Structural Change in sub-Saharan Africa: An Open Economy Perspective

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Motivation

- Structural change in sub-Saharan Africa (SSA) has been studied extensively
  - Unique patterns
    - ⋆ Employment expansion in small and low productivity manufacturing firms
    - ⋆ Deindustrialization in output
  - Existing research is largely empirical; theoretical work often ignores open economy
  - Can open economy models of structural change, calibrated to SSA countries' experiences, add to our understanding?

What We Do

- Utilize new SSA input-output tables
  - Examine patterns of structural change in SSA
  - Compare with that of developing Asia
- Adapt open economy model framework of Sposi, Yi, and Zhang (2024) to SSA countries
  - Key "shocks" are sector-specific total factor productivity (TFP) and bilateral-sector-specific trade costs
  - Model is calibrated and counterfactual exercises conducted to assess:
    - ⋆ Relative importance of two key shocks
    - ⋆ Sources of differences in structural change between SSA and developing Asia

Literature Review

- **Empirical Studies of Structural Change in SSA**: McMillan and Rodrik (2011); Gollin, Lagakos, and Waugh (2014); De Vries, Timmer, and De Vries (2015); Diao, McMillan, and Rodrik (2019); Mensah (2020); Herrendorf, Rogerson, and Valentinyi (2022); Kruse, Mensah, Sen and de Vries (2023); Diao, Ellis, McMillan, and Rodrik (2024)
- **Quantitative Structural Change Models Applied to SSA**: Sen (2023)
- **Quantitative Open Economy Models of Structural Change**: Uy, Yi, Zhang (2013); Betts, Giri, and Verma (2017); Swiecki (2017); Teignier (2018); Cravino and Sotelo (2019); Sposi (2019); Lewis, Monarch, Sposi, and Zhang (2022); Lee (2024); Sposi, Yi, Zhang (2024);
- Our contribution: Study structural change in SSA from lens of open economy model calibrated with new data on inter-sectoral linkages

New Data on Input-Output Tables for SSA countries

- Data for 11 SSA countries: African Supply and Use Tables (ASUT)
  - Cameroon, Ethiopia, Ghana, Kenya, Mauritius, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Zambia
- Annual input-output tables, 1990-2019
- Official tables are harmonized and benchmarked with NA and trade data
- Comparison group includes 11 developing Asian countries
  - Bangladesh, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam

Structural Change in SSA vs. Developing Asia

- Document three patterns of structural change
  1. Industrialization
  2. Inter-industry linkages
  3. Sectoral productivity growth

1. Industrialization

Manufacturing nominal value added share of GDP in:	2000	2018
SSA	14.5	10.4
Developing Asia	18.3	17

Note: 11 sub-Saharan African (SSA) countries, and 11 developing Asian countries. Unweighted averages.

- De-industrialization (value-added shares) amidst rising per capita income
  - SSA and DA countries appear to be on downward portion of their manufacturing 'hump'

2. Inter-industry linkages with manufacturing

- Intensification of input utilization in manufacturing by developing Asia

		2000 MFG		2018 MFG	
		SSA	DevAsia	SSA	DevAsia
$\mu_{j,k}$ – Intermediate input shares	AGR	0.15	0.13	0.15	0.13
	MIN	0.04	0.03	0.10	0.04
	MFG	0.24	0.32	0.19	0.35
	SER	0.22	0.16	0.20	0.18
β_j – Value added to gross output ratio		0.36	0.36	0.36	0.31

Note: AGR is agriculture, MIN is mining, MFG is manufacturing, and SER is services. Unweighted averages. Input is sector j, output is manufacturing.

Table1

3. Sectoral productivity growth

- Disaggregate the change in aggregate productivity into a within- and a between-effect
  - Within effect captures productivity growth within sectors
  - Structural change effect measures the productivity effect of labor reallocation across sectors
- Results
  - Reallocation of workers to sectors with higher productivity *levels* in DA and SSA
  - Productivity growth in manufacturing and services higher in DA compared to SSA

Key Features of Model

1. Multi-country, four sector model with Ricardian trade
2. Production has two layers:
   - Individual goods are produced from value-added (labor) and intermediate goods
   - Such goods are traded, and are (CES) aggregated to sector-level composite goods used for consumption or as intermediate
3. Two main sets of "shocks":
   - Sectoral total factor productivity (TFP)
   - Bilateral sectoral trade costs
4. Preferences over sector-level composite goods are non-homothetic CES

