Intermediate Inputs, External Rebalancing and Relative Price Adjustments[1]

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[1] The views expressed in the paper are those of the author and do not necessarily represent those of the IMF

Introduction

Revisit the conventional elasticity approach to the link between **external balance** and **relative price**

How do **imported intermediate (II)** inputs affect the link?

China's value added in iPad only 2%

−> Ignore II: $\Delta RMB = 10\% \Rightarrow \Delta P_{iPad} = 10\%$

−> Account for II: $\Delta RMB = 10\% \Rightarrow \Delta P_{iPad} = 0.2\%$

Aggregate economy: imported intermediates reduce openness and increase ΔP

Is this channel important?

−> With global $\frac{\text{VA trade}}{\text{gross trade}} \approx 0.75$, the effect can be significant

−> But the story potentially more complex

Introduction

Follow five steps:

1. Construct a global N-country S-sector input-output (IO) table with Gross Output (GO) flows

2. Solve for consistent N-country S-sector Value Added (VA) flows, *including* VA trade flows (Johnson and Noguera, 2010)

3. Parametrize an N-country S-sector VA macro model and implement a rebalancing exercise (Obstfeld and Rogoff, 2004)

4. Compare results with a benchmark parameterization

5. Parametrize an N-country S-sector GO macro model, implement a rebalancing exercise and compare results

Introduction

Preview of results:

–> **Imported intermediates** reduce openness and **increase the RER adjustment**

–> **Domestic intermediates** reduce cross-sectoral asymmetries in openness and **decrease the RER adjustment**

–> **Empirical estimates of Armington elasticities not** directly **applicable** in conventional rebalancing exercise

–> Each result can be **significant in economic terms**

Road Map

Structure of the rest of the presentation

1. Gross Output flows vs. Value Added flows
2. Modeling framework I: Value Added flows
3. Parameterization and Results
4. Modeling framework II: Gross Output Flows
5. Parameterization and Results
6. Summary of findings

Gross Output vs. Value Added Flows

Global Input-Output Table

A flurry of recent research on Global I-O tables (Johnson and Noguera, 2010; Koopman et al, 2010; Erumban et al., 2011; Inomata et al, 2011)

Use a Global I-O table to disentangle sectoral VA flows

$$\begin{array}{c}
\begin{bmatrix} y_1 & y_2 \end{bmatrix} \\
\equiv \\
\begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix} \\
+ \\
\begin{bmatrix} f_1 & f_2 \end{bmatrix}
\end{array}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} \equiv \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix} + \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$$

−> Rows: sectoral resource constraints

−> Columns: sectoral expenditures on production inputs

−> Both add up to gross output

Gross Output vs. Value Added Flows

Global Input-Output Table

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} \equiv \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix} + \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}$$

$$\begin{bmatrix} y_1 & y_2 \end{bmatrix} \equiv \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix} + \begin{bmatrix} f_1 & f_2 \end{bmatrix}$$

–> Final demand in Country 1: $C_1 = c_{11} + c_{21}$

–> VA in Country 1: $GDP_1 = m_{11} + m_{12} + c_{11} + c_{12} - m_{11} - m_{21}$

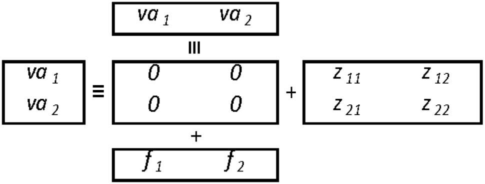
–> Exports and imports in Country 1: $X_1 = m_{12} + c_{12}$; $M_1 = m_{21} + c_{21}$

Global I-O table distinguishes between intermediate and final uses

Gross Output vs. Value Added Flows

Value Added Decomposition

Decompose GO and VA flows by destination (Johnson and Noguera, 2010)



Trace out VA of a particular sector through the Global I-O table:
−> Directly absorbed by domestic or foreign final demand,
−> Used as domestic intermediate, then absorbed at home or abroad, etc...

