world.

2.1 Modeling global interactions in real output: a GVAR approach

In the literature, Vector Autoregressions, VARs, have been largely used to study the transmission of shocks across countries. While VARs have the advantage to be easily estimated, their principal disadvantage is that they can only deal with a relatively small number of variables.

If we refer to foreign variables as "star" variables, and we extend the VAR to a VARX*, treating the foreign variables as weakly exogenous, country-specific VARX* models can be consistently combined to form a GVAR in which all the variables are endogenous. The high dimensional nature of such a model is circumvented at the estimation stage by constructing country-specific foreign variables using predetermined coefficients, and by noting that for relatively small open economies such foreign variables can be treated as weakly exogenous for the parameters of the conditional model.

Using such a modeling approach, Dees et al. (2007) are able to estimate a GVAR model for 26 economies with six variables (real output, inflation, exchange rate, a short interest rate, a long interest rate, and real equity prices) over the period 1979–2003. Although the GVAR approach allows the estimation of high-dimension systems, the six-variable reduced-form models is too large to envisage time-varying estimations. As the purpose of this article is to focus on the transmission of business cycles across countries over time, we restrict our global system to only one variable (i.e., real GDP).

Owing to its important role in the global economy, we treat the U.S. as a dominant economy. As shown by Chudik (2008), a GVAR model featuring a dominant economy implies some changes in the empirical modeling. More precisely, if we note the dominant country $i = 0$ and the other countries $i = 1, \ldots, N$, individual models for countries $i > 0$ need to be augmented by star variables $\mathbf{x}_{it}^*$ as well as variable x_{0t}. The specification of the individual models is then:

$$\mathbf{\Phi}_i \left(L, p_i\right) \mathbf{x}_{it} = \alpha_i + \mathbf{\Upsilon}_i \left(L, q_i\right) \mathbf{x}_{0t} + \mathbf{\Lambda}_i \left(L, r_i\right) \mathbf{x}_{it}^* + \mu_{it} \tag{1}$$

where $\mathbf{x}_{it}$ is real GDP in country i (with $i > 0$), $\mathbf{x}_{0t}$ is U.S. real GDP, and $\mathbf{x}_{it}^*$ is real GDP in non-U.S. foreign economies. $\mathbf{\Phi}_i$, $\mathbf{\Upsilon}_i$, and $\mathbf{\Lambda}_i$ are the coefficient matrices and L the lag operator. μ_{it} is the idiosyncratic country-specific shock, with $E(\mu_{it}'\mu_{jt}) = \sum_{ij} = \sum_{ji}'$ and $E(\mu_{it}\mu_{jt'}') = 0$ for all i,j and $t \neq t'$. p_i, q_i, r_i correspond to the lag order of respectively the domestic, U.S., and non-U.S. foreign GDP, including contemporaneous effects.

The non-U.S. foreign variables, $\mathbf{x}_{it}^*$ are computed using country-specific weights, w_{ij}. Specifically, we use for each country i:

$$\mathbf{x}_{it}^* = \sum_{j=1}^{N} w_{ij}\mathbf{x}_{jt}, \quad \text{with } w_{ii} = 0, \tag{2}$$

where w_{ij} is the weight of country j in total trade of country i, excluding the U.S. economy. The weights, w_{ij}, $j = 1, \ldots, N$ are expected to capture the importance of country j for country ith economy. Geographical patterns of trade provide an obvious source of information for this purpose and could also be effective in removing some of the remaining spatial dependencies. The weights are allowed to be time-varying so long as they are pre-determined. This is particularly important in our case since our sample includes rapidly expanding emerging economies with their fast changing trade relations with the rest of the world.

It is important to note that the model for the dominant economy $i = 0$ (the U.S. economy in our case) has to be a separate model, in which $\mathbf{x}_{0t}$ is treated endogenously with $\mathbf{x}^*_{0t}$ (Chudik 2008). The U.S. model is therefore written as:

$$\mathbf{\Theta}_0 (L, p_0) \mathbf{z}_{0t} = \mathbf{a}_0 + \mathbf{u}_{0t} \tag{3}$$

where $\mathbf{z}_{0t} = \left(\mathbf{x}'_{0t}, \mathbf{x}^{*\prime}_{0t}\right)'$, $\mathbf{\Theta}_{0t} = \left(\mathbf{\Phi}'_0, \mathbf{\Phi}^{*\prime}_0\right)'$, $\mathbf{a}_0 = \left(\alpha'_{0t}, \alpha^{*\prime}_{0t}\right)'$ and $\mathbf{u}_{0t} = \left(\mu'_{0t}, \mu^{*\prime}_{0t}\right)'$.

The country-specific models (for $i > 1$) can be written in an ECM form allowing for the possibility of cointegration between $\mathbf{x}_{it}$, $\mathbf{x}_{0t}$ and $\mathbf{x}^*_{it}$. The country-specific models can be consistently estimated separately, by treating $\mathbf{x}_{0t}$ and $\mathbf{x}^*_{it}$ as weakly exogenous I(1) variables with respect to the long-run parameters of the conditional model 1. The weak exogeneity assumption in the context of cointegrating models implies no long-run feedback from $\mathbf{x}_{it}$to $\mathbf{x}_{0t}$ and $\mathbf{x}^*_{it}$, without necessarily ruling out lagged short-run feedback between the two sets of variables. The weak exogeneity of these variables can then be tested in the context of each of the country-specific models.

The dominant-economy model ($i = 0$) can take the form of a VECM. After consistent estimation of this U.S. VECM featuring two endogenous variables $\mathbf{x}_{0t}$ and $\mathbf{x}^*_{0t}$, a conditional ECM model for $\mathbf{x}_{0t}$ is derived. This conditional model is subsequently added to the construction of the GVAR.

