



# How a Global Inter-Country Input-Output Table with Processing Trade Account Can be Constructed from GTAP Database

Marinos Tsigas and Zhi Wang

*United States International Trade Commission*

Mark Gehlhar

U.S. Department of Interior

**The 15<sup>th</sup> GTAP Conference on Global Economic Analysis  
Geneva, June 27-29, 2012**

The views expressed in this presentation are solely of the presenter. It is not meant to represent in anyway the official views of the USITC and its Commissioners



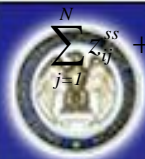
## Presentation Outline

- Motivations
- Difference between MRIO and ICIO tables
- How bilateral trade flows in GTAP database are split
- Basic ideas of the reconciliation method
  - Use reporter relative reliability index to control the reconciliation process
  - Use constraints bring additional information into the data set during reconciliation
- Separate processing trade account for a subset of developing countries
- How much adjustment was made to original V8 GTAP data



There is a resurgence in demand for global input-output tables to facilitate the analysis of production fragmentation and global value chain

- **Resurgence in the application of IO tables in the literature**
  - measurement of vertical specialization (**Hummels, Ishii, and Yi, 2001**);
  - Decomposition of gross trade to various value-added components (**Koopman, Powers, Wang and Wei, 2010**)
  - the pattern of gross versus value-added trade (**Johnson and Noguera, 2012**);
  - Accounting intermediate trade flows (**Sébastien Miroudot, Rainer Lanz, and Alexandros Ragoussis, 2010**);
  - environmental analysis (**Davis and Caldeira, 2010**);
  - Collapse of world trade during recent global financial crisis (**Bems, Johnson, and Yi, 2010**);
  - the economic impact of global rebalancing (**Petri, 2010**).
- **The launch and completion of WIOD project in EU**
- **The WTO-OECD joint initiative of value-added trade statistics**



## The Difference of ICIO tables estimated by WIOD and OECD with MCIO tables underlying GTAP database

### MCIO Table

$$(1) \quad \sum_{j=1}^N z_{ij}^{rr} + \sum_{i=1}^N z_{ij}^{mr} + v_j^r = x_j^r$$

$$(2) \quad \sum_{j=1}^N z_{ij}^{ss} + \sum_{k=1}^K y_{ik}^{ss} + \sum_{r=s}^G t_i^{sr} = x_i^s$$

$$(3) \quad \sum_{j=1}^N z_{ij}^{rm} + \sum_{k=1}^K y_{ik}^{rm} = \sum_{s=1}^G t_i^{sr}$$

### ICIO Table

$$\sum_{r=1}^G \sum_{i=1}^N (1 + mg_i^{rs}) z_{ij}^{rs} + v_k^s = x_j^s$$

$$\sum_{s=1}^G \sum_{j=1}^N (1 + mg_i^{sr}) z_{ij}^{sr} + \sum_{s=1}^G \sum_{k=1}^K (1 + mg_i^{sr}) y_{ik}^{sr} = x_i^r$$

$$\sum_{s=r}^G (1 + mg_i^{sr}) y_{ik}^{sr} = y_{ik}^{mr} \quad \sum_{s=r}^G (1 + mg_i^{sr}) z_{ij}^{sr} = z_{ij}^{mr}$$

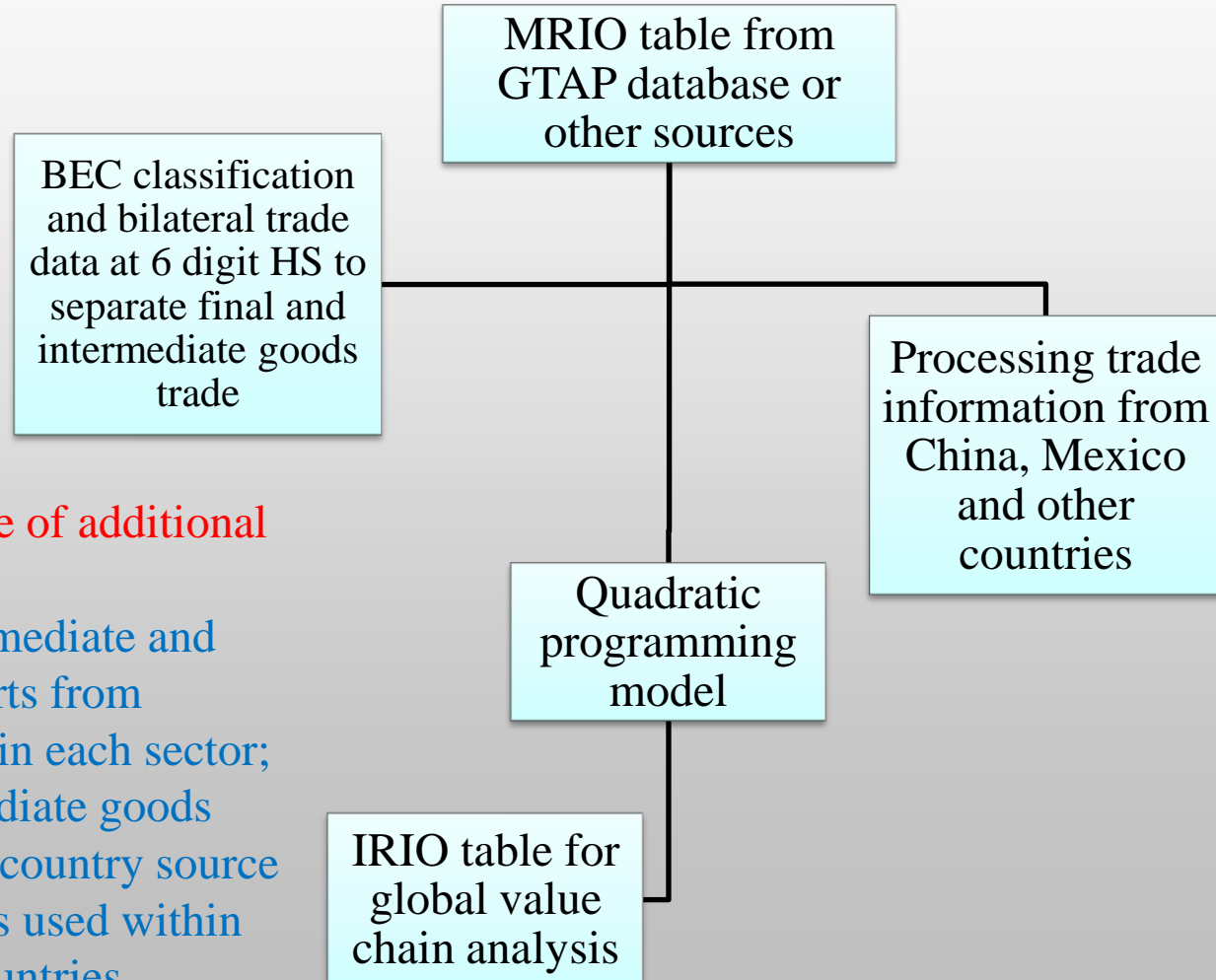
$$\sum_{j=1}^N z_{ij}^{sr} + \sum_{k=1}^K y_{ik}^{sr} = t_i^{sr}$$

Such an account guarantees that international production and trade flows exactly meet all countries' supply and demands, but stops short of assigning specific intermediate or final uses for international trade flows.

