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for Emerging Markets**

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On the Exchange Rate and Economic Policy Uncertainty Nexus: A Panel VAR Approach for Emerging Markets

Abstract

We examine the Exchange Rate Volatility (ERV) response to the Economic Policy Uncertainty (EPU) shocks from a panel VAR perspective used for the first time in this context. Focusing on Emerging Market Economies (EME), our noteworthy findings postulate that (a) both home and foreign EPU shocks are highly significant in explaining the ERV, (b) the contribution of the foreign EPU to the ERV fluctuation overcomes the local EPU's share, (c) the ERV acts as a significant transmission channel of the US-EPU to the economic activity, (d) the home EPU increases with higher US-EPU and vice versa and (e) the latter is surprisingly and markedly sensitive to EME macroeconomic conditions. Our findings are robust to different sensitivity analyses, provide novel insights into EPU international spillovers, and have interesting policy implications for EME decisions makers and investors.

JEL-Codes: G150, E440, C220.

Keywords: emerging markets, economic policy uncertainty, exchange rates volatility, panel VAR.

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1. Introduction

The predictive effects of fundamentals on exchange rate fluctuations remains one of the most discussed puzzles in international economics. While their long-run effects are confirmed (Beckmann and Czudaj, 2017), their short-run implications have much less empirical success (Chen and Chou, 2015). In the short-run, the exchange rate can be affected by transitory shocks including the Economic Policy Uncertainty (EPU) (Bartsch, 2019; Abid, 2019)⁴. As widely supported by applied studies, the latter adversely weighs on economic activity (Baker *et al.* 2016; Bloom, 2009) and financial markets (Pastor and Veronesi, 2012; Brogaard and Detzel, 2015; Arouri *et al.* 2016).

To date, the foreign exchange market (FOREX) impacts of the EPU is yet explored by a handful of studies. First, they predict that an increase in the EPU coincides with rising levels of ERV (Nilavongse *et al.* 2020; Chen *et al.* 2019; Bartsch, 2019 ; Christou *et al.* 2018, Balcilar *et al.* 2016). Second, the ERV reaction appears more sensitive to the domestic rather than the foreign EPU (Nilavongse *et al.* 2020). Technically, these empirical exercises have sustainable interest to time series frameworks mainly focusing on advanced economies (Bartsch, 2019; Nilavongse *et al.* 2020) or some major emerging markets such as China (Chen *et al.* 2019). Some notable exceptions are Balcilar *et al.* (2016) and Christou *et al.* (2018) which consider a mixture of developed and developing countries.

To complement this literature, our study primarily builds on the body of the research pioneered by Bloom (2009) in investigating the macroeconomic effects of the EPU by focusing on the ERV's reaction to both local and foreign EPU in Emerging Market Economies (EME). Our contribution to the existing debate is in several ways. The first novelty is the exclusive focus on EME as a case study when dealing with ERV⁵. These countries (i) display a higher ERV especially those having adopted floating exchange regimes (ii) face higher levels of uncertainty comparing to advanced economies (Bloom, 2009) and (iii) are extremely vulnerable to shock spillovers originating from developed countries (Bhattarai *et al.* 2019). In addition, this paper aims at revealing the extent to which considering cross sectional dependence between countries can affect the sensitivity of the ERV to the EPU. To the best of our knowledge, applying Panel VAR model, our paper is not only the first to use a panel approach but also one of the rare relying on

⁴ By EPU, we refer to the uncertainty surrounding government decision making. This uncertainty alters the economic agents' expectations regarding the future evolutions of the economic activity.

⁵ Note that Abid (2019) finds evidence of harmful effects of local EPU on exchange rates in EME. A special focus on the ERV behavior in EME to either local or foreign EPU is worth noting.

VAR approaches to quantify EPU's implications on the ERV⁶. Numerous reasons make such a methodology interesting. First, it allows to account for variables interactions and to capture market interdependences. Why such issues could be of interest? On the one hand, in a globalized economy, a shock from one country can spill to other countries/markets. Accordingly, a panel data set might help better understand such spillovers. On the other hand, apart from the impacts running from the EPU to the ERV, the literature provides significant evidence on the ability of EPU in a given country to predict the path of EPUs abroad (Gupta *et al.* 2020; Jiang *et al.* 2019)⁷. Moreover, we assume that higher currency fluctuations induce government intervention which could translate into policy uncertainty. Hence, we conjecture that a VAR setting might (i) provide a novel insight regarding the endogenous linkage of these variables and (ii) be more relevant than single- equation models which could suffer from serious endogeneity biases resulting in possible misleading results⁸. Second, our procedure offers the possibility not only to simulate impulse response functions (IRFs) conventionally used to analyze shock propagation but also to appreciate the contribution of each shock to the ERV using the forecast error variance decomposition (FEVD).

In what follows, Section 2 describes the data and the econometric framework. Section 3 reports the main findings. Section 4 deals with robustness issues. Section 5 offers some concluding remarks.

