Transformation of network connections in global merchandise trade in the context of structural shifts in Russia's foreign trade

April 16, 2025

XXV Yasin (April) International Academic Conference on Economic and Social Development

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The research was carried out within the framework of the Basic Research Program at HSE University in 2025 (ФИ-2025-63)

1. **Motivation**
2. Data and methodology
3. Empirical results
4. Conclusion

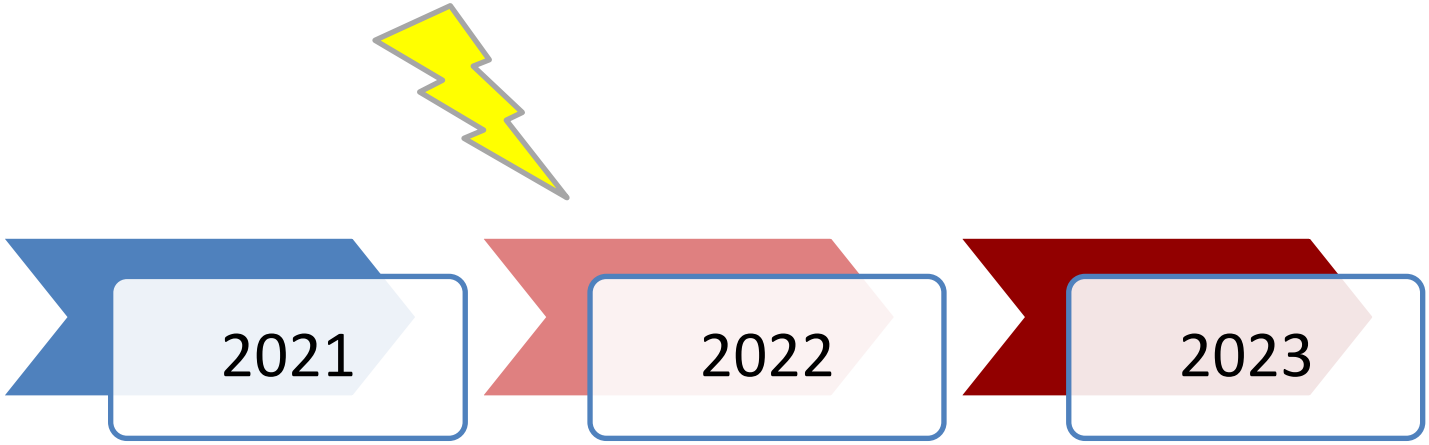
1. Motivation

- Recent shifts in global trade await to be studied
  - Since Feb 22, geographical structure of Russia's foreign trade have changed much; Sino-US confrontation is intensifying, and the fragmentation of global trade along geopolitical lines has been recorded (*Blanga-Gubbay and Rubinova, 2024*)
  - Such shifts should have influenced the entire complex of trade relations between countries, as well as the position of the largest countries in the global trade system
  - The most appropriate method for assessing these changes is the network approach

- The research on the impact of shocks on the trade network is emerging
  - From start (*Kali and Reyes, 2007*; *De Benedictis and Tajoli, 2011*), the economists mostly focused on increasing the explanatory power of the standard approaches by including network characteristics of global trade in the models
  - An emerging literature studies the impact of shocks on the world trade network as a whole and the countries' positions in the network; several papers examine the influence of the pandemic shock (*Kiyota, 2022*; *Vidya et al., 2023*), or a series of shocks such as the US-China trade war and the pandemic (*Alamsyah et al., 2023*)

1. Motivation

- Aim of the study
  - I expand the research area formed in the recent papers by using the most relevant data that accounts for the global trade dynamics in recent years
  - The study is devoted to estimating the transformation of network connections in global merchandise trade after the 2022 sanctions against Russia in the three aspects: estimating the changes in the positions in the world trade network for Russia, its main non-sanctioning partner countries and large antagonist countries



