

# Distortions and the Structure of the World Economy

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January 13, 2018

# Introduction

- ▶ *“The world economy, like the economy of a single country, can be visualized as a system of interdependent processes”*
  - ▶ Trade literature emphasizes transactions across countries
    - ▶ Subject to frictions and differences in TFP
  - ▶ Macro literature emphasizes transactions across sectors
    - ▶ Subject to distortions
- ▶ In this paper we model the world economy as one world input-output matrix
  - ▶ Country/sector as the base unit
  - ▶ The structure of the economy is endogenous
    - ▶ Expenditure shares determined by sectoral wedges (distortions-frictions) and TFP's and change with them
- ▶ A different view on the world economy

# Introduction

- ▶ Our primary interest is in identifying these wedges and study how changes in TFP and wedges affect the world economy
- ▶ Main theoretical result:
  - ▶ Derive a simple closed-form sufficient statistic to decompose wedges from TFP
    - ▶ Key: use production and consumption shares
    - ▶ Broadly applicable to macro and trade models
  - ▶ Analytically derive the elasticity of changes in the structure of production to changes in wedges and TFP
    - ▶ Can characterize the change in the entire world I-O to the change in a given country-sector pair wedge or TFP

# Introduction

- ▶ Match the entire World Input-Output Database (WIOD)
  - ▶ 35 industries, 40 countries, 1995-2011
- ▶ Main empirical result:
  - ▶ Study how changes to internal distortions affect the structure of production
    - ▶ Use the U.S. and China's I-O to illustrate results
  - ▶ Compute the 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
  - ▶ We measure the distribution and evolution of distortions (internal and external) across and within countries

# Literature

- ▶ Input-output models with misallocations, Jones (2011, 2013)
  - ▶ *“There is a fundamental identification problem: we see data on observed intermediate goods shares, and we do not know how to decompose that data into distortions and differences in technologies”*
- ▶ Literature on the importance of sectoral or local shocks for aggregate outcomes
  - ▶ Acemoglu, et al. (2012), Caliendo and Parro (2015), Atalay (2016), Caliendo, Parro, Rossi-Hansberg and Sarte (2017) and more
- ▶ Relates to studies of the effects of distortions (labor market, internals, externals)
  - ▶ see Hsieh and Klenow (2009), Boehm (2016), Boehm and Oberfield (2017), Tombe and Zhu (2015), Eaton, Kortum, Neiman and Romalis (2016)
- ▶ Relates to recent papers on global supply chains (e.g. Antras and de Gortari 2017)

# Road map

- ▶ Model
- ▶ Analytical results
- ▶ Empirical results
- ▶ Conclusion

# Model

- ▶ The World Economy consists of  $N$  countries (indexed by  $i, n$ ), and each country has  $J$  sectors (indexed by  $j, k$ )
  - ▶ Each country is endowed with equipped labor,  $L$
  - ▶ Perfect competition in both the final goods sectors and the materials sectors (could be relaxed)
- ▶ Production of intermediate goods  $Q_{ij}$ :
  - ▶ Intermediate goods ( $L$  - equipped labor;  $M$  - materials,  $A$  is TFP):

$$Q_{ij} = A_{ij} L_{ij}^{\beta} M_{ij}^{(1-\beta)},$$

with unit price

$$c_{ij} = \frac{1}{A_{ij}} w_i^{\beta} P_{ij}^{(1-\beta)},$$

where  $w$  are factor prices and  $P_{ij}$  are material goods prices

# Model

- ▶ Production of final goods, (also Materials)
  - ▶ CES production function with elasticity  $\theta$

$$M_{ij} = \left( \sum_{n,k} \iota_{nk} Q_{ijnk}^{\frac{\theta}{1+\theta}} \right)^{\frac{1+\theta}{\theta}},$$

sector  $i$  in the country  $j$  sources  $Q_{ijnk}$  of intermediate goods from the sector  $k$  in the country  $n$

- ▶ Agents in country  $i$  have CES preferences, with elasticity  $\sigma$

$$C_{ij} = \frac{\chi_{ij} P_{ij}^{-\sigma} R_i}{P_i^{(1-\sigma)}},$$

where  $P_i$  is the ideal price index,  $P_{ij}$  the price of  $C_{ij}$  the consumption goods from sector  $j$  in country  $i$ , and  $R_i$  income