2. Data and Econometric framework

Our study is conducted on a monthly basis for 8 EME: Singapore, China, Chile, India, Korea, Russia, Brazil and Mexico and includes 4 variables: the ERV, local and foreign EPUs and the domestic output. While the sample covers the period from January 2003 through December 2018, the starting date is dictated by the data availability to ensure a balanced panel structure. Our sample englobes turmoil phases that are likely to increase the EPU: the collapse of Lehman Brothers (2008), the global financial crisis (2008-2009), the loss of the AAA sovereign rating of the US in the 2011 summer for the first time of its history, the mid-2014 oil price decline and the Sino-American trade conflict (2018).

⁶ Notable exceptions are Nilavongse *et al.* (2020) and Beckmann and Czudaj, (2017) relying on time series VAR models to investigate the effects of the EPU on exchange rates' volatility and forecast errors.

⁷ For example, Gupta and Sun (2020) find significant evidence of a predictive power of wide array of EPUs in emerging and developed countries on BRIC's EPU.

⁸ Panel data models are likely to exhibit high cross-sectional dependence in the errors. This arises when countries in the panel respond not only to their own specific shocks but also to common shocks across other panel members.

Exchange rates examined are daily spot rates of the domestic currencies against the US dollar⁹. Retrieved from DataStream, they are employed to compute monthly ERV¹⁰. The local and foreign EPU's are the Baker *et al.* (2016)'s News-based indexes obtained from www.policyuncertainty.com¹¹. We use the US-EPU as a proxy for the foreign EPU since it is a benchmark of the international policy uncertainty (Das and Kumar, 2018). Finally, as measure of output, we use the industrial production index drawn either from DataStream or the OCDE database. All series are transformed in logarithm.

In Equation 1, we describe the estimated PVAR associating the panel data approach allowing unobservable individual heterogeneity to VAR models assuming the endogeneity of all the variables (Love and Zicchino, 2006).

$$Z_{it} = U_{it} + \sum_{j=1}^p A_j Z_{it-j} + \mu_{it} \quad (1)$$

, where Z_{it} includes the 4 endogenous variables discussed above. U_{it} and ε_{it} are vectors of country fixed effects and disturbance terms. Two lags are selected as they were found to be optimal according to information criteria. Then, the model is estimated using the Generalized Methods of Moments (GMM) (Abrigo and Love, 2016) and its stability condition is checked via modules of each eigenvalues of the estimated model. Next, IRFs are computed using Cholesky decomposition. A decreasing order of exogeneity specified according to a Granger causality test is used. Therefore, the following ordering of the variables is retained [Output, US-EPU, ERV, and local EPU]¹².

3. Findings and discussion

Prior to the estimation we have undertaken a preliminary analysis. Doing so, we apply first (Levin-Lin-Chu, 2002) and second (Pesaran, 2007) generation panel unit root tests and Pesaran (2004) cross sectional dependence test. We provide evidence of stationarity in level of all

⁹ We select SGD/USD; CNY/USD; KRW/USD; BRL/USD; MXN/USD; CLP/USD; INR/USD and RUB/USD exchange rates for Singapore, China, Korea, Brazil, Mexico, Chile, India and Russia.

¹⁰ The volatility is the monthly standard deviation of daily spot rates.

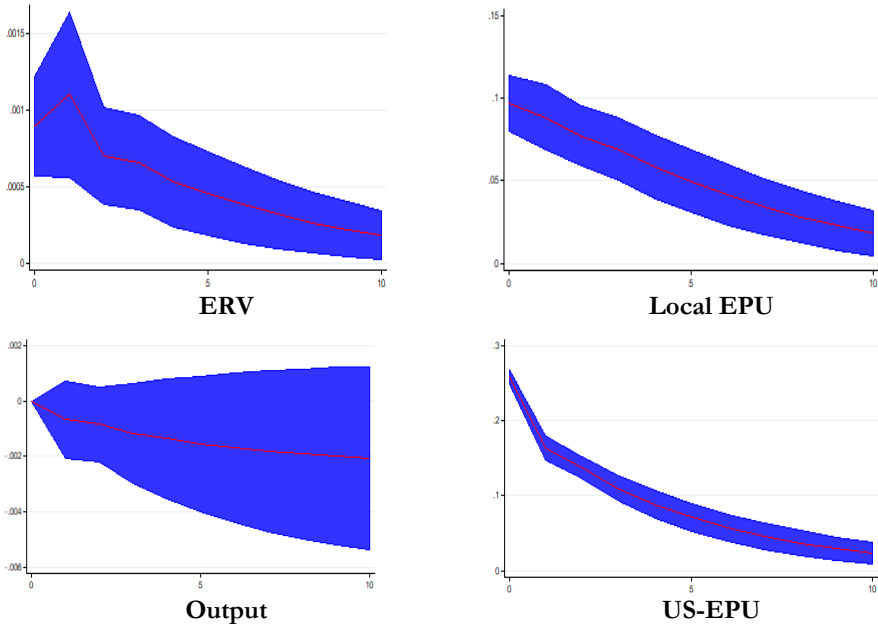
¹¹ This index is a monthly coverage of Newspapers text search of articles including at least one term related to three categories (i) economy/economic, (ii) uncertainty/uncertain and (iii) policy, legislation, deficit, regulation etc.