$(m_{21} + c_{21}) - z_{21} = (m_{12} + c_{12}) - z_{12} \geq 0$
−> re-exported imports ≥ 0
−> NX not affected

Gross Output vs. Value Added Flows

Benchmark Value Added Flows

A Global I-O representation of the benchmark sectoral VA flows

$$\begin{array}{ccccc} & & \begin{bmatrix} va_1 & va_2 \end{bmatrix} & & \\ & & \equiv & & \\ \begin{bmatrix} va_1 \\ va_2 \end{bmatrix} & \equiv & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & + & \begin{bmatrix} c_{11} - m_{21} & c_{12} + m_{12} \\ c_{21} + m_{21} & c_{22} - m_{12} \end{bmatrix} \\ & & + & & \\ & & \begin{bmatrix} f_1 & f_2 \end{bmatrix} & & \end{array}$$

–> GDP, final demand and net trade are preserved

–> But sectoral weights in final demand differ from the VA decomposition

Only first order effects from the use of intermediates are taken into account

–> E.g., if the U.S. output is exported to Mexico, it is assumed to be entirely absorbed by Mexico $\Rightarrow$ VA flows equal GO flows

Modeling Framework I: Value Added Flows

N-country, S-sector endowment economy

Consumer's problem in country n

$$\max \left(\sum_{i=1}^{S} \phi_{i,n}^{\frac{1}{\gamma}} z_{i,n}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}$$

$$z_{i,n} = \left(\sum_{j=1}^{N} \phi_{ij,n}^{\frac{1}{\omega}} z_{ij,n}^{\frac{\omega-1}{\omega}} \right)^{\frac{\omega}{\omega-1}}$$

s.t.

$$\sum_{i=1}^{S} \sum_{j=1}^{N} q_{ij} z_{ij,n} = \sum_{i=1}^{S} q_{in} \overline{va}_{in} + T_n.$$

Resource constraints: $\sum_{n=1}^{N} z_{ij,n} = \overline{va}_{ij}$ and $\sum_{n=1}^{N} T_n = 0$

External Rebalancing Exercise

Setup of the exercise:

$N = 2$ (USA-R.O.W.); $S = 2$ (manufacturing and services)
$->$ *intra*national and *inter*national price adjustments
$->$ imported and domestic cross-sectoral intermediate inputs

Parametrize the model to match VA flows from the (i) benchmark and (ii) Global I-O table

Resolve the model with $T_n = 0$ and compute ΔRER

STEP1: Aggregate Global I-O table and derive VA flows (2004, trn USD)

(a) Global IO table

	S_{usa}	M_{usa}	S_{row}	M_{row}	c_{usa}	c_{row}	Y
S_{usa}	3.7	1.2	0.1	0.1	9.1	0.1	14.3
M_{usa}	1.3	1.9	0.1	0.4	1.9	0.3	5.8
S_{row}	0.1	0.0	9.2	4.3	0.1	19.4	33.1
M_{row}	0.2	0.5	4.4	10.1	0.6	6.8	22.6
rk+wl	8.9	2.2	19.2	7.8			
Y	14.3	5.8	33.1	22.6			

(b) Benchmark income flows

	S_{usa}	M_{usa}	S_{row}	M_{row}	c_{usa}	c_{row}	Y
S_{usa}	0	0	0	0	8.6	0.3	8.9
M_{usa}	0	0	0	0	1.5	0.8	2.2
S_{row}	0	0	0	0	0.2	19.0	19.2
M_{row}	0	0	0	0	1.3	6.6	7.8
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(c) IO-based income flows

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External Rebalancing Exercise

Parameterization

STEP1: Aggregate Global I-O table and derive VA flows (2004, trn USD)

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External Rebalancing Exercise

Parameterization

STEP2: Replicate allocations in panels (b) and (c):

–> $\left\{\phi_{ij,n}^{BM}\right\}$ and $\left\{\phi_{ij,n}^{I/O}\right\}$ set to replicate sectoral expenditure shares in final demand

–> $y_{M,USA}$, $y_{S,USA}$, $y_{M,ROW}$ and $y_{S,ROW}$ set equal to factor incomes