# Distortions

- ▶ Sourcing a good from country  $n$ , sector  $k$  to country  $i$ , sector  $j$  entails a cost  $\tau_{ijnk}$ 
  - ▶ that is, have to pay  $\tau_{ijnk} c_{nk}$ .
  - ▶ we do not impose symmetry, in general  $\tau_{ijnk} \neq \tau_{nkij}$ , assume  $\tau_{ijij} = 1$
- ▶ We distinguish between
  - ▶ *Internal distortions*
    - ▶ Affect sectors within a country,  $\tau_{ijik}$
    - ▶ Example: any kind of policy that favors one sector over another, regulations, special consideration for credit, sector-specific taxes, and so on
  - ▶ *External distortions*
    - ▶ Affect sectors across countries,  $\tau_{ijnk}$  ( $i \neq n$ )
    - ▶ Example: trade costs, border taxes, tariffs for imports or exports, or differences in contract enforcement

# Consumption and Production Shares

- ▶ Share of inputs from country  $n$ , sector  $k$  in total intermediate consumption in country  $i$ , sector  $j$  given by

$$\gamma_{ijnk} \equiv \frac{X_{ijnk}}{\sum_{m=1}^N \sum_{h=1}^J X_{ijmh}},$$

$X_{ijnk}$  is expenditure in country  $i$ , sector  $j$ , on intermediate goods from country  $n$ , sector  $k$

- ▶ Counterpart in the data:
  - ▶ Input-output shares directly computed from any world input-output table

# Consumption and Production Shares

- ▶ Share of consumption good from sector  $j$  in the aggregate consumption of country  $i$  given by

$$\alpha_{ij} \equiv \frac{P_{ij} C_{ij}}{\sum_{k=1}^J P_{ik} C_{ik}}$$

- ▶ Counterpart in the data:
  - ▶ directly observable in any world input-output matrix that contain data on final expenditure

# Identification of Distortions and TFPs

- ▶ Consider first the internal distortions and the sectoral TFP
  - ▶ Start with the production side of the economy
- ▶ The share of the input of the sector  $k$  in the sector  $j$  is:

$$\gamma_{ijk} = \frac{(\tau_{ijk} c_{ik})^{-\theta} \ell_{ik}^{1+\theta}}{\sum_{m=1}^N \sum_{h=1}^J (\tau_{ijmh} c_{mh})^{-\theta} \ell_{mh}^{1+\theta}},$$

using the unit prices,

$$\gamma_{ijk} = \frac{A_{ik}^{\theta} \tau_{ijk}^{-\theta} w_i^{-\theta\beta} P_{ik}^{-\theta(1-\beta)} \ell_{ik}^{1+\theta}}{\sum_{m=1}^N \sum_{h=1}^J A_{mh}^{\theta} \tau_{ijmh}^{-\theta} w_m^{-\theta\beta} P_{mh}^{-\theta(1-\beta)} \ell_{mh}^{1+\theta}}$$

which in turn, using the definition of the sectoral price index, can be written as:

$$\gamma_{ijk} = \frac{A_{ik}^{\theta} \tau_{ijk}^{-\theta} P_{ik}^{-\theta(1-\beta)} \ell_{ik}^{1+\theta}}{\left(P_{ij}/w_i^{\beta}\right)^{-\theta}}$$

# Identification of Distortions and TFPs

- ▶ Dividing the input shares,  $\gamma_{ikik}$  and  $\gamma_{ijik}$ , to cancel the sector  $k$  TFP,  $A_{ik}$ , and  $w_i$  we get:

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

an expression for the distortion as a function of prices

- ▶ Use own sector input shares to obtain,

$$\tilde{\tau}_{ijik} \equiv \tau_{ijik} \left( \frac{A_{ij}}{A_{ik}} \right)^{\frac{1}{\beta}} \left( \frac{\iota_{ij}}{\iota_{ik}} \right)^{\frac{1+\theta}{\theta\beta}} = \left( \frac{\gamma_{ijij}}{\gamma_{ikik}} \right)^{\frac{1}{\theta\beta}} \left( \frac{\gamma_{ikik}}{\gamma_{ijik}} \right)^{\frac{1}{\theta}},$$

an expression for the composite of the distortion

- ▶ Note  $\tilde{\tau}_{ijik}$  is identified, not TFPs and distortions separately
- ▶ How to separate distortions from TFPs?
  - ▶ Turn to the consumption side of the economy

# Identification of Distortions and TFPs

- ▶ Consumption share in country  $i$ , sector  $j$

$$\alpha_{ij} = \frac{P_{ij} C_{ij}}{\sum_{k=1}^J P_{ik} C_{ik}} = \chi_{ij} \left( \frac{P_{ij}}{P_i} \right)^{1-\sigma},$$

where  $P_i$  is the ideal price index

- ▶ Dividing shares of consumption gives the ratio of prices:

$$\frac{P_{ij}}{P_{ik}} = \left( \frac{\alpha_{ij}/\chi_{ij}}{\alpha_{ik}/\chi_{ik}} \right)^{\frac{1}{1-\sigma}}$$