¹² Further description of the PVAR estimation procedure, the three information criteria considered, the computing of the IRFs and the Cholesky ordering are detailed the Appendix.

variables considered, as well as a cross-sectional correlation of EME. Confirming our initial intuition, it appears that EME are probably displaying similar macroeconomic policies features¹³.

Figure. 1 displays IRFs that plot the US-EPU spillovers to EME. We find that a positive US-EPU shock (i) foreshadows both ERV and home EPU increase and (ii) has no significant effect on output. However, our results interestingly support significant indirect effects of the US-EPU on EME activity. Firstly, we find that an ERV's increase significantly translates into an output contraction¹⁴. Secondly, combining this result with the observed positive US-EPU effects on the ERV, we emphasize the ERV role as a transmission mechanism of the negative US-EPU spillovers to the EME economic outlook. Accordingly, we conjecture that countercyclical current accounts and exports of EME (Bhattarai *et al.* 2019) could be more complicated with higher ERV induced by the foreign EPU. Such an effect leads to an aggregate supply decrease *i.e.* an output contraction. Overall, we support the role of (i) the US as a net transmitter of policy changes (Jiang *et al.* 2019), (ii) the US-EPU as negative foreign aggregate demand disturbances.

Figure.1 US-EPU shock spillovers to EME



This Figure plots the response of all the endogenous variables to a one standard deviation shock of the US-EPU at 10 months horizon. The red line presents the response of each variable. The blue boxes are the 95% confidence intervals constructed via Monte-Carlo simulations with 1000 replications.

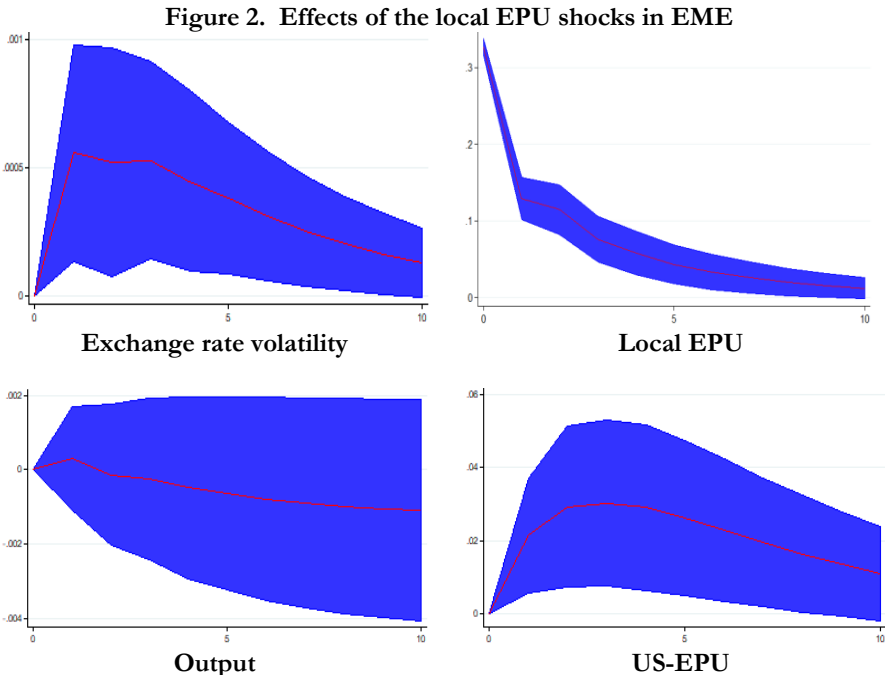
Let us now discuss the home EPU shock effects on all variables (Figure 2). Our findings show a significant raise of the ERV following an anticipated change of the domestic EPU consistent with

¹³ More information on these tests is in the Appendix of this paper. The cross sectional dependence support the adequacy of using a panel data.

¹⁴ Results are available in Appendix C.

previous works (Chen *et al.* 2019; Bartsch, 2019). It is recognized that exchange rates movements are altered through fundamentals expectations (Beckmann and Czudaj, 2017) and economic policies changes (Alesina *et al.* 1997). Naturally, a higher EPU level leads to an increase of fundamentals expectations. As a result, currencies exhibit an increased volatility (Krol, 2014).

In addition, as Nilavongse *et al.* (2020), we find no evidence of a significant output response to the domestic EPU shock. Interestingly and perhaps surprisingly, we show that the US-EPU is positively responsive to the EME-EPU. Thus, we provide novel insights into EPU international spillovers and take a step further from studies supporting the prominent influence of the US on EME (Bhattarai *et al.* 2019). Therefore, we suggest that the US economy is not immune to a negative international policy shock. Even if the US is perceived as a net exporter of EPU (Klößner and Sekkel, 2014), we show that it also appears as an importer of such an uncertainty. Relatedly, EME can be considered as an exporter of policy uncertainty. Finally, we find that a favorable economic outlook in EME (an increase in output) results in a higher US-EPU. Such a result implies that US decision makers regard favorable EME conjuncture as bad news which adversely alter their decision-making process.



This Figure plots the response of all the variables to one standard deviation of the domestic EPU at 10-month horizon. The red line presents the response of each variable. The blue boxes are the 95% confidence intervals constructed via Monte-Carlo simulations with 1000 replications.