More desirable, include detailed source/destination and supply/use information, but require additional data to separate bilateral trade flows into end use categories that delivery to sector and final users



## Database Construction: MRIO to IRIO



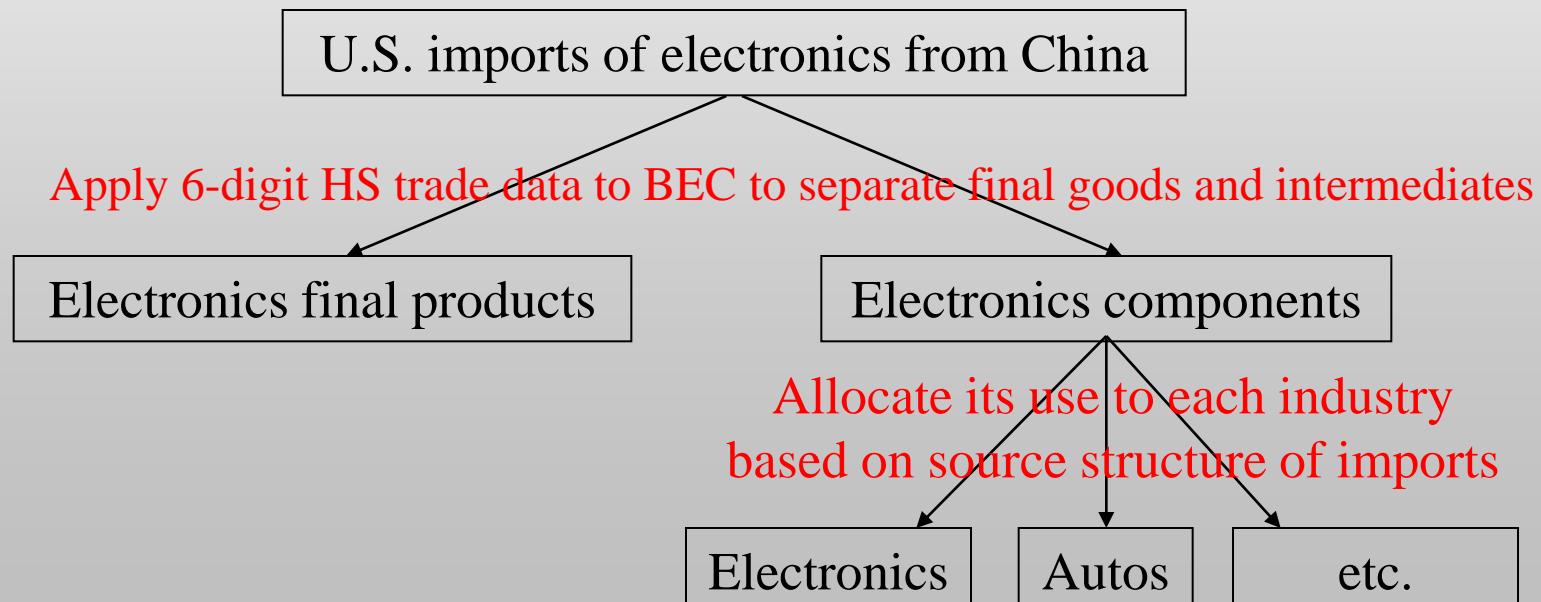
Need two major piece of additional information:

- (1) Distinguish intermediate and final use of imports from different sources in each sector;
- (2) Allocate intermediate goods from a particular country source to each sector it is used within all destination countries.



## Extension of GTAP Database: Data sources

- Start with V8 GTAP database for 2004 and 2007 two years
- Add additional detail on source and use of intermediate inputs and final goods, based on bilateral trade flows at 6-digit HS from COMTRADE and improved concordance between HS6 to UN BEC from WIOD to split trade flows in V8 GTAP into **intermediates, consumption and investment goods**
- Add detail on processing trade for Mexico and China: trade statistics and Split IO accounts (KWW and INEGI)







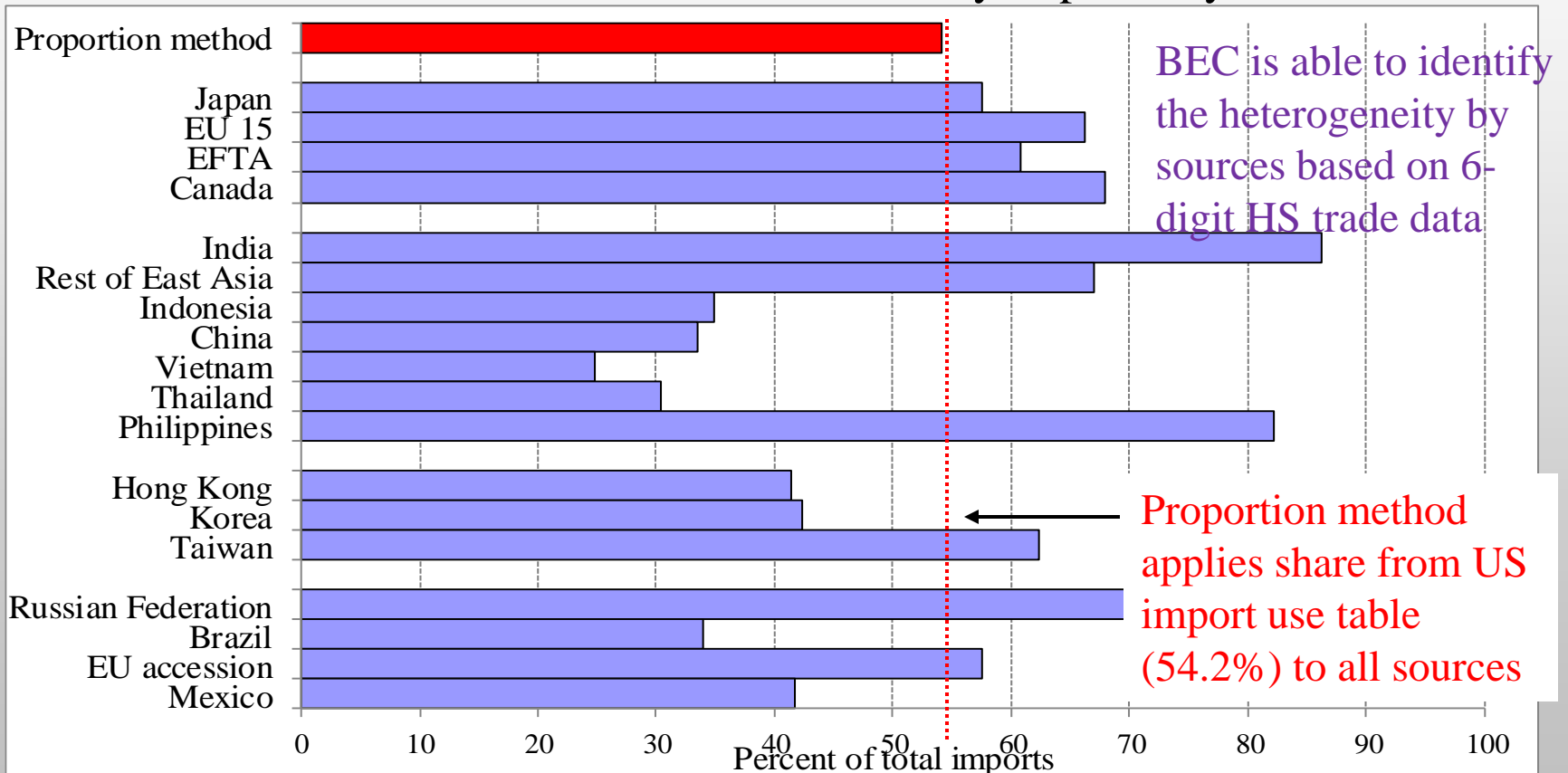
## What end-use classifications can help

