Volatility spillovers among uncertainty measures. The case of EU member states

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Abstract:

The study investigates volatility spillovers among three types of uncertainty - financial, consumer, and industrial - in EU member states in the period between January 2005 and December 2017.

The results suggest that most volatility is transmitted between countries within a given type of uncertainty. What is important, the pairs of countries that transmit uncertainty to one another are geographically related (i.e. they are neighbouring countries). Financial uncertainty can be seen as net volatility transmitter to both industrial and consumer uncertainties. The study proposes decomposition of the connectedness table into symmetric and skew-symmetric parts, which offers an attractive and comprehensive interpretation.

Keywords: economic uncertainty spillovers, EU member states, square asymmetric matrix decomposition

Introduction

Economic uncertainty appears in modern empirical literature as an important phenomenon. The increase of uncertainty results in the decline in economic activity. The depth and persistence of the economic slowdown depend on the type of uncertainty used in a given study and the specificity of the economy. The most popular uncertainty types include: financial uncertainty [8], macroeconomic uncertainty [18], [21], industrial uncertainty [4], and economic policy uncertainty [5]. Literature reports uncertainty measures which are constructed using country-specific data [8], [4], [18]. Therefore, it seems essential to discover the relations among different types of uncertainty within a given country and to recognise the types of uncertainty observed outside a country which could be transmitted to domestic economy. This knowledge allows policymakers to appropriately react to any type of uncertainty increase in domestic and foreign economy.

The majority of previous studies examine volatility spillovers within one of the types of uncertainty across countries. For example, [11], [1], [20], [17], [6], [19] analyse economic policy uncertainty spillovers among major economies. Similarly, [22], [2] examine volatility spillovers of economic uncertainty among developed economies, while [3] investigate spillovers of various types of economic policy uncertainty in Greece. However, there are, to the best of our knowledge, no papers dedicated to different types of uncertainty spillovers across countries.

The aim of the study is to analyse volatility spillovers among three types of uncertainty measures: industrial, consumer and financial, which are calculated for 21 UE member states in the period between January 2005 and December 2017.

Volatility spillovers among uncertainty measures are analysed within the connectedness table, as proposed by [13], [14]. The analysis consists of two steps. Firstly, the parameters of the VAR model, which includes all 63 uncertainty measures, are estimated using LASSO ([12], [15]). The VAR model obtained is next used to construct the connectedness table, which represents the forecast error variance decomposition of all the variables. Secondly, the connectedness table is decomposed into symmetric and skew-symmetric parts. New matrices can be examined using multidimensional statistical techniques, which offers an attractive and comprehensive interpretation. The symmetric matrix can be used to analyse the similarity of uncertainty measures regarding volatility transmission. Multidimensional scaling, as well as clustering, are applied to examine the symmetric matrix. The skew-symmetric matrix represents net volatility transmission (the difference between volatility transmitted and received, see [13] and is illustrated in the study by heat maps.

The novelty of the paper arises from two reasons. First, the study proposes a thorough analysis of three types of the uncertainty spillovers among EU member states, and, second, it offers a new approach for interpreting the connectedness table.

Methodology

Having the high-dimensional connectedness table, it is inconvenient to present the pairwise results in a way described in [13]. The network graph proposed by [12] could be vague if there are a lot of connections between objects studied. In order to interpret the contents of the connectedness table in such conditions, we propose to decompose the table into symmetric and skew-symmetric components. Formally, decomposition of any square asymmetric matrix $\boldsymbol{Q}$ is given as (see [9]):

$$\boldsymbol{Q} = \boldsymbol{S} + \boldsymbol{A} \quad (1)$$

where $\boldsymbol{S}$ is a symmetric matrix with elements calculated as averages $(q_{ij} + q_{ji})/2$, and $\boldsymbol{A}$ is a skew-symmetric matrix with elements: $(q_{ij} - q_{ji})/2$. Matrix $\boldsymbol{A}$ is skew-symmetric, which means that $\boldsymbol{A}^T = -\boldsymbol{A}$.

Matrix $\boldsymbol{S}$ represents dissimilarity between objects, and after some transformations (matrix $\boldsymbol{S}$ can be transformed into a distance matrix) can be used as an input in a clustering exercise, and the distance can be visually represented using multidimensional scaling. Skew-symmetric component $\boldsymbol{A}$ represents the difference between transmitted and received volatility, thus embodies net transmission. We propose to use heat maps to illustrate matrix $\boldsymbol{A}$.