Table 1. Forecast Error Variance Decomposition results

<i>h</i>	A. ERV				B. EPU				C. output				D. USEPU			
	ERV	USEPU	EPU	Output	ERV	USEPU	EPU	Output	ERV	USEPU	EPU	Output	ERV	USEPU	EPU	Output
12	89.9	6.9	2.6	0.4	3.2	18.9	74.6	5.9	5.1	0.2	0.1	94.5	0.1	86.6	3.1	10.0
24	89.0	6.9	2.6	1.3	3.4	17.4	65.6	13.4	6.3	0.4	0.2	92.9	1.0	74.0	2.7	22.2
36	88.3	6.9	2.6	2.0	3.6	16.3	61.5	18.4	6.7	0.5	0.2	92.3	1.7	66.3	2.4	29.4

This Table reports the FEVD results highlighting the fraction of the forecast variance of row variables (A, B, C and D boxes) attributable to innovations in columns variables. The first column “*h*” refers to the forecast horizon *i.e.* 12 months, 24 months and 36 months.

From the FEVD analysis in Table.1, we clearly observe greater relevance of the US-EPU over the local EPU in explaining the ERV. Combined, both shocks explain nearly 10% of the ERV variance and their shares remain unchanged along all forecast horizons. Such a result strengthens our evidence that alongside local variables, the US-EPU is a curial influential factor of EME currencies. Contrary to previous papers, we show in line with our IRFs, that the US-EPU contribution to the output fluctuation is spectacularly weak.

Furthermore, our FEVD highlight that the local EPU fluctuation is driven to a great extent (nearly 40%) by US-EPU and output shocks. The contribution of US-EPU (output) shocks slightly (considerably) decreases (increases) with the forecast horizon¹⁵. Specifically, the role of the US-EPU (output) shocks is more pronounced in the short (long) run.

Interestingly, we observe that the fraction of the EME output to explain the US-EPU fluctuations rises along forecast horizons to achieve one third in the long-run. This not only echoes again our IRFs simulations but also strengthens our conclusion regarding the positive EME outlook as a source of US economic disturbances.

4. Robustness checks

To further strengthen the robustness of our findings, we have undertaken sensitivity analyses. Specifically, we check if our results are altered if we (i) re-estimate IRFs using an alternative confidence bands (1%), (ii) use the Global EPU (GEPU) index as an alternative of the foreign EPU¹⁶ and (iii) cut Singapore and China out of our sample since they have adopted different exchange regimes compared to the other countries¹⁷. Our findings confirm that the overall dynamics of our PVAR are immune to all modifications thus providing strong robustness evidence¹⁸.

¹⁵ Our finding is closely related to Gupta and Sun (2020) which show for the BRIC that models including foreign EPU provide better forecasts than those with domestic EPU alone.

¹⁶ The GEPU is a proxy of the World EPU of Baker *et al.* (2016). This index measures the economic policies related uncertainty of a wide array of developed and emerging economies.

¹⁷ According to the IMF (2018), the former (latter) adopt a soft pegged regime (managed floating) regime. The remaining countries adopt floating regimes.

¹⁸ The sensitivity analysis results are detailed in Appendix D.

5. Conclusion

In this paper we use an original panel VAR methodology that accounts in particular for variable interactions, and Emerging Market (EME) interdependence to investigate the Exchange Rate Volatility (ERV) response to Economic Policy Uncertainty (EPU) shocks, which is, to our best knowledge the first attempt in this context.

Our results suggest that the ERV in EME is either sensitive to the local or foreign EPU. Such findings support the negative US uncertainty spillovers to macroeconomic activities abroad (*e.g.* Colombo, 2013) and complement this by showing that the ERV acts as a significant channel of such transmission. Finally, one of our novelties is the responsiveness of the US-EPU to EME outlook. Hence, even though the US is perceived as a net exporter of EPU, it also imports such an uncertainty from EME.

In addition, we provide novel insights into FOREX-EPU nexus which generally conclude that domestic activity (exchange rates) is more reactive to the global (home) EPU (Nilavongse *et al.* 2020). Assuming that such a difference is probably due to our procedure and specific context, we support the key role of markets cross sectional dependence when dealing with EPU implications. Then, it seems not suitable to generalize time series results and advanced economies or some major EME (*e.g.* China) findings to the whole emerging economies context.

Our findings have interesting implications to decisions makers and investors in EME. Picking sound economic policies and reducing the exposure to the US economic policy fluctuations is relevant for their future monitoring of exchange rate fluctuations. In addition, EME investors should incorporate home and abroad policy information in order to properly manage their exchange exposure and optimize portfolios allocation.

Finally, nonlinear assessments of the ERV-EPU nexus constitute worth mentioning potential avenues for future researches.