- Intermediate goods identified from gross trade flows are the **row sum of each block matrix  $Z_{sr}$  in the IO flow matrix  $Z$** .
- End use classification such as BEC distinguishes intermediate inputs from final goods in imports from each source in each sector, improve the accuracy of IO coefficients in ICIO table by **giving better row total control for each block IO coefficient matrix  $A_{sr}$** .
- End-use classifications can identify the heterogeneity of intermediate inputs entering the importing country from different sources, thus **is better than the alternative**: Proportional method assumes the intermediate share in imports from each source country are the same so it bias the total (include indirect) value-added estimates for each source country, even at aggregate level.



# Why BEC is Better than Proportional Assumption

Intermediate share of U.S. electronic machinery imports, by source, 2004







## What end-use classifications can't help

- Still have to assume proportionality to allocate intermediate inputs to each industry *within the importing country*
  - Required data not reported by most national statistical agencies
- Industry-level estimates of value-added trade based on such IRIO table may be unreliable with unknown biases, despite their theoretical tractability
- To improve the sector level results,
  - Current end use classifications need to be extended to dual use products and services trade.
  - methods need to be developed to properly distribute imports to domestic users: link firm character data from survey or economic census and customs transaction level statistics.



## The improvement of WIOD HS6 to BEC over UNSD HS6 to BEC concordance

- Among total 5718 different HS6 code from the four versions of HS:
  - 4892 are exactly mapping to one end use categories, same with UNSD concordance
  - 703 are identified as dual used products split over two or more end use categories
  - 108 are mapped into different categories
  - 15 that can not find in current UNSD concordance



# Basic Ideas of the Reconciliation Methods

Make full use of all available official statistics and related information

- Initial estimates of the same economic variables from **different sources**
- **A set of well defined consistency conditions and accounting identities**
- **Reliability information on the initial estimates**



## Problems of Proportional Adjustment

China & Hong Kong reported exports and partner reported imports, 2004, Million Dollars

Country	China reported Exports to Partners	Hong Kong domestic exports to partner	China re-exports to partner via Hong Kong	Partners imports from China and Hong Kong	Statistical discrepancy
Malta	273	5	20	92	-200.4
Russia	9,102	119	361	4,744	-110.4
Korea	27,810	2,111	2,832	32,853	-1.8
Japan	73,222	4,268	11,977	94,911	3.4



# The Adjustment Method: Objective Function and Reliability Weights

- Adjust GTAP MCIO data and a given set of initial bilateral trade statistics reported by both trading partners according to an objective function that satisfies ICIO accounting and consistence constraints.
- The objective function and relative reliability weights

$$\text{Min } S = \frac{1}{2} \left\{ \sum_{s=1}^G \sum_{r=1}^G \sum_{i=1}^N \sum_{j=1}^N \frac{(z_{ij}^{sr} - \bar{z}_{ij}^{sr})^2}{wz_{ij}^{sr}} + \sum_{s=1}^G \sum_{r=1}^G \sum_{i=1}^N \sum_{k=1}^K \frac{(y_{ik}^{sr} - \bar{y}_{ik}^{sr})^2}{wy_{ik}^{sr}} \right\}$$



# Full Use of Mirrored Bilateral Trade Statistics:

## Reliability of reported trade statistics

- Mirror trade statistics in time series are the major data source to estimate the reliability weights
- An indicator of **reporter reliability is a measure of how consistency a country reports its trade statistics relative to all its trading partners.** It should be able to catch the strength and weakness of a country's ability to consistently report its trade for each end use categories in different commodities





## Estimating variance for mirrored bilateral trade statistics: Auto regression with dummy variables

Econometric analysis of discrepancies between the two reported trade data of the same trade flows provide estimates of data reliability

$$e_{it} = a_i e_{it-1} + b_i^0 + \sum_{k=1}^n b_i^k D_t^k + \mu_{it}$$

e: mirror trade statistics discrepancies

b: symmetric bias

D: dummy variables. Represent events have a significant impact on the reporting practice in the two reporting countries

the variance:  $V(e_{it}) = \frac{V(\mu)}{(1 - a_i^2)}$



# **Full Use of Mirrored Bilateral Trade Statistics:**

Estimate reporter specific reliability indexes

- **It is the share of accurately reported trade in total trade for a special end use category in a particular sector (less than 20 percent discrepancies in mirrored data)**
- **All available bilateral trade data in the world were used to construct the reporter specific reliability indexes**
- **It has a value between 0 and 1. A large value indicates the initial estimates reported by the country are relatively more reliable for its reported exports or imports than other reporters**
- **It will encourage the model to adjust those unreliable initial data more than those reliable ones in the reconciliation process.**