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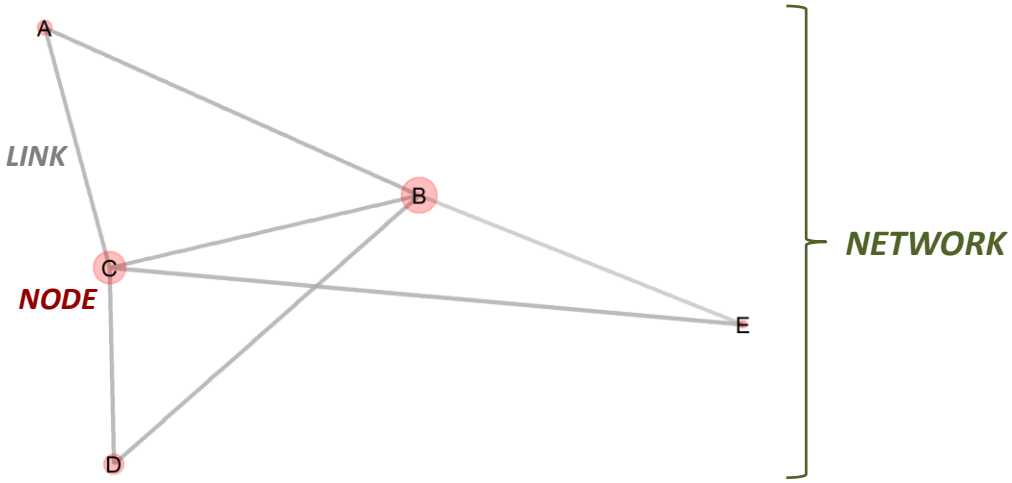
2. Data and methodology

- Data source
  - CEPII BACI database (*Gaulier and Zignano*, 2010) on bilateral trade flows
  - In January 2025, the data has been updated to account for 2023 trade flows
  - The database is enriched with data on South Korea (later UN data), Vietnam's & Iran's trade with Russia and Belarus (open sources), and those trade partners of Russia and Belarus which were present in direct 2021 data but did not report such trade in their own statistics
  - The analysis is conducted at an aggregated level (merchandise trade as a whole)
- Novelty
  - The first estimation of changes in world trade network [WTN] up to 2023 (before 2025, it was impossible to calculate network metrics for 2023, and estimates for 2022 may not be indicative due to structural changes and price turbulence)
  - The study focuses on Russia and compares the changes in the positions of Russia's largest non-sanctioning partner countries and antagonist countries in the WTN

2. Data and methodology

- The concept
  - Partner countries are considered as **nodes (or vertices)**,
    bilateral foreign trade flows are considered as **links (or edges)**,
    and the entire set of nodes & links in global trade is a **directed network (or graph)**



  - I calculate common network metrics (*Freeman, 1979*; *Bonacich, 1987*; *Wasserman and Faust, 1994*; *Watts and Strogatz, 1998*; *White and Harary, 2001*; *Burt, 2004*) for several recent years both for major countries (degree, betweenness, closeness, and eigenvector centrality measures; Burt's constraint index) and for the network as a whole (edge and vertex connectivity; clustering coefficients; assortativity)

2. Data and methodology

- Indicators for each node *i*

edges (impact)

- Degree centrality: $\boldsymbol{DC_i^{(out)} = \frac{\sum_j^N w_{i,j}}{N-1}}$, $\boldsymbol{DC_i^{(in)} = \frac{\sum_j^N w_{j,i}}{N-1}}$, where $w_{j,i}$ – weight of the edge between nodes *i* and *j* [w=1 for trade link, w=0 otherwise], *N* – no of nodes in the network
- Eigenvector centrality: $\boldsymbol{EC_i = \frac{1}{\lambda}\sum_{j\neq i}^N w_{j,i}\, EC_j}$, where λ – proportionality coefficient from the set of simultaneous equations (the node's *EC* is proportional to its neighbours' *EC*)

