Trade and Global Value Chains in the EU: A Dynamic Augmented Gravity Model

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Outline

1. Aims
2. GVCs & Trade in value added
3. GVCs & NA measures
4. Factory Europe
5. Empirical application
6. Conclusions & Further Steps
Objective

Assessing the empirical importance of product fragmentation/GVCs and countries’ interdependence on bilateral trade flows

Focus

The so-called “Factory Europe” - an “hub and spoke” system centered on Germany and characterized by strong supply chain connections between countries (Baldwin & Lopez-Gonzales 2014)

Added value

We present augmented specifications of (static and dynamic) gravity eq. w/ fragmentation/GVC and NA measures

Main Conclusion

We demonstrate empirically that product fragmentation/GVCs outweigh (in magnitude and statistical significance) the “euro effect”
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Why focusing on value added trade statistics?

- Nowadays countries have developed **comparative advantages** in specific parts of the value chains.

- Standard Gross trade statistics are not able to reveal the "foreign value added" of exports producing biased assessments of RCA (relevant for policymaking).

- Value added trade statistics provide information about the actual value added in the production of exported goods, challenging conventional wisdoms.

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The Data set

World I/O Database (WIOD) - (Timmer et al., 2012)

- It contains I/O tables for the global economy with transactions from origin to destination, by distinguishing final and intermediate use.
- Data are disaggregated into 41 ctrs (EU members incl.) and 35 sectors for the period 1995-2011.
- All data collected from national sources are converted into US dollars.
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Koopman et al. (2014)’s Gross Export Decomposition

*Source: Koopman et al. (2014)*
GVCs indicators

The GVC Participation index

- Following Koopman et al. (2011), it adds FVA and IVA
- The GVC participation index for country i and industry k is:
  \[ GVCpar_{ik} = \frac{FVA_{ik}}{E_{ik}} + \frac{IVA_{ik}}{E_{ik}} \]
- where E stands for gross exports, FVA is foreign VA embodied in countries’ exports and IVA is the domestic VA embodied in third countries’ gross exports

The GVC Position index

- Following Koopman et al. (2011), it measures the level of involvement of a country in vertically fragmented production (i.e., the extent to which the country’s specialization is upstream or downstream in the GVCs)
- The GVC position index for country i and industry k is:
  \[ GVCpos_{ik} = \frac{IVA_{ik}}{E_{ik}} / \frac{FVA_{ik}}{E_{ik}} \]
Why NA?

Background

- NA enables to represent the network of trade flows by giving emphasis to the structure of the network itself.
- NA takes into account the “effect of the others” in the bilateral relations (i.e., the set of all possible trade relations that affect a dyadic flow).

Identification Strategy

- to include centrality measures in the empirical analysis to take account of the "third country effect" (De Benedictis & Tajoli, 2011; De Bruyne et al., 2013).
- We can identify factors that vary only in the exporter and importer dimensions (i.e., mass variables, gvc indices, etc.).
- We use alternative NA measures (i.e., the out-strength/in-strength degree centrality and the weighted out-eigenvector/in-eigenvector centrality) provided by De Benedictis et al., 2014.
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- We use alternative NA measures (i.e., the out-strength/in-strength degree centrality and the weighted out-eigenvector/in-eigenvector centrality) provided by De Benedictis et al., 2014.
Centrality measures can be classified into four main groups (Jackson, 2010):

1. **Degree centrality**, that measures how a node is connected to others (with strength centrality as a weighted version);
2. **Closeness centrality**, that shows how easily a node can be reached by other nodes;
3. **Betweenness centrality**, that describes how important a node is in terms of connecting other nodes;
4. **Eigenvector centrality or Bonacich centrality**, that associate node’s centrality to the node neighbors’ characteristics, directly referring to how important, central, influential or tightly clustered a node’s neighbors are.
As an example of local centrality measure, we apply the strength centrality that is computed by aggregating the weights of the arcs connected to the node and normalizing by the total number of countries.

The out-strength and in-strength centrality measures are computed as follows:

$$C_{S_{out}} = \frac{\sum_{j \neq i}^{N} T_{ij}}{(N - 1)}$$

$$C_{S_{in}} = \frac{\sum_{j \neq i}^{N} T_{ji}}{(N - 1)}$$

where $N$ is the total number of countries in the network, $i$ is the exporting countries, $j$ is the importing countries, $T$ is the trade flow (export or import flows), and $N - 1$ is a normalized factor.

The strength centralities measure the 'average' flow of imports and the 'average' flow of exports.
Global centrality measure

- As an example of global centrality measure we apply the *eigenvector centrality*. A node’s *eigenvector centrality* is determined by the eigenvector centrality of its neighbors. In the weighted version, the system of equations can be written in matrix form as:

\[(I - W) \vec{C}_E = 0,\]  

where \(I\) is a \(n \times n\) identity matrix, \(W\) is the trade weighted adjacency matrix and \(\vec{C}_E\) is the \(n \times 1\) vector of countries’ eigenvector centralities.