2.2 Solution of the reduced GVAR model

Once the individual country models are estimated, all the endogenous variables of the global economy need to be solved simultaneously. We first re-write Eq. 1 as

$$\mathbf{A}_i(L, p_i, q_i, r_i)\mathbf{z}_{it} = \varphi_{it}, \quad \text{for } i = 0, 1, 2, \ldots, N \tag{4}$$

where

$$\mathbf{A}_i(L, p_i, q_i, r_i) = [\mathbf{\Phi}_i (L, p_i), \ -\mathbf{\Upsilon}_i (L, q_i), \ -\mathbf{\Lambda}_i (L, r_i)], \quad \mathbf{z}_{it} = \begin{pmatrix} \mathbf{x}_{it} \\ \mathbf{x}_{0t} \\ \mathbf{x}^*_{it} \end{pmatrix},$$

$$\mathbf{\Upsilon}_0 (L, q_0) = 0, \quad \varphi_{it} = \alpha_i + \mu_{it}.$$

Let $p = \max(p_0, p_1, \ldots, p_N, q_0, q_1, \ldots, q_N, r_0, r_1, \ldots, r_N)$ and construct $\mathbf{A}_i(L, p)$ from $\mathbf{A}_i(L, p_i, q_i, r_i)$ by augmenting the $p - p_i$, $p - q_i$, or $p - r_i$ additional terms in powers of L by zeros. Also note that

$$\mathbf{z}_{it} = \mathbf{W}_i \mathbf{x}_t, \quad i = 0, 1, 2, \ldots, N, \tag{5}$$

where $\mathbf{x}_t = \left(\mathbf{x}'_{0t}, \mathbf{x}'_{1t}, \ldots, \mathbf{x}'_{Nt}\right)'$ is a vector that collects all the endogenous variables of the system, and $\mathbf{W}_i$ is a matrix defined by the country-specific weights, w_{ij}.

With the above notations, Eq. 4 can be written equivalently as $\mathbf{A}_i(L, p)\mathbf{W}_i\mathbf{x}_t = \varphi_{it}$, $i = 0, 1, \ldots, N$, and then stack to yield the VAR(p) model in $\mathbf{x}_t$:

$$\mathbf{G}\,(L,p)\,\mathbf{x}_t = \varphi_t, \tag{6}$$

where

$$\mathbf{G}\,(L,p) = \begin{pmatrix} \mathbf{A}_0(L, p)\mathbf{W}_0 \\ \mathbf{A}_1(L, p)\mathbf{W}_1 \\ \vdots \\ \mathbf{A}_N(L, p)\mathbf{W}_N \end{pmatrix}, \; \varphi_t = \begin{pmatrix} \varphi_{0t} \\ \varphi_{1t} \\ \vdots \\ \varphi_{Nt} \end{pmatrix}. \tag{7}$$

The GVAR(p) model can now be solved recursively, and used for forecasting or GIR analysis in the usual manner.

Chudik and Pesaran (2007) show that such an approach is optimal to deal with the "curse of dimensionality" in the case of large linear dynamic systems, by showing that under restrictions on the coefficients of an unrestricted VAR, an infinite-dimensional VAR can be arbitrarily well characterized by a large number of finite-dimensional models such as the GVAR model.

3 Empirical results

The empirical analysis is conducted for the 26 economies included in the GVAR model. The dataset includes quarterly data for real GDP on a sample from 1979 to 2009. Before presenting the estimation results, we provide in Sect. 3.1 some details about the data used and about the construction of foreign output series. The empirical results have been conducted in two different steps. First, we estimate the model over the whole sample and give impact elasticities of shocks to U.S. activity to the other economies as well as impulse response functions (Sect. 3.2). To account for possible changes in the sensitivity of the economies to U.S. cyclical developments, we then estimate the same model recursively and on a rolling window (Sect. 3.3).

3.1 Data

The dataset spans over a period of 123 quarters (from 1979Q1 to 2009Q3) and covers 33 countries with 25 of these modeled separately and the remaining countries grouped into a single euro area economy comprising 8 of the 11 countries that joined the euro in 1999.[2] The real GDP series for the 33 countries of the GVAR model come mainly

[2] The 25 countries modeled separately are: Argentina, Australia, Brazil, Canada, China, Chile, Indonesia, India, Japan, Malaysia, Mexico, Norway, New Zealand, Peru, Philippines, Saudi Arabia, Sweden, Singapore, South Korea, South Africa, Switzerland, Thailand, Turkey, United Kingdom, and United States. As in

from the IMF International Financial Statistics (IFSs) database to update the Dees et al. (2007) database (which ended in 2003Q4). For cases where the IFS data were either too volatile relative to the original dataset or not available, the original dataset was used and we extrapolated forward using the growth rate of the latest IFS data. Seasonal adjustment was performed for countries for which seasonal adjusted series are not provided by the IFS. Finally, to make the dataset complete, we had to interpolate for Saudi Arabia from annual to quarterly series using the procedure described in Supplement A of Dees et al. (2007).

For each country, we have computed a non-U.S. foreign GDP series, by applying Eq. 2. The weights used (w_{ij}) are time-varying bilateral weights of exports and imports (3 year moving average) derived from the IMF Direction of Trade Statistics database.[3] As explained above, the U.S. GDP is explicitly added to each country-specific equation as the U.S. economy is treated as a dominant unit in the model.[4] To give an idea of this dominance, Fig. 2 gives the average weight of selected economies in their partners' trade. The U.S. is first (with around an average share of 18%), followed by the euro area (16%), Japan (11%), and the U.K. (8%). Among the following countries, it is worth noting the increasing importance of trade relationships with China, Rep. of Korea, and Mexico over the sample horizon.