no of shortest paths*

- Closeness centrality: $\boldsymbol{CC_i^{(out)} = \frac{N-1}{\sum_{j\neq i}^N d_{i,j}}}$, $\boldsymbol{CC_i^{(in)} = \frac{N-1}{\sum_{j\neq i}^N d_{j,i}}}$, where $d_{i,j}$ – distance (no of non-repetitive vertices in the shortest path) between nodes *i* and *j* [for WTN, min=0.5 if all trade of *i* is mediated, max=1 if all trade of *i* is of a direct nature]
- Betweenness centrality: $\boldsymbol{BC_i = \frac{1}{\gamma}\sum_{l,k:\, l\neq k\neq i}^N (g_{l,i,k}/g_{l,k})}$, where $g_{l,k}$ – no of shortest paths between nodes *l* and *k*, $g_{l,i,k}$ – no of shortest paths between nodes *l* and *k* through node *i*

mediation

- Burt's constraint: $\boldsymbol{C_i = \sum_{j:\, j\neq i}^N c_{i,j}}$ is the sum of bilateral constraints from all nodes *j*, where $c_{i,j} = \left(p_{i,j} + \sum_{q:\, q\neq j\neq i}^N p_{i,q}p_{q,j}\right)^2$, and $p_{i,j} = \left(w_{i,j} + w_{j,i}\right)/\sum_{k:\, k\neq i}^N \left(w_{i,k} + w_{k,i}\right)$ is the relative strength of the direct link between *i* and *j*, while $\sum_{q:\, q\neq j\neq i}^N p_{i,q}p_{q,j}$ is the relative strength of indirect links between *i* and *j* through all nodes *q*

** **Shortest path** is the shortest sequence of non-repetitive vertices between two nodes*

2. Data and methodology

- Indicators for WTN as a whole

clustering

- Local clustering coefficient: $\boldsymbol{LCC_i} = \frac{\sum_{j,k:\, k\neq j\neq i} \boldsymbol{w_{i,j} w_{i,k} w_{j,k}}}{\sum_{j,k:\, k\neq j\neq i} \boldsymbol{w_{i,j} w_{i,k}}}$ is the share of connected neighbours, where $\sum_{j,k:\, k\neq j\neq i} w_{i,j} w_{i,k} w_{j,k}$ is the number of "triangles" with node *i*, and $\sum_{j,k:\, k\neq j\neq i} w_{i,j} w_{i,k}$ is the number if potential "triangles" for node *i*
- Global clustering coefficient: $\boldsymbol{GCC} = \frac{\sum_{i,j,k:\, k\neq j\neq i} \boldsymbol{w_{i,j} w_{i,k} w_{j,k}}}{\sum_{i,j,k:\, k\neq j\neq i} \boldsymbol{w_{i,j} w_{i,k}}}$ is like *LCC* for the whole set of *i*

connectivity

- Vertex connectivity: $\boldsymbol{K} = \boldsymbol{min}\{\boldsymbol{\kappa_{i,j:\, i\neq j}}\}$, where $\kappa_{i,j}$ is the minimum number of nodes whose deletion causes the disconnection of nodes *i* and *j*
- Edge connectivity: $\boldsymbol{\Lambda} = \boldsymbol{min}\{\boldsymbol{\lambda_{i,j:\, i\neq j}}\}$, where $\lambda_{i,j}$ is the minimum number of edges whose deletion causes the disconnection of nodes *i* and *j*

homophily

- Assortativity index: $\boldsymbol{r} = \frac{\sum_a \boldsymbol{e_{a,a}} - \sum_a (\sum_b \boldsymbol{e_{a,b}} \sum_a \boldsymbol{e_{a,b}})}{\boldsymbol{1} - \sum_a (\sum_b \boldsymbol{e_{a,b}} \sum_a \boldsymbol{e_{a,b}})}$ is the measure of connection between similar nodes, where $e_{a,a}$ is the share of edges that connect nodes of the same group *a*, and $e_{a,b}$ is the share of edges that connect nodes of different groups *a* and *b* [r=1 for much better connection of similar nodes, r=-1 for much better connection of dissimilar nodes]