- ▶ After substitution the expression for the distortion

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

- ▶ *Intuition:* undistorted economy equates relative consumption to input shares

# Identification of Distortions and TFPs

**Proposition 1.** *In a world with  $N$  countries (indexed by  $i, n$ ) and  $J$  sectors (indexed by  $j, k$ ) the change ( $\hat{x} \equiv x_{t+1}/x_t$ ) in internal distortions are given by:*

$$\hat{\tau}_{ijk} = \frac{(\hat{\gamma}_{ikik}/\hat{\gamma}_{ijik})^{\frac{1}{\theta}}}{(\hat{\alpha}_{ik}/\hat{\alpha}_{ij})^{\frac{1}{1-\sigma}}}.$$

*The external distortions are given by:*

$$\hat{\tau}_{ijnk} = \frac{(\hat{\gamma}_{nknk}/\hat{\gamma}_{ijnk})^{\frac{1}{\theta}}}{(\hat{\alpha}_{nk}/\hat{\alpha}_{ij})^{\frac{1}{1-\sigma}}} \left( \frac{\hat{P}_i}{\hat{P}_n} \right).$$

*The TFPs are given by:*

$$\frac{\hat{A}_{ij}}{\hat{A}_{ik}} = \left( \frac{\hat{\gamma}_{ijij}}{\hat{\gamma}_{ikik}} \right)^{\frac{1}{\theta}} \left( \frac{\hat{\alpha}_{ij}}{\hat{\alpha}_{ik}} \right)^{-\frac{\beta}{1-\sigma}}.$$

# Identification of Distortions and TFPs

**Corollary 1.** *With no demand shifters, in a world with  $N$  countries (indexed by  $i, n$ ) and  $J$  sectors (indexed by  $j, k$ ) the internal distortions are given by:*

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

*The external distortions are given by:*

$$\tau_{ijnk} = \frac{(\gamma_{nknk}/\gamma_{ijnk})^{\frac{1}{\theta}}}{(\alpha_{nk}/\alpha_{ij})^{\frac{1}{1-\sigma}}} \left( \frac{P_i}{P_n} \right).$$



# Generalizations

- ▶ More general production

$$M_{ij} = \left( \sum_{n,k} \iota_{ijnk} Q_{ijnk}^{\frac{\theta}{1+\theta}} \right)^{\frac{1+\theta}{\theta}}$$

- ▶ under the assumption of time invariant weights and that weights are orthogonal to distortions, result in Proposition 1 still holds
- ▶ Different elasticities across goods
  - ▶ The result extends to the case of nested CES

# Changes in the Input-Output Structure

- ▶ We derive elasticities of the input-output shares with respect to internal distortions
  - ▶ In our model the input-output matrix is endogenous

**Proposition 2.** *The elasticity of input-output share  $\gamma_{ijnk}$  with respect to changes in all distortions  $\tau$  in the world is given by*

$$\frac{d \log \gamma_{ijnk}}{d \log \tau} = -\theta + \theta \frac{d \log P_{ij}}{d \log \tau} - \theta(1 - \beta) \frac{d \log P_{nk}}{d \log \tau} - \theta \beta \frac{d \log w_n}{d \log \tau}$$

- ▶ Generically, change in the world's input-output structure to changes in distortions and productivities is given by:

$$\Gamma = \mathcal{F}(\theta, \beta, \gamma_{lsmh})A + \mathcal{H}(\theta, \beta, \gamma_{lsmh})\tau + \mathcal{O}(\theta, \beta, \gamma_{lsmh})\omega,$$

# Changes in the Input-Output Structure

- ▶ To reduce the notational burden, consider country  $i$ , and two sectors  $j, k$ 
  - ▶ Normalize  $w_i = 1$
  - ▶ Let

$$\tilde{\gamma}_{isip} \equiv \frac{\gamma_{isip}}{1 - \gamma_{isip}(1 - \beta)}, \text{ for } s, p \in \{j, k\},$$

**Proposition 3.** *The elasticities of the input-output shares with respect to sectoral TFPs and distortions are given by:*