Although we estimate models at a country level (the euro area being considered here as a single economy), we also wish to derive regional responses to shocks. Hence, for Emerging Asia, Latin America, and other developed countries, we will aggregate impulse response functions following Dees and Vansteenkiste (2007) using weights based on the PPP valuation of country GDPs, which are thought to be more reliable than weights based on U.S. dollar GDPs.

3.2 Estimation over the whole sample

We start estimating the country-specific models described in Eq. 1 over the whole sample. Unit root tests show that we cannot reject the presence of unit roots in the real GDP series for most countries, while we reject non-stationarity for their first log-

Footnote 2 continued
Dees et al. (2007), the euro area data are obtained by aggregating GDPs of Germany, France, Italy, Spain, Netherlands, Belgium, Austria, and Finland.

3 These weights are based on a 3-year rolling window to smooth out some of the nonsecular year-to-year trade fluctuations. Other types of weights could have been used (e.g., financial weights). However, alternative weighting scheme might be subject to too-frequent changes and could introduce an undesirable degree of randomness into the analysis.

4 Chudik (2008) studies the differences between a model with the United States as a dominant economy and a model where the United States is treated as the other economies. The differences appear relatively limited though in most cases significant. Our choice to treat the United States as dominant is mostly motivated from an econometric viewpoint as the foreign component of the U.S. model could not be in our case considered as weakly exogenous, therefore, biasing the estimation. We could also envisage treating another economy (e.g., the euro area) as a dominant unit. However, weakly exogeneity tests (see below) do not justify such an approach.

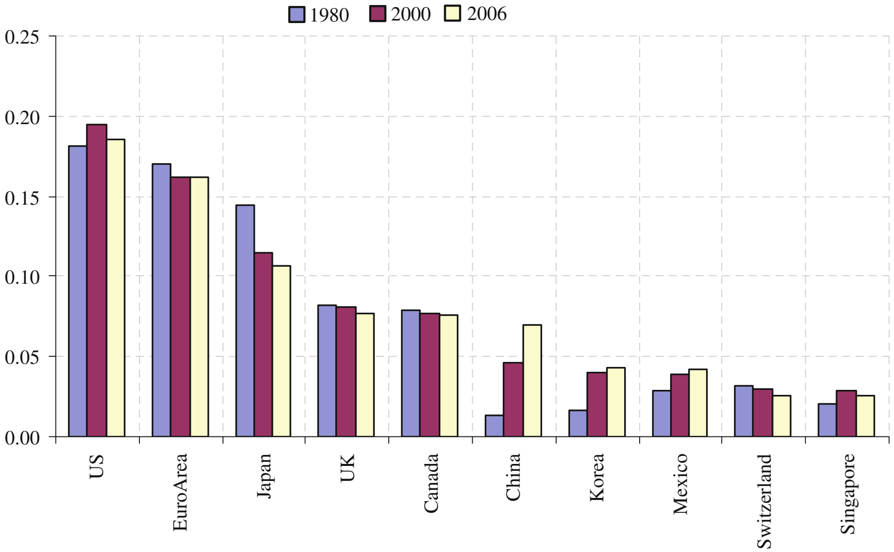

Fig. 2 Ranking of selected economies according to their average weight in partners' trade. *Source*: IMF Direction of Trade Statistics

differences.[5] As a result, we test the presence of cointegration relationships between $\mathbf{x}_{it}$, $\mathbf{x}_{0t}$ and $\mathbf{x}^*_{it}$. We also test whether country-specific foreign variables are weakly exogenous. We then use the estimation results to compute the contemporaneous effects of foreign activity on domestic GDP. To assess the dynamics of the propagation of a shock to U.S. GDP to the rest of the world, we also compute GIR functions. These results give us the general picture over the sample, which will be later on put into perspective by a time-varying approach.

3.2.1 Cointegration and weakly exogeneity tests

As real GDP series have a unit root, we individually estimate each country-VARX* model in its vector error-correcting form using Johansen's trace statistics and the critical values obtained in Mac Kinnon et al. (1999). As reported in Table 1, test results suggest that there is one cointegration relationship between $\mathbf{x}_{it}$, $\mathbf{x}_{0t}$ and $\mathbf{x}^*_{it}$.

The main assumption underlying our estimation strategy is the weak exogeneity of $\mathbf{x}_{0t}$ and $\mathbf{x}^*_{it}$ of each country i (with $i > 0$). After estimating the individual ECM country models, weak exogeneity is formally tested according to the approach in Johansen (1992). In particular, we conduct F-tests for the joint significance of the error-correction terms taken for the individual models in the partial model for the supposed weakly exogenous variable. Results of these tests are reported in Table 1. Except in 3 cases out of 50, weak exogeneity assumption is not rejected at the 5% level, confirming the weak exogeneity of U.S. and foreign variables.

5 Unit root tests are not shown here. They are available upon request. Test results over a slightly shorter sample are available in Dees and Saint-Guilhem (2009).

Table 1 *F*-statistics for testing the weak exogeneity of the country-specific foreign variables and trace statistics for testing cointegration

	Weak exogeneity tests		Cointegration tests
	$\mathbf{x}_{0t}$	$\mathbf{x}^*_{it}$	Trace stat
Argentina	0.22	2.43	53.53
Australia	0.08	0.38	34.67
Brazil	0.71	0.37	39.28
Canada	0.30	3.82	38.81
China	2.48	3.67	25.45
Chile	0.01	0.81	39.84
Euro area	0.78	2.78	50.51
Indonesia	0.51	0.56	46.39
India	1.09	0.00	28.48
Japan	0.01	0.00	47.02
Malaysia	0.41	0.55	48.11
Mexico	1.97	1.93	34.69
Norway	1.71	0.06	52.44
New Zealand	3.82	0.81	45.41
Peru	0.15	2.77	35.77
Philippines	0.10	0.36	33.95
Saudi Arabia	0.00	0.92	55.88
Sweden	0.57	7.69*	44.07
Singapore	3.72	0.22	40.34
South Korea	0.56	0.11	56.03
South Africa	0.29	0.01	27.36
Switzerland	0.08	6.34*	37.10
Thailand	1.01	1.04	37.68
Turkey	3.99*	0.95	48.11
United Kingdom	0.08	0.00	55.60
United States	–	–	29.86

