BANK FOR INTERNATIONAL SETTLEMENTS

Global Value Chains and Effective Exchange Rates

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NIPFP, May 2019

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Background: Real effective exchange rate (REER)

- A commonly used measure of competitiveness
- Many applications
  - currency misalignment and manipulation
  - vulnerability to crises (Chinn, 2000; Goldfajn and Valdés, 1999; Gagnon 2012)

"..we look at several variables, but certainly we've looked, as I think I've said in the last press conference, at the exchange rate in effective terms; "
Mario Draghi, January 2016.

"..net exports are being held down by weak economic growth in several of our major trading partners and the appreciation of the dollar."
Janet Yellen, July 15, 2015

Main Contribution in This Paper

- New model of REER to better capture movements in competitiveness in a world with global value chains
- Create database of country and sector level REERs using inter-country input output tables.

The Concept of REER

$$\triangle REER_J = \triangle V_J = \sum_{i=1}^{n} w_{Ji} \triangle p_i$$

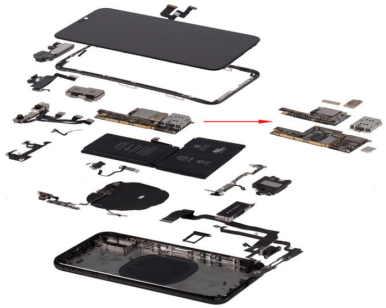
- V_J: value added by country J
- w_{Ji} are exchange rate weights
- $\triangle$ denotes log change from steady state

- Partial equilibrium concept
  - Primitive shocks not modeled
  - No restrictions on trade balance
- All papers (including ours) work in this setting

Problems With Conventional REERs (like IMF)

1. Ignore intermediate inputs and global value chains
   - Both offshoring and domestic outsourcing are ignored
   - In the data, around 60 percent of world trade comprises of trade in intermediate goods
2. Ignore sectoral heterogeneity within countries
   - Strong evidence documenting sectoral heterogeneity (Wang, Wei and Zhu ,2014)
   - Affects both components of REERs-weights and prices

Importance of Considering Trade in Intermediates



..→[Japan] → **[China]** → **[US]**

- Standard real exchange rate measures (IMF, OECD, Fed etc):
  - Classify iPhone as China's product (produced entirely in China)
  - China competes with other smart phone manufacturers
  - Decrease in Japanese prices reduce Chinese competitiveness
- In reality:
  - China is just the final assembly point for iPhones
  - Competes with other providers of these "assembly services"
  - Decrease in Japanese prices may increase China's competitiveness

Importance of Incorporating Sectoral Heterogeneity

Example: Two sector Chinese Economy

	Electronics Sector	Non traded goods sector
%Domestic value added	34-40 percent	100 percent
Fraction Exported	high(˜90percent)*	Low(˜0)

(*source: Koopman, Wang and Wei,2012)

- Fraction of value added in aggregate "Chinese good" >40 percent
  - **Over-predicts Chinese value added in exports**

Need for Sector Level REERs

- World economy increasingly marked by specialization and global value chains
- Different sectors within a country can show very different behavior with regard to competitiveness
- Sectoral measures of competitiveness therefore promise to be an important addition to the information set of policy makers.

This Paper

- New model of REER
  - Construct sector and country level REER weights and indices
  - Develop seperate REER indices for value added and gross output competitiveness
- Focus on short run changes in competitiveness
  - Take GVC and production outsourcing pattern as given

Related Literature

- REER

	IMF	Fed	BIS	BJ	BST	BZ	This paper
Value added competitiveness				√			√
Sector level heterogeneity						√	√
Trade in intermediate goods				√	√		√
Heterogenous elasticities							√

*BJ: Bems and Johnson (2012); BST:Bayoumi et al. (2013);BZ:Bennett and Zarnic (2009)

- Global Value Chains /Export Accounting/Vertical Specialization:
  - Auer, Levchenko and Saure (2016), Borin and Mancini (2015), Koopman, Wang and Wei (AER2014, NBER wp 2014,), Wang, Wei and Zhu(2014), Hummels, Ishii and Yi (2001) etc.