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Appendices

Appendix A. PVAR framework: the IRFs implementation

One of the advantages of using the PVAR methodology is to explicitly introduce fixed effects which means that (i) each country in the sample can have a specific level of each variable used and (ii) the fixed effect can potentially capture other invariant factors (*e.g.* exchange rate regimes, country size, financial regulation etc) (Grossmann *et al.* 2014). However, estimation biases may occur since fixed effects are correlated with regressors containing lagged dependent variables (Love and Zicchino, 2006). In such a circumstance, it is necessary to eliminate fixed effect using the “Helmert” method commonly used for that purpose¹⁹. In doing so, we preserve the orthogonality between transformed variables and lagged regressors which are used to instrument the VAR dynamics. Finally, the estimation is conducted using the Generalized Method of Moments (GMM).

One of the advantages of the VAR models is to allow evaluating the effects of one variable to another endogenous variable when keeping the other variables constant. This is what is called an orthogonal shock. Such a reaction is captured in the impulse response functions (IRFs) framework. Once all the coefficients of the PVAR model have been estimated the confidence bands of the orthogonalized IRFs are computed via Monte Carlo simulations as initially developed by Love and Zicchino (2006). To this end, we use the variance covariance matrix and the estimated coefficients from the PVAR to randomly build a draw of the VAR coefficients. Hence, the 5th and 95th percentiles are generated by replicating this procedure 1000 times in such a way confidence interval of the IRFs are obtained.

Nevertheless, the variance-covariance matrix is unlikely to be diagonal (Love and Zicchino, 2006). Accordingly, it is necessary to preserve the orthogonality of the residuals in order to isolate shocks to one variable in the VAR system. In this case, a usual convention is to adopt a Cholesky decomposition of the variance-covariance matrix of the residuals *i.e.* transforming the VAR in a recursive form for an identification purpose. Such a decomposition assumes that the variables should be ordered in the system following an ascending degree of endogeneity. More formally,

¹⁹ The “Helmert” procedure removes the mean of the future observation available in each country-year.

when a variable x appears earlier in the system and a variable y appears later, this means that x is exogenous with respect to y in the short run (Love and Zicchino, 2006).

In order to properly identify the variables ordering in the IRFs, a Granger causality test as in Goodell et al. 2020 is performed. The corresponding results are reported in Table A.1.

Table.A.1 Granger causality analysis

	US-EPU	ERV	EPU	Output
US-EPU	-	0.065*	0.000***	0.806
ERV	0.801	-	0.001***	0.046**
EPU	0.018**	0.878	-	0.843
Output	0.000***	0.033**	0.000***	-

This table displays results of the Granger causality test applied in order to check for the degree of exogeneity of our variables. This helps specify the appropriate ordering of the variables to properly undertake the Cholesky decomposition. In columns, explained variables are mentioned. The causing variables are given in rows. Significant p-values at 1, 5 and 10% are shown by ***, ** and *.

The results of the Granger causality test provide insight on how our four variables should be included in the PVAR model following the Cholesky decomposition. Based on the results reported in the Table A.1, we conclude that the most endogenous variable is the local EPU since it is Granger caused by all the other variables. The US-EPU and the ERV exhibit the same endogeneity degree since they are both Granger caused by 2 variables among 3. Finally, the most exogenous variable is output because it is only Granger caused by one variable. Therefore, our variables are listed in the PVAR estimation, the IRFs and the FEVD as follows: [Output, US-EPU, ERV, and EPU].

Appendix B. Preliminary Analysis

Table B.1 Preliminary tests results

Variables	1 st generation panel unit root test of Levin-Lin-Chu (2002)	Pesaran (2004) CD test	2 nd generation panel unit root test of Pesaran (2007)
ERV	-13.986***	25.84***	-5.25***
US-EPU	-10.51***	73.32***	-
EPU	-8.18**	15.9***	-3.06***
Output	-5.209***	30.94***	-2.70***
GEPU	-5.64***	73.32***	-

This table recapitulates the obtained results of 1st and 2nd generation panel unit root tests and cross-sectional dependence test. GEPU indicates the global EPU index used in the robustness check purpose. ** and *** indicate statistical significance at 5 and 1 % levels respectively.

Regarding the preliminary analysis, we have, first, conducted the Levin-Lin-Chu (2002) 1st generation unit root test that reveals the stationarity of all the variables used in this paper. Second, we have undertaken the Pesaran (2004) CD test in order to check for the cross-sectional dependence (the null hypothesis assumes no cross-sectional dependence). The results clearly support the rejection of the null hypothesis. Such a result conducted us to check for the presence of unit roots relying on 2nd generation Pesaran (2007) panel unit root test. Assuming cross sectional dependence, this test highlights the stationarity of almost all variables. Note that the Pesaran (2007) test is not able to provide results with respect the US-EPU and Global EPU (robustness check) since the same variable is used for all the countries in the sample. We assume that these two variables are stationary in level based on the Levin-Lin-Chu (2002)'s test.

