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Influence of petroleum and gas trade of Russia on EU economies from the Google matrix analysis of UN COMTRADE data

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Abstract. Using the United Nations COMTRADE database [1] we apply the reduced Google matrix (REGOMAX) algorithm to analyze the multiproduct world trade in years 2004-2016. Our approach allows to determine the trade balance sensitivity of a group of countries to a specific product price increase from a specific exporting country taking into account all direct and indirect trade pathways via all world countries exchanging 61 UN COMTRADE identified trade products. On the basis of this approach we present the influence of trade in petroleum and gas products from Russia, USA, Saudi Arabia and Norway determining the sensitivity of each EU country. We show that the REGOMAX approach provides a new and more detailed analysis of trade influence propagation comparing to the usual approach based on export and import flows. The crisis contagtion on this world multiproduct trade network, induced by increase of petroleum price, is also analyzed.

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The statistical data of UN COMTRADE and the World Trade Organization (WTO) Statistical Review 2018 demonstrate the vital importance of the international trade between world countries for their development and progress. Also the whole world economy deeply depends on the world trade. At present the UN COMTRADE database contains data for 294 UN countries and former countries with more than 10^4 trade products. Thus the whole matrix of trade monetary flows reaches a large size $\sim 10^6$. In fact for each year the commercial exchange between countries represents the directed network with transactions of various commodities (products) expressed in their US dollar (USD) values of the given year.

It is clear that the recent research developments in the field of complex networks should find useful applications for analysis of this multiproduct World Trade Network (WTN). In [2,3] it was proposed to use the methods of the Google matrix G, PageRank and CheiRank algorithms for analysis of the WTN. The PageRank algorithm had been invented by Brin and Page [4] for the ranking of nodes of the World Wide Web (WWW) being at the foundation grounds of the Google search engine [4]. The applications of these methods to a variety of real directed networks are described in [6]. In contrast to the usual economy approach based on bilateral import and export flows, the Google matrix analysis treats all world countries on equal grounds (since all columns with outgoing country flows of G are normalized to unity so that rich and poor countries have equal consideration) and also the PageRank and CheiRank algorithms take into account the whole chain of transactions incorporating the importance of specific network nodes. This is drastically different from the simple bilateral transactions of import and export.

Usually in directed networks, like WWW or Wikipedia, the PageRank vector of the Google matrix plays the dominant role since its components are on average proportional to the number of ingoing links. For the WTN the ingoing flows are related to import. However, the outgoing flows, related to export, are also important for trade. Thus we also use the Google matrix G^*, constructed from the inverted transaction flows, with its PageRank eigenvector, called CheiRank vector. The components of this vector are on average proportional to the number of outgoing links in the original WTN. The construction rules of G and G^* for the case of multiproduct WTN are described in detail.

In many cases it is important to know the effective interactions of trade transactions for a specific region (i.e., for selected nodes of the global network) on which one wants to focus the analysis. This requires to know not only direct links between nodes but also the indirect (or hidden) links which connect the selected nodes via the remaining part of the global network. Recently the reduced Google matrix (REGOMAX) algorithm has been invented in and tested with various directed networks. This algorithm originates from the scattering theory of nuclear and mesoscopic physics and the field of quantum chaos. In this

work, using the COMTRADE data, we apply the REGOMAX algorithm to analyze the influence on European Union (EU) countries of petroleum and gas trade from Russia (RU), USA (US), Saudi Arabia (SA) and Norway (NO). With this approach we are able to measure the sensitivity of EU countries to the supply of petroleum and gas from one of these four countries taking into account the global WTN, i.e., taking into account all direct and indirect transactions of 61 major products with the rest of the world.

We collected the multiproduct (multicommodities) trade data from UN COMTRADE database for $N_c = 227$ countries, $N_p = 61$ products given by 2 digits from the Standard International Trade Classification (SITC) Rev. 1, and for years 2004, 2008, 2012, 2016. These 61 products represent all smaller subdivided specific products which number goes up to $\sim 10^4$. This approach was used in [3]. However, in this way there we had the effect of global price change of petroleum or gas for all countries. Here, we want to determine the sensitivity of country balance to a flow of petroleum from a specific country (e.g. RU, US, or SA).

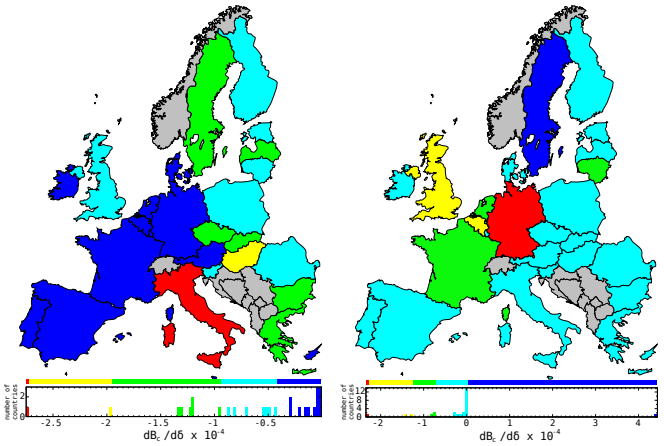

Fig. 1. EU countries balance derivative $dB_c/d\delta$ induced by an increase of gas price from Russia (left panel) and Norway (right panel) in 2016. The color categories are obtained using the Jenks natural breaks classification method.

We present in Fig. 1 EU trade balance sensitivity to gas from RU and Norway (NO) in 2016. EU sensitivities to RU gas is one order of magnitude weaker for gas than petroleum. The price increase of the RU gas mainly affects Italy (IT) while other Western EU countries being relatively not sensitive. Again RU neighboring countries are the most sensitives to RU gas import. The most sensitive EU economies to Norwegian gas are DE economy (and to a lesser extent GB and BE economies) which would be affected by NO gas price increase and SE economy which would benefit from it. The positive balance trade sensitivity for SE is certainly due to the entanglement of NO-SE economies. The others economies are insensitive to NO gas (see peak of fourteen EU countries with balance trade around 0 in Fig. 1 right panel).

In this work we developed the reduced Google matrix (REGOMAX) analysis of the multiproduct world trade network with a specific accent to sensitivity of EU country trade balance to petroleum and gas prices from Russia, USA, Saudi Arabia and Norway. In particular we observe that, during the 2004-2016 time period, most of the EU countries are sensitive to price increase of Russian petroleum and petroleum products. The situation is different for Saudi Arabia and US petroleum price influence for which east and central EU countries are relatively less affected. The Netherlands, which is the best EU petroleum importer and exporter, is during this time period the most affected EU country by the price increase of either Russia, Saudi Arabia, or USA. The influence of Russian gas is mostly exerted to Eastern EU countries among which ancient USSR satellites, Western EU countries being insensitive with the exception of Italy. Although Norway is the second gas supplier for EU, the Norway price increase influences only few EU countries, affecting Germany during the whole 2004-2016 time period, France in 2004, Belgium in 2004 and 2012, and The Netherlands in 2012, but benefiting to Sweden (excepting around 2008).

We show that comparing to the usual export-import consideration this REGOMAX approach takes into account the cascade of chain influence propagation via all nontrivial pathways of trade relations between countries. Due to this feature this approach is more powerful compared to only nearby link analysis considered in the import-export approach. Thus the REGOMAX method allows to recover indirect influence of petroleum or gas price from a specific country on EU trade. We argue that the further investigation of such indirect influence will play an important role in petroleum or gas crisis contamination propagation in EU trade.

We also present the network analysis of crisis contagion on the world multiproduct trade network induced by increase of petroleum price.

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