Roadmap

- Brief sketch of the full model
- Illustrative numerical examples
- Data and empirical results
- Conclusion

Model

Model: Features

- Multi-Country multi-sector model allowing for arbitrary input-output linkages and global value chains.
- n countries and m sectors within each country
- Each country-sector is a production entity endowed with its own unique production technology
  - Takes inputs from (potentially) all other entities and combines with own value added
- n representative consumers -one for each country
  - Consumption bundle is an aggregate of nm goods.
- Partial Equilibrium framework
  - Prices are exogenous
  - Output (endogenous) is a function of prices

Model Setup: Production

- n countries, m sectors

$$Q_l^c = \left[(w_l^{vc})^{1/\sigma^3} (V_l^c)^{\frac{\sigma^3-1}{\sigma^3}} + (w_l^{Xc})^{1/\sigma^3} (X_l^c)^{\frac{\sigma^3-1}{\sigma^3}} \right]^{\frac{\sigma^3}{\sigma^3-1}}$$

Aggregate	Components	Elasticity	
X_l^c	$\{X_{sl}^c\}_{s=1}^m$	σ^2	
X_{sl}^c	$X_{sl}^{cc}, X(f)_{sl}^c$	σ^{1h}	Macro-Elasticity
$X(f)_{sl}^c$	$\{X_{sl}^{ic}\}_{i=1,i\neq c}^n$	σ^1	Micro-Elasticity

▸ full expressions

Final Demand and Market Clearing

Aggregate	Components	Elasticity	
F^c	$\{F_s^c\}_{s=1}^m$	θ^1	
${F_s}^c$	$F_s^{cc}, F(f)_s^c$	θ^{1h}	Macro Elasticity
$F(f)_s^c$	$\{F_s^{ic}\}_{i=1,i\neq c}^n$	θ^2	Micro Elasticity

▸ full expressions

▸ elasticity estimates

Market Clearing Condition:

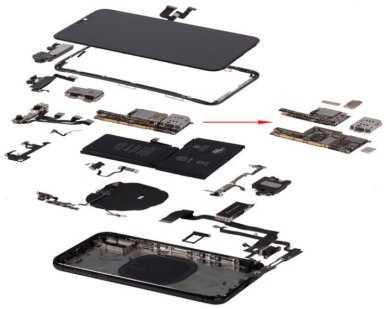
$$Q_l^c = \sum_{i=1}^{n} F_l^{ci} + \sum_{j=1}^{m}\sum_{k=1}^{n} X_{lj}^{ck}, \forall(c,l)$$

Model Solution and REER Expressions

$$\left(\hat{V}\right)_{nm} = \underbrace{\left[W_V\right]_{nmXnm}\left(\hat{p^v}\right)_{nm}}_{GVC-REER} + \left[W_{FV}\right]_{nmXnm}\left(\hat{F}\right)_{nm}$$

$$\left(\hat{Q}\right)_{nm} = \underbrace{\left[W_Q\right]_{nmXnm}\left(\hat{p^v}\right)_{nm}}_{Q-REER} + \left[W_{FQ}\right]_{nmXnm}\left(\hat{F}\right)_{nm}$$

Illustrative Example: A stylized three country, two sector global value chain



..→[Japan] → **[China]** → **[US]**

(Sector J_1 in country J exports raw materials to sector C_2 in country C, which combines them with its own value added input to produce final goods which are then subsequently consumed in C and exported to U.)

Illustrative Example cont.: putting numbers..

Our framework works with the full IO table..

		J		C		U		JFinal	CFinal	Ufinal	total output
		J_1	J_2	C_1	C_2	U_1	U_2				
J	J_1	0	0	0	2	0	0	1	0	0	3
	J_2	0	0	0	0	0	0	1	0	0	1
C	C_1	0	0	0	0	0	0	0	2	0	2
	C_2	0	0	0	0	0	0	0	1	2.5	3.5
U	U_1	0	0	0	0	0	0	0	0	2	2
	U_2	0	0	0	0	0	0	0	0	1	1
VA		3	1	2	1.5	2	1				
total output		3	1	2	3.5	2	1				

..whereas the remaining frameworks in the literature begin with a simplifying assumption of aggregating across sectors in a country. The consequences are illustrated in the following slides

	J	C	U	J final	C final	U final	Total output
J	0	2	0	2	0	0	4
C	0	0	0	0.5	2.5	2.5	5.5
U	0	0	0	0	0	3	3
Value added	4	3.5	3				
Total output	4	5.5	3				

Illustrative Example cont.: Sectoral heterogeneity and REER weights

Comparison of weight assigned by country U to country J and C under the different REER schemes

	GVC-REER	VAREER (BJ)	IMF	Q-REER
W_{UJ}	0.57	0.36	0	0.57
W_{UC}	0.43	0.67	1	0.43

- Compared to VAREER and IMF, GVC scheme assigns lower weight to C and higher to J, recognizing the GVC nature of the trade flows
- Since U does not have any intermediate imports, GVC-REER=Q-REER
  - the two quantities differ for country C with imports intermediate inputs GVC-REER (W_{CJ}=0.56) and Q-REER (W_{CJ}=-1.33)