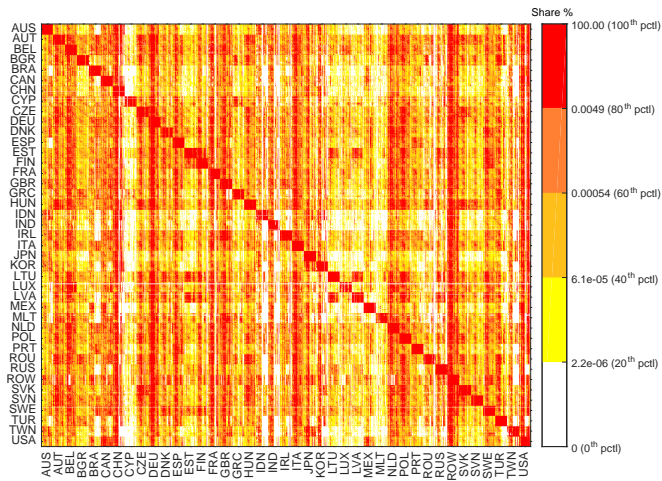
$$\frac{d \log \gamma_{ijk}}{d A_{ij}} = \theta \frac{\tilde{\gamma}_{ikij} \tilde{\gamma}_{ikik} (1 - \beta) - \tilde{\gamma}_{ijij}}{1 - \tilde{\gamma}_{ikij} (1 - \beta) \tilde{\gamma}_{ijik} (1 - \beta)},$$

$$\frac{d \log \gamma_{ijk}}{d \log \tau_{ijk}} = -\theta \frac{1 - \tilde{\gamma}_{ijik}}{1 - \tilde{\gamma}_{ikij} (1 - \beta) \tilde{\gamma}_{ijik} (1 - \beta)},$$

- ▶ Use the multi-country, multi-sector version of the model
  - ▶ Model the world economy as the World Input-Output Matrix
- ▶ This presentation:
  - ▶ WIOD, 40 countries, 35 industries, 1995-2011
  - ▶ Focus: China, US, World
  - ▶ For expositional purposes use  $\theta = \sigma = 4$ 
    - ▶ Work in progress with different elasticities