## Average Exporter Relative Reliability Index 1995-2007, China

Commodity	MEAN	CV	MIN	MAX
Food and beverages (15)	0.81	0.06	0.71	0.88
Chemicals (24)	0.78	0.12	0.63	0.88
Basic metals (27)	0.72	0.17	0.46	0.89
Wood and products (20)	0.60	0.39	0.29	0.87
Paper and paper products (21)	0.53	0.31	0.22	0.80
Wearing apparel (18)	0.24	0.56	0.04	0.42
Rubber and plastic products (25)	0.14	0.65	0.07	0.39
Auto and Parts (34)	0.09	1.08	0.02	0.36
Leather products (19)	0.09	0.24	0.05	0.14
Electrical machinery (31)	0.07	1.09	0.03	0.33

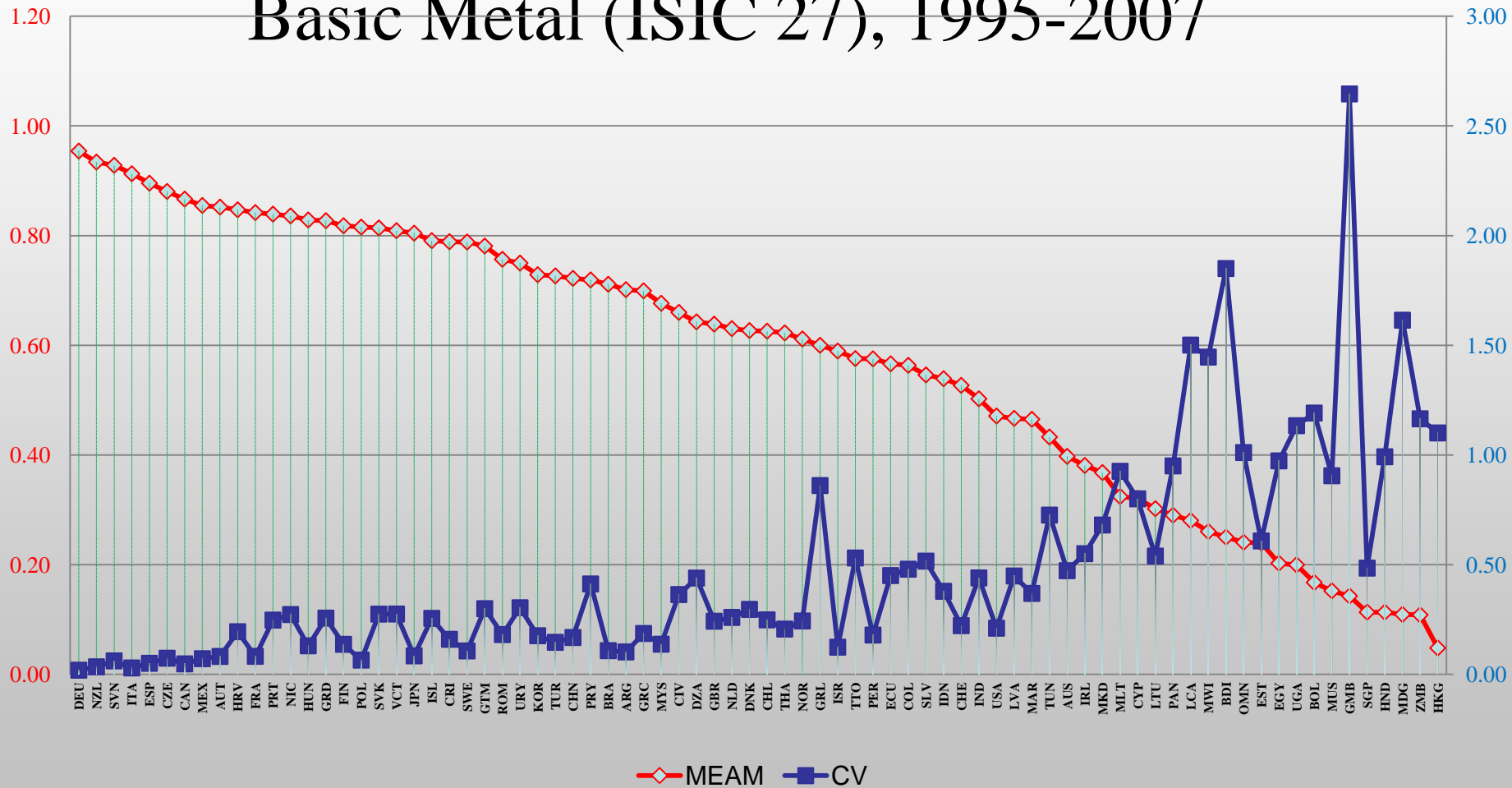


## Average Importer Relative Reliability Index 1995-2007, The United States

Commodity	MEAN	CV	MIN	MAX
Auto and Parts (34)	0.95	0.02	0.92	0.97
Wood products (20)	0.92	0.05	0.83	0.97
Machinery and equipment (29)	0.91	0.06	0.77	0.97
Paper and paper products (21)	0.91	0.06	0.79	0.95
Food and beverages (15)	0.85	0.04	0.80	0.90
Textiles (17)	0.55	0.19	0.39	0.71
Wearing apparel (18)	0.54	0.10	0.43	0.61
Tobacco products (16)	0.50	0.34	0.17	0.71
Leather products (19)	0.30	0.34	0.16	0.48
Printed and recorded matter (22)	0.16	0.60	0.05	0.40

