Misallocation in a Global Economy

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Introduction

- Develop a model of the world economy as input-output relationships and product distortions
  - One Input-Output matrix (with country/sector as the base unit)
  - A different view on the world economy
  - Trade literature emphasizes transactions across countries subject to distortions (trade costs)
  - Macro literature emphasizes domestic distortions
- Here, one I-O matrix with transactions across suppliers and demanders
  - Suppliers from different sectirs and countries
  - Subject to distortions, internal or external

Introduction

- Goal: Model world's I-O matrix and identify distortions
- Main theoretical result:
  - Decompose TFPs from Distortions
  - Derive a simple closed-form sufficient statistics for calculation of the distortions and TFPs
  - Key: use of the CES production and CES consumption shares
    - Broadly applicable: e.g., Eaton and Kortum, Melitz, etc.
- Main empirical result:
  - Distribution and evolution of distortions (internal and external) across and within countries
  - Elasticity of world's GDP to changes in internal/external distortions across countries
    - Internal are an order of magnitude more important
  - Elasticity of individual country-sector pairs ranked

Simple example

- One country, two sectors: j, k; free mobility of labor across sectors, perfect competition
- Production:
  - Final goods (L - equipped labor; M - materials):

$$Q_j = A_j L_j^{\beta} M_j^{(1-\beta)}$$

    with unit price

$$c_j = \frac{1}{A_j} w_j^{\beta} P_j^{1-\beta}$$

  - Materials, CES production:

$$M_j = \left[(Q_{jj})^{\frac{1}{1+\theta}} + (Q_{jk})^{\frac{1}{1+\theta}} \right]^{\frac{1+\theta}{\theta}}$$

- Consumption, CES:

$$C = \left[C_j^{(\sigma-1)/\sigma} + C_k^{(\sigma-1)/\sigma} \right]^{\frac{\sigma}{\sigma-1}}$$

Distortions (Misallocation)

- Moving goods from the sector k to sector j entails a distortion (cost): τ_{jk}
  - that is, have to pay $\tau_{jk} c_k$
  - note that in general $\tau_{jk} \neq \tau_{kj}$
- Assume $\tau_{jj} = \tau_{kk} = 1$
- Examples of distortions:
  - misallocation, differential sectoral taxes, differential destination-specific markups
  - also possible to have "external" distortions with more than one country (trade costs, tariffs, misallocation)

Production side

- Share of input from the sector j or k in the intermediate consumptin of j
  - The first key ingredient in the calculation of the sufficient statistics

$$\gamma_{jk} \equiv \frac{(\tau_{jk} c_k)^{-\theta}}{(c_j)^{-\theta} + (\tau_{jk} c_k)^{-\theta}} = \frac{A_k^{\theta} \tau_{jk}^{-\theta} P_k^{-\theta(1-\beta)}}{A_j^{\theta} P_j^{-\theta(1-\beta)} + A_k^{\theta} \tau_{jk}^{-\theta} P_k^{-\theta(1-\beta)}}$$

$$\gamma_{jk} = \frac{A_k^{\theta} \tau_{jk}^{-\theta} P_k^{-\theta(1-\beta)}}{(P_j / w^{\beta})^{-\theta}}$$

- Then

$$\tau_{jk} = \left(\frac{P_j}{P_k}\right) \left(\frac{\gamma_{kk}}{\gamma_{jk}}\right)^{\frac{1}{\theta}}$$

- Using the definition of the price index we get

$$\tau_{jk} = \left(\frac{A_j}{A_k}\right)^{-1/\beta} \left(\frac{\gamma_{jj}}{\gamma_{kk}}\right)^{\frac{1}{\theta\beta}} \left(\frac{\gamma_{kk}}{\gamma_{jk}}\right)^{\frac{1}{\theta}}$$

- But not τ and A separately, only the "composite distortion"

Consumption side

- The ideal price index is

$$P = \left[(P_j)^{1-\sigma} + (P_k)^{1-\sigma}\right]^{1/(1-\sigma)}$$

- Sectoral consumption shares:

$$\alpha_j = \frac{P_j C_j}{P_j C_j + P_k C_k} = \left(\frac{P_j}{P}\right)^{1-\sigma}$$

$$\alpha_k = \frac{P_k C_k}{P_j C_j + P_k C_k} = \left(\frac{P_k}{P}\right)^{1-\sigma}$$

- And we get the second key ingedient

$$\frac{P_j}{P_k} = \left(\frac{\alpha_j}{\alpha_k}\right)^{\frac{1}{1-\sigma}}$$

Consumption and Production Side

- From the production side:

$$\tau_{jk} = \left(\frac{P_j}{P_k}\right)\left(\frac{\gamma_{kk}}{\gamma_{jk}}\right)^{\frac{1}{\theta}}$$

- From the consumption side:

$$\frac{P_j}{P_k} = \left(\frac{\alpha_j}{\alpha_k}\right)^{\frac{1}{1-\sigma}}$$

- Putting it all together:

$$\tau_{jk} = \left(\frac{\gamma_{kk}}{\gamma_{jk}}\right)^{\frac{1}{\theta}}\left(\frac{\alpha_j}{\alpha_k}\right)^{\frac{1}{1-\sigma}}$$

Sufficient statistics

Theorem

In a world with N countries (indexed by i, n) and J sectors (indexed by j, k) the internal distortions are given by

$$\tau_{ijik} = \left(\frac{\gamma_{ikik}}{\gamma_{ijik}}\right)^{\frac{1}{\theta}} \left(\frac{\alpha_{ij}}{\alpha_{ik}}\right)^{\frac{1}{1-\sigma}}$$

The external distortions are given by

$$\tau_{ijnk} = \left(\frac{\gamma_{ikik}}{\gamma_{ijnk}}\right)^{\frac{1}{\theta}} \left(\frac{\alpha_{ij}}{\alpha_{nk}}\right)^{\frac{1}{1-\sigma}} \left(\frac{w_i}{w_n}\right)$$

The TFPs are given by

$$\frac{A_{ij}}{Ai_k} = \frac{(\alpha_{ij})^{-\frac{\beta_{ij}}{1-\sigma}}}{(\alpha_{ik})^{-\frac{\beta_{ik}}{1-\sigma}}} \left(\frac{\gamma_{ijij}}{\gamma_{ikik}}\right)^{\frac{(1-\beta)}{\theta}}$$

Generalizations

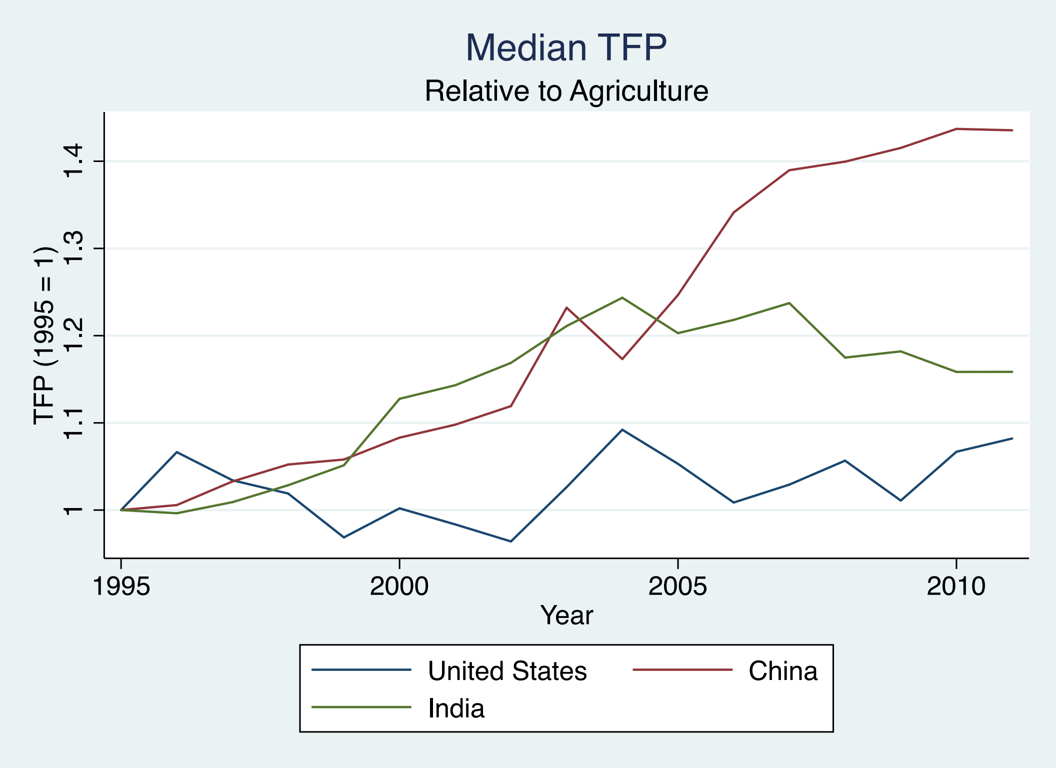
- Easy to have multiple sectors and multiple countries
  - Internal distortions: identical theorem applies
  - "External" distortions: need also to have the ratio of the wages
  - TFPs: can find upto 1 normalization for each country.
- More general CES production