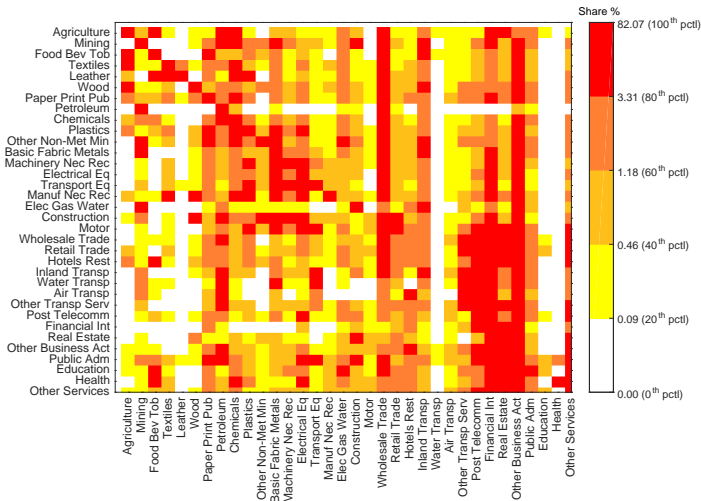
# World Economy

Figure: Global expenditure shares across sectors and countries in 2011



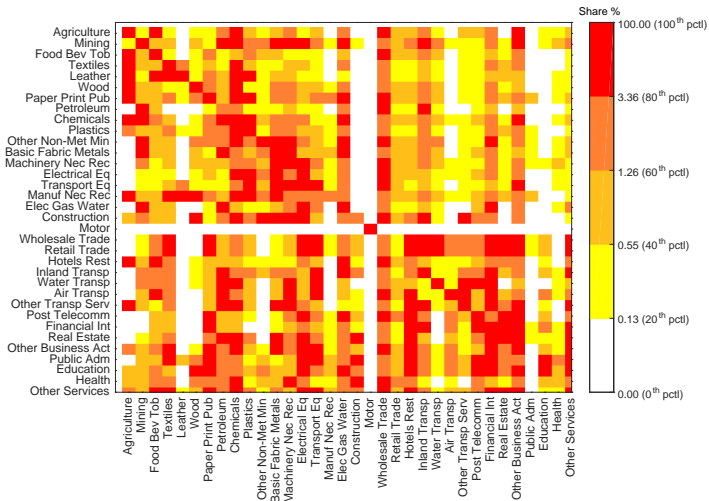
# U.S. Economy

Figure: U.S. expenditure shares across sectors and countries in 2011



# China's Economy

Figure: China's expenditure shares across sectors and countries in 2011



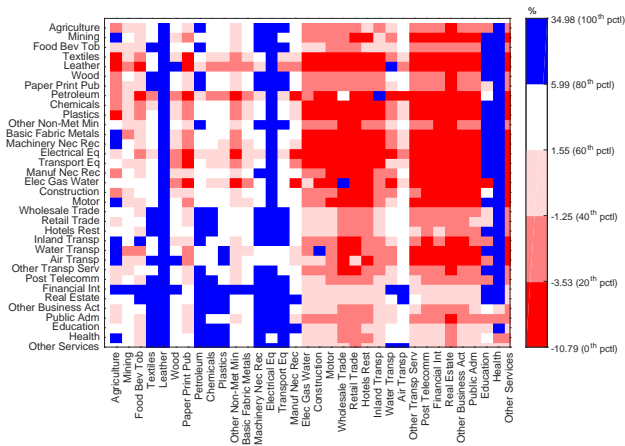
# Endogenous IO

- ▶ We compute how the input-output structure changes with internal distortions
  - ▶ Consider a 10 percent decline in internal (within the country) distortions in the manufacturing industries
  - ▶ First the reduction in distortions applied to the purchase of goods
    - ▶ US buyers
    - ▶ China buyers
  - ▶ Second the reduction in distortions applied to selling goods
    - ▶ US sellers
    - ▶ China sellers
  - ▶ Focus on the U.S. and China
- ▶ We then compute the effects on the U.S. from reducing internal distortions in China's manufacturing sector



# Change in U.S. expenditure shares

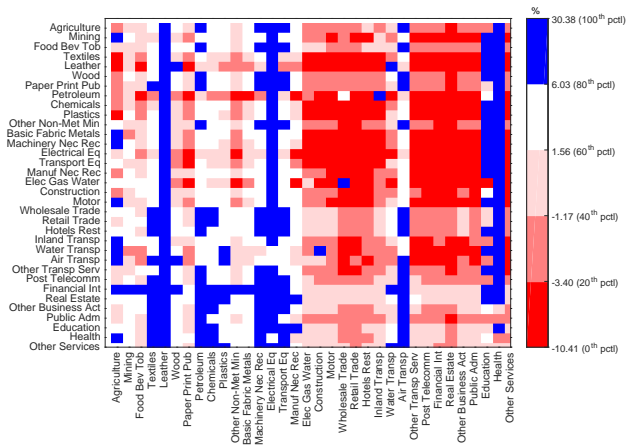
Figure: 10% reduction in China's internal distortions in manuf. purchases



U.S. manufacturing industries (percentage changes)

# Change in U.S. expenditure shares

Figure: 10% reduction in China's internal distortions in manuf. sells



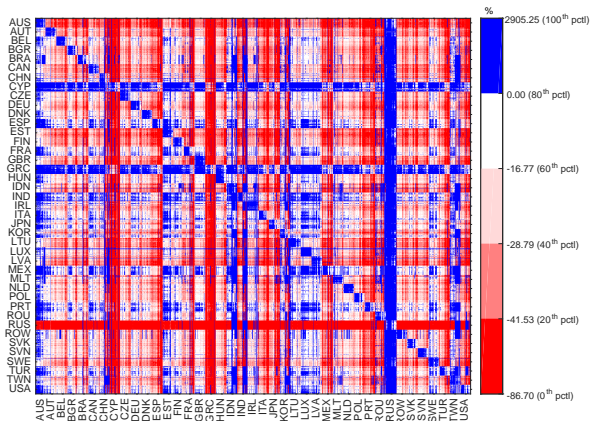
U.S. manufacturing industries (percentage changes)

# World Elasticities

- ▶ We now take a global perspective of the input-output shares
  - ▶ We compute the global elasticity of expenditure shares and elasticity of world's real GDP to changes in internal distortions
    - ▶ 10% reduction in internal distortions from purchasing goods
  - ▶ We then compute the elasticity of world's GDP with respect to external distortions
    - ▶ 10% reduction in external distortions from purchasing goods
  - ▶ Discuss the relative importance of the internal versus external distortions
    - ▶ Which distortions have the highest elasticity?

# Change in global expenditure shares

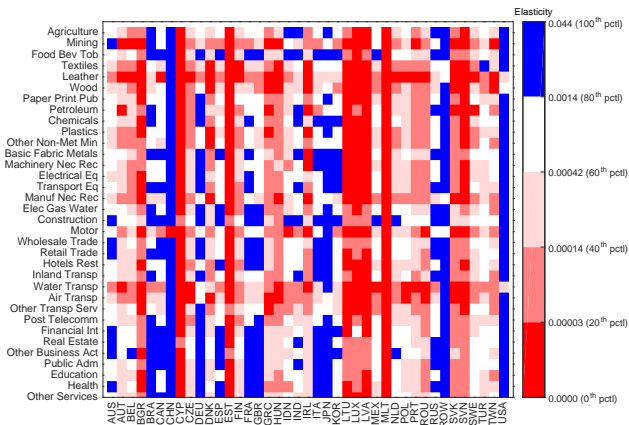
Figure: 10 percent reduction in internal distortions all over the world



Global expenditure shares (percentage changes)