Notes: * indicates significance at 5% for weak exogeneity tests. For cointegration tests, the 5% critical values for Trace (Mac Kinnon et al. 1999) are 35.19 for all countries except the United States (with three variables) and 20.26 for the Unites States (with two variables)

3.2.2 Contemporaneous effects of foreign activity on domestic GDP

The order of the country-specific VARX* (p_i, q_i, r_i) models is fixed to 2 lags. Evidence from information criteria tend to indicate this is a reasonable choice to capture most of the dynamics at stake.

To summarize the estimates, Table 2 presents the contemporaneous effects of foreign activity on domestic GDP. These estimates can be interpreted as impact elasticities of domestic GDP with respect to foreign (U.S. and non-U.S.) GDP. Most of these elasticities are significant and have a positive sign, as expected. They are particularly informative as regards the international linkages between the domestic economies and their international environment. These elasticities tend to be large for very open economies, and the impact elasticity with U.S. GDP seems to depend from the trade proximity of the economies with the U.S. For example, the elasticities of domestic GDP to U.S. GDP are large and significant for Canada, Mexico, Chile, Singapore,

Table 2 Contemporaneous effects of foreign GDP (U.S. and non-U.S.) on domestic growth

	Impact elasticities	
	U.S. GDP	Non-U.S. foreign GDP
Argentina	0.37	0.39#
Australia	0.30**	−0.01
Brazil	0.02	0.45
Canada	0.46**	−0.09
China	−0.02	0.08
Chile	0.73**	0.56#
Euro area	0.16**	0.43**
Indonesia	0.09	0.59**
India	0.30**	−0.39
Japan	0.06	0.16
Malaysia	−0.20	1.15**
Mexico	0.52**	0.71**
Norway	0.39**	0.52#
New Zealand	0.03	0.48#
Peru	−0.64#	1.06*
Philippines	−0.13	0.26#
Saudi Arabia	−0.12	−0.12
Sweden	0.32*	1.31**
Singapore	0.57**	0.81**
South Korea	0.00	0.85**
South Africa	0.06	0.11
Switzerland	0.05	0.51**
Thailand	0.14	0.99**
Turkey	0.26	0.98
United Kingdom	0.15#	0.44*
United States	–	0.29**

Note: **, *, and # indicate significance at 1, 5, and 10%, respectively.

and Australia. For other countries, the non-U.S. foreign components seem to be more important, like for the euro area, the U.K., most other European countries, and most of the Asian countries. This component is also relatively large and significant for the U.S. (a 1% change in foreign GDP in a given quarter leads to an increase of 0.3% in U.S. GDP within the same quarter).

3.2.3 Generalized impulse response functions

Although the contemporaneous effects give a good indication of how an economy reacts to its international environment, the transmission of shocks does not occur immediately, and the analysis of the dynamics of the transmission is necessary. Figure 3 gives the GIRs of a 1% shock to U.S. GDP on the other economies. Of course, the shock has here no structural interpretation. We use the GIR approach as proposed in Koop et al. (1996), which considers shocks to individual errors and integrates out