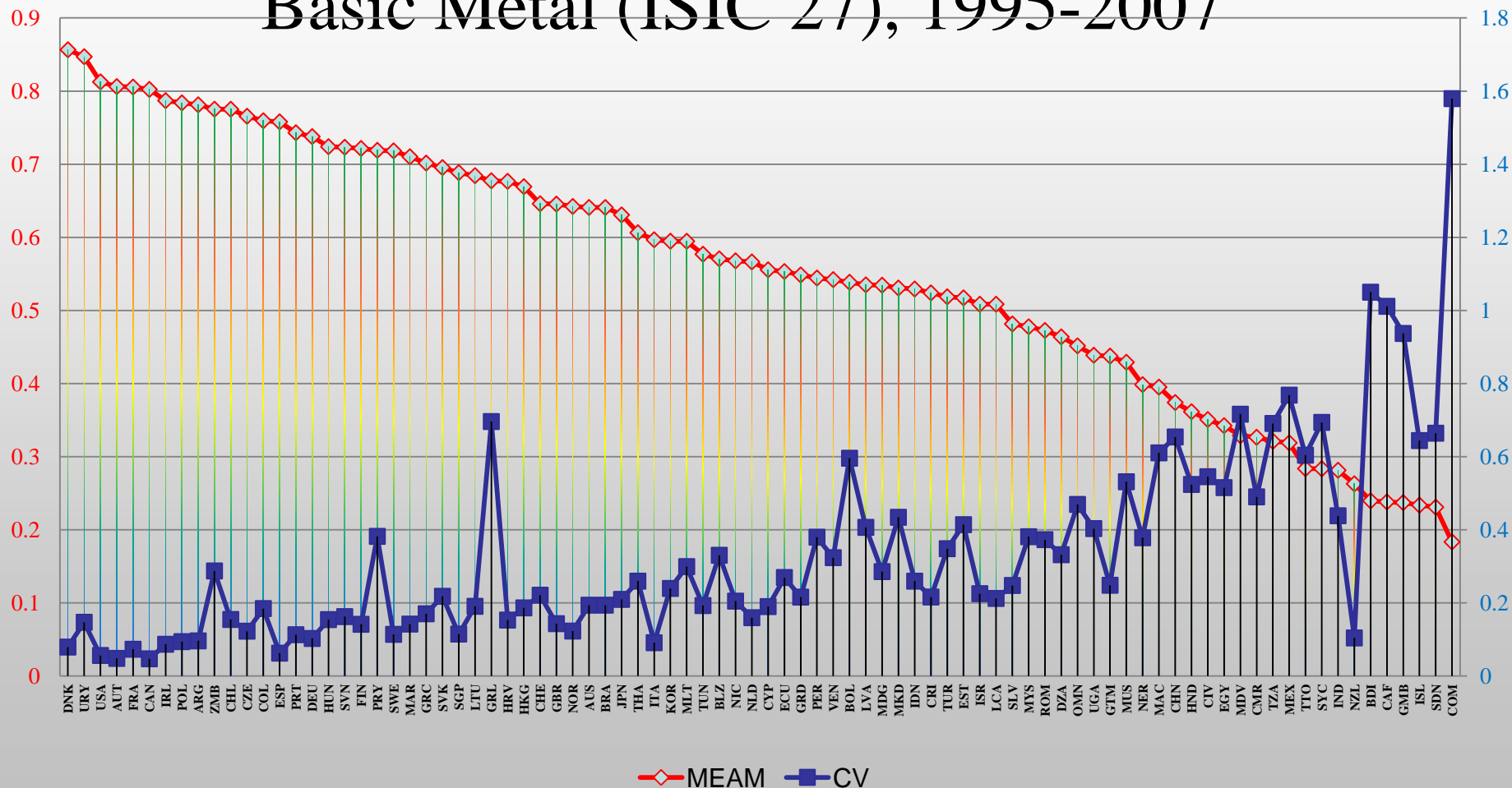


# Average Exporter Relative Reliability Index Basic Metal (ISIC 27), 1995-2007





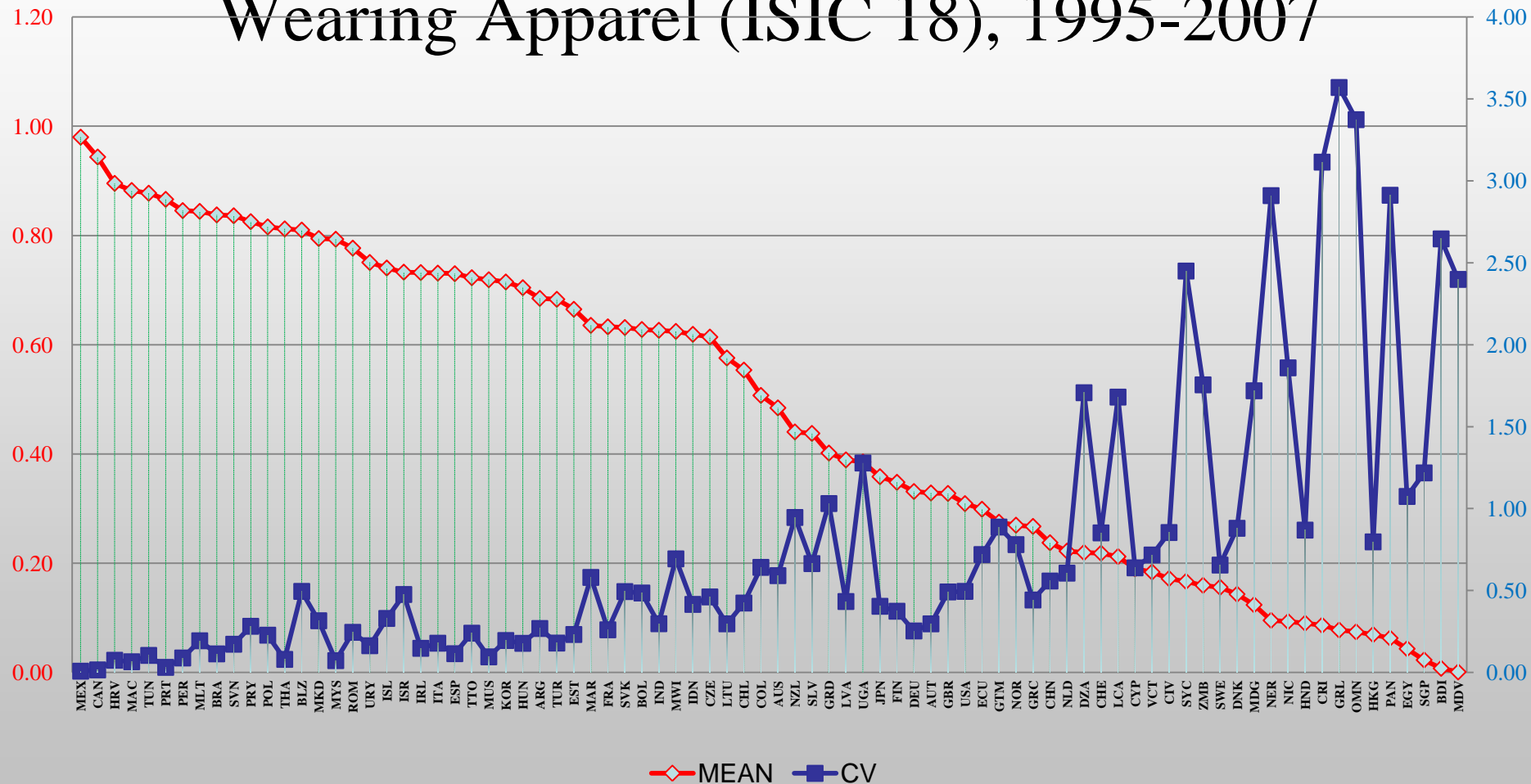
# Average Importer Relative Reliability Index Basic Metal (ISIC 27), 1995-2007