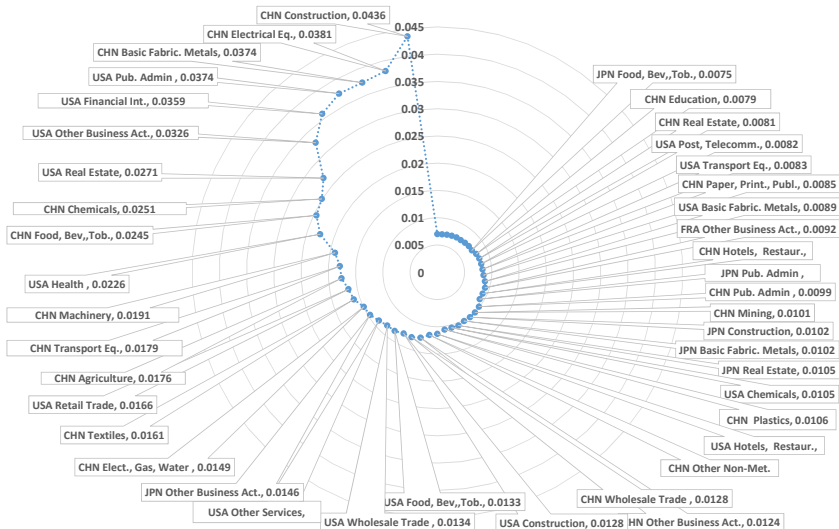
# World's real GDP elasticity

Figure: Elasticity to changes in internal distortions

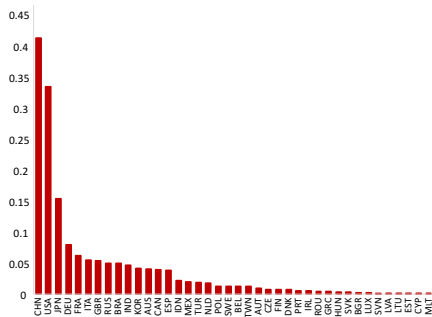


# World's real GDP elasticity

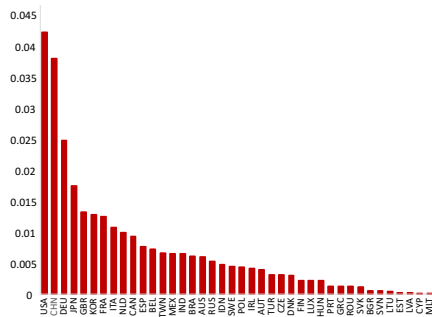
Figure: Elasticity to changes in internal distortions (top 60 markets)



# World's real GDP elasticity internal vs. external



(a) Internal distortions



(b) External distortions

normalized

# Measurement

- ▶ We measure the change in frictions across time for all countries
  - ▶ Large heterogeneity in the growth of internal distortions across sectors and countries ▶ distortions
  - ▶ Smaller dispersion for countries such as U.S. and Japan compared with China ▶ distortions
- ▶ We measure the change in TFP by sector and country
  - ▶ Higher growth rate in services than manufactures ▶ world's TFP  
▶ sectoral TFP
  - ▶ For the case of U.S., we compare our measures with estimates from the BLS ▶ U.S. TFP



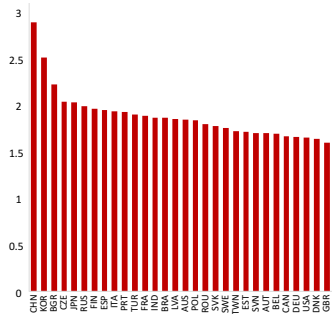
# Measurement

- ▶ Study the effects of actual changes in internal distortions
  - ▶ Show how the global input-output was affected by actual changes in frictions ▶ IO change
  - ▶ Compute how actual change in internal distortions have shaped world GDP
    - ▶ We find large heterogeneity
    - ▶ For instance lower distortions in construction in China had a positive impact in world's GDP while plastics and metals had a negative impact ▶ GDP change

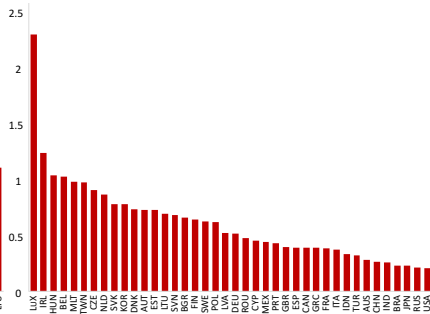
# Conclusion

- ▶ Our paper achieves several goals
  - ▶ First, we argue that it is important to study the world economy as a global I-O matrix
  - ▶ Second, that a simple CES model can reconcile the observed world I-O
- ▶ Derive sufficient statistics to compute distortions and TFP, broadly applicable to a class of models
  - ▶ We propose a way to solve the identification problem between distortions and TFP in the macro literature
- ▶ Internal distortions can have significant impact on the world economy, even more than external distortions