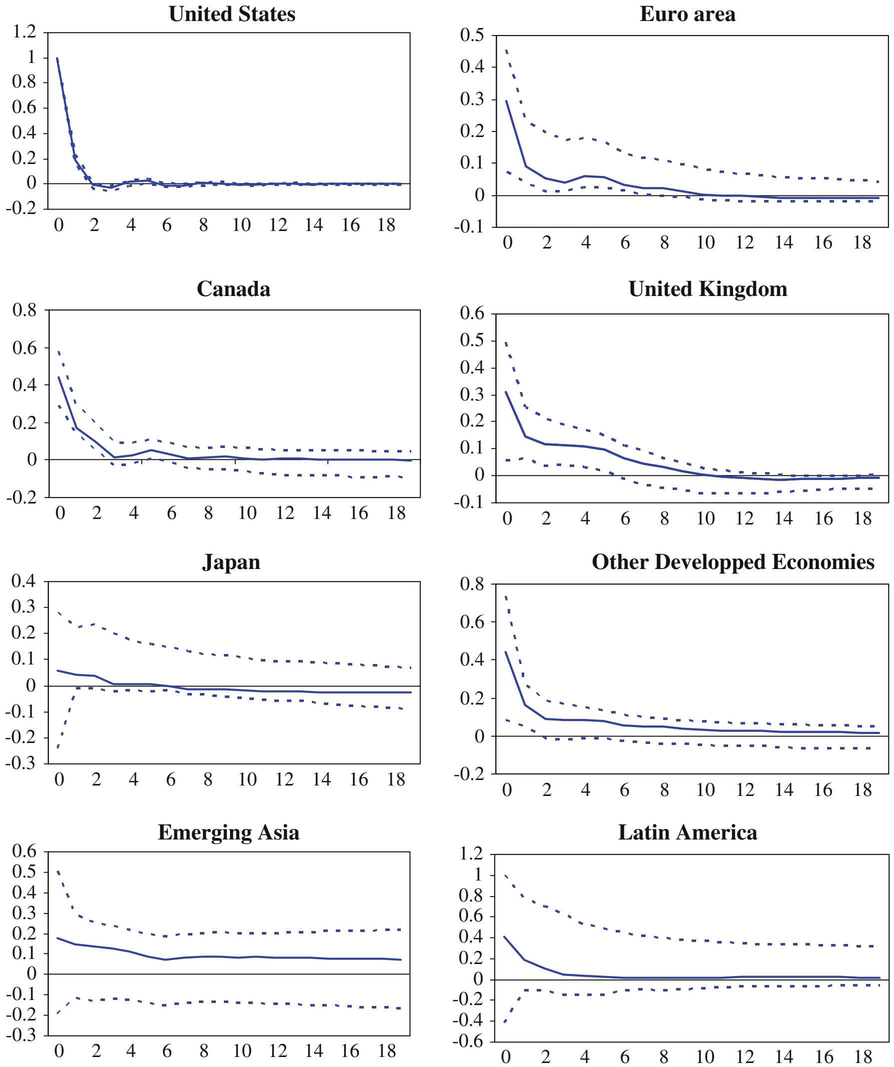

Fig. 3 Impulse response functions of a 1% shock to U.S. real GDP growth. *Note*: *Dotted lines* indicate 95% bias-corrected bootstrap confidence intervals

the effects of the other shocks using the observed distribution of all the shocks without any orthogonalization. It is worth noting that the GIR is invariant to the ordering of the variables and the countries in the GVAR model. In our case, this is particularly important since no theory is able to give us a relevant ordering of countries within the global economy.

An important caveat of this approach concerns the identification of a U.S. shock. It is clearly difficult to identify a purely U.S.-specific shock, whose nature is entirely idiosyncratic. Moreover, the nature of the shock might also alter the way the shock is transmitted to the rest of the world. Another possibility would have been to distinguish the shocks according to their nature (demand or supply shocks), requiring the inclusion of additional variables (such as prices). However, such a modeling of the international linkages would have prevented us from performing the time-varying analysis, owing to too large a dimension of the system. Instead, our approach has remained on purpose very agnostic, while keeping as comprehensive as possible the representation of international linkages. By including a large number of countries in the modeling of the world economy, the GVAR approach allows us to account for the complexity of global interdependencies in a transparent and coherent framework and to give some idea about the dynamics of the propagation of shocks. A more detailed modeling in terms of the nature of the shocks and their transmission channels would definitely be at the expense of both the rich geographical coverage and the time-varying dimension.

To assess the degree of uncertainty surrounding the GIR functions, we compute bias-corrected bootstrap confidence intervals based on the methodology proposed in Kilian (1998). Finally, we aggregate country-specific impulse responses by region to summarize the large set of information available. This aggregation features three geographic areas, in addition to the main developed economies, namely, Other Developed Economies (composed of Australia, New Zealand, Sweden, Norway, and Switzerland), Latin America (Argentina, Brazil, Chile, Mexico, Peru), and Emerging Asia (China, India, Indonesia, Malaysia, Thailand, Philippines, South Korea and Singapore).

The shock on U.S. GDP is temporary on growth (i.e., permanent on real GDP level). In the U.S., the effect dies out quickly. The same pattern can be observed for countries where the effect on impact is relatively large. For instance, the 1% increase in U.S. real GDP increases euro area and U.K. GDP by 0.3% on impact on average (with a range of bootstrap estimates comprised between 0.1 and 0.5%) and by more than 0.4% in Canada and Other Developed Economies. The effect is absorbed after two to six quarters. The response for Japan turns out to be small and non-significant. Concerning emerging economies, the U.S. shock has larger impacts on Latin America compared with Emerging Asia. The responses are, however, subject to uncertainty as pointed out by the bootstrap confidence intervals. For the aggregates, the confidence intervals hide, however, some heterogeneity within the region. In Emerging Asia, for instance, as the GIR functions are not significant for China, whose weight is very large in the region, this tends to widen the regional confidence intervals.

3.3 Evidence of changes over time

We start our time-varying analysis by performing recursive estimation of our model. This allows us to test the stability of the relationships over time. Then, we re-estimate our model on a rolling window of 15 years, starting first with the estimation of the time-varying contemporaneous effects of foreign output before computing time-varying GIR.

3.3.1 Recursive estimation and stability tests

To test the stability over time of the parameters, we first perform a recursive estimation of the model. As above, we summarize the estimates by showing the contemporaneous impacts of U.S. and non-U.S. foreign GDP on domestic GDP (Fig. 4). While it is difficult to identify clear break points, we can see that the values of the estimates vary over time. To test the stability of the parameters, we also perform the CUSUM of squares test (Brown et al. 1975). The test suggests parameter instability in 18 countries[6] out of the 26, as the cumulative sum of squares move clearly out of the 5% significance lines for these countries.[7]

3.3.2 The changing role of foreign variables over time

While the recursive estimation points to some instability in the relationships between domestic and foreign activity, it remains difficult to identify clear trends in the sensitivity of the various economies to their international environment. We then perform rolling estimates to assess how much and in which direction this sensitivity has changed over time.[8]

Figure 5 reports the rolling estimates of the contemporaneous impacts of U.S. and non-U.S. foreign GDP on domestic GDP, together with 95% bootstrap confidence intervals. To allow for sufficient observations, the estimation has been realised using a 15-year rolling window (i.e., 60 observations). In Fig. 5, the date reported corresponds to the end of the window. The graph starts therefore in 1994Q1 (i.e., estimation over 1979Q1–1994Q1) and ends in 2009Q3 (i.e., estimation over 1991Q3–2009Q3).

Starting with the United States, the impact elasticity with respect to foreign GDP has remained very close to the value resulting from the whole sample estimation (around 0.3). It seems, however, that this impact has gradually decreased in the late 1990s and early 2000s before rising again in most recent periods, especially those including the latest recession episode.