Two Key Equations: Production and Preferences

Production function for variety $v \in [0,1]$ in sector j and country n:

$$y_n^j(v) = a_n^j(v) \left(A_n^j \ell_n^j(v)\right)^{\nu_n^j} E_n^j(v)^{1-\nu_n^j}. \tag{1}$$

- $a_n^j(v)$ is Eaton-Kortum productivity term distributed as Frechet with scale parameter T and variance parameter θ
- A_n^j is standard TFP
- E_n^j is Cobb-Douglas function of composite intermediates ($E_n^{k,j}$) from each sector k

Non-homothetic CES preferences over aggregate consumption per worker:

$$\sum_{j \in \{a,mi,ma,s\}} \omega_{c,n}^j \left(\frac{C_n}{L_n}\right)^{\frac{1-\sigma}{\sigma}\varepsilon^j} \left(\frac{c_n^j}{L_n}\right)^{\frac{\sigma-1}{\sigma}} = 1, \tag{2}$$

- σ is elasticity of substitution; ε^j is utility elasticity of sectoral consumption

International Trade

- Varieties $v \in [0, 1]$ are traded between countries
- $d_{ni}^{j} \geq 1$: d units of variety in sector j shipped from i so n can receive one unit
- Trade is based on Ricardian comparative advantage
  - Sector-level net export surpluses or deficits can exist
- Trade is balanced at country-level
- Increased openness leads to increased specialization, which raises "effective" TFP through reallocation of resources

Model Mechanisms ($\sigma = 1$; homothetic preferences)

- Consider scenario in which income elasticities and substitution elasticities equal 1.
  - Also, assume economy is value-added only (no intermediate)
- Then, employment (and value-added) share in sector j equals:

$$l_j = \omega_j + N_{nj} \tag{3}$$

  where ω_j is preference weight on sector j and N_{nj} is net export share of GDP of sector j
- For country with a comparative advantage in sector j, an increase in openness will lead to an increase in employment in that sector (because N_{nj} increases)

Model Mechanisms ($\sigma < 1$; non-homothetic preferences)

- Positive productivity shock in manufacturing leads to:
  1. Reduction in manuf value-added share owing to low substitution elasticity
  2. Possible increase in manuf value-added share through non-homothetic preferences demand channel
  3. Possible increase in manuf value-added through comparative advantage
- Reduction in trade costs in manufacturing affects structural change via same adjustment margins as above
  - On margin, comparative advantage effect larger, and demand channel smaller

Calibration: Countries and Parameters

1. Countries
   - One SSA (or DA) country at a time with 9 other countries: U.S., China, India, Japan, Germany, France, Great Britain, Italy, and ROW (all other countries in OECD ICIO Tables)

2. Parameters
   - Share of value-added in sectoral production (country-specific): ASUT and ADB MRIOT
   - Armington preference weights (same for all countries): 2011 OECD ICIOT
   - Trade elasticity: 4; (Simonovska and Waugh, 2014)
   - Substitution elasticity between sectors: 0.4 (Sposi, 2019)
   - Income elasticities: Agriculture – 0.32; Mining – 0.41; Services – 1.5 (Comin *et al*, 2021)

Calibration of Sectoral TFP

$$Z^j_{n,t} = B^j_n \frac{W^{\nu^j_n}_{n,t} \left(p^{e,j}_{n,t}\right)^{1-\nu^j_n}}{p^j_{n,t}} \tag{4}$$

where $Z^j_{n,t}$ is "measured" TFP, $p^{e,j}_{n,t} = \prod_i (p^i_{n,t})^{\mu^j_n}$ and $\sum_i \mu^i_n = 1$

$$A^j_{n,t} = \left(\gamma^j Z^j_{n,t} \left(\pi^j_{n,n,t}\right)^{\frac{1}{\theta^j}}\right)^{\frac{1}{\nu^j_n}} \tag{5}$$

where

1. $A^j_{n,t}$ is fundamental TFP (cf. Finicelli *et al*, 2013)
2. $\pi^j_{n,n,t}$ is country n, sector j, domestic spending share