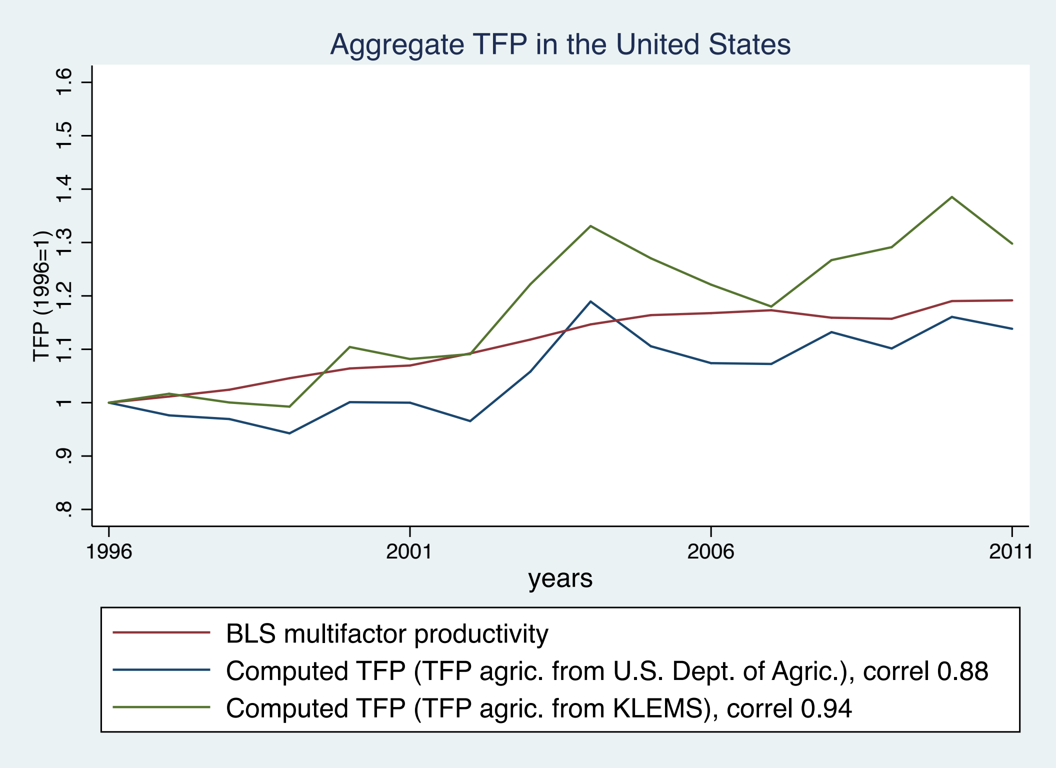
$$M_j = \left[\chi_j \left(Q_j\right)^{\frac{1}{1+\theta}} + \chi_k \left(Q_k\right)^{\frac{1}{1+\theta}}\right]^{\frac{1+\theta}{\theta}}$$

  - need to either have the ratio χ_j/χ_k,
  - or use "hat" algebra to find the changes in distortions
- Eaton-Kortum, Melitz, etc:
  - trivial to extend.

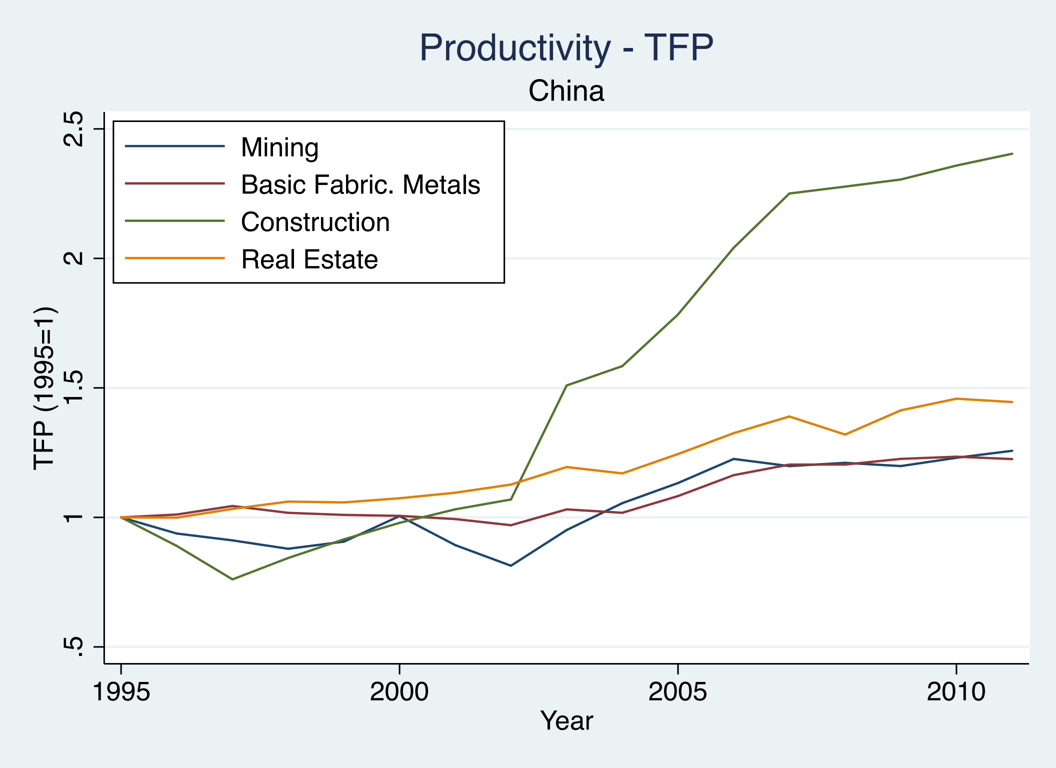
Data

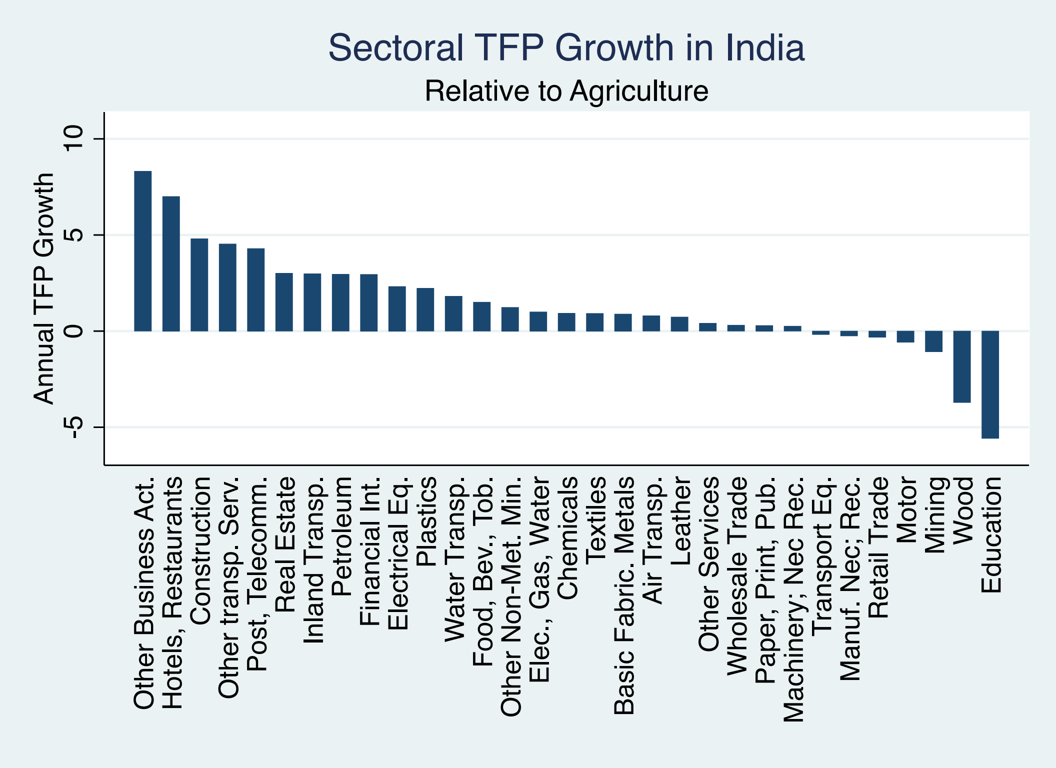
- Use the multi-country, multi-sector version of the model
  - Model the world economy as the World Input-Output Matrix
- This presentation:
  - WIOD, 1995-2011
  - Focus: China, India, US

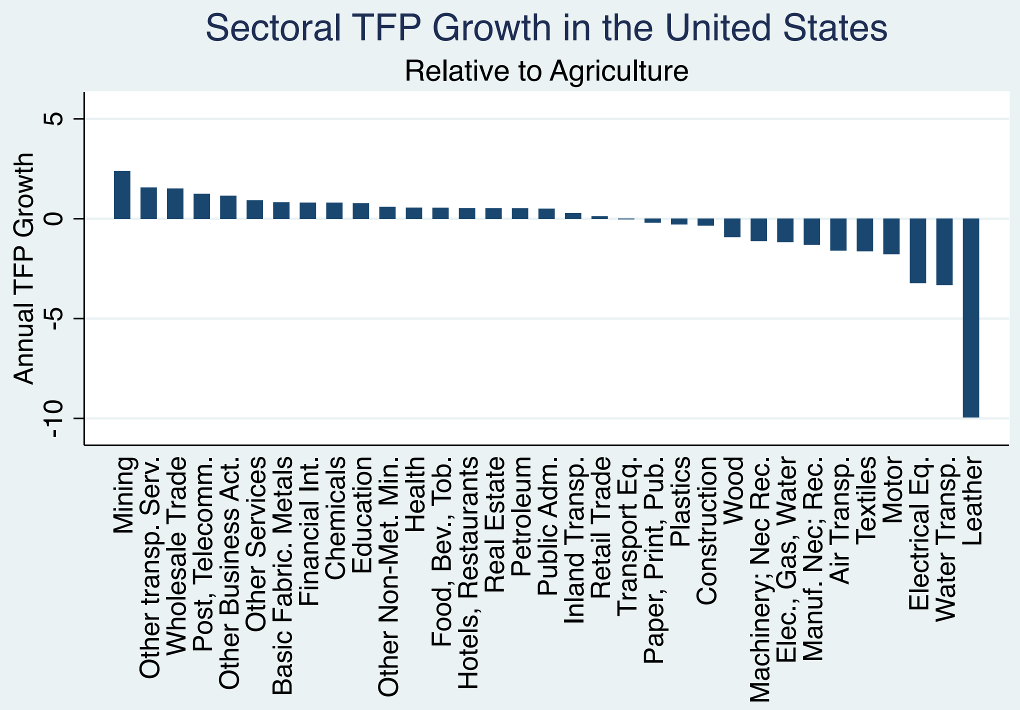

Median TFP
Relative to Agriculture
TFP (1995 = 1)
1
1.1
1.2
1.3
1.4
1995
2000
2005
2010
Year
United States
China
India