For the euro area, the impact elasticity with respect to U.S. GDP (0.2 on average, see above) has varied over time (from 0.1 to 0.3) without displaying any particular trend. After some decline in periods ending in the early 2000s, some increase in the impact elasticity can be observed in the most recent samples. The impacts of non-U.S. foreign GDP have continuously declined (from 0.6 to 0.2), though increasing again when the sample includes the 2007–2009 financial crisis. The time-varying estimation for the U.K. and Japan shows large swings in the impact of U.S. GDP, and remains overall subject to large uncertainty (as indicated by the confidence intervals). This is mostly due to particular events these economies faced during the period. For the U.K., while it seems that the economy was weakly related to the U.S. for most periods, the non-U.S. foreign influences (mostly the other European economies) remain

[6] Instability of the parameters has been found for Brazil, Australia, Canada, Chile, China, India, Indonesia, Korea, New Zealand, Peru, Philippines, Saudi Arabia, Singapore, South Africa, Thailand, Turkey, United Kingdom, and United States.

[7] Graphical representations of the CUSUM of squares test is not included here but are available upon request.

[8] Another way of allowing for a time-varying effect might have been through using the product of U.S. output and a time-varying trade weight as the explanatory variable in the model of the non-U.S. economies. The difficulty with this approach is that it makes the strength of the linkage solely depend on trade, whereas it might be related to financial integration.

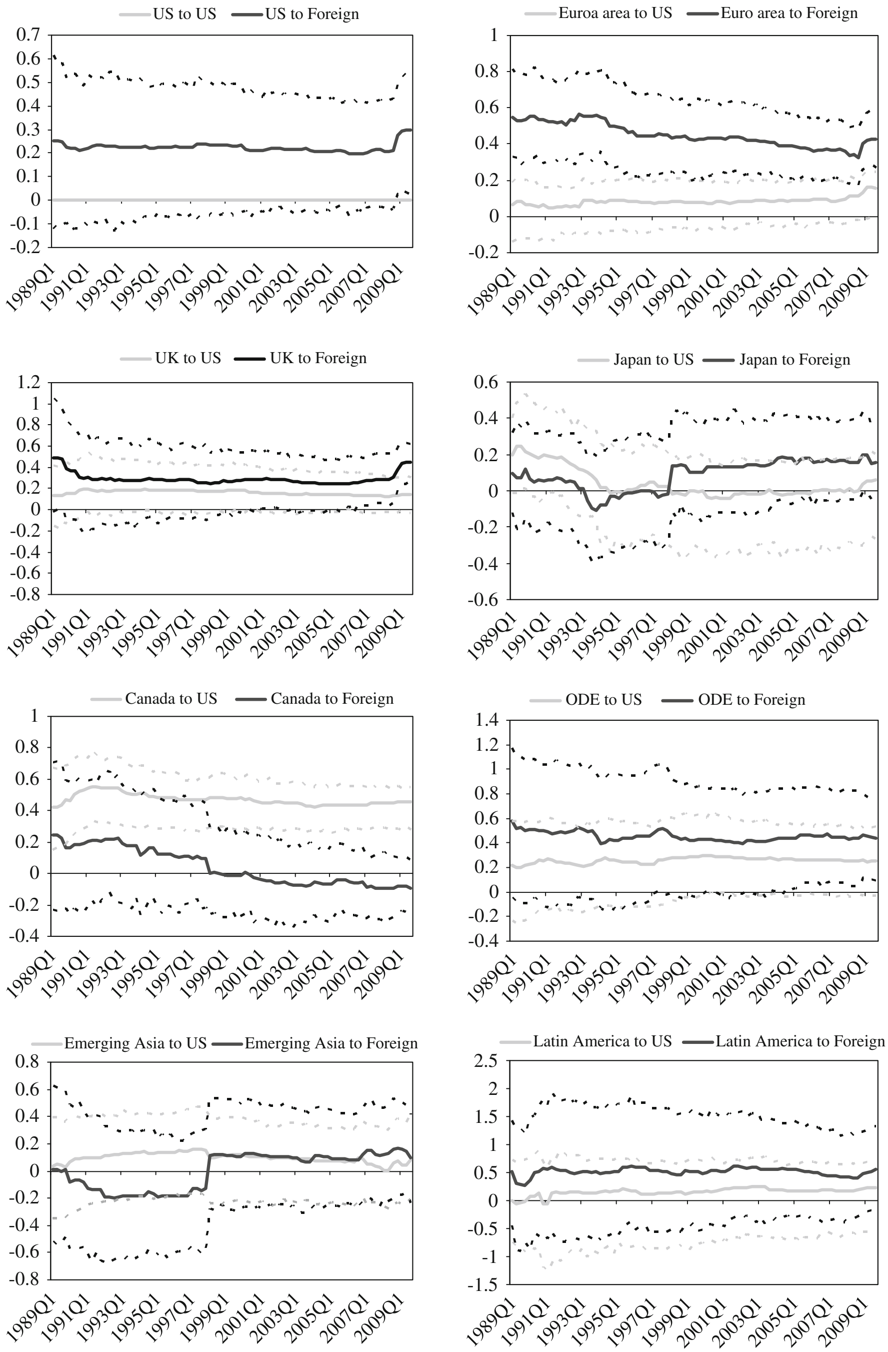

Fig. 4 Recursive estimates of impact elasticity of real GDP to U.S. and foreign real GDP