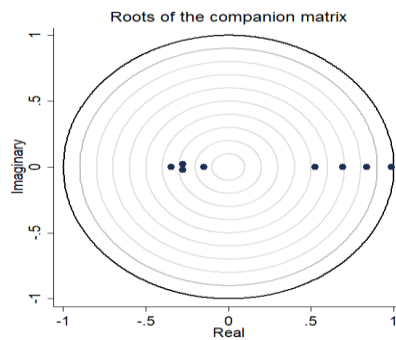
Appendix C. PVAR estimation

Table C.1. Optimal lag selection

Lags	HQ	SIC	AIC
1	-158.129	96.77	1.802
2	-177.33*	-7.40*	-70.71*
3	-85.60	-0.63	-32.28

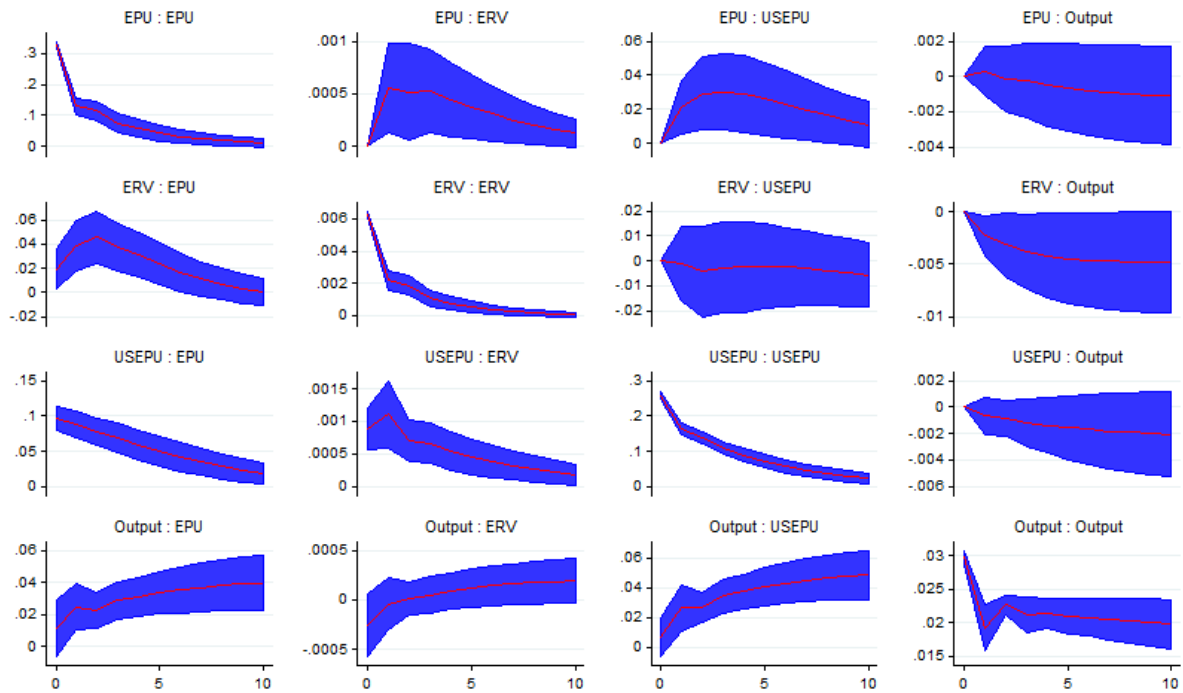
This table summarizes the results of the information criteria considered in order to properly choose the lags to include in the VAR system. In such an empirical methodology, the optimal lag selection is a crucial step. We make the choice of initially considering 3 lags since having a higher number of lags generates a loss of degree of freedom. This may result in over-parametrization. The result reported in this Table unanimously suggests 2 lags for the endogenous variables since it broadly minimizes the 3 information criteria.

Figure C.2. Baseline specification stability



The results reported in this graph indicate that all eigenvalues are inside the unit circle. Consequently, the estimated PVAR fully satisfies the stability condition.

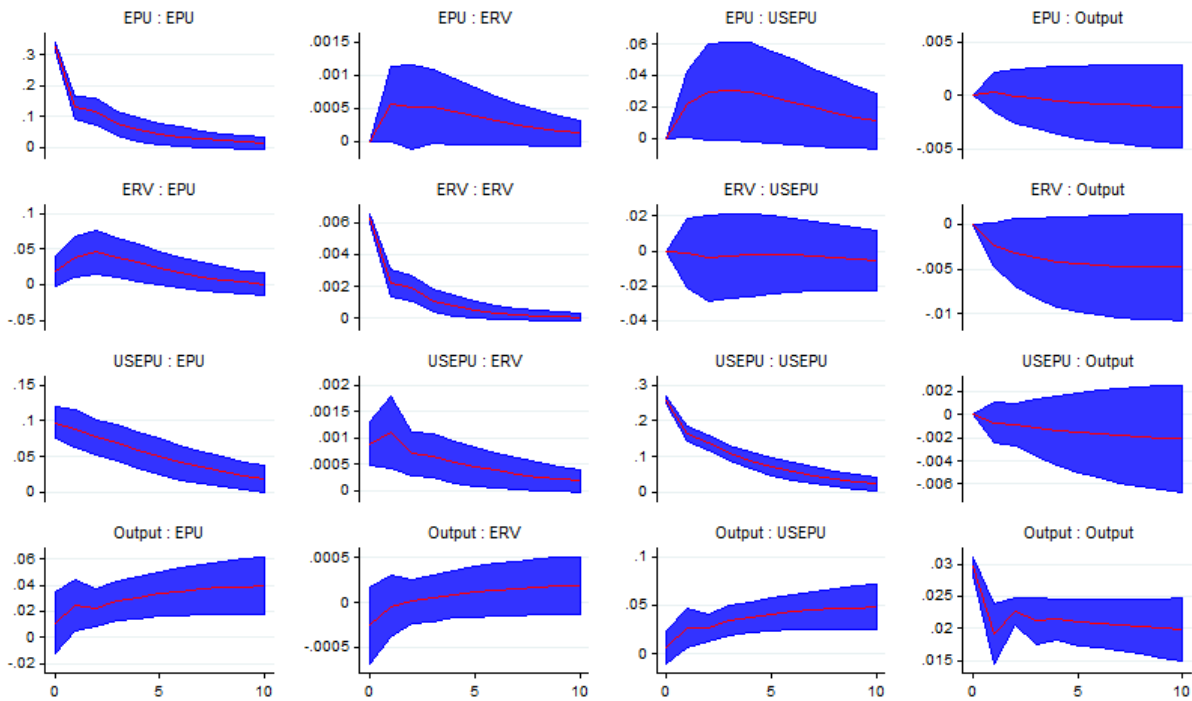
Figure C.3. IRFs for benchmark PVAR model