–> T_{USA} set to match net trade

Two distinct parametrizations for $\left\{\phi_{ij,n}^{k}\right\}$

Elasticities: $\gamma < \omega$ (Feenstra, Obstfeld and Russ, 2010, report $\gamma = 0.5$ and $\omega = 1$)

Fig.1: Response of RER to a 1% of GDP reduction in external imbalance

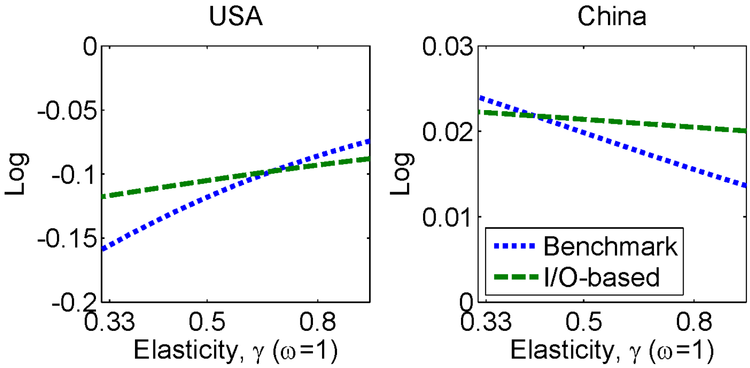
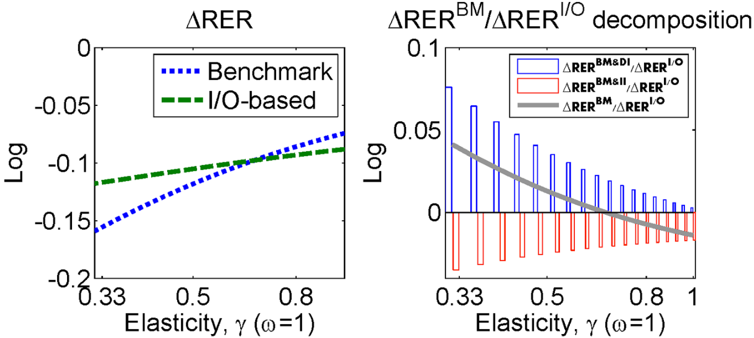


Fig.2: Decomposition of deviations in the RER response



−> II effect: benchmark *under*estimates ΔRER

−> DI effect: benchmark *over*estimates ΔRER.

−> The sign of the DI effect depends on $\omega \gtrless \gamma$

Modeling Framework II: Gross Output Flows

N-country, S-sector endowment economy

Demand in country n:

$$U_n = \left(\sum_{i=1}^{S} \mu_{i,n}^{\frac{1}{\eta}} \left(\sum_{j=1}^{N} \mu_{ij,n}^{\frac{1}{\nu}} c_{ij,n}^{\frac{\nu-1}{\nu}} \right)^{\frac{\nu}{\nu-1}\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}$$

b.c.

$$\sum_{i=1}^{S} \sum_{j=1}^{N} p_{ij} c_{ij,n} = \sum_{i=1}^{S} q_{in} \overline{va}_{in} + T_n.$$

Supply in sector i of country n:

$$y_{in} = \left(\delta_{in}^{\frac{1}{\lambda}} \overline{va}_{in}^{\frac{\lambda-1}{\lambda}} + (1-\delta_{in})^{\frac{1}{\lambda}} \left(\sum_{i=1}^{S} \theta_{i,n}^{\frac{1}{\alpha}} \left(\sum_{j=1}^{N} \theta_{ij,n}^{\frac{1}{\beta}} m_{ij,n}^{\frac{\beta-1}{\beta}} \right)^{\frac{\beta}{\beta-1}\frac{\alpha-1}{\alpha}} \right)^{\frac{\alpha}{\alpha-1}\frac{\lambda-1}{\lambda}} \right)^{\frac{\lambda}{\lambda-1}}$$