Illustrative Example cont.: Sectoral heterogeneity and REER indices

- Consider the price vector: $\hat{p_{c_1}} = 1$, $\hat{p_{c_2}} = 0$, $\hat{p_{J_1}} = \hat{p_{J_2}} = \hat{p_{U_1}} = \hat{p_{U_2}} = 0$.
- Since the value added share of C_1 and C_2 in C are 0.57 and 0.43 respectively, the computed change in aggregate price index in C is given by $\hat{p_c} = 0.57$.

$$\begin{aligned} \hat{VAREER_U} &= W_{UC}\hat{p_c} = 0.57 * 0.43 = 0.25 \\ \hat{GVC - REER_U} &= W_{UC_1}\hat{p_{c_1}} + W_{UC_2}\hat{p_{c_2}} = 0 * 1 + 0.43 * 0 = 0 \end{aligned}$$

- *Intuition: Since the only price change concerns the sector in C which is entirely domestically oriented, competitiveness of U should not be affected, as rightly concluded by the GVC-REER measure.*

Data

- Source: World Input-Output Database(WIOD), augmented by the Asian Development Bank (ADB) statistics group
- Main features:
  - Inter-Country Input-Output (ICIO) tables at the country-sector level, both quantities and prices
  - 40 countries and 35 sectors within each country
  - Sample: 1995-2011(1996-2009 for prices)
  - Detailed description in Timmer et. al (2012) , (2015).

Results

1. REER weights
2. Sector level REER indices
3. Multilateral and bilateral (country-level) REER indices (country level)

Range of REER weights generated by the framework

	Dimension
country by country	n by n by T
country by country-sector	n by nm by T
country-sector by country	nm by n by T
country-sector by country-sector	nm by nm by T

- Each is relevant depending on the policy question.
  - For instance, if a shock originates in the US real estate sector, the country by country sector weights are most suited to capturing the impact on a foreign country
  - Other measures in the literature only generate country by country weights

Illustration of REER weights: Biggest Competitors for Japan in 2007 based on different REER weighting schemes

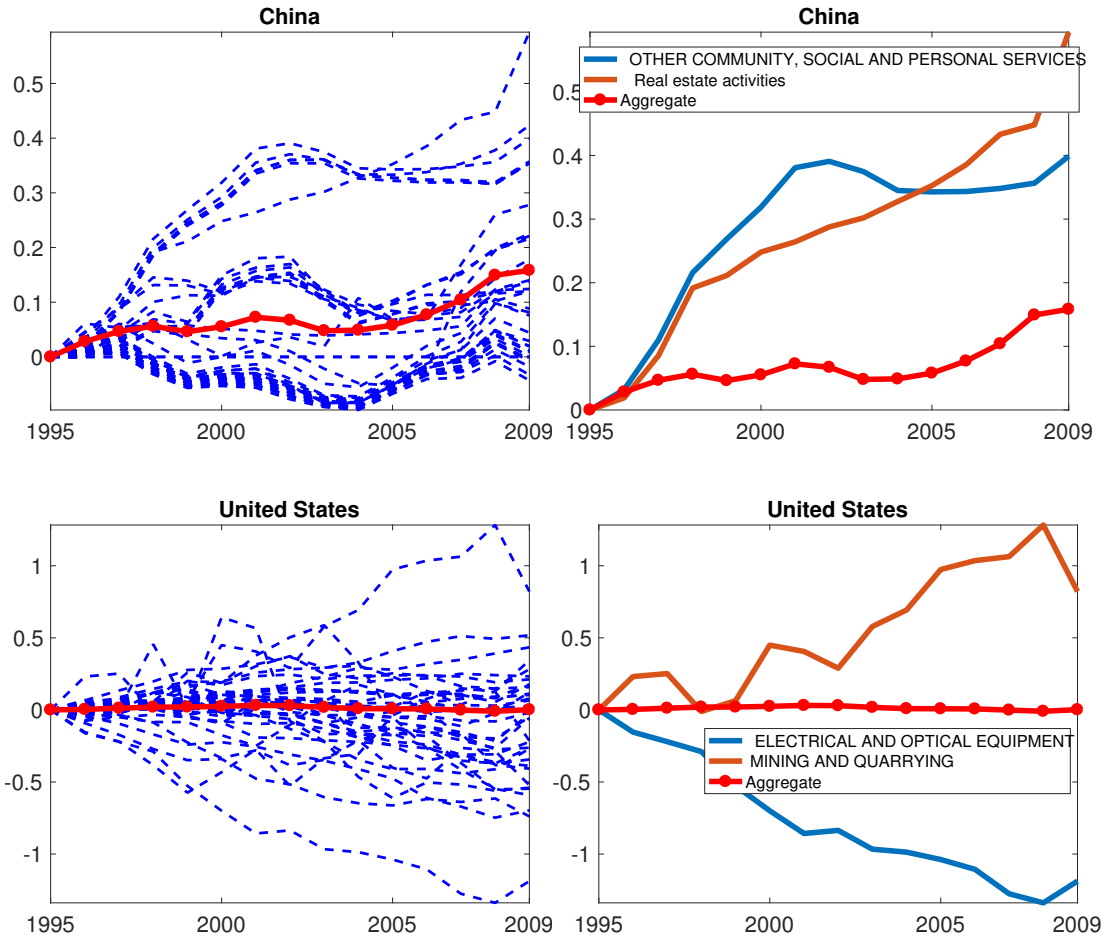
Rank	**GVC-REER**	IMF
1	'ROW'	'ROW'
2	'United States'	'China'
3	'China'	'United States'
4	'Germany'	'Korea'
5	'Korea'	'Taiwan'

