Economic Development under Global Production Fragmentation: Value-Added in Exports of 93 Countries between 1970 and 2008

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Contributions of the Paper

- Extends the analysis of GVCs to developing countries
- Uses an input-output framework while circumventing actual input-output tables
- Generates a data set of 93 countries and 19 industrial sectors for 1970 – 2008
- Preliminary look at the effects of specializing in production stages on the growth of domestic value-added in exports

Role of Industrialization in Development

- Without Global Fragmentation
  - Industrialization yields competencies that give a country a comparative advantage in manufacturing
  - Export competitiveness results from a comparative advantage in the complete production of final manufactured products
- With Global Fragmentation
  - Industrial competencies can be gained by unbundling stages of production as a result of lower information and communication costs
  - Export competitiveness results from specialization in production stages in which a country has a comparative advantage
- Does specialization necessarily increase domestic value-added in exports?

Input-Output Framework

	D_{Agr}	D_{Mfg}	D_{Serv}	Final Demand	Exports	Gross Output
D_{Agr}	***Z*** domestic			***FD*** domestic	***E*** domestic	***X***
D_{Mfg}						
D_{Serv}						
M_{Agr}	***Z*** imports			***FD*** imports	***E*** imports	***M***
M_{Mfg}						
M_{Serv}						
Value-Added	***VA***					
Gross Output	***X'***					

Input-Output Framework

- Technical Coefficients
  - $\boldsymbol{A_{domestic} = Z_{domestic}(\widehat{X})^{-1}}$
  - $\boldsymbol{A_{imports} = Z_{imports}(\widehat{M})^{-1}}$
  - $\boldsymbol{A_{total} = A_{domestic} + A_{imports}}$

- System of Equations
  - Uses of domestic output: $\boldsymbol{X = A_{domestic}X + FD_{domestic} + E_{domestic}}$
  - Uses of imports: $\boldsymbol{M = A_{imports}M + FD_{imports} + E_{imports}}$
  - Gross Output: $\boldsymbol{X' = X'A_{total} + VA}$

- Expressed with Leontief Inverse
  - $\boldsymbol{X = (I - A_{domestic})^{-1}(FD_{domestic} + E_{domestic})}$
  - $\boldsymbol{M = \left(I - A_{imports}\right)^{-1}(FD_{imports} + E_{imports})}$

Domestic Value-Added in Exports

- Value-Added Per Unit of Gross Output
  - $\boldsymbol{V} = \widehat{\boldsymbol{VA}}(\widehat{\boldsymbol{X}})^{-1}$
- Domestic Value-Added in Exports
  - $DVAX = \boldsymbol{V}(\boldsymbol{I} - \boldsymbol{A}_{domestic})^{-1}\boldsymbol{E}_{domestic}$
  - Yields the domestic input requirements embodied in exports weighted by the value-added share of gross output
- DVAX Ratio
  - $DVAXr = \frac{DVAX}{E_{domestic}+E_{imports}}$
  - Alternative interpretations reflect the channel through which value-added in trade affects the domestic economy

Approximating DVAX

- $DVAX = \boldsymbol{V}\left(\boldsymbol{I} - \boldsymbol{Z}_{domestic}(\widehat{\boldsymbol{X}})^{-1}\right)^{-1}\boldsymbol{E}_{domestic}$
- $\boldsymbol{Z}^{est}_{domestic} = \boldsymbol{Z}^{est}_{total} - \boldsymbol{Z}^{est}_{imports}$
- **Step 1**: Estimate $\boldsymbol{Z}_{total}$
  - $\boldsymbol{ii}^{u}_{total} = \boldsymbol{X}' - \boldsymbol{VA}$
    - Available in actual data
  - How to distribute $\boldsymbol{ii}^{u}_{total}$ across supplying industries?
    - Proxy coefficient table $\boldsymbol{C}^{proxy}_{total}$
    - $\boldsymbol{Z}^{est}_{total} = \boldsymbol{C}^{proxy}_{total}\,\widehat{\boldsymbol{ii}}^{u}_{total}$
  - $\boldsymbol{C}^{proxy}_{total}$ is based on an average across countries from WIOD

Approximating DVAX

- **Step 2**: Estimate $\boldsymbol{Z}_{imports}$
  - $\boldsymbol{ii}^{s}_{imports}$ is available from trade data
  - How to distribute $\boldsymbol{ii}^{s}_{imports}$ across using industries?
    - Proxy coefficient table $\boldsymbol{R}^{proxy}_{total}$
    - $\boldsymbol{Z}^{est}_{imports} = \boldsymbol{R}^{proxy}_{total}\,\widehat{\boldsymbol{ii}}^{s}_{imports}$
  - $\boldsymbol{R}^{proxy}_{total}$ is based on an average across countries from WIOD
  - However…
    - $\boldsymbol{Z}^{est}_{imports}$ is not balanced and needs row constraints (i.e., $\boldsymbol{ii}^{s}_{imports}$) and column constraints (i.e., $\boldsymbol{ii}^{u}_{imports}$)
    - GRAS is used to balance (Lenzen et al. 2007)