# World's real GDP elasticity internal vs. external



(a) Internal distortions

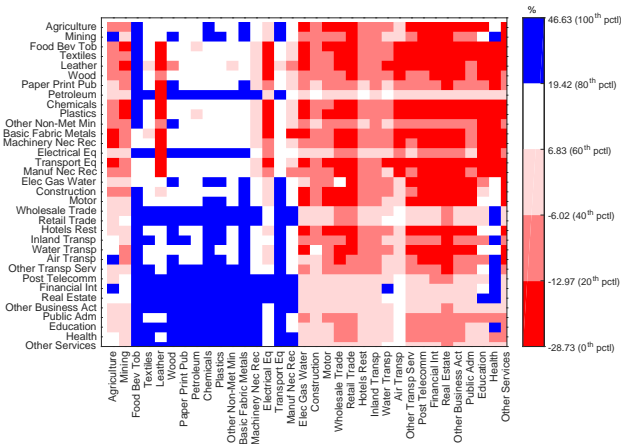


(b) External distortions

Normalized by country i's share in world GDP [▶ back](#)

# Change in U.S. expenditure shares

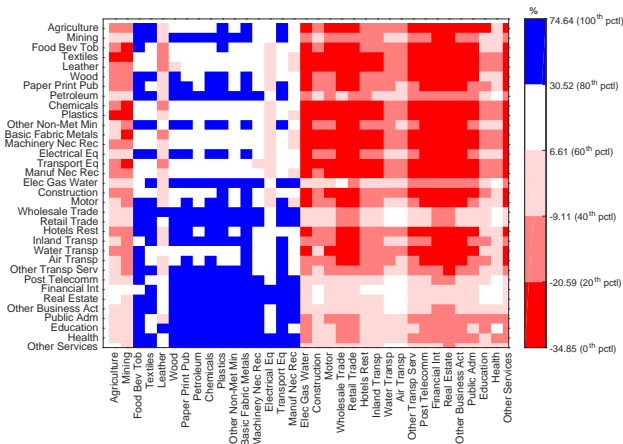
Figure: 10% reduction in internal distortions in manufacturing purchases



U.S. manufacturing industries as buyers (percentage changes)

# Change in U.S. expenditure shares

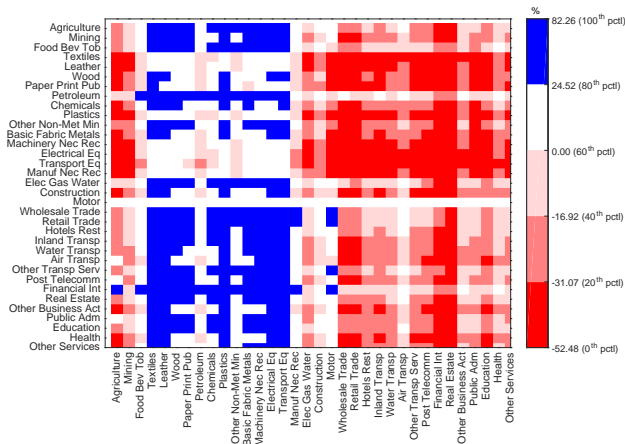
Figure: 10% reduction in internal distortions in manufacturing sells



U.S. manufacturing industries as sellers (percentage changes)

# Change in China's expenditure shares

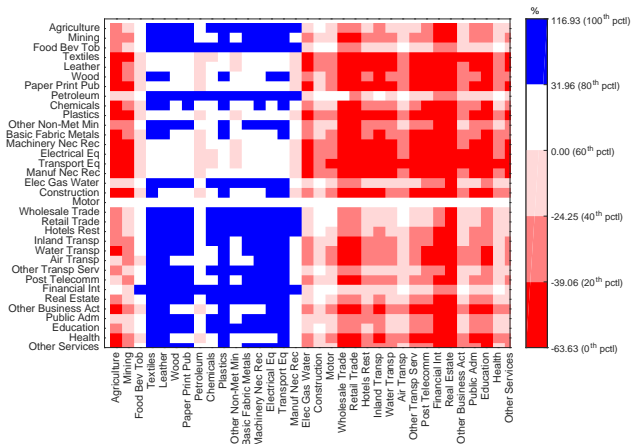
Figure: 10% reduction in internal distortions in manufacturing purchases



China's manufacturing industries as buyers (percentage changes)