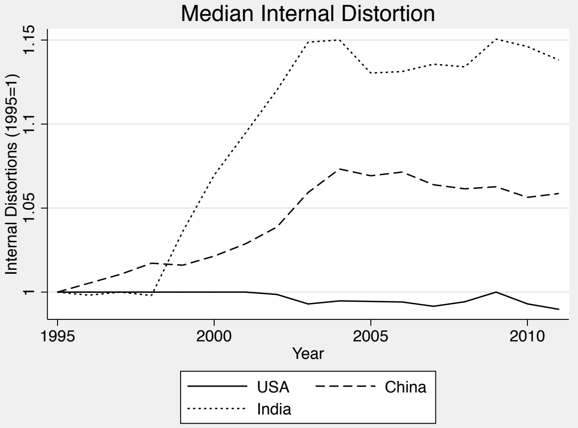

Aggregate TFP in the United States
TFP (1996=1)
.8
.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1996
2001
2006
2011
years
BLS multifactor productivity
Computed TFP (TFP agric. from U.S. Dept. of Agric.), correl 0.88
Computed TFP (TFP agric. from KLEMS), correl 0.94

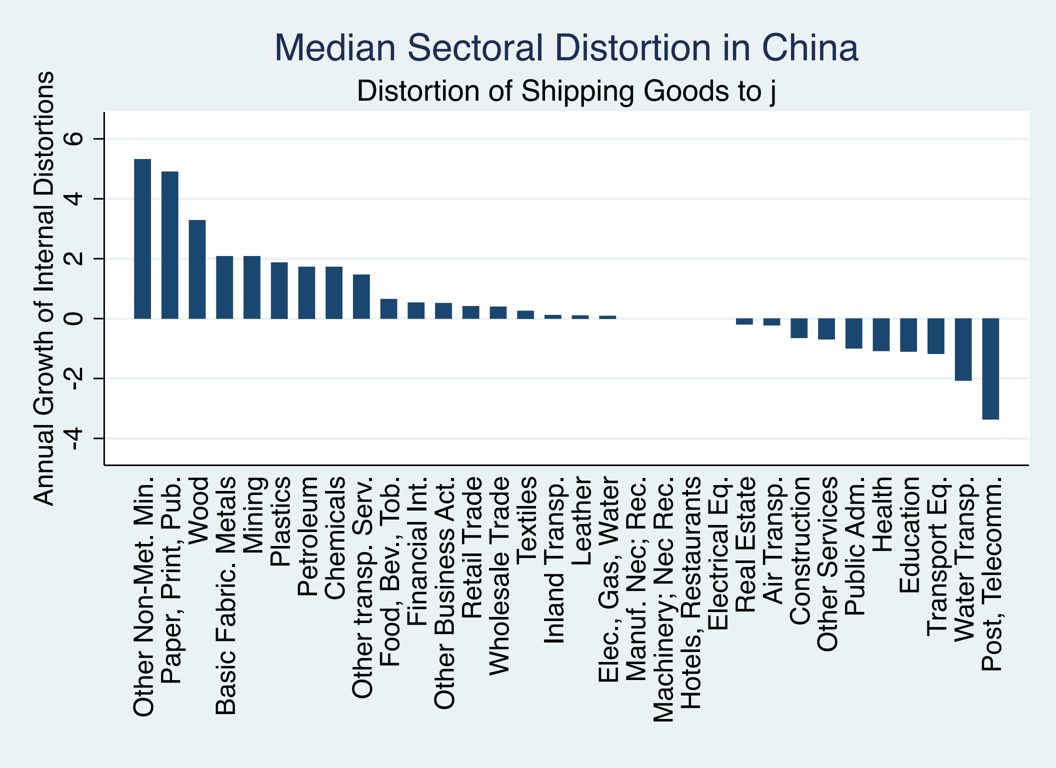
Sectoral TFP Growth in China
Relative to Agriculture
Annual TFP Growth
15
10
5
0
-5
Post, Telecomm.
Water Transp.
Air Transp.
Elec., Gas, Water
Education
Construction
Health
Other Services
Electrical Eq.
Inland Transp.
Plastics
Transport Eq.
Real Estate
Leather
Wood
Food, Bev., Tob.
Textiles
Machinery; Nec Rec.
Chemicals
Hotels, Restaurants
Other Business Act.
Paper, Print, Pub.
Mining
Other transp. Serv.
Basic Fabric. Metals
Petroleum
Other Non-Met. Min.
Financial Int.
Manuf. Nec; Rec.
Wholesale Trade
Retail Trade

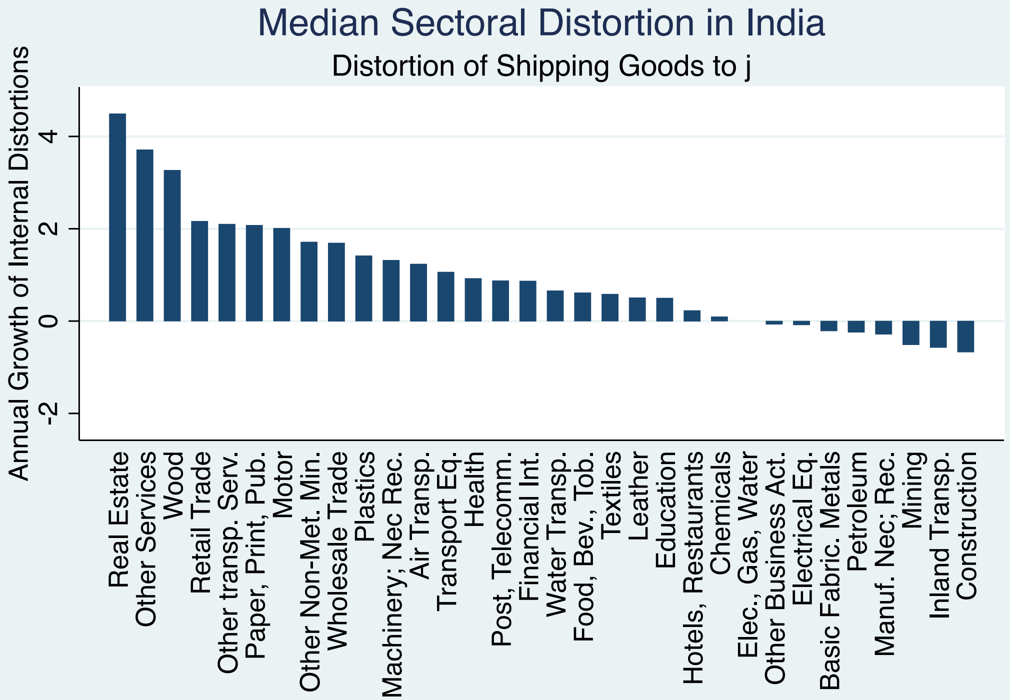

Productivity - TFP
China
Mining
Basic Fabric. Metals
Construction
Real Estate
TFP (1995=1)
.5
1
1.5
2
2.5
1995
2000
2005
2010
Year

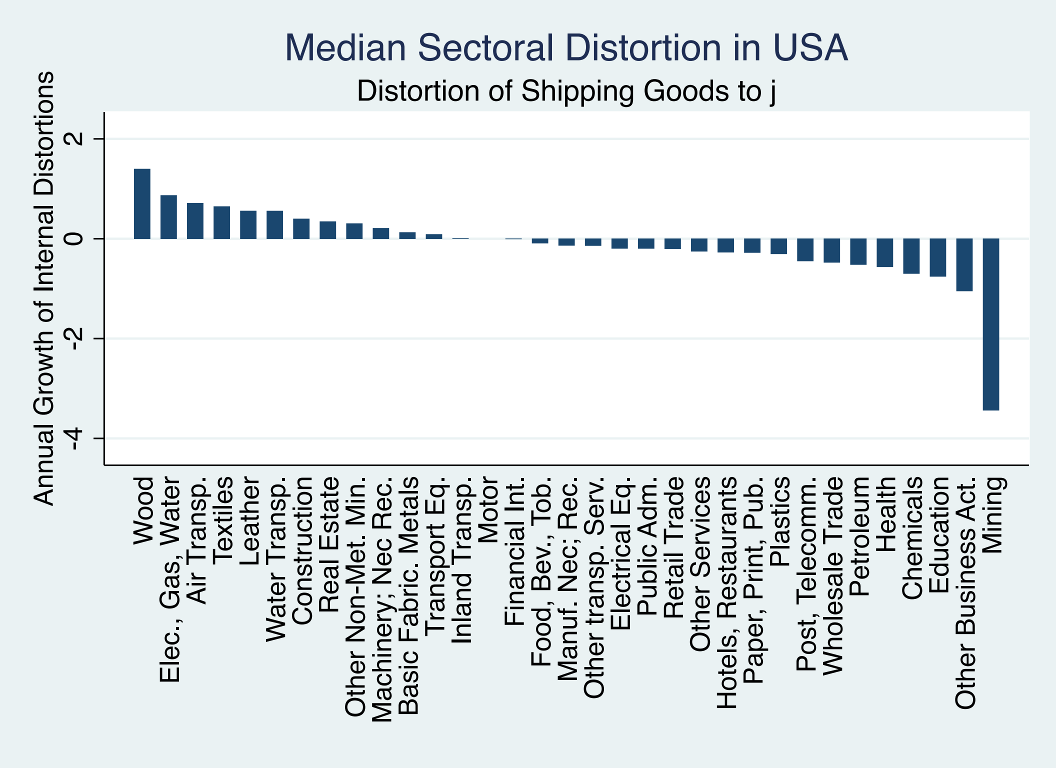

Sectoral TFP Growth in India
Relative to Agriculture
Annual TFP Growth
10
5
0
-5
Other Business Act.
Hotels, Restaurants
Construction
Other transp. Serv.
Post, Telecomm.
Real Estate
Inland Transp.
Petroleum
Financial Int.
Electrical Eq.
Plastics
Water Transp.
Food, Bev., Tob.
Other Non-Met. Min.
Elec., Gas, Water
Chemicals
Textiles
Basic Fabric. Metals
Air Transp.
Leather
Other Services
Wholesale Trade
Paper, Print, Pub.
Machinery; Nec Rec.
Transport Eq.
Manuf. Nec; Rec.
Retail Trade
Motor
Mining
Wood
Education