Calibration of Bilateral, Sectoral Trade Costs

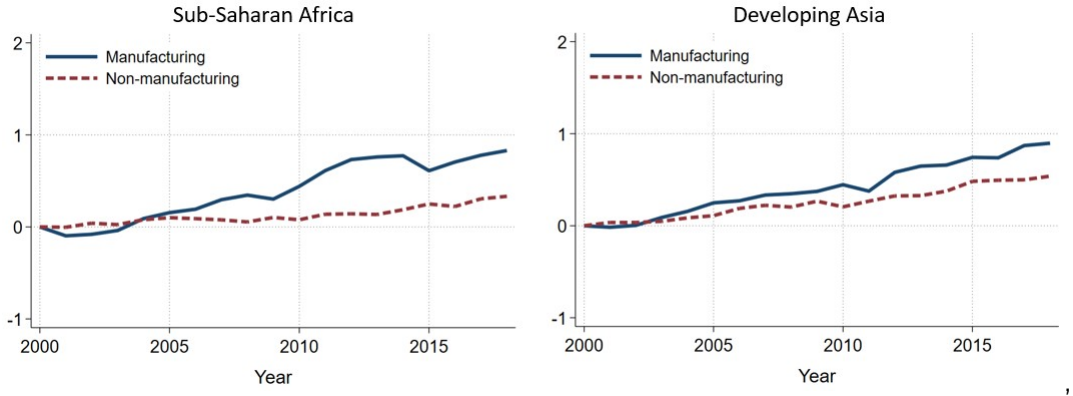
$$d^j_{n,i,t} = \left(\frac{\pi^j_{n,i,t}}{\pi^j_{i,i,t}} \right)^{-\frac{1}{\theta_j}} \left(\frac{p^j_{n,t}}{p^j_{i,t}} \right) \tag{6}$$

where

1. Data on $p^j_{n,t}$ come from Inklaar et al. (2023)
2. $\pi^j_{n,i,t}$ is country n, sector j, share of spending on goods from country i

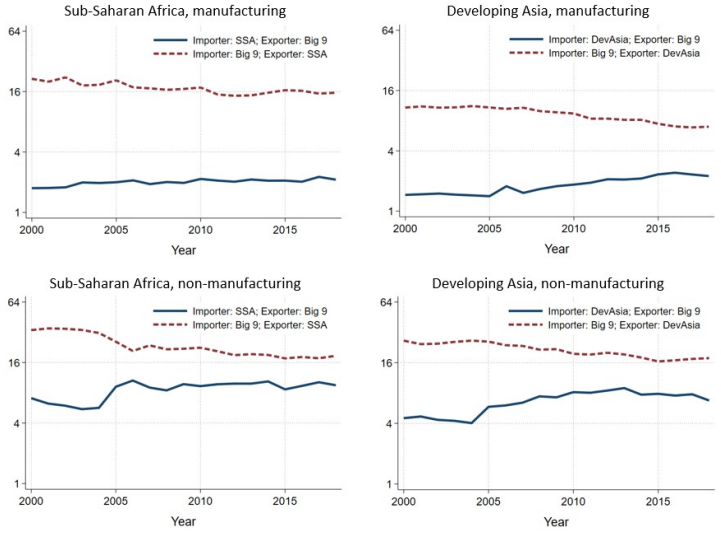
Table1

Calibrated Productivities: TFP growth in Manuf Higher than Non-Manuf



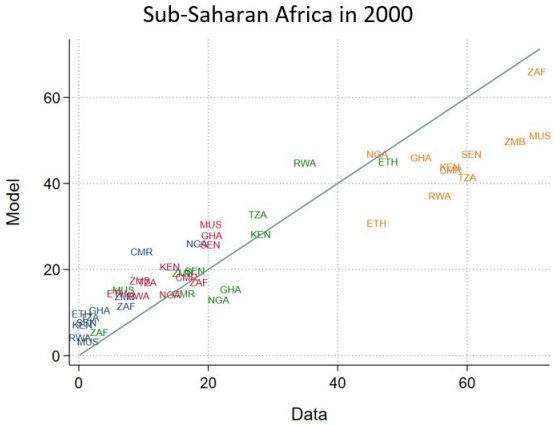
Note: Figure shows median trend (in logs) of model-implied fundamental productivity across countries in each year