Resource constraints: $\sum_{n=1}^{N} c_{ij,n} + \sum_{n=1}^{N} m_{ij,n} = y_{ij}$ and $\sum_{n=1}^{N} T_n = 0$

External Rebalancing Exercise II

IF:

–> $\lambda = \alpha$

–> $\alpha = \eta$ and $\beta = \nu$

–> $T_n = 0$

$\Rightarrow \Delta RER_{GO} = \Delta RER_{VA}$ (GO model reduces to the VA model)

ELSE:

$\Delta RER_{GO} \neq \Delta RER_{VA}$

Which model to use? Empirical estimates of elasticities applicable only in the GO model

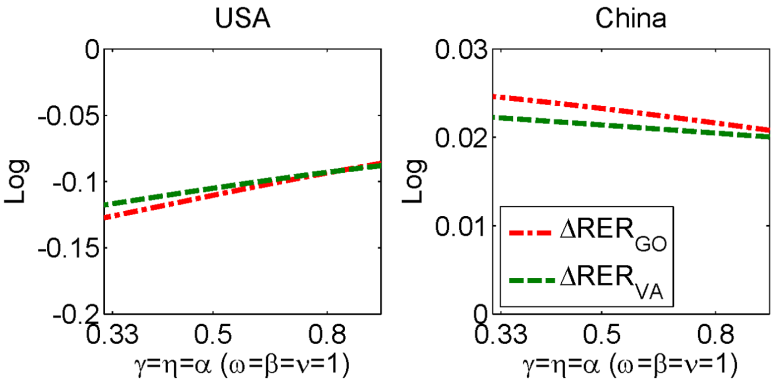
GO model parameterization:

–> $\lambda = 1$ (evidence from I-O tables)

–> $\alpha = \eta$; $\beta = \nu$ (convenience?)

–> Set other parameters to replicate allocations in panel (a)

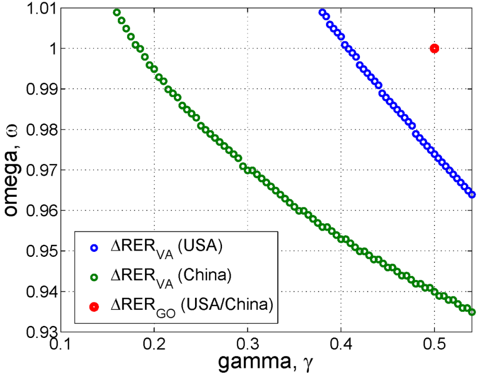
Fig.3: Response of RER to a 1% of GDP reduction in external imbalance



External Rebalancing Exercise II

Results

Fig.4: Elasticity pairs $\{\gamma, \omega\}$ that generate $\Delta RER_{VA} = \Delta RER_{GO}$



Parameters: λ=1; α=η=0.5; β=ν=1 $(\Rightarrow \Delta \text{RER}_{GO}^{USA}$=-10.5; $\Delta \text{RER}_{GO}^{CHN}$=2.4)

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Conclusions

A methodology for tracing out the effect of intermediates in a Macro model with an application to external rebalancing

Allowing for intermediates can significantly alter model results:
–> **“Imported Intermediates“ effect**: conventional parameterization *under*estimates RER adjustment (overstates openness)
–> **“Domestic Intermediates“ effect:** conventional parameterization *over*estimates RER adjustment (overstates cross-sectoral asymmetries in openness)
–> **"Elasticity" effect:** Estimated Armington GO elasticities differ from VA elasticities

Preferable to study rebalancing in a GO framework

Other applications?

Appendix: Value Added Decomposition

Decompose sectoral VA flows by destination (Johnson and Noguera, 2010):

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \left(I - \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \right)^{-1} \begin{bmatrix} c_{11} \\ c_{21} \end{bmatrix} + \left(I - \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \right)^{-1} \begin{bmatrix} c_{12} \\ c_{22} \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$$

$$z_{ij} = (1 - \alpha_{1j} - \alpha_{2j}) y_{ij}$$

$$\begin{bmatrix} va_1 \\ va_2 \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$$

where $\alpha_{ij} = m_{ij} / y_j$