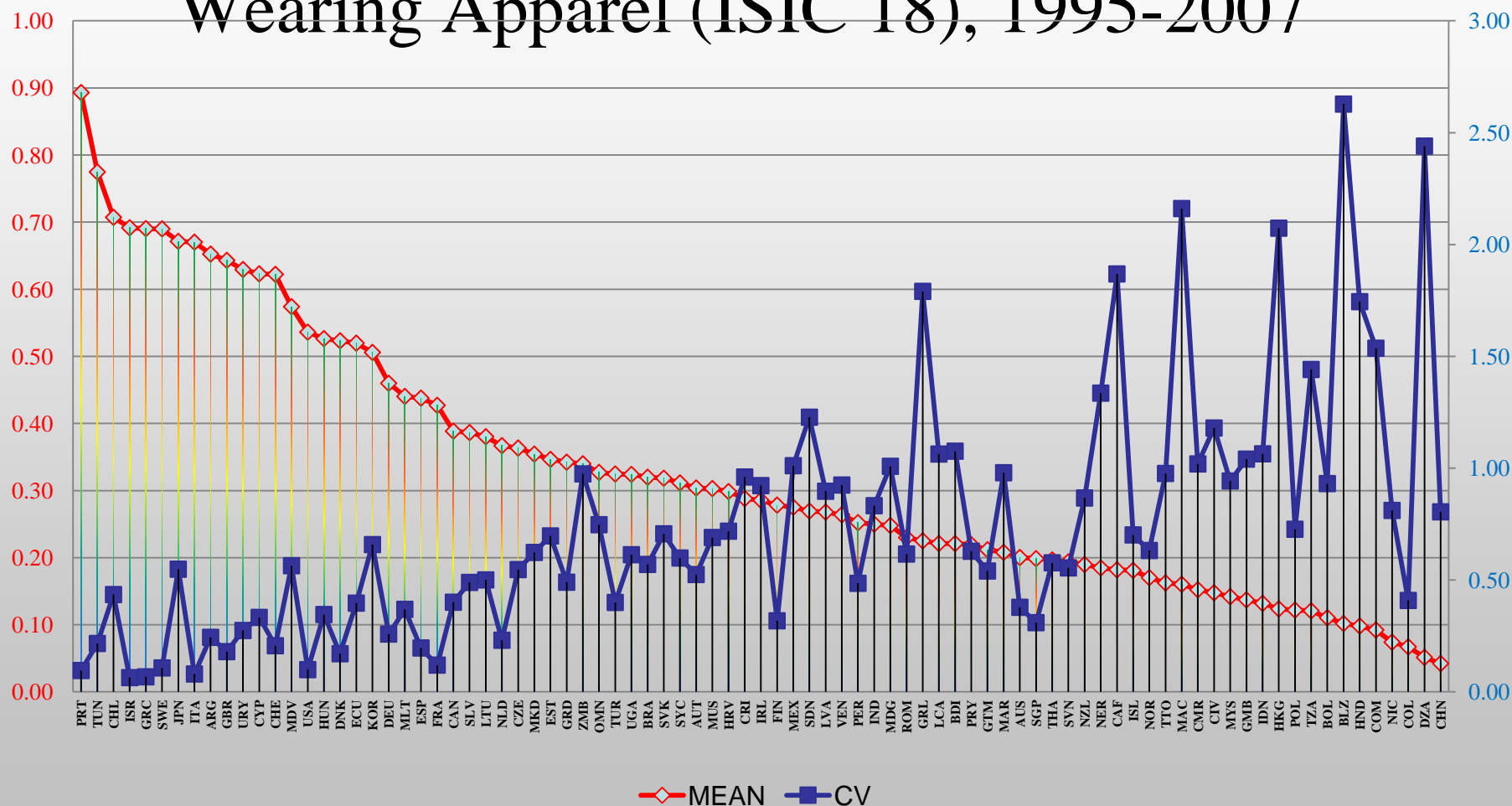


# Average Exporter Relative Reliability Index Wearing Apparel (ISIC 18), 1995-2007





# Average Importer Relative Reliability Index Wearing Apparel (ISIC 18), 1995-2007





# Full Use of Mirrored Bilateral Trade Statistics: Initial value and constraints

- **Combine mirror trade data into initial estimates using reliability as weights**

$$rlwgt(u,i,s,r) \frac{(rxindex(u,i,s)+rminindex(u,i,r))}{rminindex(u,i,r)} =$$

$$VFM0(i,K,S,R) \frac{(ord(s) - ord(r))}{ord(s)} = rlwgt("P",i,s,r) * VFM0m(i,k,s,r) + (1-rlwgt("P",i,s,r)) * VFM0x(i,K,S,R);$$

- **Constraints that contain solution in a reasonable range**

$$MINEQ_{int}(k,i,s,r) \dots VFMn(k,i,S,R) + minadj_{int}(k,i,s,r) = G = MIN(VFM0x(K,i,S,R), VFM0m(K,i,S,R));$$

$$MAXEQ_{int}(k,i,s,r) \dots VFMn(k,i,S,R) - maxadj_{int}(k,i,s,r) = L = Max(VFM0x(K,i,S,R), VFM0m(K,i,S,R));$$



# The Adjustment Method:

## Sufficient constraints with meaningful information

--- Starting execution: elapsed 0:00:05.642  
--- GTAPV8IO07ptr.gms(812400) 1863 Mb  
--- Generating QCP model gtapbal  
--- GTAPV8IO07ptr.gms(812402) 8111 Mb  
--- 14,273,659 rows 19,515,138 columns 64,752,823 non-zeroes  
--- GTAPV8IO07ptr.gms(812402) 7631 Mb

### S O L V E   S U M M A R Y

MODEL	gtapbal	OBJECTIVE	S1
TYPE	QCP	DIRECTION	MINIMIZE
SOLVER	CPLEX	FROM LINE	812402

\*\*\*\* SOLVER STATUS    1 Normal Completion  
\*\*\*\* MODEL STATUS    1 Optimal  
\*\*\*\* OBJECTIVE VALUE   6646029090021.8350



## Separate Processing Trade Account

- WTO has identified more than 130 countries that use some form processing exports (WTO and IDE JETRO, 2011) and reports that about 20% of developing country exports come from Export Processing Zones (EPZs). China and Mexico are the two largest users of export processing regimes in the developing world, and together account for about 85% of worldwide processing exports
- We extend Koopman, Wang, and Wei (JDE, 2012) into a multi-country global setting that separate standard IO table of China and Mexico into normal and processing trade account.
- The basic idea is to use data from the ICIO table to determine sector-level total imports/exports, and processing trade data from China and Mexico to determine the relative proportion of processing and normal exports, thus split both Chinese and Mexico economies into two separate blocks, each with its own IO structure.