- Using the Perron-Frobenius theorem, we can consider the entries of the relevant (principal) eigenvector as a measure of country centralities.

- In general, countries with a high value of eigenvector centrality are the ones which are connected to many other countries which are, in turn, connected to many others.

- Also in this case, we apply both the *out and in-eigenvector* centrality measures.
The EU FVA Network (main buyers)

* Authors’ elaboration from WIOD

Only flows higher than 10th percentile are represented
Participation and Position (2010), EU countries
# Relative positions of EU trade partners for selected EZ members (2009)

<table>
<thead>
<tr>
<th>Germany</th>
<th>Austria</th>
<th>Belgium</th>
<th>Finland</th>
<th>France</th>
<th>Italy</th>
<th>Greece</th>
<th>Portugal</th>
<th>Spain</th>
<th>Ireland</th>
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</thead>
<tbody>
<tr>
<td>GRC 1.80</td>
<td>GBR 2.31</td>
<td>GBR 2.76</td>
<td>MTI 3.46</td>
<td>ITA 1.42</td>
<td>NLD 1.02</td>
<td>ESP 1.56</td>
<td>ESP 2.94</td>
<td>LVA 2.28</td>
<td>GBR 4.31</td>
</tr>
<tr>
<td>GBR 1.74</td>
<td>GRC 1.91</td>
<td>GBR 2.65</td>
<td>GBR 1.98</td>
<td>ESP 1.20</td>
<td>GBR 0.95</td>
<td>NLD 1.38</td>
<td>ITA 2.76</td>
<td>LTV 1.56</td>
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<tr>
<td>ESP 1.58</td>
<td>ESP 1.73</td>
<td>LVA 2.42</td>
<td>PRT 1.84</td>
<td>GBR 1.15</td>
<td>ITA 1.28</td>
<td>ROM 2.02</td>
<td>ROM 1.45</td>
<td>GRC 3.43</td>
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</tr>
<tr>
<td>ITA 1.41</td>
<td>ITA 1.58</td>
<td>IRL 2.23</td>
<td>EST 1.69</td>
<td>DEU 1.01</td>
<td>FIN 0.84</td>
<td>FRA 1.18</td>
<td>GBR 1.89</td>
<td>EST 1.45</td>
<td>DNK 2.50</td>
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<tr>
<td>IRL 1.35</td>
<td>FRA 1.29</td>
<td>ESP 1.99</td>
<td>ESP 1.68</td>
<td>ROM 0.98</td>
<td>GRC 0.78</td>
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<td>ROM 1.78</td>
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<td>POL 1.11</td>
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<td>NLD 1.58</td>
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<td>FIN 0.91</td>
<td>BGR 0.72</td>
<td>PRT 0.97</td>
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<td>GRC 1.50</td>
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<td>ROM 0.71</td>
<td>FRA 1.27</td>
<td>SWE 1.51</td>
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<td></td>
</tr>
</tbody>
</table>

| Authors’ calculations |

P. Montalbano, S. Nenci, L. Rotili

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The model specification: standard gravity

\[ x_{ijt} = \beta_0 + \beta_1 gdp_{it} + \beta_2 gdp_{jt} + \beta_3 ETA_{ijt} - p_i^{1-\sigma} - p_j^{1-\sigma} + \epsilon_{ijt} \] (3)

where small letters denote variables in natural logarithms

- \( i \) is the exporting country; \( j \) the importing country, and \( t \) the year;
- \( x \) are bilateral trade flows;
- \( gdp \) is the nominal GDP;
- \( ETA \) is a set of dummies for controlling for the presence of European trade agreements (i.e., EMU, EU and others regional memberships);
- \( p_i^{1-\sigma} \) and \( p_j^{1-\sigma} \) are time varying multilateral (price) resistance terms (Anderson & Van Wincoop, 2003);
- \( \epsilon \) is the error term.
The model specification: our augmented dynamic gravity