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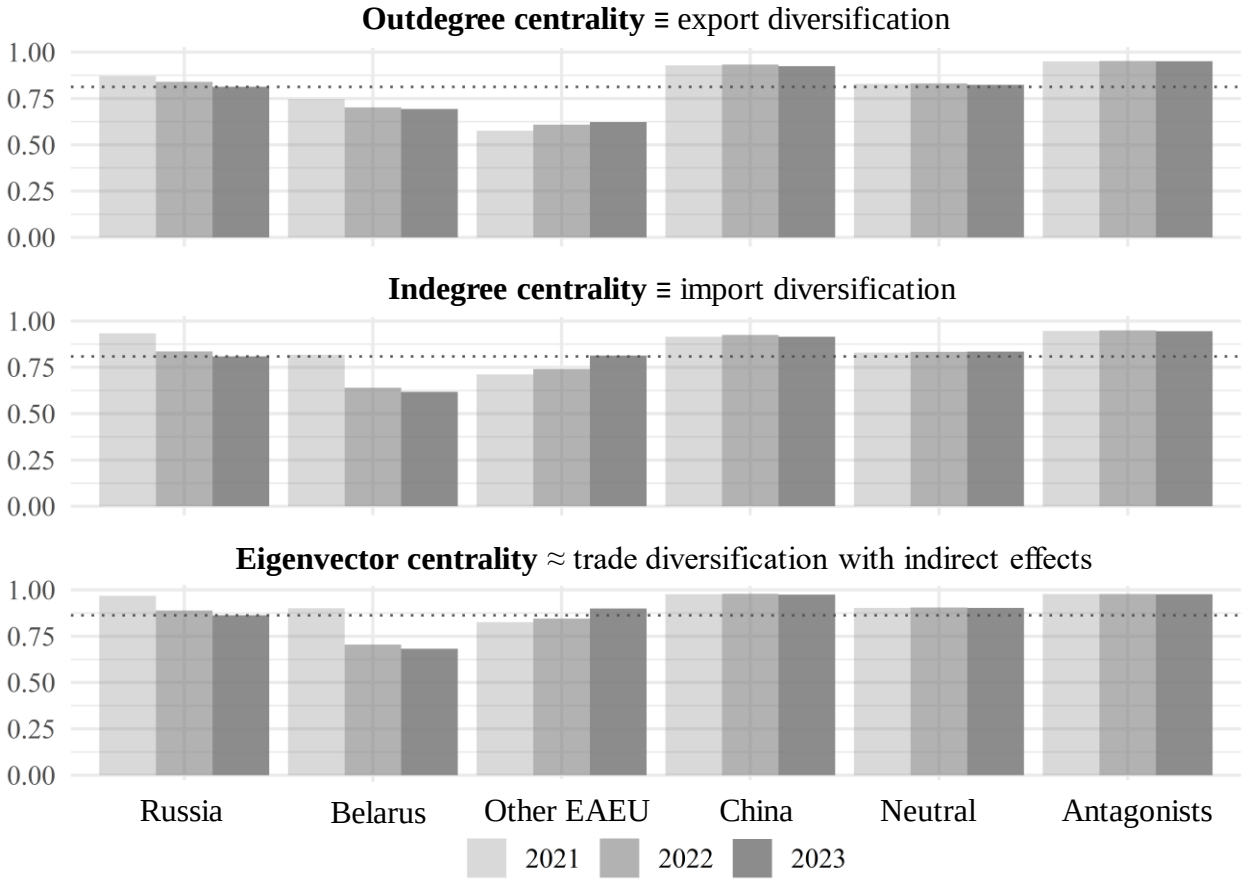
3. Empirical results