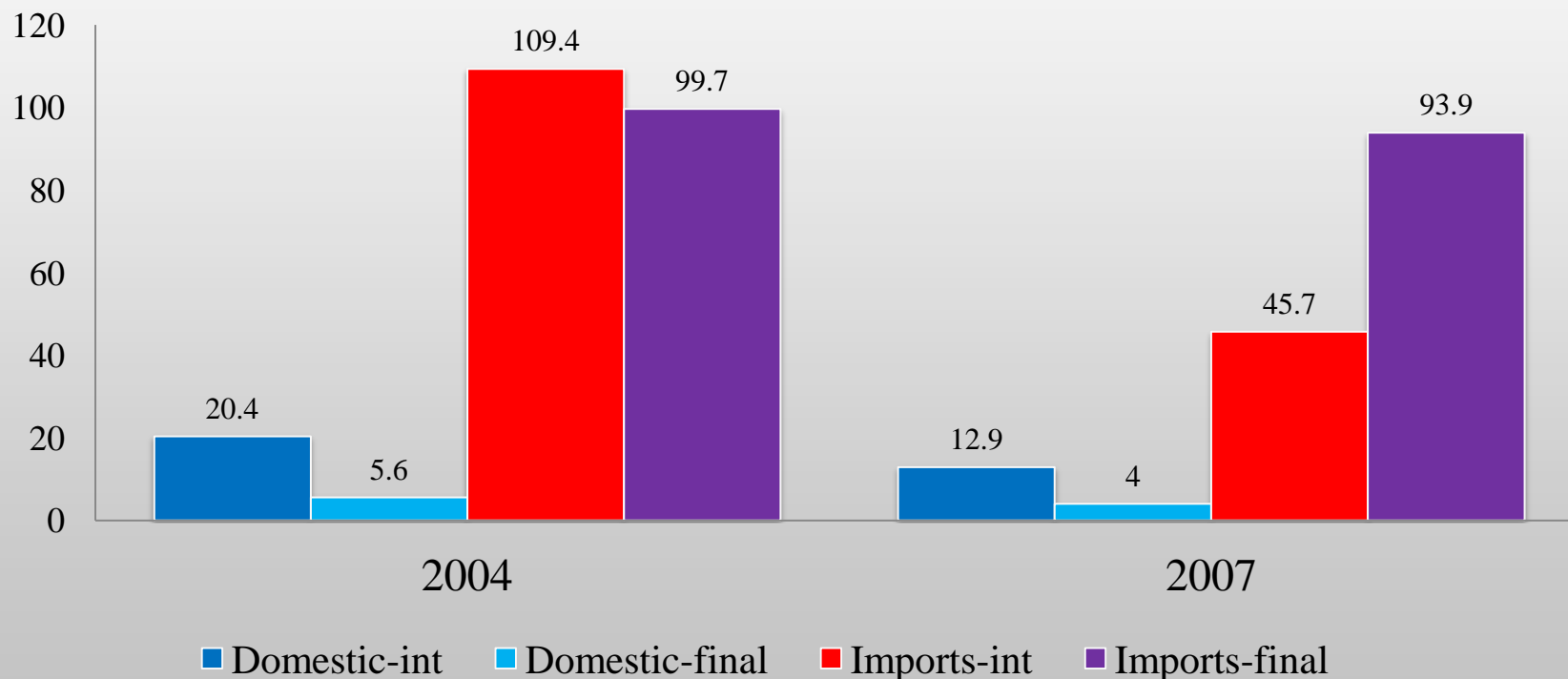
## What is fixed and What is adjusted

- All supply side variables, including total gross output (TVOM), primary factor payment (VFM), supply of international transportation margin (VST) and bilateral trade flows (VXMD), as well as all tax wedges are fixed as constant at V8 GTAP level;
- Domestic and imported purchase goods and services (VDFM, VDPM, VDGM, VIFM, VIPM, VIGM) are adjusted to fit the balance condition in the ICIO table.