- GVC scheme recognizes the complementary nature of GVC trade with China and assigns a lower rank to it.

Comparison of biggest sector level competitors for China in 2007

		Constant Elasticity
1	'ROW'	'Mining and Quarrying'
2	'USA'	'Renting of M&Eq and Other Business Activities'
3	'USA'	'Public Admin and Defense; Compulsory Social Security'
4	'USA'	'Real Estate Activities'
5	'USA'	'Financial Intermediation'
6	'ROW'	'Agriculture, Hunting, Forestry and Fishing'
7	'USA'	'Wholesale Trade and Commission Trade, Except auto'
8	'ROW'	'Wholesale Trade and Commission Trade, Except auto'
9	'USA'	'Retail Trade, Except auto; Repair of Household Goods'
10	'USA'	'Health and Social Work'

Sectoral REERs



Countries with highest and lowest divergence of REERs across sectors

High Dispersion		Low Dispersion	
Czech Republic	0.19	Malta	0.02
Slovak Republic	0.15	China	0.03
Russia	0.13	Ireland	0.04
Bulgaria	0.12	Taiwan	0.04
Sweden	0.11	Spain	0.05

Notes: The dispersion is computed as the average standard deviation of REER movements within a country (i.e an average of 14 observations on the standard deviation for each time period).

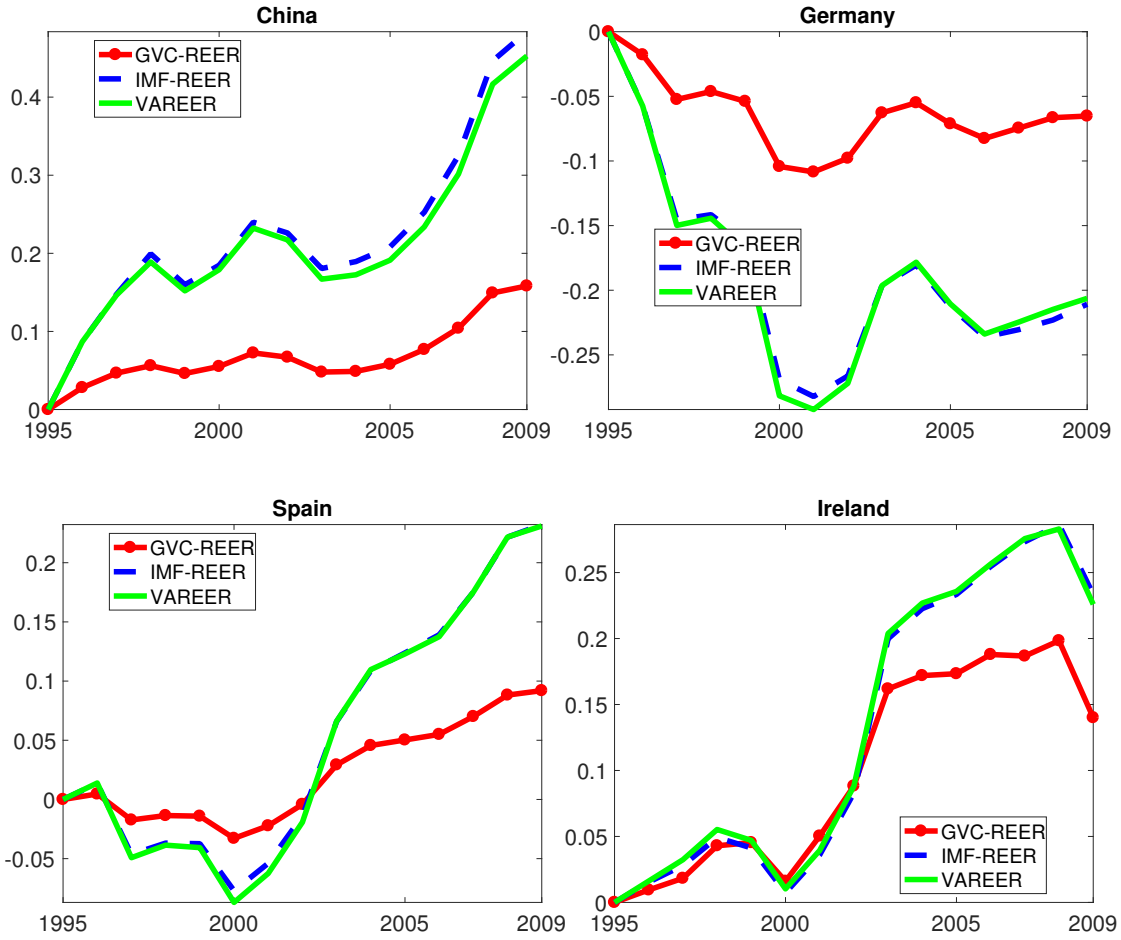
Median Change in competitiveness from 1995-2009 across different sector groups