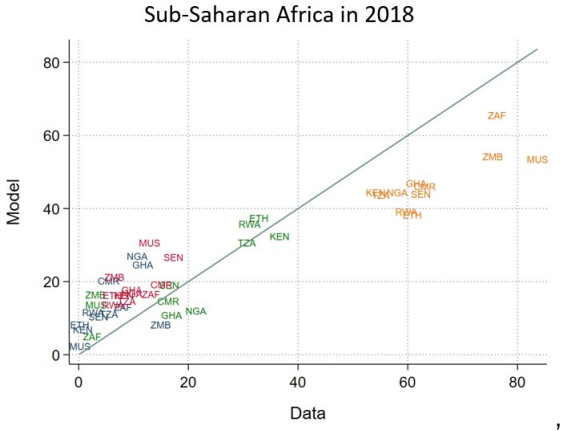
Calibrated Trade Costs: Decline in "Big 9" import trade costs



Note: Figure shows median trade cost across countries in each year

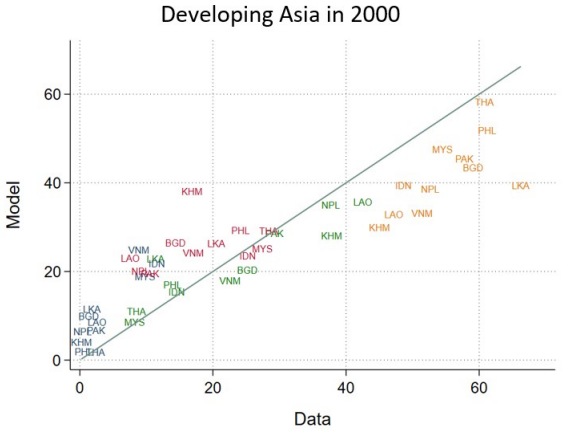
Model Fit, Sectoral Value-Added Shares: SSA countries

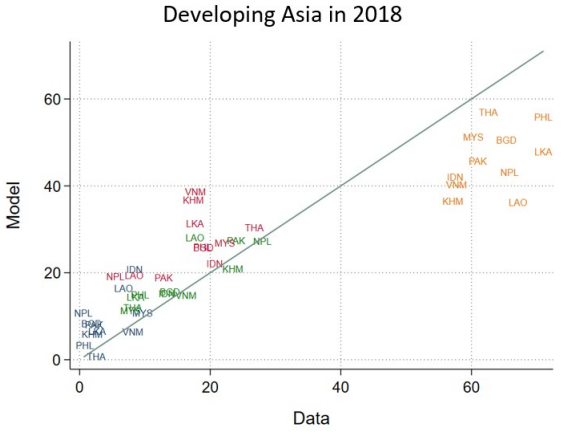




Note: Sector colors: Green – agriculture; Blue – mining; Red – manufacturing; Orange – services

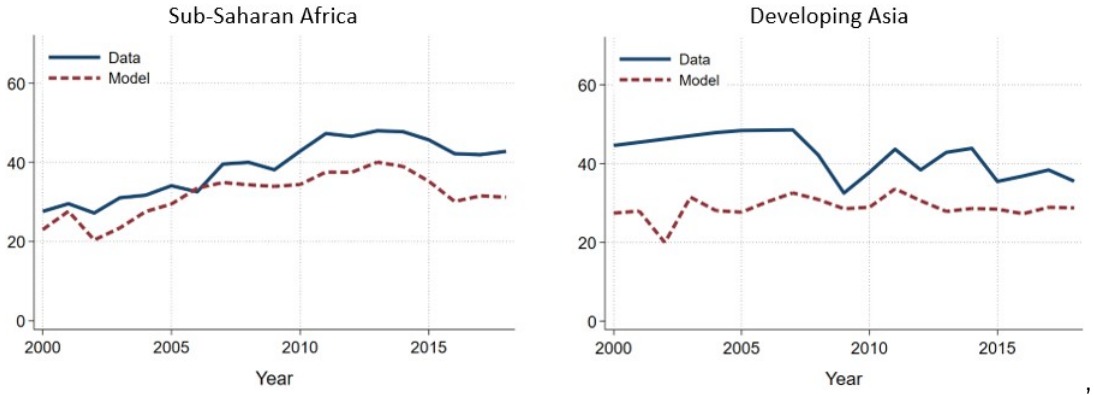
Model Fit, Sectoral Value-Added Shares: DA countries