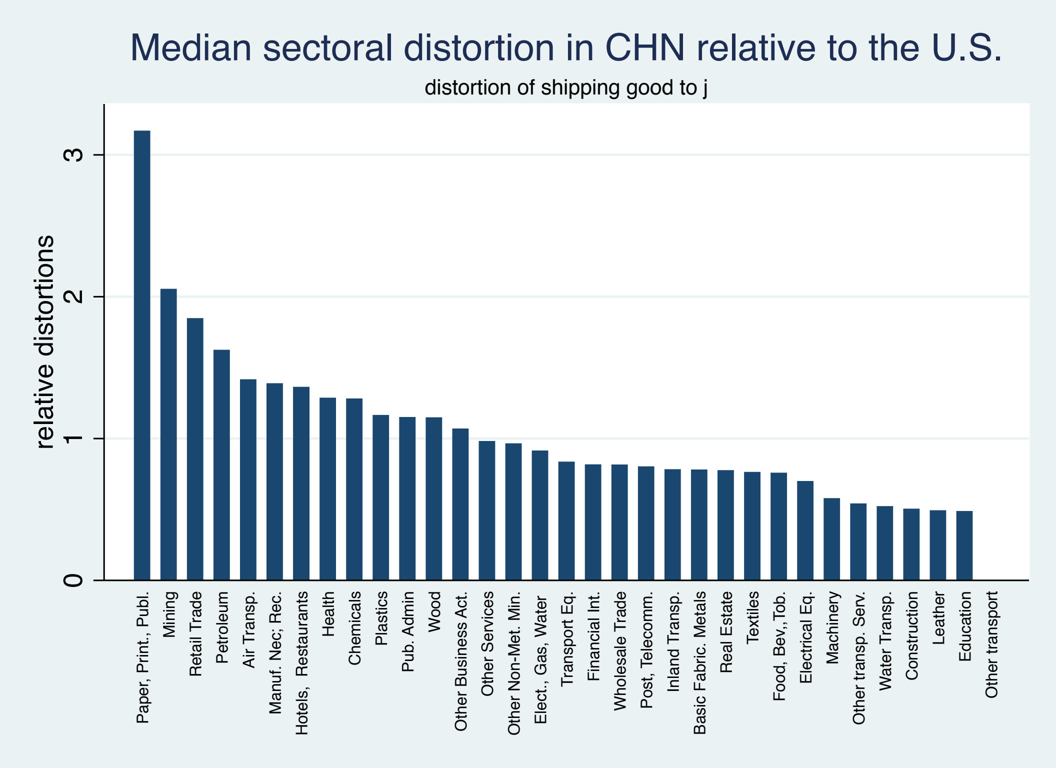

Sectoral TFP Growth in the United States
Relative to Agriculture
Annual TFP Growth
5
0
-5
-10
Mining
Other transp. Serv.
Wholesale Trade
Post, Telecomm.
Other Business Act.
Other Services
Basic Fabric. Metals
Financial Int.
Chemicals
Education
Other Non-Met. Min.
Health
Food, Bev., Tob.
Hotels, Restaurants
Real Estate
Petroleum
Public Adm.
Inland Transp.
Retail Trade
Transport Eq.
Paper, Print, Pub.
Plastics
Construction
Wood
Machinery; Nec Rec.
Elec., Gas, Water
Manuf. Nec; Rec.
Air Transp.
Textiles
Motor
Electrical Eq.
Water Transp.
Leather


Median Internal Distortion
Internal Distortions (1995=1)
1.15
1.1
1.05
1
1995
2000
2005
2010
Year
USA
China
India

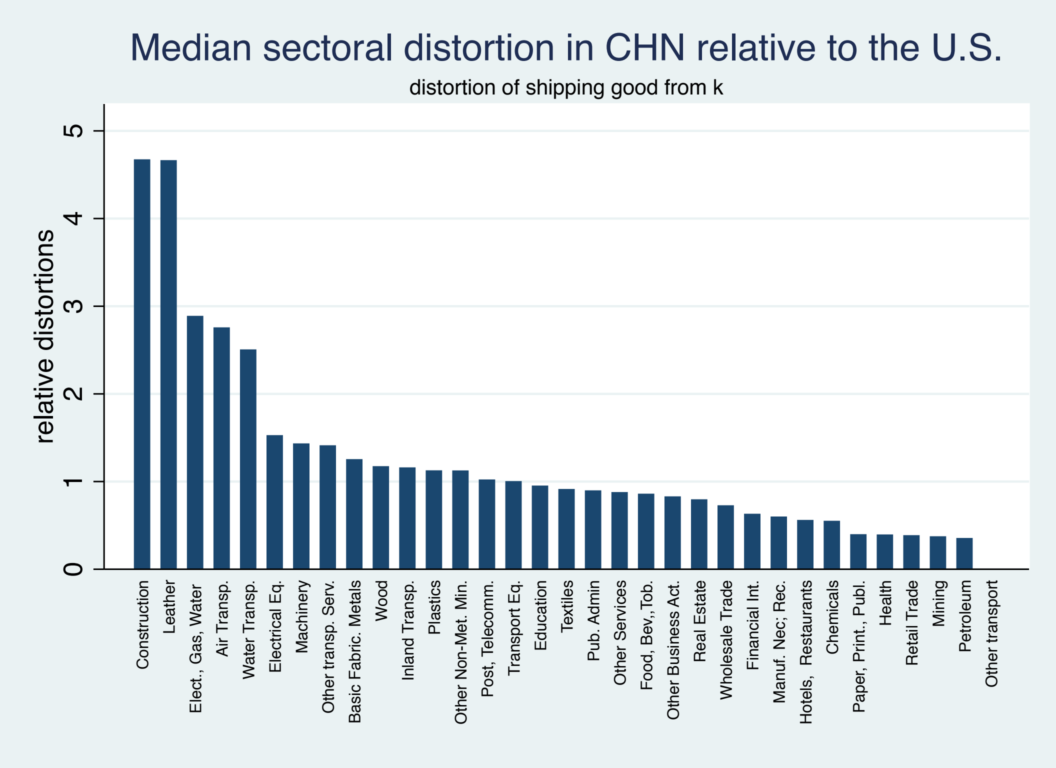

Median Sectoral Distortion in China
Distortion of Shipping Goods to j
Annual Growth of Internal Distortions
6
4
2
0
-2
-4
Other Non-Met. Min.
Paper, Print, Pub.
Wood
Basic Fabric. Metals
Mining
Plastics
Petroleum
Chemicals
Other transp. Serv.
Food, Bev., Tob.
Financial Int.
Other Business Act.
Retail Trade
Wholesale Trade
Textiles
Inland Transp.
Leather
Elec., Gas, Water
Manuf. Nec; Rec.
Machinery; Nec Rec.
Hotels, Restaurants
Electrical Eq.
Real Estate
Air Transp.
Construction
Other Services
Public Adm.
Health
Education
Transport Eq.
Water Transp.
Post, Telecomm.