Proposed decomposition is additive, and, as the two components are orthogonal, the sum of squares of the two matrices is also additive, which could be derived from the following equation:

$$\sum_{i=1}^{n}\sum_{j=1}^{n} q_{ij}^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} s_{ij}^2 + \sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}^2. \quad (2)$$

As a result, the two components can be analysed independently.

Data and empirical results

The analysis of volatility spillovers among the three types of uncertainty measures, i.e. industrial, consumer and financial, conducted in 21 EU member states is based on the monthly data spanning the period from January 2005 to December 2017. The study does not include Cyprus, Croatia, Estonia, Ireland, Luxemburg, Malta and Slovenia due to the lack of data from these countries. To construct country-specific industrial and consumer uncertainty indicators, the data are obtained from the Joint Harmonised EU Programme of Business and Consumer Surveys (BCS), which is coordinated by the European Commission (2016). The country-specific financial uncertainty proxies are computed using the volatility of actual returns of the main stock markets indices in particular countries. The data are obtained from Thomson Reuters Datastream.

Construction of different uncertainty measures

Industrial uncertainty indices for each country (*INDU_country*) are constructed on the basis of the responses to the forward-looking question in the BCS. Following [4], uncertainty is understood as the dispersion of managers' responses to the survey question: *How do you* *expect your production to develop over the next 3 months?* The possible answers are*: increase, remain unchanged* or *decrease*. Industrial uncertainty index is measured as:

$$INDU\_country_t = \sqrt{Frac_t^+ + Frac_t^- - (Frac_t^+ - Frac_t^-)^2}, \quad (3)$$

where $Frac_t^+$ is the weighted fraction of managers with "increase" responses at time t, and $Frac_t^-$ is the weighted fraction of managers with "decrease" responses at time t.

Country-specific consumer uncertainty indices (*C_country*) are constructed using BCS dataset. The dispersion of consumers' expectations is measured using the following question: *How do you expect the financial position of your household to change over the next 12 months?* Respondents select one of six possible categories (*get a lot better, get a little better, stay the same, get a little worse, get a lot worse,* and *don't know*). Following [7], consumer uncertainty index is calculated using Theil's entropy formula as:

$$C\_country_t = -\frac{1}{n}\sum_{i=1}^{n} a_{i,t} log\left(a_{i,t}\right), \quad (4)$$

where $a_{i,t}$ is the share of respondents choosing each type of response at time t, and *n* is the number of response categories for each forward-looking question.

Following Bloom (2009), Bachmann et al. (2013), and Choi et al. (2017), country-specific financial uncertainty indices (*S_country*) are measured by the realized volatility of aggregate stock market returns from each country using the formula:

$$S\_country_t = 100\sqrt{T\sum_{s=1}^{T} r_s^2}\ , \quad (5)$$

where r_s is daily returns of the stock market from each trading day *s,* and *T* is the stock market's number of trading days in a month.

Fig. 1a-1c present three types of uncertainty measures which are calculated using Eq. 3-5 in particular EU member states.