Note: Sector colors: Green – agriculture; Blue – mining; Red – manufacturing; Orange – services

Model Fit: Manufacturing import expenditure shares



Note: Figure shows median import expenditure share in manufacturing across countries in each year

Calibration Results Summary and Counterfactuals

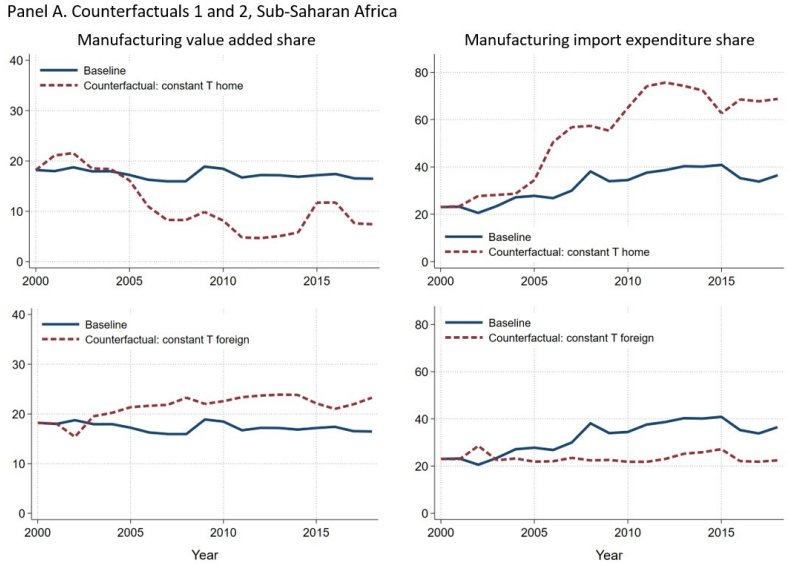
Summary of calibration results:

1. Sector-level TFP growth higher in manufacturing, and in DA countries
2. Model tends to over-predict mining and manufacturing and under-predict services
   - RMSE: Similar fit between SSA and DA countries; Fit in 2000 is slightly better than in 2018
3. Model fits manufacturing import expenditure shares in SSA better than in DA

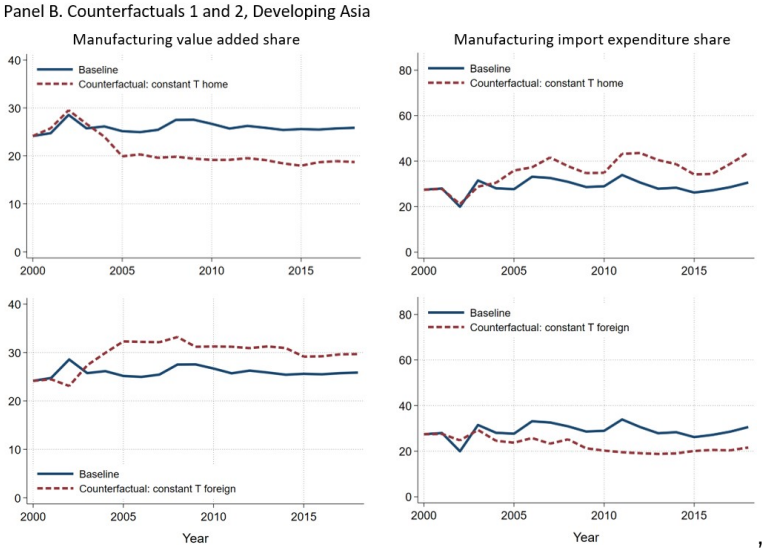
Counterfactuals (to unpack results further):