	GVC-REER (Value added)				Q-REER (Gross output)		
	Primary	Secondary	Tertiary		Primary	Secondary	Tertiary
EME	-0.05	0.07	-0.10	EME	-0.06	0.06	-0.08
AE	0.07	0.10	-0.09	AE	0.14	0.12	-0.10

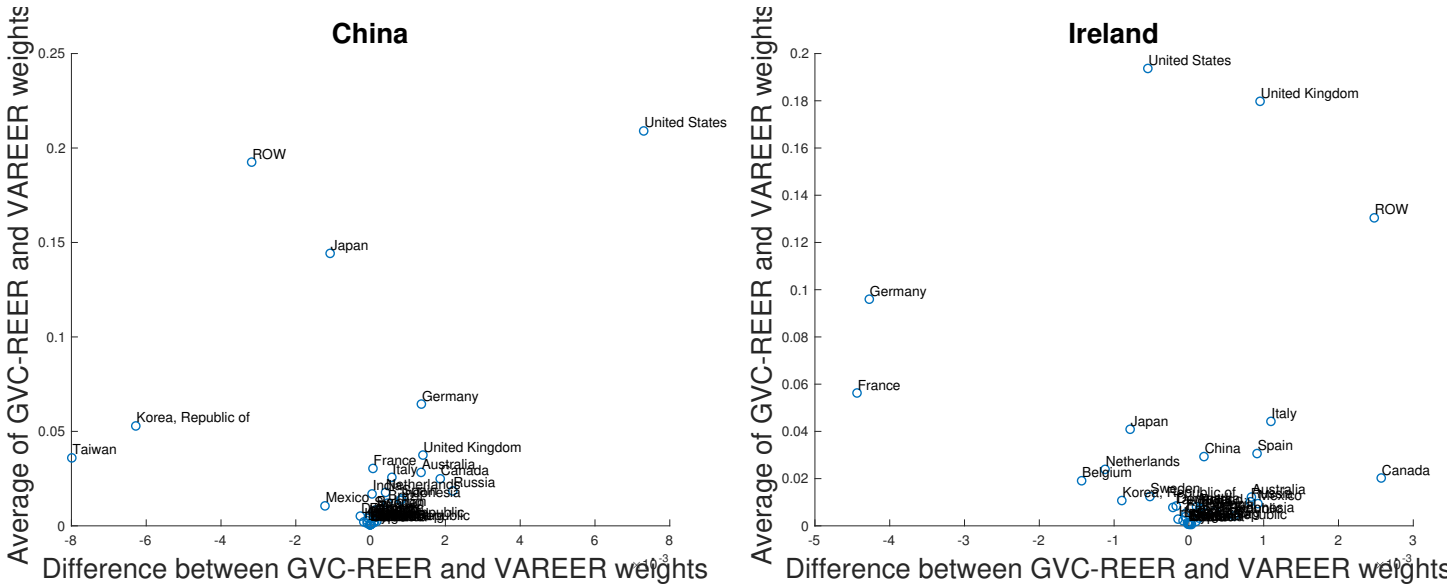
Notes: The numbers represent simple medians of the cumulative change in the effective exchange rate from 1995 to 2009. "EME" and "AE" denotes emerging markets and advanced economies respectively.