Following Olivero & Yotov (2012):

\[
x_{ijt} = \alpha_0 + \alpha_1 x_{ijt-1} + \alpha_2 \text{gdp}_{it} + \alpha_3 \text{gdp}_{it-1} + \alpha_4 \text{gdp}_{jt} + \alpha_5 \text{gdp}_{jt-1} + \alpha_6 E\text{T}A_{ijt} + \alpha_7 E\text{T}A_{ijt-1} + \\
+ \alpha_8 gvc_{it} + \alpha_9 gvc_{it-1} + \alpha_{10} gvc_{jt} + \alpha_{11} gvc_{jt-1} + \alpha_{12} \eta_{it} + \alpha_{13} \eta_{it-1} + \\
+ \alpha_{14} \eta_{jt} + \alpha_{15} \eta_{jt-1} + \gamma_t + \mu_{ijt}
\]

where small letters denote variables in natural logarithms

- \( i \) is the exporting country; \( j \) the importing country, and \( t \) the year;
- \( gvc \) are indices of international fragmentation of production and global value chains;
- \( \eta_i \) and \( \eta_j \) are network centrality measures (proxy for multilateral (price) resistance term;
- \( \gamma_t \) is a set of time fixed effects;
- the rest of the variables are the same as in the standard equation.
## SGMM Gravity estimates (out/in-strength)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>L. Log exports</td>
<td>0.533***</td>
<td>0.549***</td>
<td>0.597***</td>
<td>0.570***</td>
<td>0.602***</td>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<td>Log GDP exporter</td>
<td>0.113</td>
<td>0.375**</td>
<td>0.145</td>
<td>0.324**</td>
<td>0.570***</td>
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<td>(0.499)</td>
<td>(0.017)</td>
<td>(0.365)</td>
<td>(0.031)</td>
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<td>0.127</td>
<td>-0.161</td>
<td>-0.00509</td>
<td>0.397***</td>
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<td>(0.485)</td>
<td>(0.381)</td>
<td>(0.077)</td>
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<td>-0.0422</td>
<td>-0.0448+</td>
<td>-0.0463+</td>
<td>-0.0288</td>
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<td>(0.112)</td>
<td>(0.176)</td>
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<td>(0.133)</td>
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<td>Lagged EMU (yes=1)</td>
<td>0.0681</td>
<td>0.0700**</td>
<td>0.0317</td>
<td>0.0833**</td>
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<td>(0.016)</td>
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<td>(0.976)</td>
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<tr>
<td>L. Log FVA exporter</td>
<td>0.814**</td>
<td>1.014***</td>
<td>0.197</td>
<td>0.179**</td>
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<td>(0.000)</td>
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<tr>
<td>L. Log FVA importer</td>
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<td>(0.170)</td>
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<td>Log outdegree strengthi</td>
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<td>0.346***</td>
<td>0.444***</td>
<td>0.351***</td>
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<td>(0.002)</td>
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<td>Log in-degree strengthi</td>
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<td>-0.296**</td>
<td>-0.288***</td>
<td>-0.488***</td>
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<td>(0.015)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.000)</td>
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<td>Log out-degree strengthj</td>
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<td>0.216</td>
<td>0.0881</td>
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<tr>
<td>(0.588)</td>
<td>(0.704)</td>
<td>(0.207)</td>
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<td>Log in-degree strengthj</td>
<td>1.271***</td>
<td>1.011***</td>
<td>1.193***</td>
<td>1.129***</td>
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<tr>
<td>(1.048)</td>
<td>(0.872)</td>
<td>(0.613)</td>
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<td>cons.</td>
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<td>(0.146)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<td>no</td>
<td>no</td>
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<tr>
<td>Time dummy</td>
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<tr>
<td>Exporter*time dummy</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>Importer*time dummy</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
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</tbody>
</table>

Robust s.e. clustered by pair in parentheses; *** p<0.01, ** p<0.05, * p<0.10, +p<0.15
### SGMM Gravity estimates (out/in-eigenvector)