This figure plots the reaction of all the variables to a positive one standard deviation shock of each variable in the PVAR system along with 95% error bands (impulse: response). The blue boxes are the 95% confidence intervals constructed via Monte-Carlo simulations with 1000 replications. All graphs show the response at 10 months horizon. Non-zero effects *i.e.* significant shocks impacts are observed when the zero line is outside of the corridor.

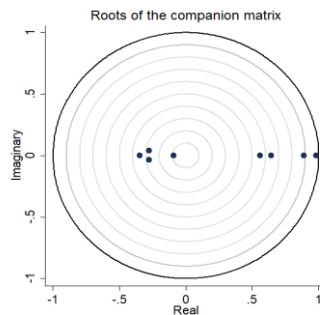
Appendix D. Robustness Check

Figure D.1 IRFs with alternative confidence band (1%)



This figure plots the reaction of all the variables to a positive one standard deviation shock of each variable in the PVAR system along with 99 % error bands (impulse: response). The blue boxes are the 99% confidence intervals constructed via Monte-Carlo simulations with 1000 replications. All graphs show the response at 10 months horizon. Non-zero effects *i.e.* significant shocks impacts are observed when the zero line is outside of the corridor.

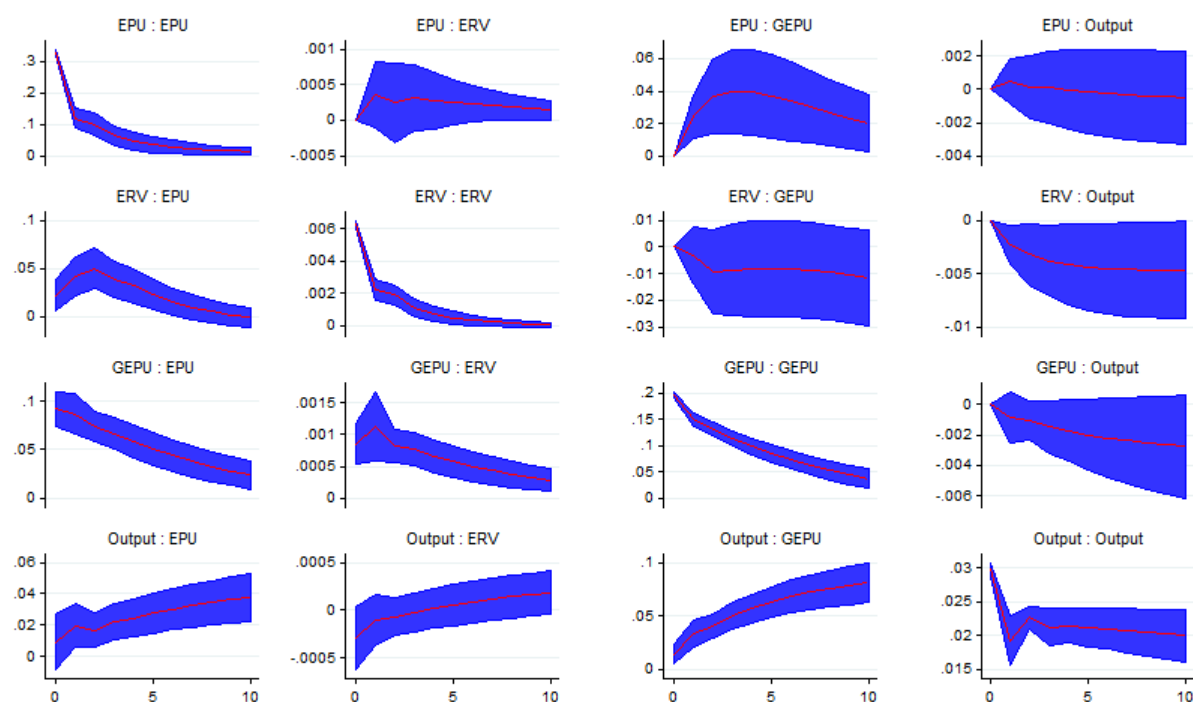
Figure D.2. Stability of the PVAR with Global EPU



In order to select the optimal lag for this alternative specification, we have considered, as in the baseline model, the three information criteria discussed above. The results suggest 2 lags (not reported here but available upon request) to be introduced in the PVAR system.