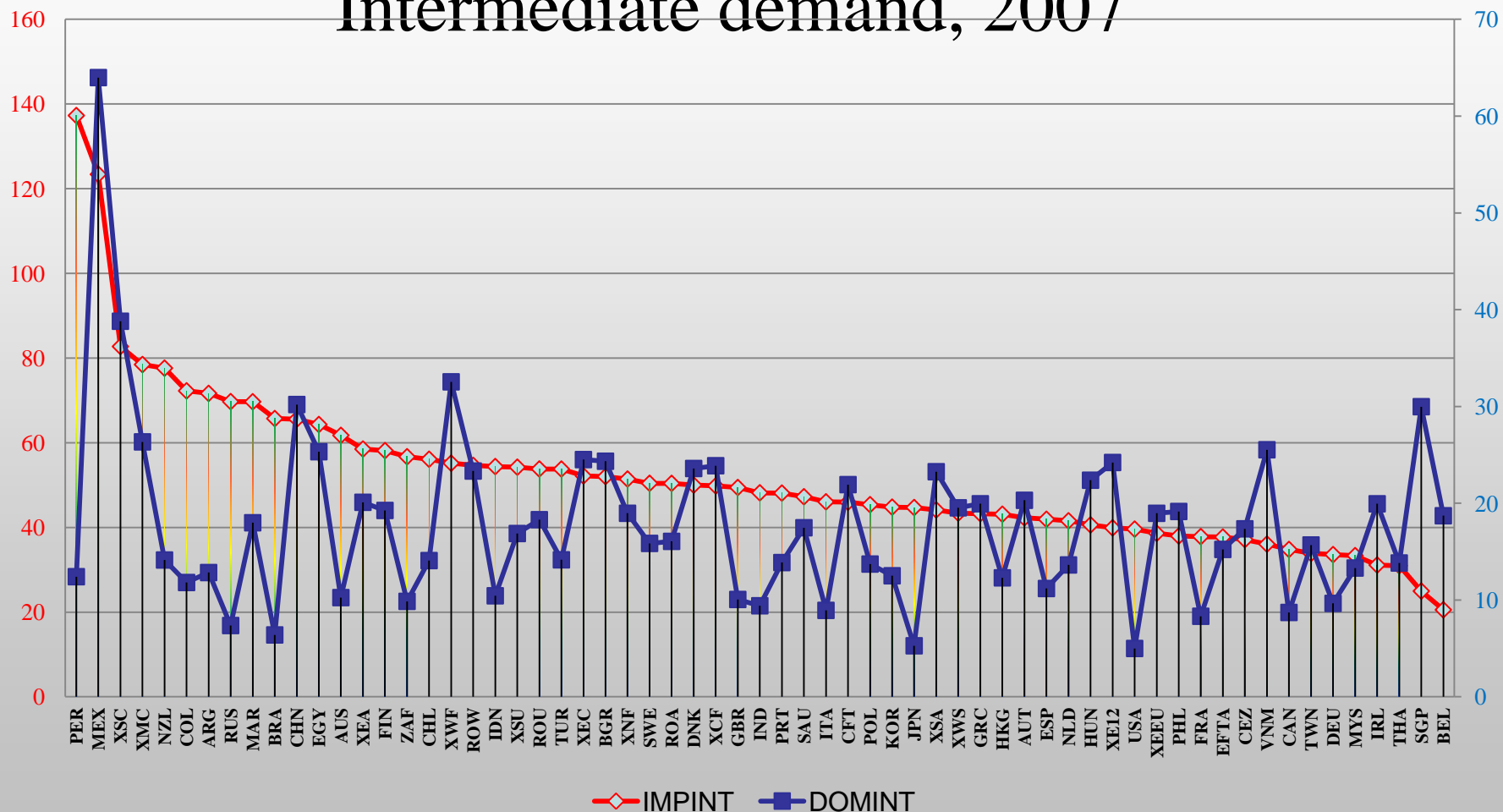


# Mean Absolute Percentage Adjustment: Aggregate demand, 2007



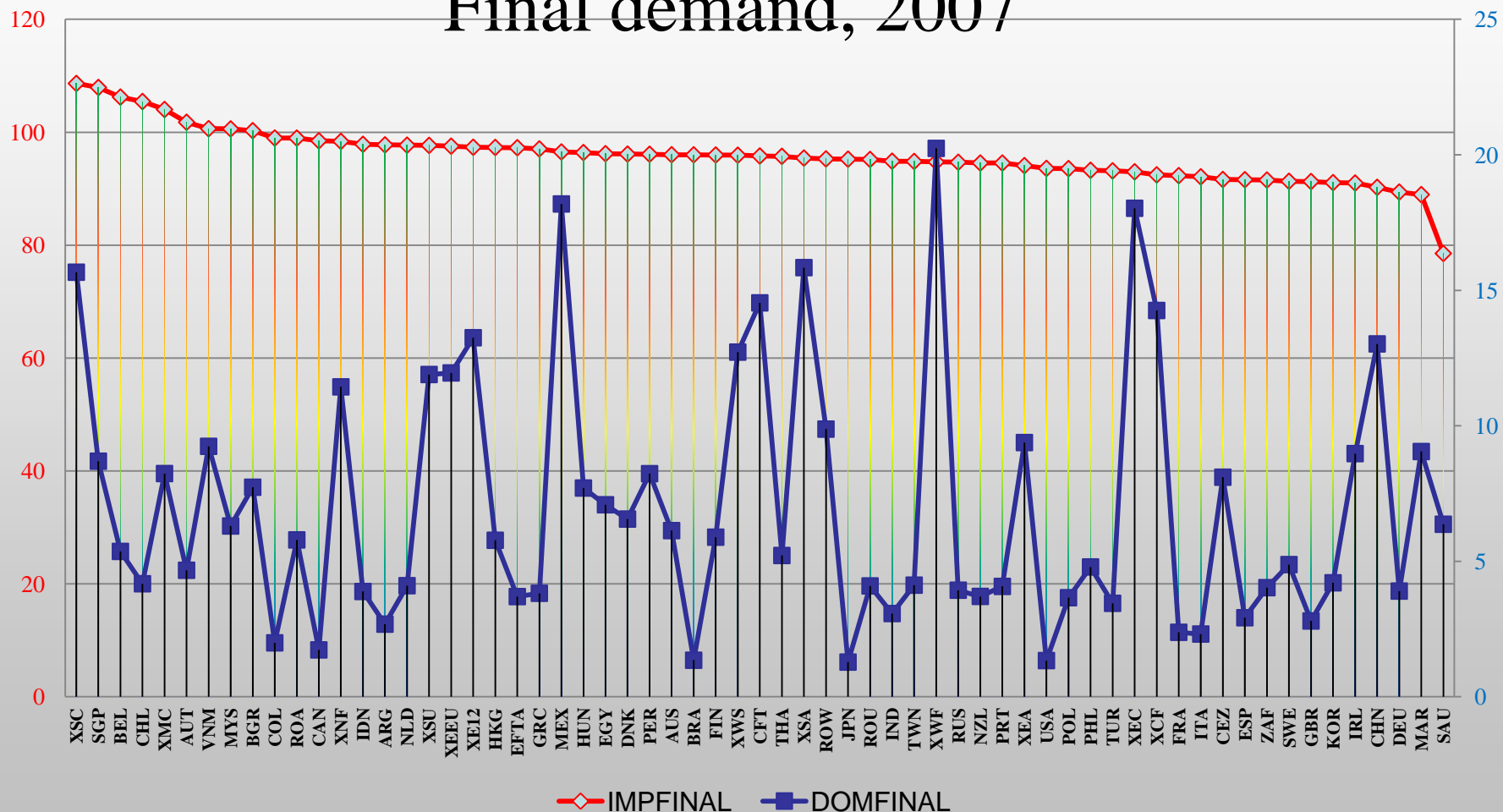


# Mean Absolute Percentage Adjustment Intermediate demand, 2007





# Mean Absolute Percentage Adjustment Final demand, 2007





## Conclusion

- We discussed how an ICIO Table with processing trade account can be constructed from GTAP database
- We first provides a theoretical foundation show that the MRIO table embodied in GTAP database is mathematically consistent with an ICIO table and what additional information is needed for the transformation
- We then use a quadratic programming model with reliability weights in its objective function to extend version 8 GTAP database into an ICIO table, covering 63 countries and 41 sectors, we also separate processing trade account for a subset of developing countries. We hope this extended database can be widely used in analytical and policy work

### MRIO table in GTAP database

		Intermediate input	Final use (C+I+G)		Gross Output
	DIM	1,2,..., N	1	1	1
Domestic Production for domestic use & exports	1 . . . N	$Z^{rr}$	$Y^{rr}$	$E^r = \sum_{s \neq r}^G T^{rs}$	$X^r$
Import supply	1 . . . N	$Z^{mr}$	$Y^{mr}$	$M^r = \sum_{r \neq s}^G T^{sr}$	
Value-added	1	$V^r$			
Gross output	1	$X^r$			

### Extended IRIO Table

		Intermediate input	Domestic final use	Split exports to intermediate and final use for each destination		
	DIM	1,2,..., N	1	1,2,...,(G-1)N	1,2,..., G-1	1
Domestic Production for domestic use & exports	1 . . . N	$Z^{rr}$	$Y^{rr}$	$Z^{rs}_{r \neq s}$	$Y^{rs}$	$X^r$
Split Import supply by end uses for each source	1 . . . (G-1) N	$Z^{sr}_{s \neq r}$			$Y^{sr}$	
Value-added	1	$V^r$				
Gross output	1	$X^r$				