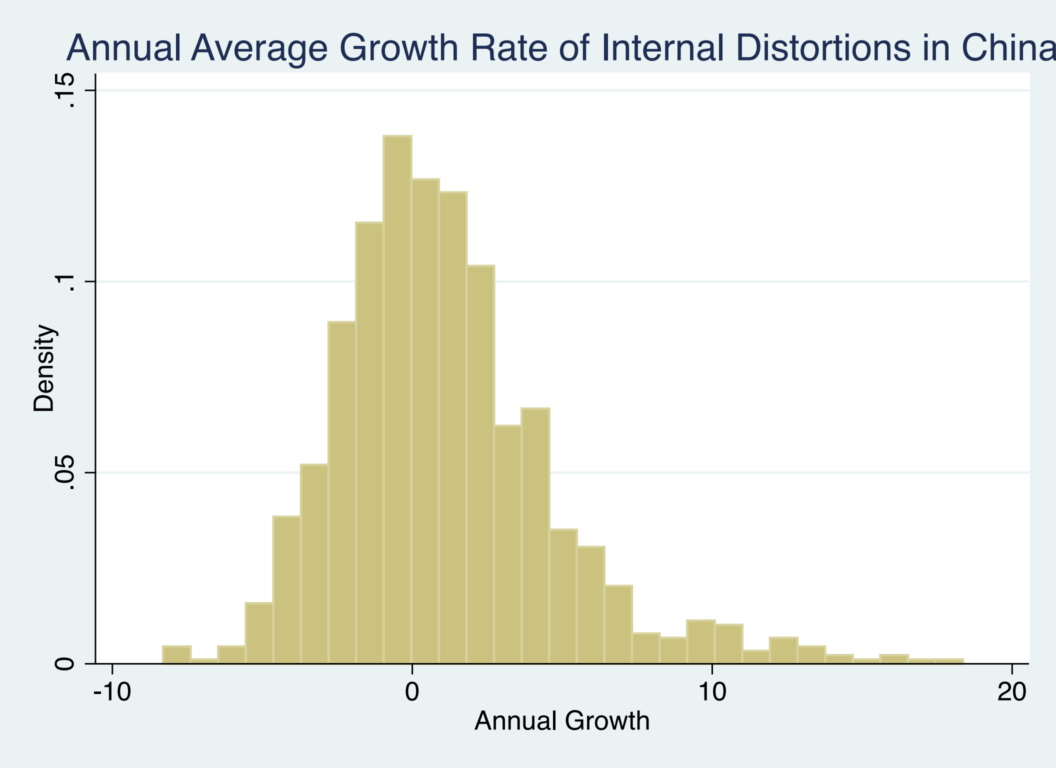

Median Sectoral Distortion in India
Distortion of Shipping Goods to j
Annual Growth of Internal Distortions
-2
0
2
4
Real Estate
Other Services
Wood
Retail Trade
Other transp. Serv.
Paper, Print, Pub.
Motor
Other Non-Met. Min.
Wholesale Trade
Plastics
Machinery; Nec Rec.
Air Transp.
Transport Eq.
Health
Post, Telecomm.
Financial Int.
Water Transp.
Food, Bev., Tob.
Textiles
Leather
Education
Hotels, Restaurants
Chemicals
Elec., Gas, Water
Other Business Act.
Electrical Eq.
Basic Fabric. Metals
Petroleum
Manuf. Nec; Rec.
Mining
Inland Transp.
Construction

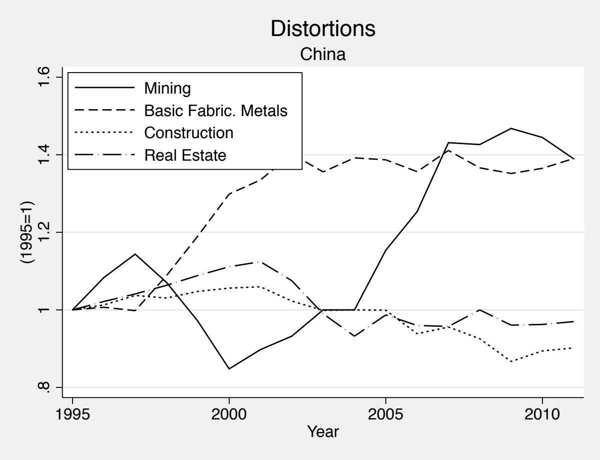

Median Sectoral Distortion in USA
Distortion of Shipping Goods to j
Annual Growth of Internal Distortions
2
0
-2
-4
Wood
Elec., Gas, Water
Air Transp.
Textiles
Leather
Water Transp.
Construction
Real Estate
Other Non-Met. Min.
Machinery; Nec Rec.
Basic Fabric. Metals
Transport Eq.
Inland Transp.
Motor
Financial Int.
Food, Bev., Tob.
Manuf. Nec; Rec.
Other transp. Serv.
Electrical Eq.
Public Adm.
Retail Trade
Other Services
Hotels, Restaurants
Paper, Print, Pub.
Plastics
Post, Telecomm.
Wholesale Trade
Petroleum
Health
Chemicals
Education
Other Business Act.
Mining



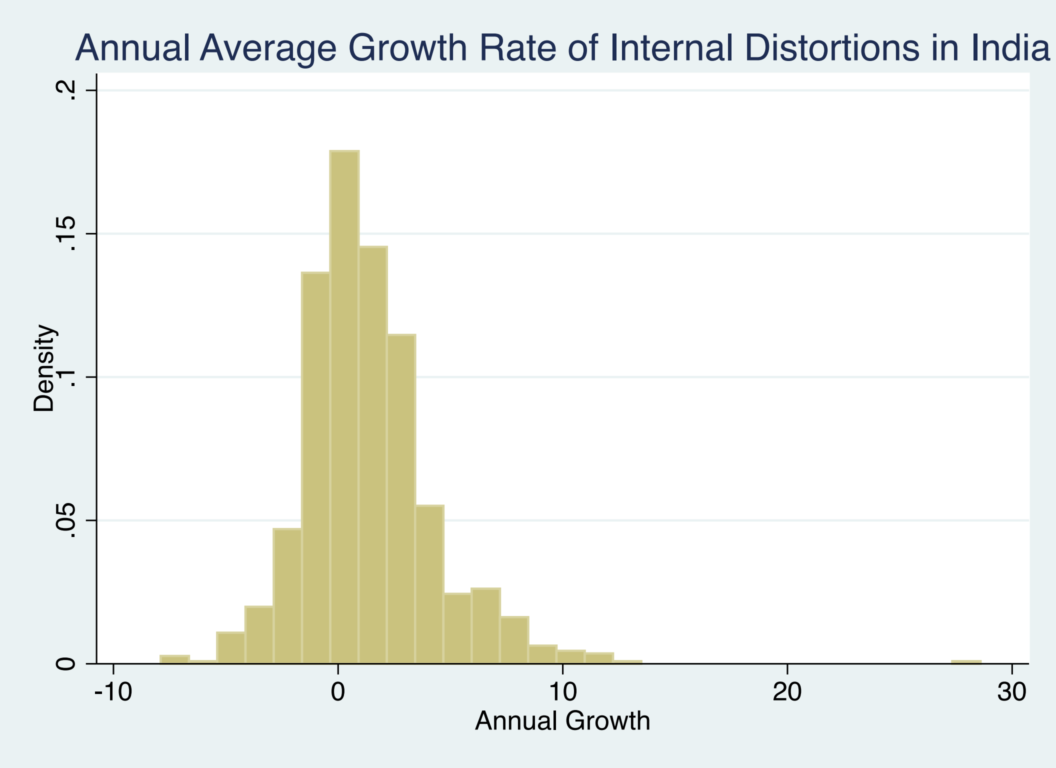
Median sectoral distortion in CHN relative to the U.S.
distortion of shipping good to j
relative distortions
0
1
2
3
Paper, Print., Publ.
Mining
Retail Trade
Petroleum
Air Transp.
Manuf. Nec; Rec.
Hotels, Restaurants
Health
Chemicals
Plastics
Pub. Admin
Wood
Other Business Act.
Other Services
Other Non-Met. Min.
Elect., Gas, Water
Transport Eq.
Financial Int.
Wholesale Trade
Post, Telecomm.
Inland Transp.
Basic Fabric. Metals
Real Estate
Textiles
Food, Bev,,Tob.
Electrical Eq.
Machinery
Other transp. Serv.
Water Transp.
Construction
Leather
Education
Other transport


Median sectoral distortion in CHN relative to the U.S.
distortion of shipping good from k
relative distortions
0
1
2
3
4
5
Construction
Leather
Elect., Gas, Water
Air Transp.
Water Transp.
Electrical Eq.
Machinery
Other transp. Serv.
Basic Fabric. Metals
Wood
Inland Transp.
Plastics
Other Non-Met. Min.
Post, Telecomm.
Transport Eq.
Education
Textiles
Pub. Admin
Other Services
Food, Bev,, Tob.
Other Business Act.
Real Estate
Wholesale Trade
Financial Int.
Manuf. Nec; Rec.
Hotels, Restaurants
Chemicals
Paper, Print., Publ.
Health
Retail Trade
Mining
Petroleum
Other transport

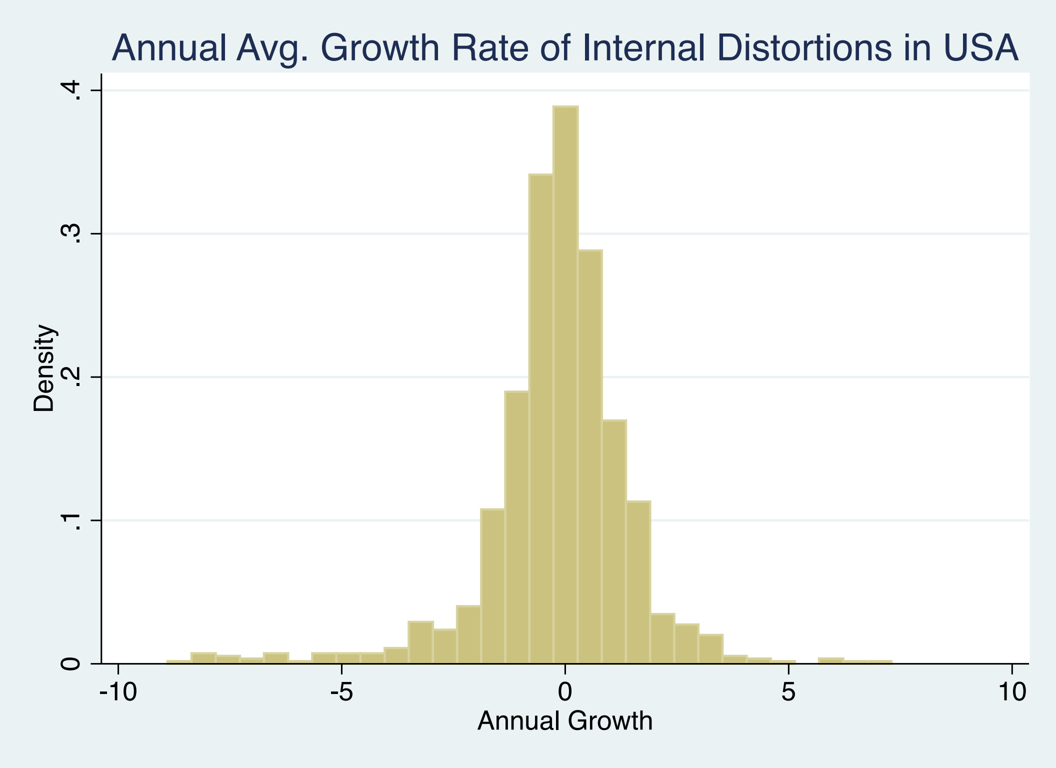

Annual Average Growth Rate of Internal Distortions in China
Density
0
.05
.1
.15
-10
0
10
20
Annual Growth