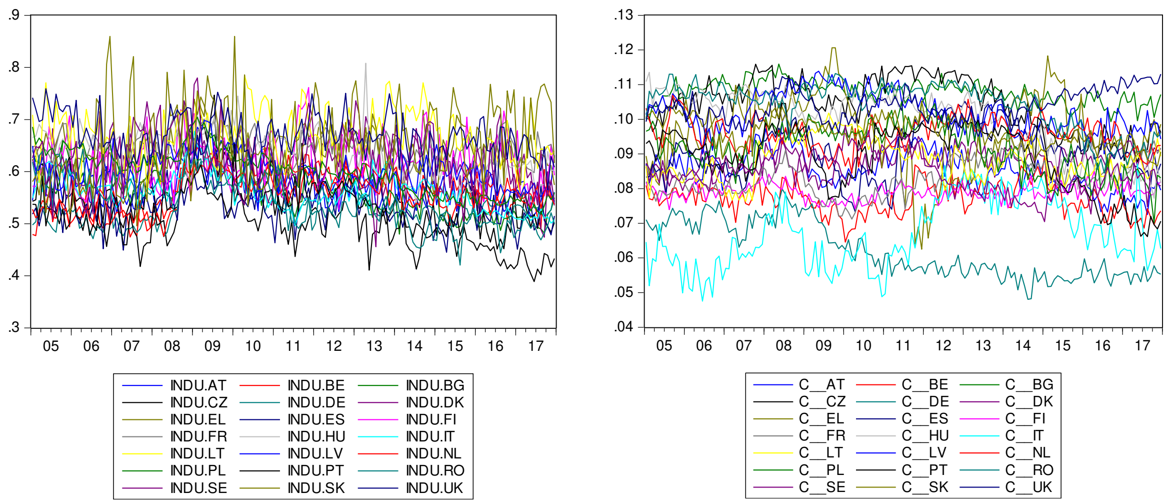

Fig. 1a Industrial uncertainty

Fig 1b. Consumer uncertainty

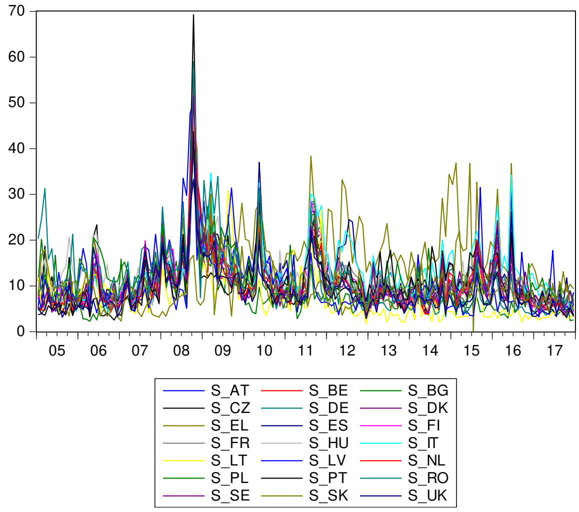

Fig. 1c Financial uncertainty

Results of decomposition of the connectedness table

In the first step, the VAR model with two lags is estimated[1] using LASSO. The connectedness table of 63x63 dimension is next decomposed into symmetric and skew-symmetric components (Eq.1 and Eq. 2). The symmetric part $\boldsymbol{S}$ is used to analyse the similarity of uncertainty measures regarding volatility transmission. It is assumed that the more related two uncertainties are, which means high volatility transmission between them, the more similar they are, and the smaller distance between them is observed. In order to transform $\boldsymbol{S}$ into a distance matrix, first, we remove the diagonal elements in $\boldsymbol{S}$, and next, we use the formula: $100 - s_{ij}$ for all non-diagonal elements of $\boldsymbol{S}$[2]. The final matrix can be interpreted as a distance matrix and can be used to cluster different uncertainty measures and to visualize the distance between them. The left panel of Fig. 2 presents a dendrogram obtained for Ward's method and the Euclidean distance. Fig. 2 (the left panel) presents two separate clusters in the dendrogram. The first cluster includes only financial uncertainties for each country, while the second cluster contains industrial and consumer uncertainties. The smallest distance is obtained for uncertainty measures of the same type which represent the neighbouring countries. Such pairs constitute consumer uncertainty for Hungary and the Czech Republic, Italy and Spain, and industrial

[1] Two-lags model seems to be enough to observe the spillover effect between uncertainties, although robustness check shows that different numbers of lags provide similar results.

[2] Another formula, i.e. $\mathrm{Max}_{ij\{s_{ij}\}} - s_{ij}$, is used, and the results are similar.

uncertainty for Germany and the Netherlands, Finland and Sweden[3]. When financial uncertainty is considered, the groups of related countries include: Lithuania and Latvia; Austria and Czech Republic; Italy and Spain; the Netherlands, France, Belgium and Germany; Denmark and Finland.

Similar results are obtained when multidimensional scaling is applied (the right panel of Fig. 2). Colours are used to determine different types of uncertainties. The red colour represents financial uncertainties (country-specific), the green one - industrial uncertainties, and the blue one - consumer uncertainties. As can be seen, financial uncertainty for each country (except Slovakia) is located close to each other in the diagram. The remaining uncertainties seem to constitute another cluster, which is, however, less homogenous. All industrial and most of consumer uncertainties appear in the top-right part of Fig.2. There is, however, a group of consumer uncertainties which represent Central Eastern European countries (Poland, Hungary, the Czech Republic, Romania) in the bottom-right part.