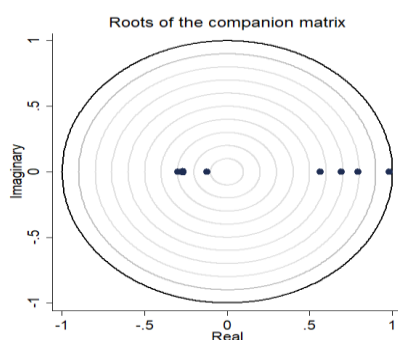
As for the benchmark specification, the results mentioned in Figure D.2 indicate that all eigenvalues are inside the unit circle. Hence, the stability of the PVAR model is verified again.

Figure D.3. IRFs for the model with Global EPU



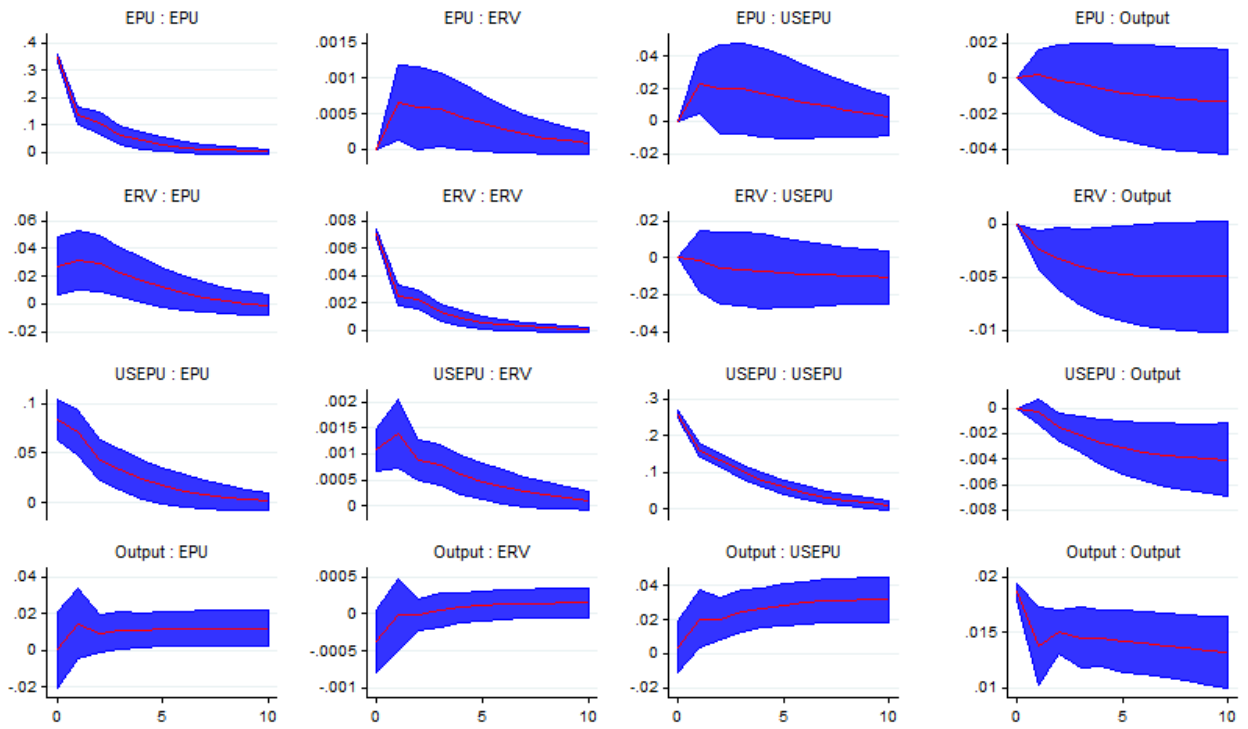
This figure plots the reaction of all the variables to a positive one standard deviation shock of each variable in the PVAR system along with 95 % error bands (impulse: response). The blue boxes are the 95% confidence intervals constructed via Monte-Carlo simulations with 1000 replications. All graphs show the response at 10 months horizon. Non-zero effects *i.e.* significant shocks impacts are observed when the zero line is outside of the corridor. EPU and GEPU are respectively the local and the global EPUs.

Figure D.4. Stability of the PVAR excluding Singapore and China from the sample



As for the previous robustness specification, the optimal lag is chosen based on the three information criteria also retained in the baseline model. Regarding the stability condition, we can observe on Figure D. 4 that eigenvalues are inside the unit circle, which indicates the stability of this alternative PVAR specification.

Figure D.5. IRFs for the model without Singapore and China



This figure plots the reaction of all the variables to a positive one standard deviation shock of each variable in the PVAR system along with 95% error bands (impulse: response). Confidence bands are illustrated in the blue box and are computed using Monte Carlo simulations with 1000 replications.