<table>
<thead>
<tr>
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<tr>
<td>L. Log exports</td>
<td>0.533***</td>
<td>0.647***</td>
<td>0.647***</td>
<td>0.617***</td>
<td>0.678***</td>
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<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>Log GDP exporter</td>
<td>0.280*</td>
<td>0.609***</td>
<td>0.421***</td>
<td>0.586***</td>
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<tr>
<td></td>
<td>(0.091)</td>
<td>(0.000)</td>
<td>(0.009)</td>
<td>(0.000)</td>
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<tr>
<td>Log GDP importer</td>
<td>0.518***</td>
<td>0.383**</td>
<td>0.600***</td>
<td>0.306*</td>
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<tr>
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<td>(0.001)</td>
<td>(0.016)</td>
<td>(0.000)</td>
<td>(0.065)</td>
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<tr>
<td>EMU (yes=1)</td>
<td>0.0725+</td>
<td>-0.0357</td>
<td>-0.0529*</td>
<td>-0.0549*</td>
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<td>(0.112)</td>
<td>(0.270)</td>
<td>(0.099)</td>
<td>(0.065)</td>
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<tr>
<td>EU (yes=1)</td>
<td>-0.00164</td>
<td>0.336***</td>
<td>0.248***</td>
<td>0.171***</td>
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<tr>
<td></td>
<td>(0.976)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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<tr>
<td>Log FVA exporter</td>
<td>0.768***</td>
<td>0.954***</td>
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<td></td>
<td>(0.000)</td>
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<tr>
<td>Log FVA importer</td>
<td>0.0776</td>
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<td></td>
<td>(0.586)</td>
<td>(0.275)</td>
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<tr>
<td>Log Pos exporter</td>
<td>-0.307***</td>
<td>0.103</td>
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<td>(0.001)</td>
<td>(0.425)</td>
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<tr>
<td>Log Pos importer</td>
<td>-0.232***</td>
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<td>(0.008)</td>
<td>(0.150)</td>
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<tr>
<td>Log outdegree eigenvector_i</td>
<td>0.356***</td>
<td>0.313***</td>
<td>0.376***</td>
<td>0.254***</td>
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<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.003)</td>
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<tr>
<td>Log indegree eigenvector_i</td>
<td>-0.154***</td>
<td>-0.280***</td>
<td>-0.129***</td>
<td>-0.441***</td>
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<td>(0.000)</td>
<td>(0.081)</td>
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<tr>
<td>Log outdegree eigenvector_j</td>
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<td>-0.165</td>
<td>0.00926</td>
<td>-0.0959</td>
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<tr>
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<td>(0.491)</td>
<td>(0.213)</td>
<td>(0.945)</td>
<td>(0.424)</td>
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<td>Log indegree eigenvector_j</td>
<td>0.384***</td>
<td>0.651***</td>
<td>0.315***</td>
<td>0.861***</td>
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<td>(0.001)</td>
<td>(0.000)</td>
<td>(0.003)</td>
<td>(0.000)</td>
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</tr>
<tr>
<td>cons.</td>
<td>-0.403+</td>
<td>-8.043***</td>
<td>-12.58***</td>
<td>-12.08***</td>
<td>-10.70***</td>
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<td>(0.146)</td>
<td>(0.000)</td>
<td>(0.000)</td>
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</table>

**Country pair dummy**
- no no no no no
- No Obs 14318 12559 12559 12559 12559

**Time dummy**
- no yes yes yes yes
- AB test (AR2) 0.810 0.747 0.794 0.795 0.792

**Exporter*time dummy**
- yes no no no no
- No Instr. 928 100 132 132 164

**Importer*time dummy**
- yes no no no no
- R-sq 0.954 0.942 0.952 0.942 0.955

Robust s.e. clustered by pair in parentheses; *** p<0.01, ** p<0.05, * p<0.10, +p<0.15
<table>
<thead>
<tr>
<th></th>
<th>LSDV</th>
<th>SGMM</th>
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<tr>
<td>L. Log exports in intermediates</td>
<td>0.502***</td>
<td>0.531***</td>
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<td>(0.000)</td>
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<td>EMU (yes=1)</td>
<td>0.0519</td>
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<td>(0.250)</td>
<td>(0.072)</td>
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<td>Lagged EMU (yes=1)</td>
<td>-0.0311</td>
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<td>(0.524)</td>
<td>(0.593)</td>
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<td>EU (yes=1)</td>
<td>-0.0157</td>
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<td></td>
<td>(0.766)</td>
<td>(0.791)</td>
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<td>Lagged EU (yes=1)</td>
<td>-0.0174</td>
<td>0.0340</td>
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<tr>
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<td>(0.729)</td>
<td>(0.550)</td>
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<td>Cons</td>
<td>3.549***</td>
<td>-0.280</td>
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<td>(0.353)</td>
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<tr>
<td>N</td>
<td>14355</td>
<td>14355</td>
</tr>
<tr>
<td>R-sq</td>
<td>0.976</td>
<td>0.900</td>
</tr>
</tbody>
</table>

Country pair dummy: yes  yes
Exporter*time dummy: yes  yes
Importer*time dummy: yes  yes
Conclusions

- Augmenting gravity equation with indices of production fragmentation/GVC and trade interdependence, we assess the empirical relevance of supply chains for bilateral trade across EU member countries.

- Specifically, estimates show, on average, a strong positive relation between the FVA content of the exporting countries and the magnitude of their exports of final goods.

- These suggest the relevance of the “Factory countries” on bilateral flows of final goods.

- Conversely, the relationship between the magnitude of imports of final goods and the upstream position of the importing countries remains ambiguous.

- As expected, a strong positive association of out-strength/eigenvector centrality of exporters & in-strength/eigenvector centrality of importers with bilateral flows is actually in place.

- Preliminary results show that the impact of the EU trade integration process is better specified when regressions properly account for vertical specialization and the effects of the others on each bilateral trade.
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Further Steps

We would like to address explicitly the following critical issues:

- countries and industries’ heterogeneity;
- trade off between endogeneity and instruments’ proliferation;
- better MRT identification by using alternative NA measures.
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