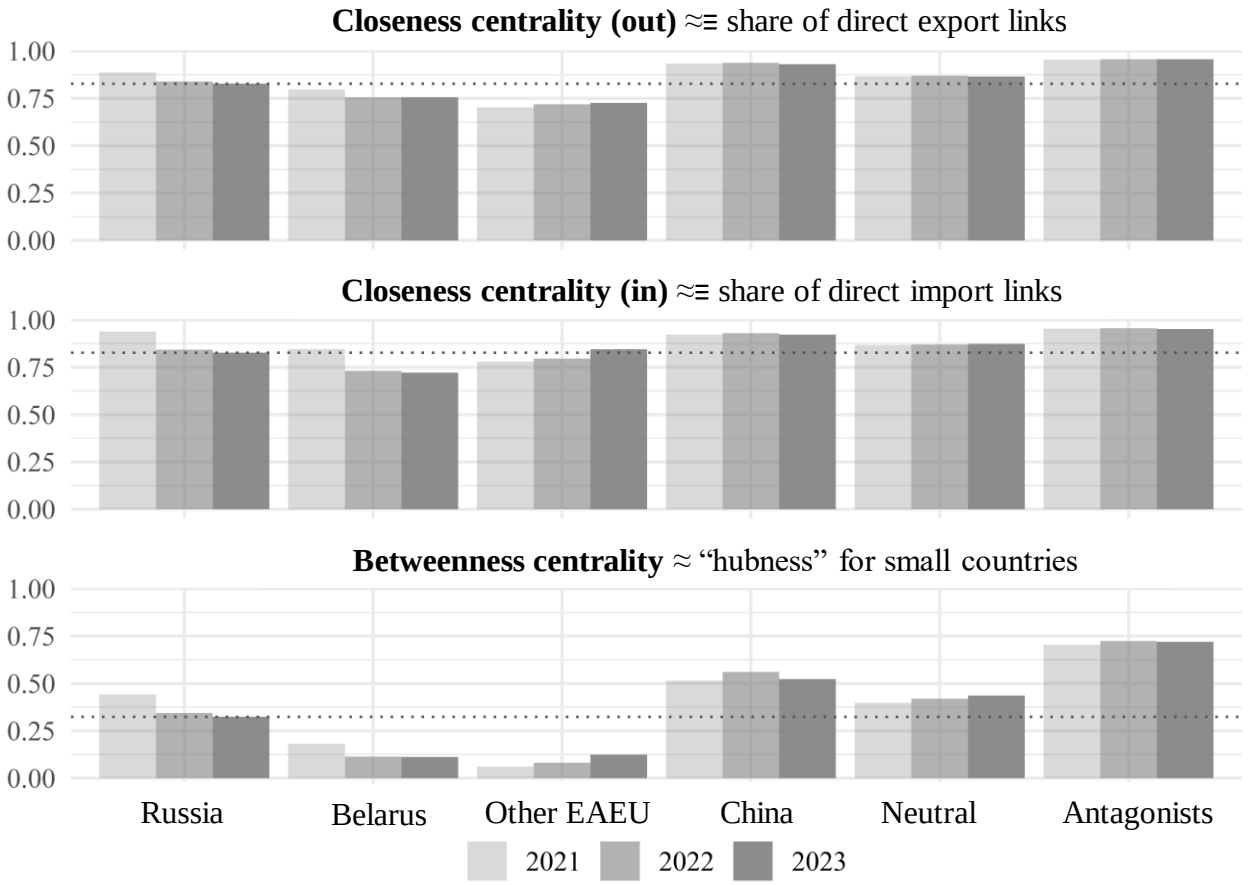
- **"Impact centralities":** pronounced reduction for Russia and Belarus
- Moderate improvement for other EAEU countries (higher no of links)
- Miserable changes for China, neutral and antagonist countries*



** **Antagonists** are countries that has imposed sanctions on Russia after 2022; other countries are regarded as **neutral***