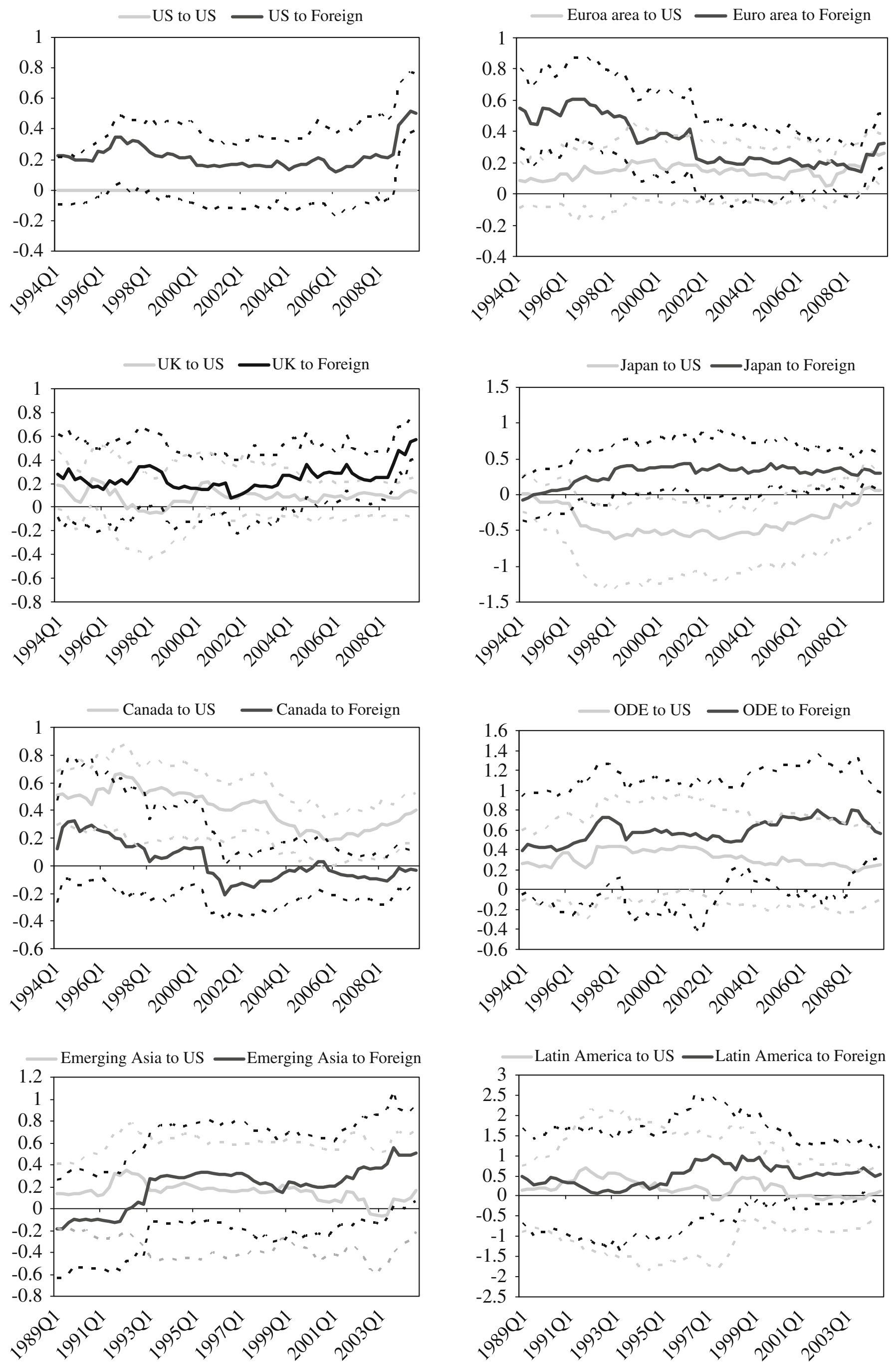

Fig. 5 Rolling estimations of impact elasticity of real GDP to U.S. and foreign real GDP. *Note*: *Dotted lines* indicate 95% bootstrap confidence intervals

relatively strong and significant (with an impact elasticity ranging between 0.2 and 0.5). For Japan, the "lost decade" seems also to feature a complete disconnection with the U.S. economy, while the non-U.S. component (mostly the other Asian economies) gained both importance and significance. It is worth noting that this apparent disconnection reflects only contemporaneous influences. Only the analysis of the dynamics of the transmission (see below) will allow us to identify possible lagged impacts and/or impacts through third partners. As for the euro area, the most recent periods including the latest global recession feature an increase in the sensitivity to U.S. real GDP.

In Canada, the contemporaneous role of the U.S. in domestic activity remains large, though gradually decreasing (from more than 0.8 in the earlier periods to 0.2 in the periods 1990s and early 2000s). The most recent periods also features some increase in the sensitivity to U.S. GDP. The non-U.S. foreign GDP remains non-significant whatever periods considered, showing that the U.S. economy remains the main player in Canada's international environment. Conversely, for the Other Developed Economies, the non-U.S. foreign GDP has become increasingly important (with an impact elasticity higher than 0.6 in some sub-periods), while the influence of the U.S. economy has remained broadly unchanged.

Finally, for emerging economies, the role of non-U.S. foreign GDP seems to have increased, possibly reflecting the strengthening in regional integration and the growing importance of South–South trade. Conversely, the role of the U.S. (on impact) seems to have lost importance and is in most cases insignificant.

Overall, while the sensitivity to foreign influences seems to vary over time, it remains difficult to identify any clear trend, although for most countries the impacts of a change in U.S. GDP seem to have decreased somewhat over time. However, the most recent periods, that include the 2007–2009 financial crisis, show some renewed increase in the degree of sensitivity to the U.S. economy. This result does not necessarily imply that the influence of the U.S. economy has increased lately, but rather that the financial crisis was the trigger of a world-wide recession that had global components. The fact that the impact elasticity of U.S. GDP to its foreign counterpart has also increased in the most recent periods shows how second-round effects can amplify the cross-country transmission of cyclical developments.

3.3.3 The changing dynamics of transmission of U.S. cyclical developments over time

Figure 6 shows the profiles of the GIR functions of a 1% increase in U.S. GDP for selected economies (euro area, U.K., Canada, and Other Developed Economies) and their evolution over the rolling samples.[9] Similarly to the impact elasticities, the date reported corresponds to the end of a 15-year period.