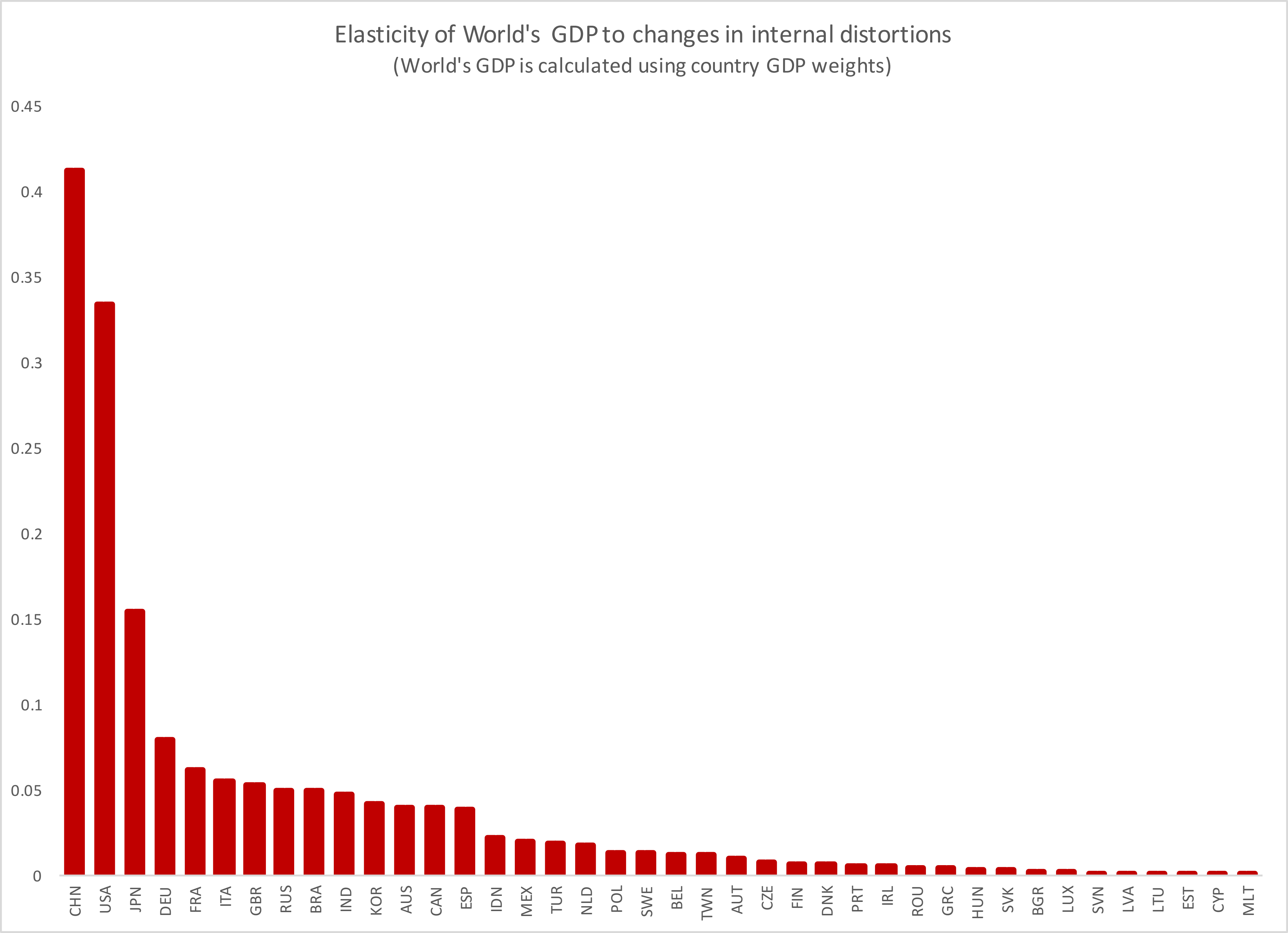


Distortions
China
Mining
Basic Fabric. Metals
Construction
Real Estate
(1995=1)
1.6
1.4
1.2
1
.8
1995
2000
2005
2010
Year

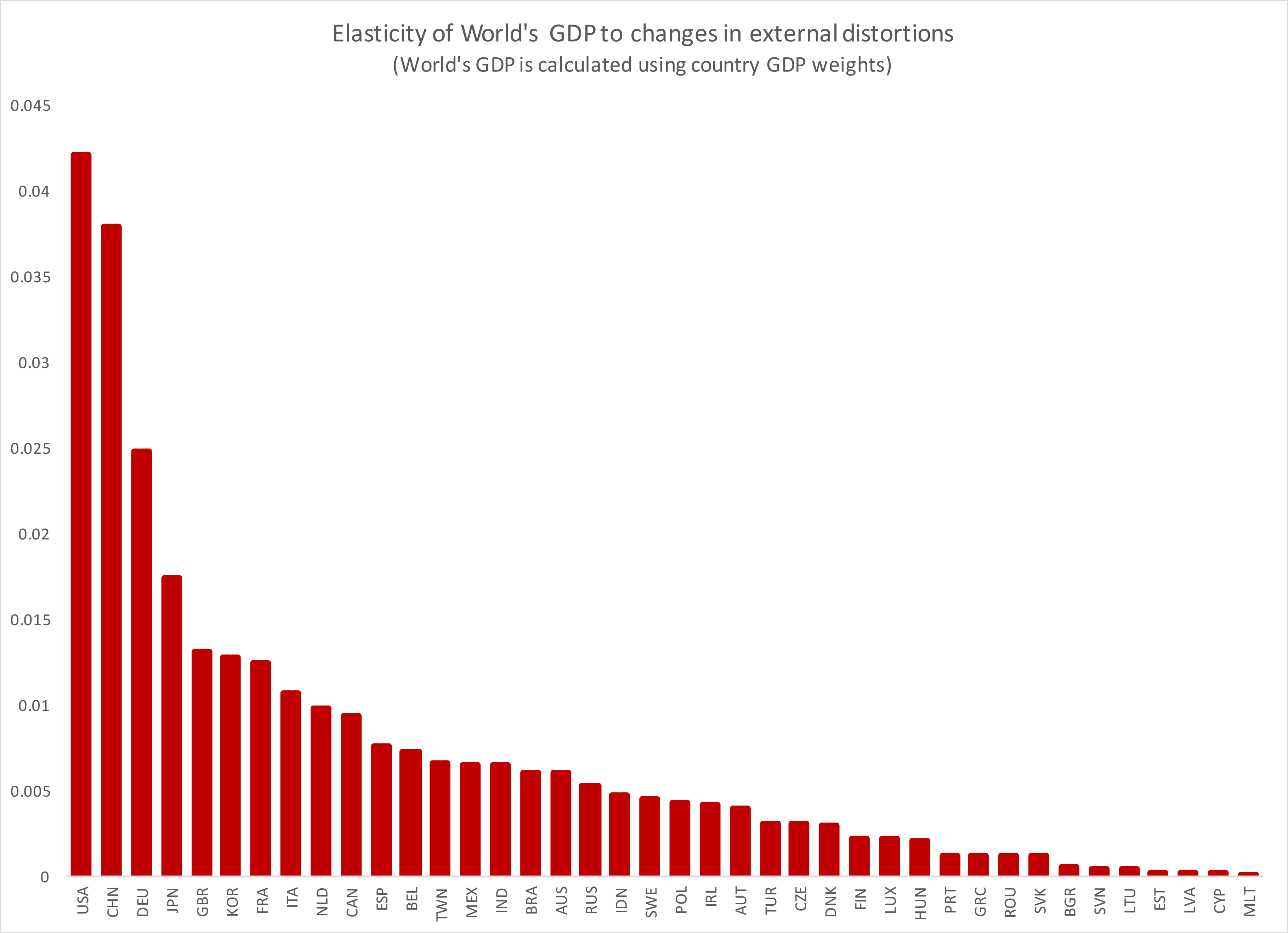


Annual Average Growth Rate of Internal Distortions in India
Density
0
.05
.1
.15
.2
-10
0
10
20
30
Annual Growth