Approximating DVAX

- **Step 3**: Estimate $\boldsymbol{ii}^{u}_{imports}$
  - Proxy vector $\boldsymbol{F}^{proxy}$ depicts shares of foreign-sourced intermediates in total-sourced intermediates by industry
    - $\boldsymbol{F}^{proxy}$ is based on an average across countries from WIOD
    - There is variation in penetration of imported intermediates across industries but less variation across countries
  - Estimate a distribution of imported intermediates by using industry
    - $\widehat{\boldsymbol{D}} = \widehat{\boldsymbol{F}}^{proxy}\widehat{\boldsymbol{ii}}^{u}_{total}$ (latter is known from ***X'*** and ***VA***)
  - Estimate a distribution of imported intermediates relative to the sum of total intermediates by using industry
    - $\widehat{\boldsymbol{H}} = \widehat{\boldsymbol{D}}\left(\widehat{\boldsymbol{ii}}^{sum}_{total}\right)^{-1}$ (latter is known from $\widehat{\boldsymbol{ii}}^{u}_{total}$)
  - Estimate imported intermediates by using industry
    - $\widehat{\boldsymbol{ii}}^{u}_{imports} = \widehat{\boldsymbol{H}}\widehat{\boldsymbol{ii}}^{sum}_{imports}$ (latter is known from $\widehat{\boldsymbol{ii}}^{s}_{imports}$)

Source Data

- Gross Output and Value-Added
  - UN Official Country Data
  - UN National Accounts Main Aggregates
  - UNIDO INDSTAT
- Trade Flows
  - UN Comtrade
  - Feenstra et al. (2005)
- Caveats
  - No trade flows in services (may bias DVAXr)
  - Gross output and value-added in basic prices but intermediates in purchase prices (may bias technical coefficients)
  - $\boldsymbol{C}_{total}^{proxy}$, $\boldsymbol{R}_{total}^{proxy}$, and $\boldsymbol{F}^{proxy}$ are based on a "one-size fits all" approach
  - Results hinge on $\boldsymbol{C}_{total}^{proxy}$, $\boldsymbol{R}_{total}^{proxy}$, and $\boldsymbol{F}^{proxy}$

Validation

- WIOD with and without Complete Information
  - One size fits all: average across all WIOD countries in 1995
  - Grouping countries into regions for different years
  - Overall fit reasonably good
  - Grouping countries improves the fit especially at the aggregate level

- Constructed Data Set and WIOD
  - Correlations between 0.88 and 0.93 in agreement with correlations for WIOD, OECD-WTO TiVA, and Johnson and Noguera (2014)
  - Differences explained by sectoral detail and lack of trade in services

- Constructed Data Set and Johnson and Noguera (2014)
  - Reflects long-term trends
  - Differences arise because of conceptual differences between DVAX and VAX and because of end year differences (2008 v. 2009)

Does DVAXr Explain Growth in DVAX?

- $\Delta \ln(DVAX)_{j,t} = \propto_0 + \beta \ln(DVAXr)_{j,t-k} + \gamma X + \eta_j + \upsilon_t + \varepsilon_{j,t}$
  - Lagged values reduce endogeneity
  - Fixed effects control for unobserved heterogeneity

- Preliminary Results
  - β is negative and statistically significant in all but one specification
  - DVAX grows faster when the initial domestic contribution to exports is lower

	(1) Δln(DVAX)	(2) Δln(DVAX)	(3) Δln(DVAX)	(4) Δln(DVAX)	(5) Δln(DVAX)	(6) Δln(DVAX)
DVAXr	-0.0342	-0.0693***	-0.0443**	-0.0931**	-0.148***	-0.0961**
N	2,902	2,902	2,902	2,902	2,902	2,902
R^2	0.001	0.010	0.065	0.035	0.100	0.132
Controls	No	Yes	No	No	No	Yes
Year FE	No	No	Yes	No	Yes	Yes
Country FE	No	No	No	Yes	Yes	Yes

Conclusions

- Methodology widely applicable to study production fragmentation across time and countries
  - Good fit and systematic improvements possible
- Data set contains 93 countries and 19 industrial sectors from 1970 to 2008
  - To be extended by at least 10 countries from 1963 to 2015
- First results indicate a negative correlation between the initial DVAXr levels and subsequent growth of DVAX
  - To be extended to explore time periods and groups of countries

Discussion

- How accurate are the proxies (i.e., C, R, and F)?
  - Two Assumptions
    - Share of intermediates sourced by an industry can be approximated by a given set of countries
    - Foreign penetration of industries holds across a given set of countries
  - C and R yield the same technology assumptions across countries
  - F yields equal shares of foreign-sourced intermediates across countries
  - Bullón et al. (2014) warn against overarching assumptions for developing countries

- How effective is WIOD for validation given its use for proxies?
  - Why would we expect anything other than high correlations in tables 1 and 2?
  - Tables 3 and 4 demonstrate differences
  - Countries in WIOD not in Pahl (2016) data set?

Discussion

- Are UN Comtrade data designed for international comparison?
  - Conversion to a single currency?
  - Variation in price levels (i.e., purchasing power)?
  - May be relevant for DVAX but not DVAXr?
- Plans for an IV approach?
  - DVAXr is composed of DVAX
  - Are lags consistent with the related literature?
    - Common substitute in other applications
    - Kummritz (2016) and Boffa et al. (2016) do not use lags?
- Comprehensive interpretation of the sign on DVAXr in the context of the conceptual framework?
  - Estimation strategy discusses possibility of a positive sign
  - Results discuss the actual negative sign