For the euro area, while the shock faded away rapidly for the first samples, it has become more persistent over time. The samples including the 2007-2009 financial crisis obvisously feature a higher volatility in the response in the short-term but also

[9] The charts for the other economies are not shown here because the responses over the whole sample were not significant (see Fig. 3). They are, however, available upon request.

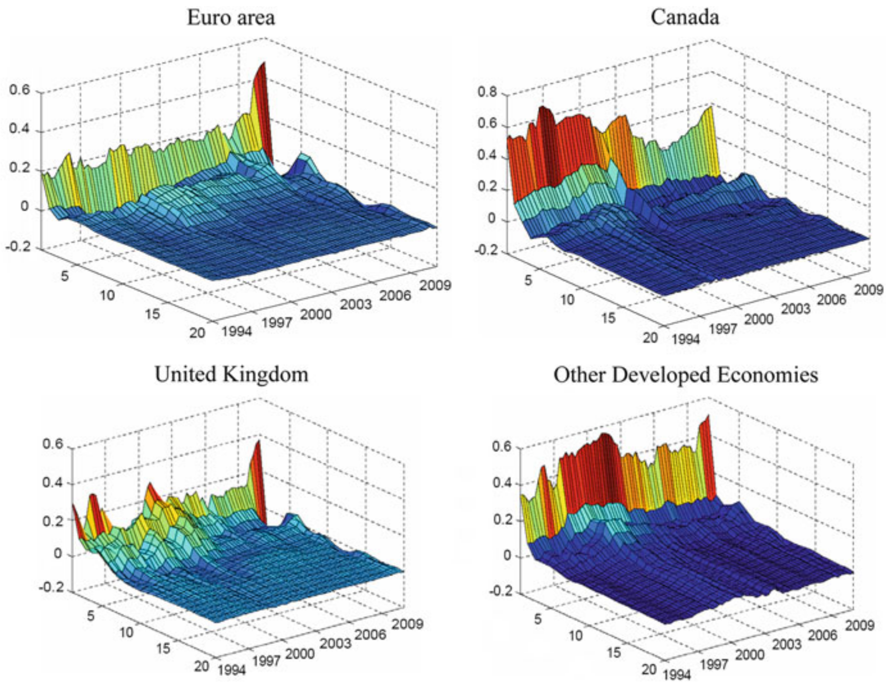

Fig. 6 Impulse response functions of a 1% shock to U.S. real GDP on selected economies' real GDP growth. *Note*: The *graphs* represent impulse response functions over 20 quarters after the shock. The *years* refer to the end of the 15-year rolling estimation samples

more persistence over the medium-term. Most of the comments for the euro area are also valid for the U.K., Canada and the Other Developed Economies.

Overall, the time-varying GIR functions show that despite the relatively limited (or declining) role the U.S. economy has contemporaneously on the rest of the world, its importance remains very large. This underlines the fact that the U.S. influences might have become more indirect (going more through third partners and creating snow-ball effects). No clear trend emerges from the time-varying analysis, although some slight decline in the responses might be noticed in some economies. More importantly, it seems that the impacts have become more persistent compared to earlier periods. This might indicate that the increasing trade and financial integration worldwide might have strengthened the transmission of shocks. The U.S. shocks might have, therefore, become more global as they travel from the U.S. to the rest of the world, reenforcing the persistence of their impacts.

4 Concluding remarks

When the United States entered into recession at the end of 2007, the ability of the global economy to "decouple" from U.S. cyclical developments has been questioned. While there were some signs of decoupling in the first quarters following the U.S.

downturn, they disappeared rapidly toward the end of 2008, when the crisis became more global and the economic cycles turned out to be more synchronous across the world.

While the increasing economic integration at the world level and the resulting emergence of large economic players, like China, is likely to have weakened the role of the U.S. economy as a driver of global growth, the influence of the United States on other economies remains, however, larger than direct trade ties would suggest.

This article attempts to provide some evidence on the international linkages by analyzing how a change in U.S. GDP is transmitted to the rest of the world and to what extent such a transmission has changed over time. The empirical analysis shows various results. First, the economies with a large trade exposure with the U.S. economy have a relatively larger sensitivity to U.S. developments. However, even for countries that do not trade so much with the U.S., they are largely influenced by its dominance through other partners' trade. Moreover, while no clear trend seems to emerge, it seems that the role of the U.S. in the global economy has changed over time. Although we are not able to identify any clear break points in the sample, a recursive estimation of our model points to some instability over time for most countries. This is confirmed by a rolling estimation that shows some noticeable differences in the transmission of U.S. shocks over time. Overall, for most countries—the latest recession excluded—a change in U.S. GDP had weaker impacts—though more persistent—for most recent periods. The latest recession, however, led to some renewed increase in the sensitivity of the economies to U.S. developments. This might question somehow the robustness of our findings, given that the inclusion of this episode triggers marked changes in the results. At the same time, one has to acknowledge that the 2007–2009 global downturn followed an exceptionally severe financial crisis. Also, our results show that the U.S. economy too became more sensitive to foreign influences during this particular episode, underlying the global nature of the recession. Beyond this particular episode, the framework used in this article could prove a useful forecasting tool to assess the impact of country-specific shocks to the world economy. In this respect, it would be optimal to make forecasts over different estimation windows and then pool them, as an average forecast across different windows. This is likely to dominate forecast from a single window—especially, when the model is subject to parameter instability—as shown by Pesaran et al. (2009).[10] This is left for further research.

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[10] This is shown when forecasting the mean of a given process which is subject to breaks, so long as the last break date is not too close to the end of the sample. This is true irrespective of the size of the breaks. See Pesaran et al. (2009) for further details.

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