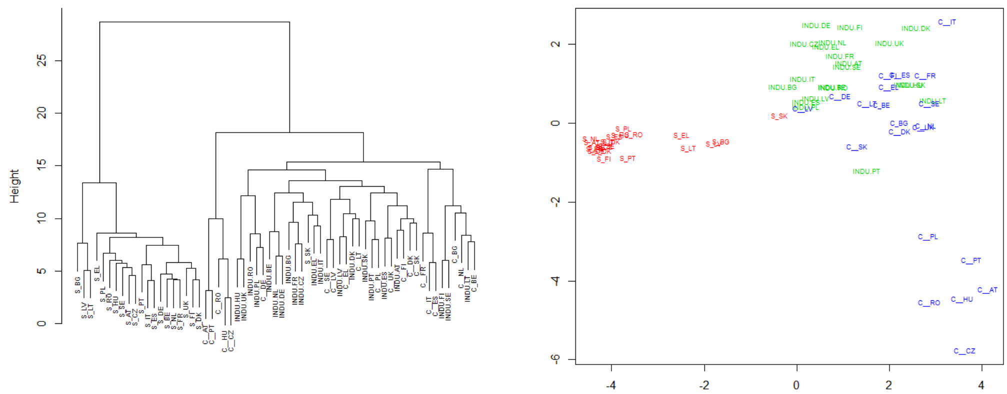

Fig. 2. The symmetric part of the connectedness table – the dendrogram for Ward's method and the Euclidean distance (left) and the results of multidimensional scaling (right)

Skew-symmetric part of the connectedness table

The heat map presented in Fig. 3 reveals asymmetry in all considered pairs. The uncertainties are ordered according to net volatility transmission. The uncertainties on the left (the horizontal axis) are net volatility transmitters, and the uncertainties on the right are net volatility receivers. Colours represent the difference between the amount of volatility transmitted and received for all possible pairs of the uncertainties. The blue colour indicates

[3] Still, one can notice similar uncertainties representing different categories and distant countries e.g. C_AT, C_PT, INDU_PT, C_PL.

that the uncertainty from the horizontal axis is a net volatility transmitter against the uncertainty from the vertical axis, while the red colour shows the opposite relation. As Fig. 3 reveals, the majority of financial uncertainties for each country (except Slovakia) are net volatility transmitters. All these uncertainties transmit more volatility to the remaining uncertainties (consumer and industrial) than they receive from them. On the other hand, four consumer uncertainties (the right end of the horizontal axis) turn out to be the largest volatility receivers. In the middle of the horizontal axis, there are measures for both industry and consumer uncertainty. However, it is worth noticing that the strongest asymmetry (the difference between volatility transmitted and received), marked by the most intensive red (blue) colour, is observed for pairs of consumer uncertainties (e.g. consumer uncertainty in Italy (C_IT) transmits volatility to consumer uncertainty in Spain (C_ES)).