Country level REER indices

- **GVC-REER diverges most from the other measures in the literature**



Comparison of VAREER and GVC-REER weights for China and Ireland



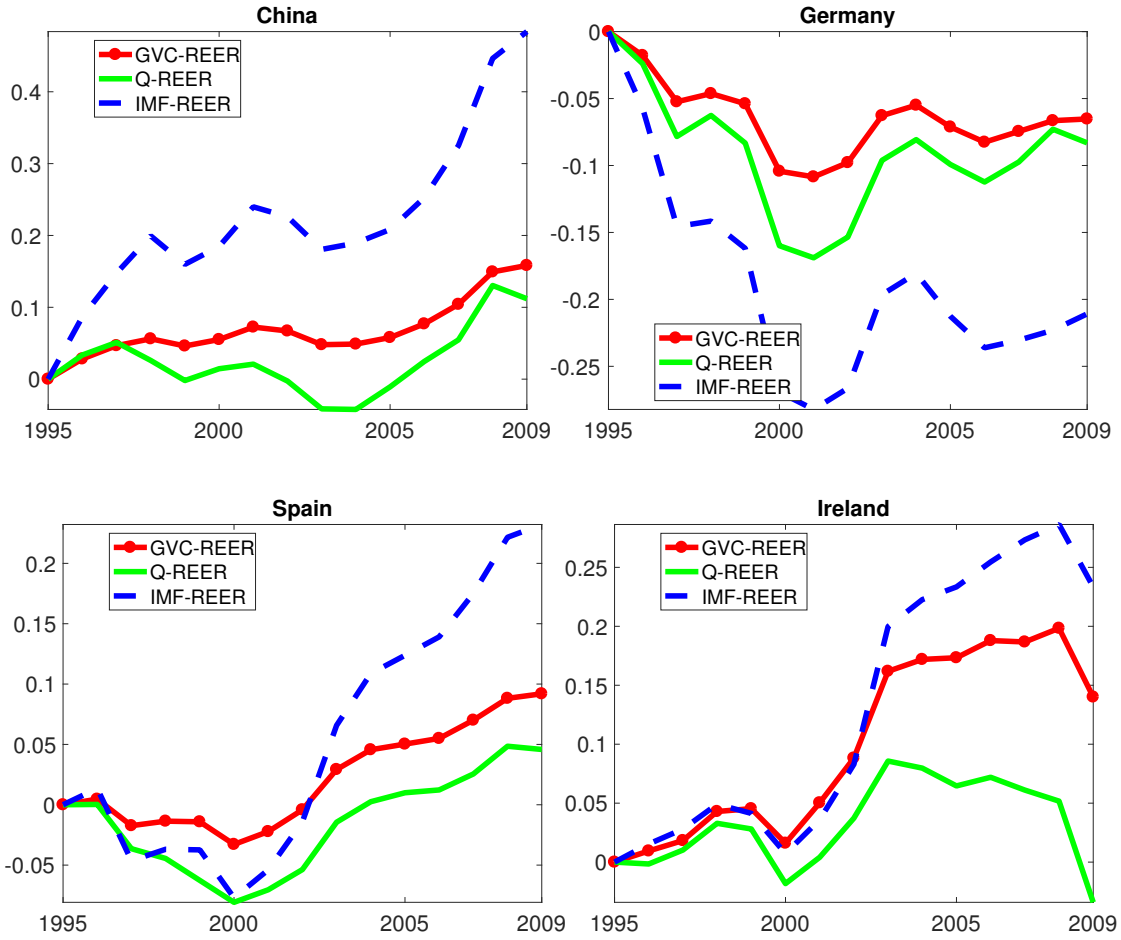
Decomposing the difference between GVC-REER and VAREER (BJ): The role of prices and weights

$$
\begin{aligned}
REER\_GAP_{it} &= VAREER_{it} - (GVC - REER_{it}) \\
&= \sum_{j=n}^{n} W_t^{i,j,VAREER} \hat{p}_t^j - \sum_{j=1}^{n} \sum_{s=1}^{m} W_{s,t}^{i,j,GVC-REER} \hat{p_{s,t}}^j \\
&= \underbrace{\sum_{j=1}^{n} \left(W_t^{i,j,VAREER} - W_t^{i,j,GVC} \right) \hat{p}_t^j}_{Term1} \\
&\quad \underbrace{+ W_t^{i,j,GVC} \hat{p}_t^j - \sum_{j=1}^{n} \sum_{s=1}^{m} W_{s,t}^{i,j,GVC-REER} \hat{p_{s,t}}^j}_{Term2}
\end{aligned}
$$

Decomposing the difference between GVC-REER and VAREER (BJ): The role of prices and weights

Country	REER GAP (%)	Contributions (share in %)	
		Weights	Prices
'Brazil'	-4.99	-7.53	2.54
'China'	-29.44	-29.98	0.54
'Germany'	14.1	13.28	0.82
'India'	-4.92	-6.82	1.9
'Romania'	-36.24	-39.11	2.87
'United States'	-1.66	-1.64	-0.02
median	**-5.44**	**-7.3**	**0.82**

Value added (GVC-REER) vs gross output (Q-REER) competitiveness: Comparison for select countries



Bilateral RER

- Typically defined as: $RER^{hf} = \hat{p}(V)^f - \hat{p}(V)^h$
- This is appropriate for some purposes (like comparison of cost of living across countries)
- But is misleading as a gauge of competitiveness
- We propose a reweighing similar to the multilateral weights