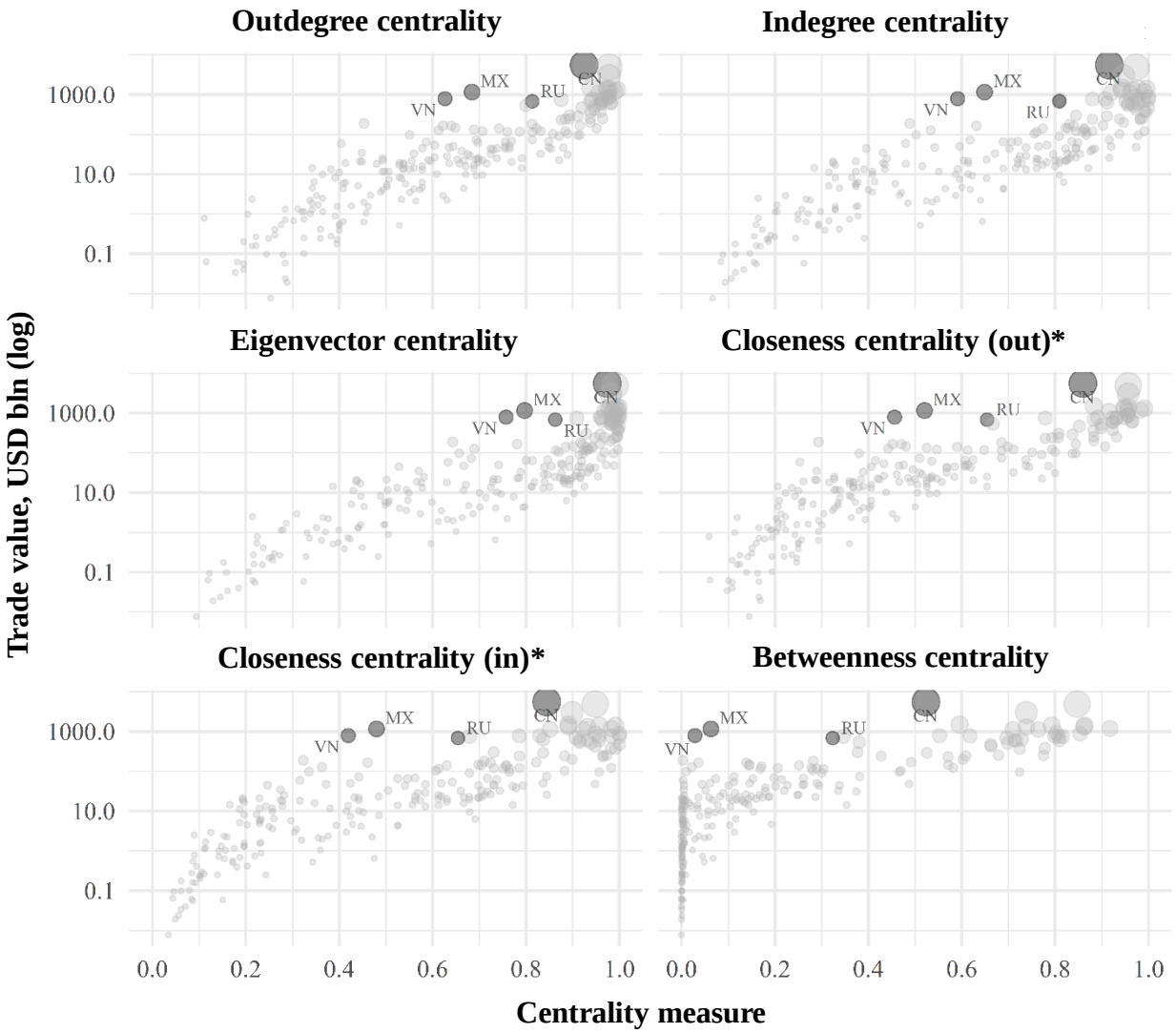
3. Empirical results

- **"Path centralities":** a bit lighter reduction for Russia and Belarus
- Modest improvement for other EAEU countries (reexports)
- Notable improvement for neutral countries (mediation)