1. Focus on five countries in SSA and DA for which manufacturing share fit was best.

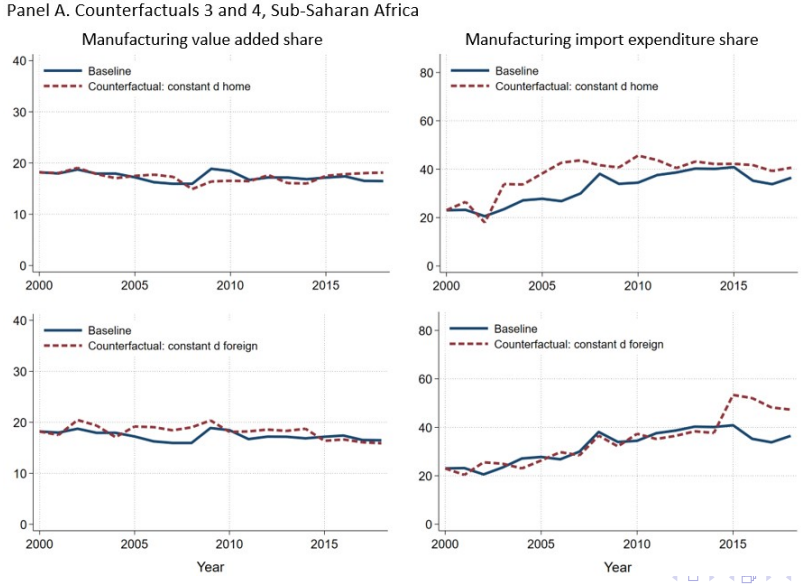
Counterfactual: Constant TFP over time in SSA or "Big 9"



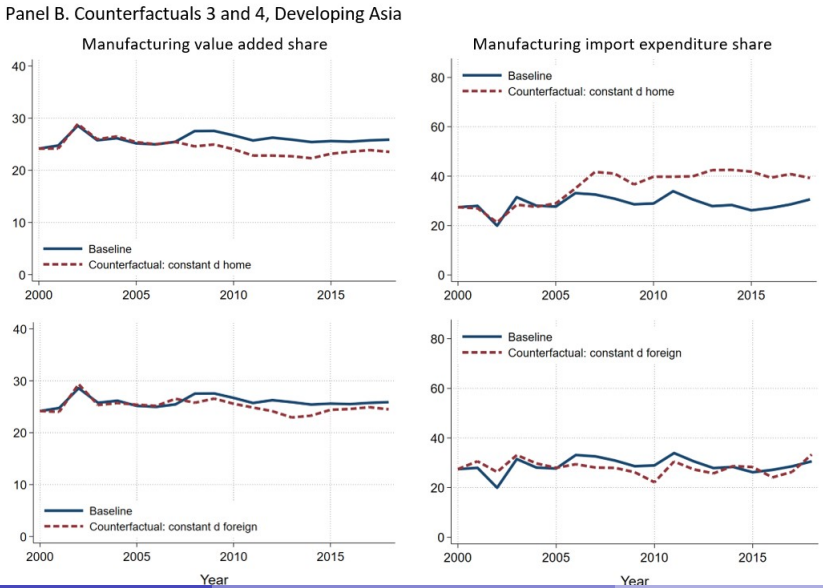
Counterfactual: Constant TFP over time in DA or "Big 9"



Counterfactual: Constant Trade costs in SSA or "Big 9"

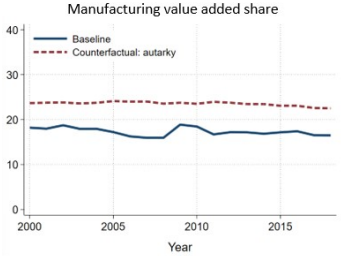


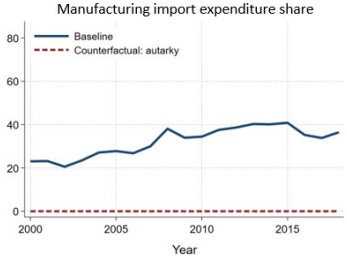
Counterfactual: Constant Trade costs in DA or Big 9



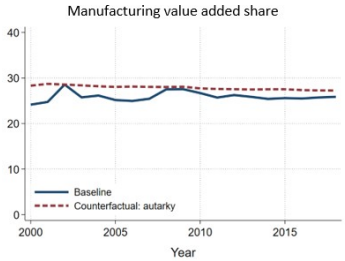
Counterfactual: Autarky in SSA or DA

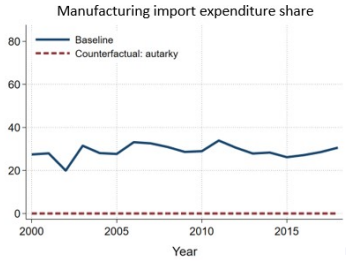
Panel A. Counterfactual 5, Sub-Saharan Africa