# Change in China's expenditure shares

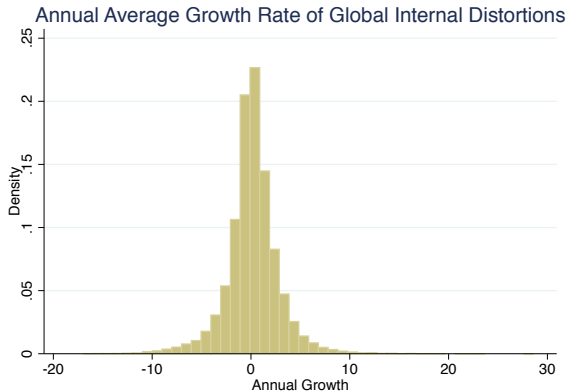
Figure: 10% reduction in internal distortions in manufacturing sells



China's manufacturing industries as sellers (percentage changes)

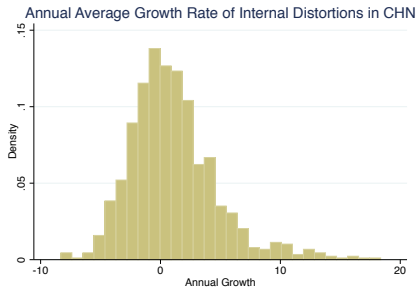
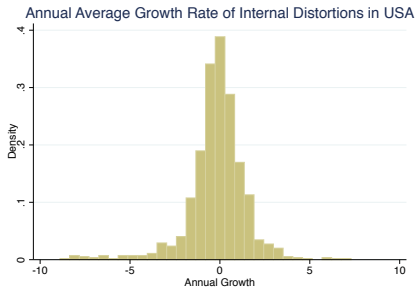
# Measurement - Distortions

- ▶ Measure changes in domestic distortions, 1995-2011





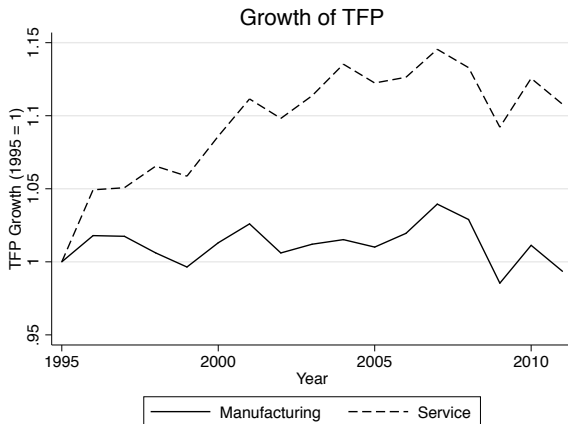
# Measurement - Distortions



► back

# Measurement - TFP

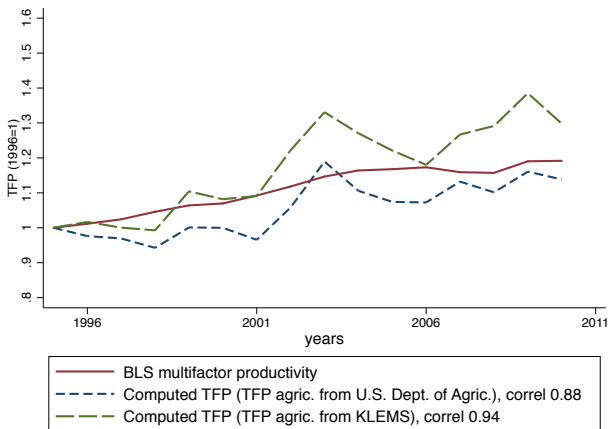
Figure: World's TFP annual growth rate





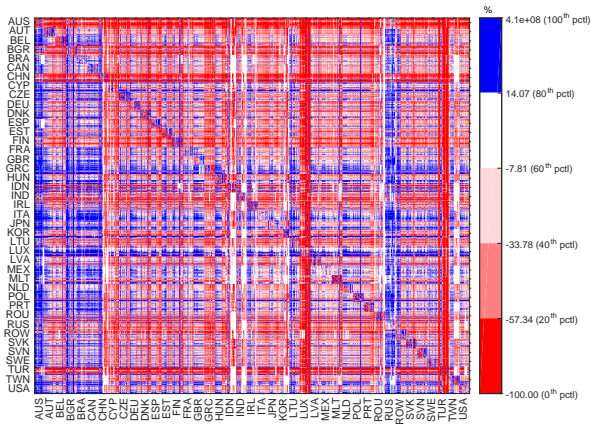
# Measurement - TFP

Figure: U.S. aggregate TFP



# Effects of Actual Changes in Internal Distortions

Figure: Global expenditure shares (percentage changes)



# Effects of Actual Changes in Internal Distortions

Figure: Growth in world's GDP