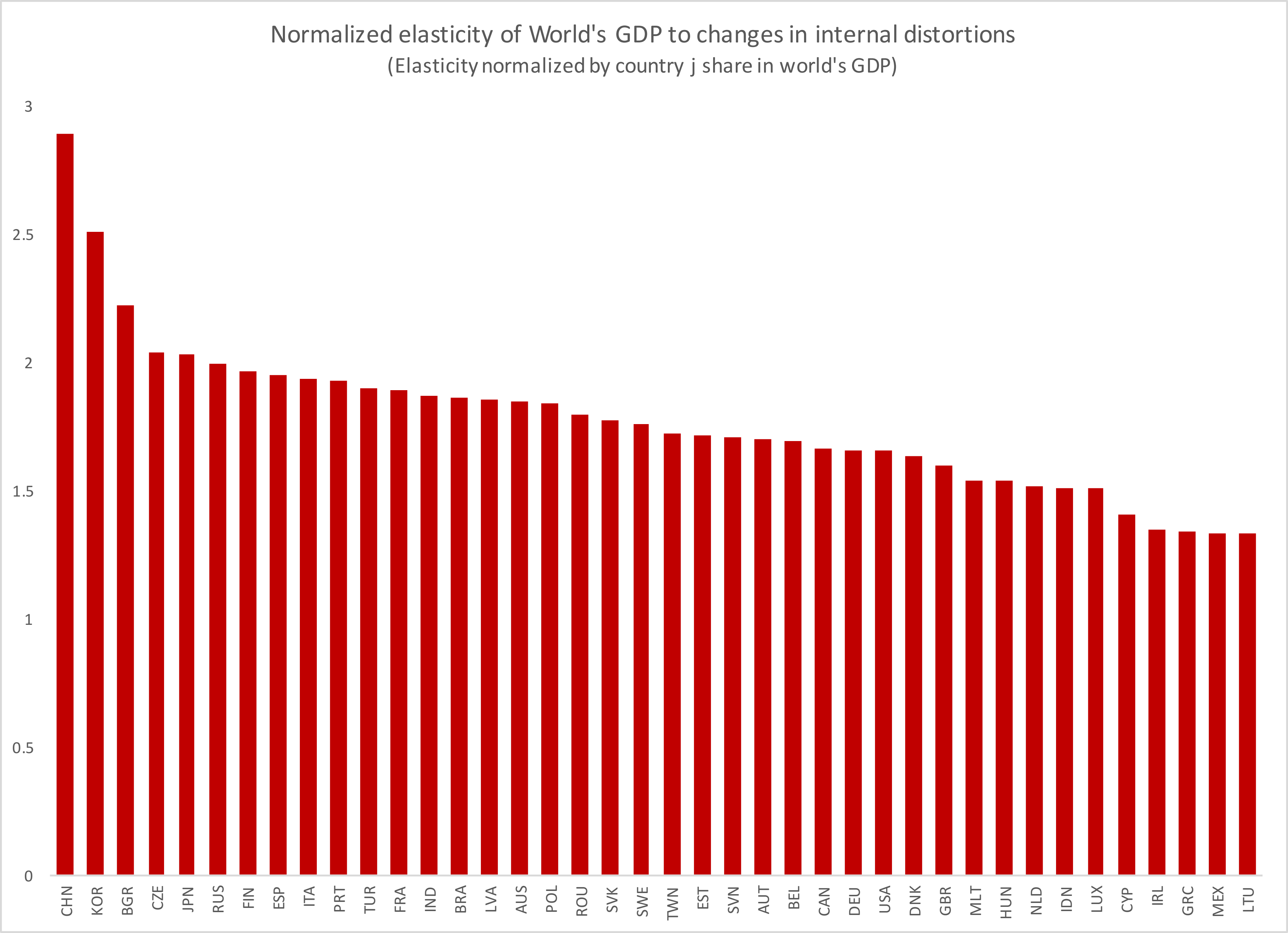

Annual Avg. Growth Rate of Internal Distortions in USA
Density
0
.1
.2
.3
.4
-10
-5
0
5
10
Annual Growth

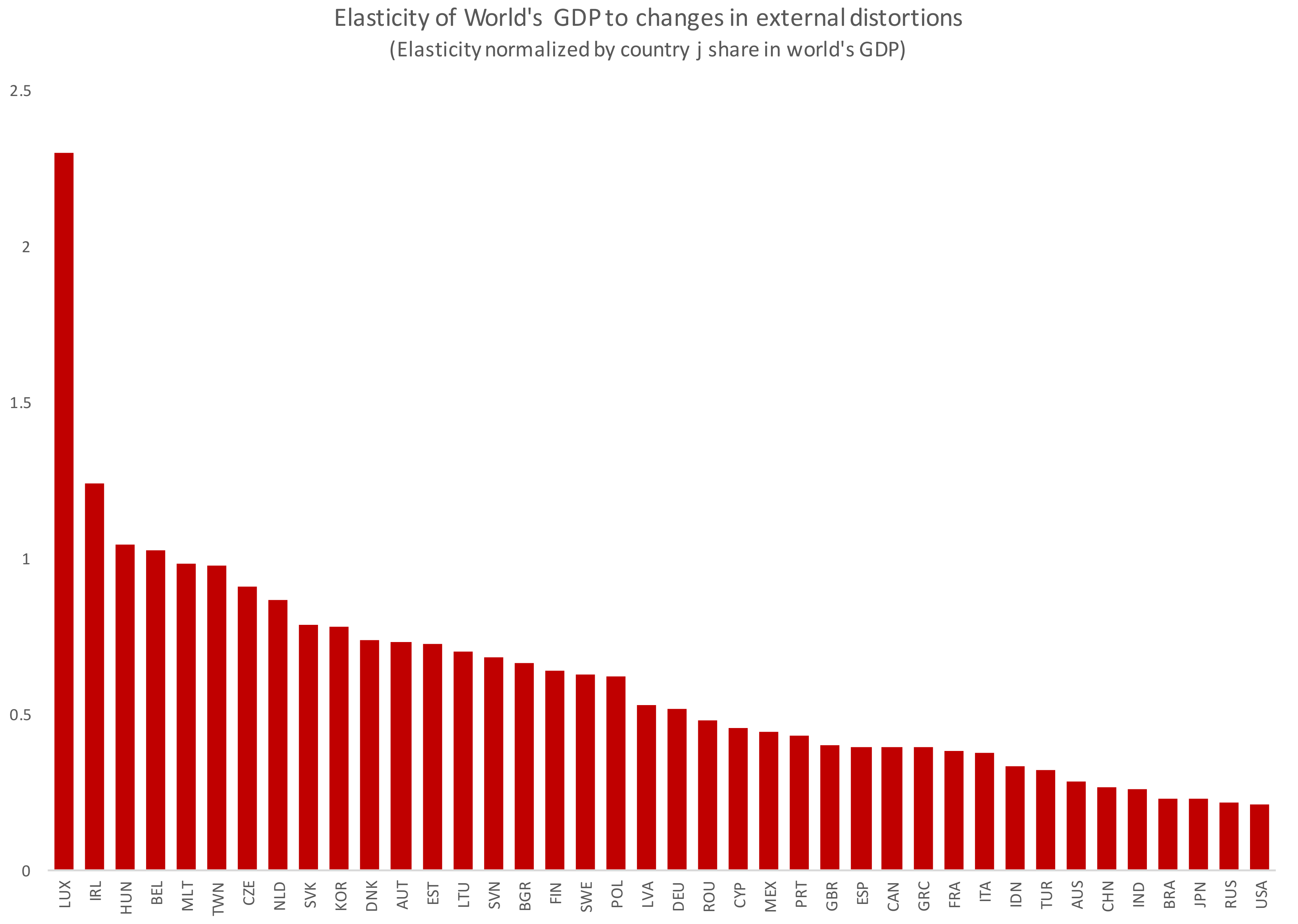


Elasticity of World's GDP to changes in internal distortions
(World's GDP is calculated using country GDP weights)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
CHN
USA
JPN
DEU
FRA
ITA
GBR
RUS
BRA
IND
KOR
AUS
CAN
ESP
IDN
MEX
TUR
NLD
POL
SWE
BEL
TWN
AUT
CZE
FIN
DNK
PRT
IRL
ROU
GRC
HUN
SVK
BGR
LUX
SVN
LVA
LTU
EST
CYP
MLT



Elasticity of World's GDP to changes in external distortions
(World's GDP is calculated using country GDP weights)
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
USA
CHN
DEU
JPN
GBR
KOR
FRA
ITA
NLD
CAN
ESP
BEL
TWN
MEX
IND
BRA
AUS
RUS
IDN
SWE
POL
IRL
AUT
TUR
CZE
DNK
FIN
LUX
HUN
PRT
GRC
ROU
SVK
BGR
SVN
LTU
EST
LVA
CYP
MLT


Normalized elasticity of World's GDP to changes in internal distortions
(Elasticity normalized by country j share in world's GDP)
3
2.5
2
1.5
1
0.5
0
CHN
KOR
BGR
CZE
JPN
RUS
FIN
ESP
ITA
PRT
TUR
FRA
IND
BRA
LVA
AUS
POL
ROU
SVK
SWE
TWN
EST
SVN
AUT
BEL
CAN
DEU
USA
DNK
GBR
MLT
HUN
NLD
IDN
LUX
CYP
IRL
GRC
MEX
LTU