Example: Bilateral RER

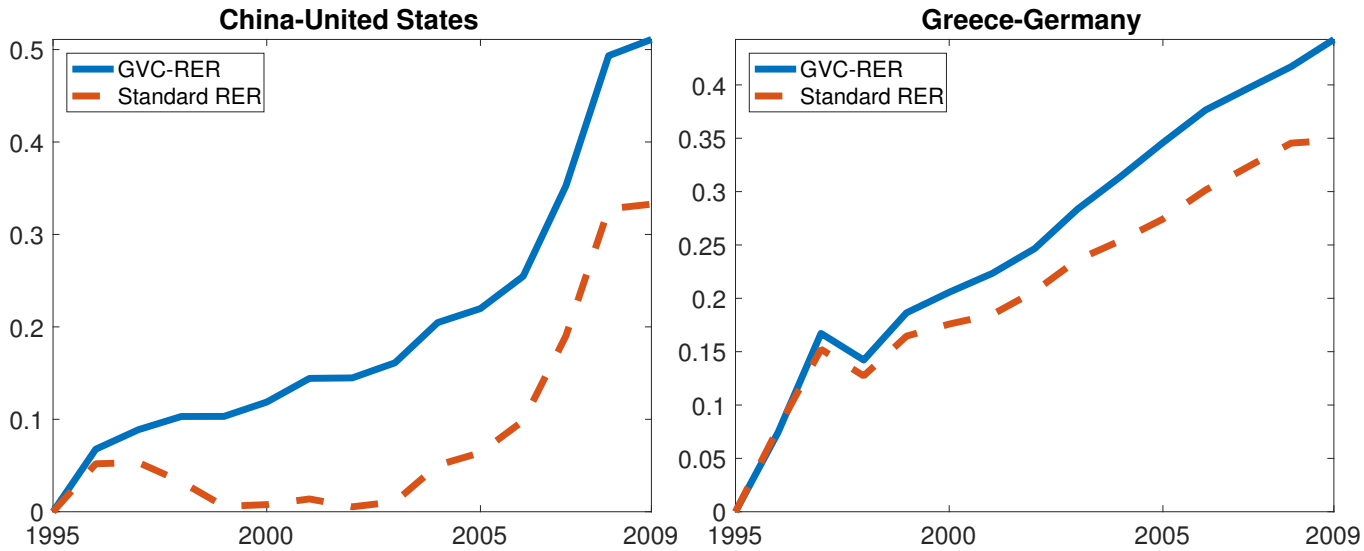
C_1: Traded good; C_2: non traded good

		C		U		CFinal	Ufinal	total output
		C1	C2	U1	U2			
C	C1	0	0	0	0	1	1	2
	C2	0	0	0	0	3	0	3
U	U1	0	0	0	0	0	1	1
	U2	0	0	0	0	0	1	1
VA		2	3	1	1			
total output		2	3	1	1			

$$\hat{p^v}(c_1) = -0.01, \hat{p^v}(c_2) = 0.02, \hat{p^v}(u_1) = 0, \hat{p^v}(u_2) = 0$$

- Given the price changes, $\hat{REER}_{US}$ indicates an increase in competitiveness of the US ($\hat{REER}_{US}$=0.008)
  - This is misleading since US competes only with C1 and $p^V(c_1) \downarrow$
  - The conceptually correct should indicate a fall in competitiveness of the US

Comparison of GVC-RER and standard RER bilateral exchange rates



- After correctly adjusting for GVC participation:
  - China's exchange rate exhibits a much stronger appreciation against the US
  - Fall in competitiveness (i.e real appreciation) of Greece against Germany is much sharper

Stability of GVC-REER weights over time

- Sectoral input-output data required to compute GVC-REER indices is often only available at low frequency (annual or less)
- Stability of weights over time is important for timely updating and practical usefulness of the indicators
- To check for this, we recompute GVC-REER using fixed weights (calibrated to the year 2005) and compare with time varying ones

Level of aggregation	Country level GVC-REER	Sector level GVC-REER
	Correlations	Correlations
mean	0.995	0.994
maximum	0.998	1.00
minimum	0.95 (Indonesia)	0.77

- **Main Takeaway: Weights are relatively stable over time, so GVC-REER indices can be computed in real time.**

Conclusion

Main contribution: REER measure improving upon existing measures

- REER weights and indices at the country, country-sector and bilateral country levels
- Separate measures for value added and gross output competitiveness
- Allow for both trade in intermediate inputs and sectoral heterogeneity in GVC participation
- In the data, allowing for sectoral heterogeneity (which is the novel feature in the model) contributes most to the differences in REERs

Thank You!