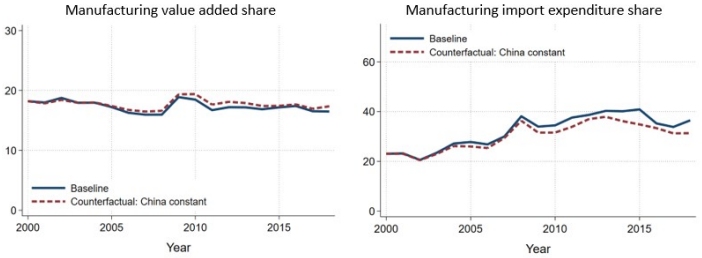
Panel B. Counterfactual 5, Developing Asia



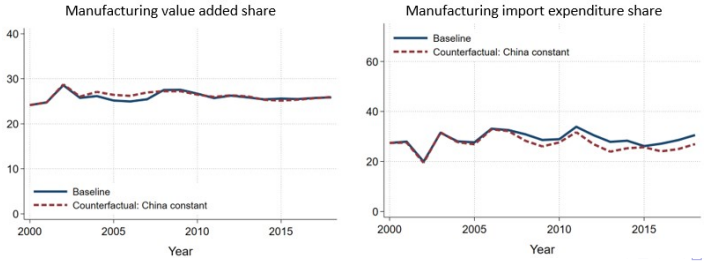


Counterfactual: Constant TFP and Trade Costs for China; SSA or DA

Panel A. Counterfactual 6, Sub-Saharan Africa



Panel B. Counterfactual 6, Developing Asia



Summary of Counterfactuals and Future Work

Summary:

1. Qualitatively, results are similar for SSA and DA countries
2. Domestic sectoral TFP growth important for manufacturing value-added
3. Trade costs do not matter directly, but they do matter in a "supporting" role – propagate foreign TFP shocks to SSA and DA countries
4. China matters, but not as much as all the other countries

Future Work:

1. Introduce frictions to generate unequal wages across sectors and employment shares not equal to value-added shares
2. Calibrate more than one SSA (or DA) country at a time to study intra-SSA linkages

Descriptive statistics

a. 2018

		Output sector j							
		AGR		MIN		MFG		SER	
		SSA	DA	SSA	DA	SSA	DA	SSA	DA
$4*\mu_{j,k}$ – Intermediate input shares	AGR	0.11	0.09	0.01	0.004	0.15	0.13	0.02	0.01
	MIN	0.006	0.001	0.05	0.05	0.10	0.04	0.02	0.01
	MFG	0.06	0.13	0.11	0.12	0.19	0.35	0.11	0.16
	SER	0.15	0.07	0.26	0.13	0.20	0.18	0.32	0.23
β_j – Value added to gross output ratio		0.67	0.72	0.57	0.70	0.36	0.31	0.54	0.58
Value added share		0.19	0.16	0.06	0.04	0.10	0.17	0.65	0.63
Gross export share		0.11	0.06	0.19	0.04	0.34	0.57	0.36	0.33
π_j – Import expenditure share		0.06	0.10	0.21	0.32	0.44	0.43	0.08	0.07
Export to gross output ratio		0.09	0.13	0.44	0.17	0.23	0.32	0.08	0.10

b. 2000

		Output sector j							
		AGR		MIN		MFG		SER	
		SSA	DA	SSA	DA	SSA	DA	SSA	DA
$4*\mu_{j,k}$ – Intermediate input shares	AGR	0.08	0.11	0.002	0.004	0.15	0.13	0.02	0.02
	MIN	0.002	0.001	0.01	0.02	0.04	0.03	0.01	0.01
	MFG	0.07	0.11	0.13	0.13	0.24	0.32	0.11	0.16
	SER	0.11	0.07	0.24	0.16	0.22	0.16	0.31	0.22
β_j – Value added to gross output ratio		0.74	0.71	0.62	0.69	0.36	0.36	0.56	0.58
Value added share		0.22	0.23	0.05	0.04	0.15	0.18	0.59	0.55
Gross export share		0.22	0.08	0.16	0.04	0.39	0.58	0.23	0.30
π_j – Import expenditure share		0.05	0.07	0.16	0.36	0.34	0.45	0.07	0.09
Export to gross output ratio		0.11	0.08	0.56	0.25	0.19	0.35	0.05	0.12

Back to empirics Back to trade costs