Elasticity of World's GDP to changes in external distortions
(Elasticity normalized by country j share in world's GDP)
2.5
2
1.5
1
0.5
0
LUX
IRL
HUN
BEL
MLT
TWN
CZE
NLD
SVK
KOR
DNK
AUT
EST
LTU
SVN
BGR
FIN
SWE
POL
LVA
DEU
ROU
CYP
MEX
PRT
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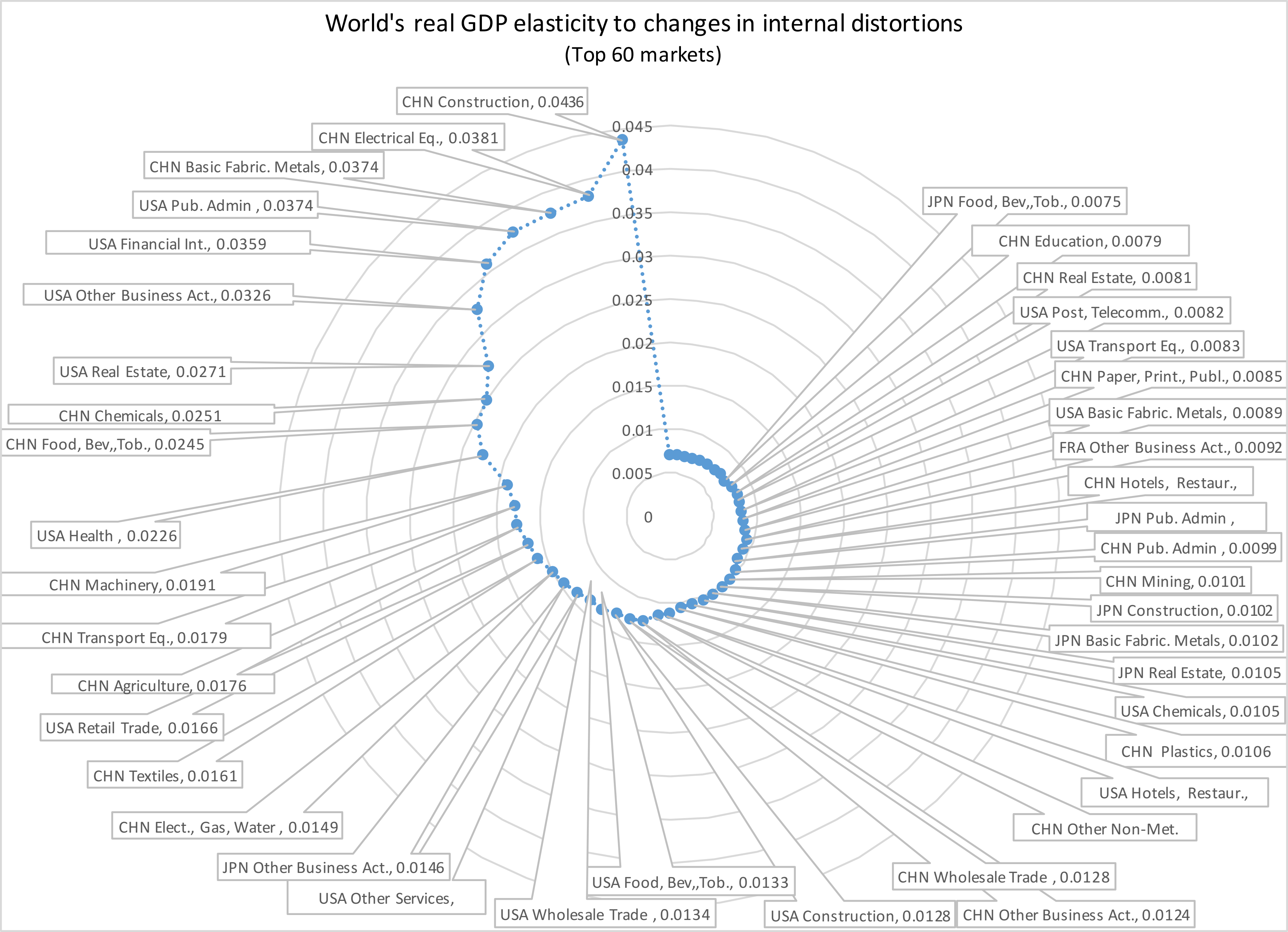
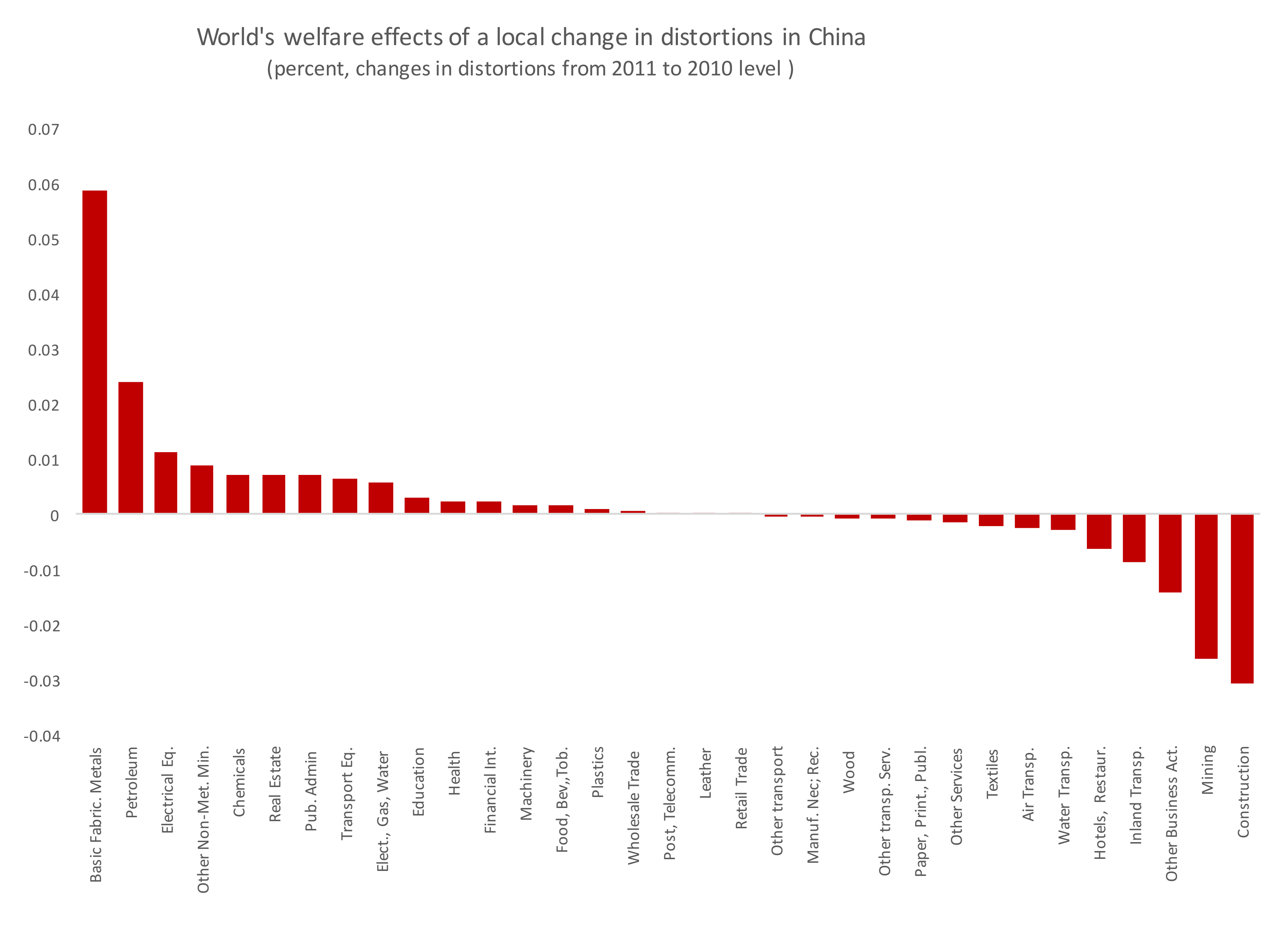
IND
BRA
JPN
RUS
USA


World's real GDP elasticity to changes in internal distortions
(Top 60 markets)
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
CHN Construction, 0.0436
CHN Electrical Eq., 0.0381
CHN Basic Fabric. Metals, 0.0374
USA Pub. Admin , 0.0374
USA Financial Int., 0.0359
USA Other Business Act., 0.0326
USA Real Estate, 0.0271
CHN Chemicals, 0.0251
CHN Food, Bev,,Tob., 0.0245
USA Health , 0.0226
CHN Machinery, 0.0191
CHN Transport Eq., 0.0179
CHN Agriculture, 0.0176
USA Retail Trade, 0.0166
CHN Textiles, 0.0161
CHN Elect., Gas, Water , 0.0149
JPN Other Business Act., 0.0146
USA Other Services,
USA Wholesale Trade , 0.0134
USA Food, Bev,,Tob., 0.0133
USA Construction, 0.0128
CHN Wholesale Trade , 0.0128
CHN Other Business Act., 0.0124
CHN Other Non-Met.
USA Hotels, Restaur.,
CHN Plastics, 0.0106
USA Chemicals, 0.0105
JPN Real Estate, 0.0105
JPN Basic Fabric. Metals, 0.0102
JPN Construction, 0.0102
CHN Mining, 0.0101
CHN Pub. Admin , 0.0099
JPN Pub. Admin ,
CHN Hotels, Restaur.,
FRA Other Business Act., 0.0092
USA Basic Fabric. Metals, 0.0089
CHN Paper, Print., Publ., 0.0085
USA Transport Eq., 0.0083
USA Post, Telecomm., 0.0082
CHN Real Estate, 0.0081
CHN Education, 0.0079
JPN Food, Bev,,Tob., 0.0075


World's welfare effects of a local change in distortions in China
(percent, changes in distortions from 2011 to 2010 level)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
Basic Fabric. Metals
Petroleum
Electrical Eq.
Other Non-Met. Min.
Chemicals
Real Estate
Pub. Admin
Transport Eq.
Elect., Gas, Water
Education
Health
Financial Int.
Machinery
Food, Bev,,Tob.
Plastics
Wholesale Trade
Post, Telecomm.
Leather
Retail Trade
Other transport
Manuf. Nec; Rec.
Wood
Other transp. Serv.
Paper, Print., Publ.
Other Services
Textiles
Air Transp.
Water Transp.
Hotels, Restaur.
Inland Transp.
Other Business Act.
Mining
Construction

Conclusion

- Model the world I-O matrix
- Identify distortions in I-O transactions
- Derive sufficient statistics to compute distortions and TFP, broadly applicable to a class of models
- Internal distortions may have significant impact on the world economy

Welfare

- Using the equilibrium condition of the model, we obtain

$$\frac{w}{P} = \left[\sum_{j=1}^{J} \left(\gamma_{jj}/A_j^{\theta}\right)^{(1-\sigma)/\theta\beta}\right]^{-1/(1-\sigma)}$$