3. Empirical results

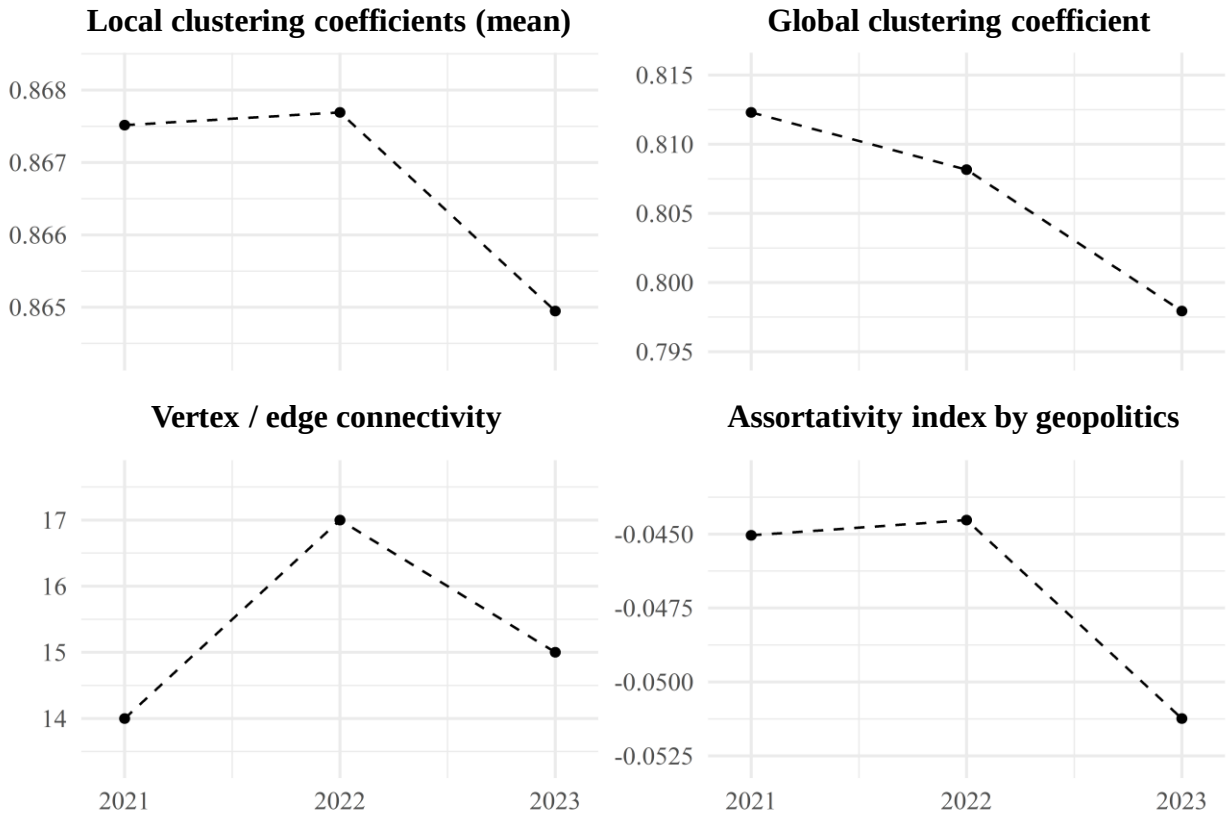
- There is a direct link between trade and centrality measures
- **VN** & **MX** have the lowest centralities among large traders
- **RU** has worsened its centrality scores but it is still integrated more diversely than US-oriented **VN** & **MX**



** Closeness centralities are rescaled to **{0 – 1}** for comparison reasons*

3. Empirical results

- The WTN as a whole has remained stable under the rise of sanctions and turbulence
  - A bit **less clustering** ≡ the emergence of new trade flows (new links between countries)
  - A bit **more connectivity** ≡ new trade contacts for countries at the "trade periphery"
  - A bit **less assortativity** ≡ antagonists and neutral countries expanded their trade ties



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4. Conclusion

- A **network approach** has been applied to global trade
  - Centrality metrics for Russia as well as for other countries and country groups (Belarus, other EAEU countries, China, neutral countries and antagonists)
  - Metrics for the WTN as a whole: clustering, connectivity, assortativity

- Changes in the architecture of world trade in 2022-2023 were mainly associated with the restructuring of trade flows around Russia, i.e., they helped to **maintain stability** of the global trade system
  - Changes in centrality indices were pronounced only for Russia, Belarus and EAEU; the exception is an increase in the betweenness centrality for neutral countries, which, however, was not reflected in an increase in other centrality measures
  - Centralities for China in 2022-2023 have remained almost unchanged compared to 2021, despite escalating confrontation between China and Western countries
  - Overall, the weakened clustering reflected the emergence of new trade flows, while the frequency of interactions between antagonist countries and neutral countries increased due to restructuring of trade routes