Appendix

Extra Slides

General Model: Production

$$Q^{c}_{\cdot l} = \left[(w^{vc}_{l})^{1/\sigma^{3}(c,l)} (V^{c}_{l}) \frac{\sigma^{3}(c,l)-1}{\sigma^{3}(c,l)} + (w^{Xc}_{l})^{1/\sigma^{3}(c,l)} (X^{c}_{l}) \frac{\sigma^{3}(c,l)-1}{\sigma^{3}(c,l)} \right] \frac{\sigma^{3}(c,l)}{\sigma^{3}(c,l)-1}$$

$$X^{c}_{l} = \left[\sum_{s=1}^{m} (w^{c}_{sl})^{1/\sigma^{2}(c,l)} (X^{c}_{sl}) \frac{\sigma^{2}(c,l)-1}{\sigma^{2}(c,l)} \right] \frac{\sigma^{2}(c,l)}{\sigma^{2}(c,l)-1}$$

$$X^{c}_{sl} = \left[(w^{cc}_{sl})^{1/\sigma^{1h}_{s}(c,l)} (X^{cc}_{sl}) \frac{\sigma^{1h}_{s}(c,l)-1}{\sigma^{1h}_{s}(c,l)} + (w(f)^{c}_{sl})^{1/\sigma^{1h}_{s}(c,l)} (X(f)^{c}_{sl}) \frac{\sigma^{1h}_{s}(c,l)-1}{\sigma^{1h}_{s}(c,l)} \right] \frac{\sigma^{1h}_{s}(c,l)}{\sigma^{1h}_{s}(c,l)-1}$$

$$X(f)^{c}_{sl} = \left[\sum_{i=1, i\neq c}^{n} (w^{ic}_{sl})^{1/\sigma^{1}_{s}(c,l)} (X^{ic}_{sl}) \frac{\sigma^{1}_{s}(c,l)-1}{\sigma^{1}_{s}(c,l)} \right] \frac{\sigma^{1}_{s}(c,l)}{\sigma^{1}_{s}(c,l)-1}$$

back

Genral Model: Final Demand

$$F^c = \left[\sum_{s=1}^{m} (\kappa_s^c)^{1/\rho^2(c)} (F_s^c)^{\frac{\theta^2(c)-1}{\theta^2(c)}} \right]^{\frac{\theta^2(c)}{\theta^2(c)-1}}$$

$$F_s{}^c = \left[(\kappa_s^{cc})^{1/\theta_s^{1h}(c)} (F_s^{cc})^{\frac{\theta_s^1(c)-1}{\theta_s^1(c)}} + (\kappa(f)_s^c)^{1/\theta_s^{1h}(c)} (F(f)_s^c)^{\frac{\theta_s^{1h}(c)-1}{\theta_s^{1h}(c)}} \right]^{\frac{\theta_s^{1h}(c)}{\theta_s^{1h}(c)-1}}$$

$$F_s^c(f) = \left[\sum_{i=1, i\neq c}^{n} (\kappa_s^{ic})^{1/\theta_s^1(c)} (F_s^{ic})^{\frac{\theta_s^1(c)-1}{\theta_s^1(c)}} \right]^{\frac{\theta_s^1(c)}{\theta_s^1(c)-1}}$$

back

Elasticity Estimation Details 1 of 3

- Start with a general armington aggregator:

$$D_t = \left[\sum_{k \in K} (w_k)^{1/\eta} (D_{kt})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

- Demand function:

$$\triangle^r ln(s_{kt}) = -(\eta - 1) \triangle^r ln(p_{kt}) + \epsilon^r_{kt}$$

(where $s_{kt} = \frac{p_{kt} D_{kt}}{\sum_{k \in K} p_{kt} D_{kt}}$)

- Specify supply function exogenously

$$\triangle^r ln(p_{kt}) = \left(\frac{\rho}{1+\rho} \right) \triangle^r ln(s_{kt}) + \delta^r_{kt}$$

back

Elasticity Estimation Details 2 of 3

- Combine the two to get the final estimation equation:

$$Y_{kt} = \theta_1 Z_{1kt} + \theta_2 Z_{2kt} + u_{kt}$$

- Moment condition: $E(u_{kt}) = 0$
  - consistency relies on $T \to \infty$

$$Y_{kt} = (\triangle^r ln(p_{kt}))^2 \ , Z_{1kt} = (\triangle^r ln(s_{kt}))^2$$
$$Z_{2kt} = (\triangle^r ln(p_{kt}))(\triangle^r ln(s_{kt})), \text{and } u_{kt} = \frac{\epsilon^r_{kt}\delta^r_{kt}}{1-\phi}$$
$$\theta_1 = \frac{\phi}{(\eta-1)^2(1-\phi)} \theta_2 = \frac{2\phi-1}{(\eta-1)(1-\phi)}$$

back

Thank You

back