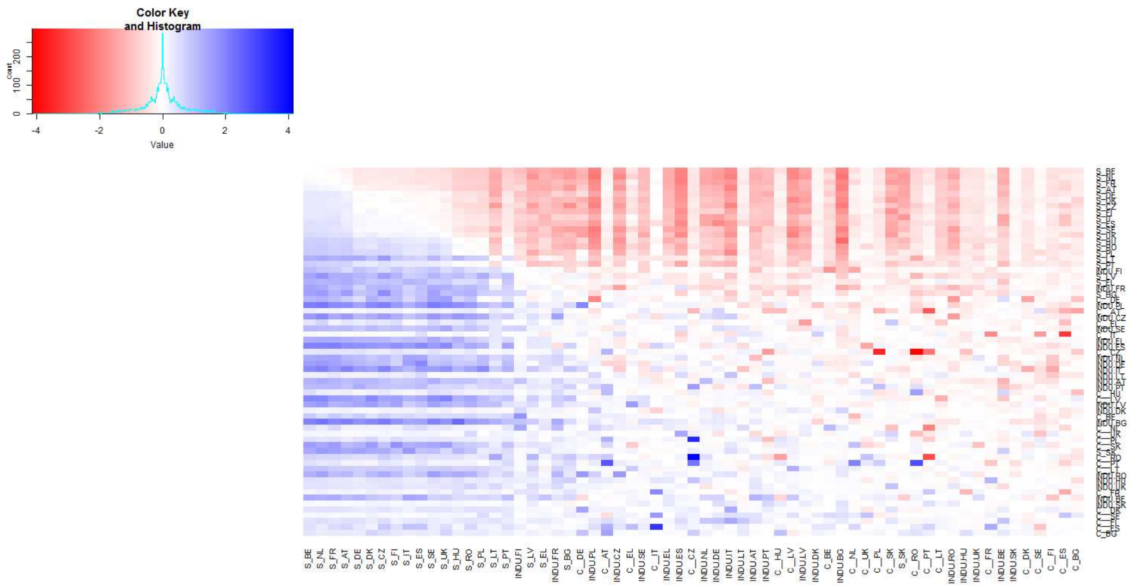

Fig. 3. The skew-symmetric part - a heat map

Conclusion

The most general conclusion that can be drawn from the study states that most volatility is transmitted within a particular type of uncertainty. This means that a shock of a particular type of uncertainty observed in one country is mainly transmitted to the same type of uncertainty in another country. However, it is worth noticing that pairs of countries which transmit uncertainty to one another are geographically related (i.e. they are neighbouring countries). Transmission of a different type of uncertainty within a given country is limited. Another conclusion refers to a situation when three types of uncertainty are considered: in such case financial uncertainty can be seen as net volatility transmitter. This means that both foreign anddomestic financial uncertainties are transmitted to industrial and consumer uncertainties in each country.

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References

[1] Ajmi, A. N., Gupta, R., & Kanda, P. T. (2014). Causality between Economic Policy Uncertainty across Countries: Evidence from Linear and Nonlinear Tests. *Frontiers in Finance & Economics*, *11*(1), 73–102.

[2] Antonakakis, N., Gabauer, D., & Gupta, R. (2018b). *Greek Economic Policy Uncertainty: Does it Matter for the European Union?* (No. 201840).

[3] Antonakakis, N., Gabauer, D., Gupta, R., & Plakandaras, V. (2018a). Dynamic connectedness of uncertainty across developed economies: A time-varying approach. *Economics Letters*, *166*, 63-75.

[4] Bachmann, R., Elstner, S., & Sims, E. R. (2013). Uncertainty and economic activity: Evidence from business survey data. *American Economic Journal: Macroeconomics*, *5*(2), 217-49.

[5] Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *The Quarterly Journal of Economics*, *131*(4), 1593-1636.

[6] Balli, F., Uddin, G. S., Mudassar, H., & Yoon, S. M. (2017). Cross-country determinants of economic policy uncertainty spillovers. *Economics Letters*, *156*, 179-183.

[7] Balta, N., Fernández, I.V., & Ruscher, E. (2013). Assessing the impact of uncertainty on consumption and investment. *Section I, Quarterly Report on the Euro Area*, 12, 7–6.

[8] Bloom, N. (2009). The impact of uncertainty shocks. *Econometrica*, 77(3), 623-685.

[9] Borg, I., & Groenen, P. (2003). Modern multidimensional scaling: theory and applications. *Journal of Educational Measurement*, *40*(3), 277-280.

[10] Choi, S., Furceri, D., Huang, Y., & Loungani, P. (2017). Aggregate uncertainty and sectoral productivity growth: the role of credit constraints. *Journal of International Money and Finance*. in press https://doi.org/10.1016/j.jimonfin.2017.07.016

[11] Colombo, V. (2013). Economic policy uncertainty in the US: Does it matter for the Euro area?. *Economics Letters*, *121*(1), 39-42.

[12] Demirer, M., Diebold, F. X., Liu, L., & Yilmaz, K. (2018). Estimating global bank network connectedness. *Journal of Applied Econometrics*, *33*(1), 1-15.

[13] Diebold, F. X., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal*, *119*(534), 158-171.

[14] Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, *28*(1), 57-66.

[15] Diebold, F. X., & Yilmaz, K. (2015). *Financial and macroeconomic connectedness: A network approach to measurement and monitoring*. Oxford University Press, USA.

[16] European Commission (2016) The joint harmonised EU programme of business and consumer surveys (user guide), available at http://ec.europa.eu/economy_finance/db_indicators/surveys/documents/bcs_user_guide_en.pdf, last accessed on 10 July 2018.

[17] Gupta, R., Pierdzioch, C., & Risse, M. (2016). On international uncertainty links: BART-based empirical evidence for Canada. *Economics Letters*, *143*, 24-27.

[18] Jurado, K., Ludvigson, S. C., & Ng, S. (2015). Measuring uncertainty. *The American Economic Review*, *105*(3), 1177-1216.

[19] Kang, S. H., & Yoon, S. M. (2018). Dynamic connectedness network in economic policy uncertainties. *Applied Economics Letters*, 1-5.

[20] Klößner, S., & Sekkel, R. (2014). International spillovers of policy uncertainty. *Economics Letters*, *124*(3), 508-512.

[21] Rossi, B., & Sekhposyan, T. (2015). Macroeconomic uncertainty indices based on nowcast and forecast error distributions. *American Economic Review*, *105*(5), 650-55.

[22] Yin, L., & Han, L. (2014). Spillovers of macroeconomic uncertainty among major economies. *Applied Economics Letters*, *21*(13), 938-944.