The Mystery of Capital Prices

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VERY PRELIMINARY

The Mystery of Capital Prices

- Two views about the importance of capital goods price distortions in developing countries
  1. Traditional view: barriers matter, and trade policies and trade barriers (broadly defined) put a tax on imported capital goods, reducing imports (e.g., Díaz Alejandro 1970, Eaton & Kortum 2000)
  2. New view: barriers don't matter (e.g., Hsieh & Klenow 2007, Waugh 2009), and we can assume the deviations from the law of one price are uncorrelated with (not relevant for) development

- Our paper
  - This debate is not resolved
  - Can we really trust the raw price of capital (PK) data?
  - International Comparison Program (ICP) PK "data" correlate with nothing but are noisy/unreliable
  - Trade-based imputed PK "data" do correlate with ICP, are indirect measures but correlate much better with development.
  - We need better PK data, but this is hard/costly to collect

What We Do

1. Get more "data"
   - Subheading ICP data for equipment goods from the World Bank-2005 round
     - Redo country-product-dummy price (CPD) imputation for these items (N=80 countries, 2005). *Note: OECD data are secret!*
   - Collect larger trade flows dataset for equipment goods
     - Extend Eaton-Kortum estimates of trade-based prices (63 importing and 114 exporting countries, 1995–99)
2. Cross checking the price "data"
   - Correlate ICP published data with our CPD estimates? <u>NO</u>
   - Correlate ICP and CPD with new EK estimates? <u>NO</u>
   - Correlate ICP, CPD and EK estimates with trade policy? <u>EK only</u>
   - Correlate ICP, CPD and EK estimates with log(GDP per capita)? <u>EK only</u>

Findings and Implications

3. The mystery remains
   - What should we believe?
   - Eaton & Kortum trade based prices support the traditional story.
   - Hsieh & Klenow revisionism if ICP PK data are correct. Are they?

4. Why does this matter?
   - If traded K goods are not more expensive in poor countries, removal of barriers that affect the cost of capital does not affect relative PK in poor countries;
     - Capital stocks would be well measured and differences in income across countries are explained by low TFP (consensus view).
   - If the lack of correlation between PK and development in the ICP data is due to imperfect data and if trade-derived price differences of capital goods are strongly related to underdevelopment:
     - MPK capital in poor countries would differ at local prices and world prices, capital stocks would be mis-measured, and eliminating policy-induced parts barriers would make a big difference.

Digression: ICP and PK

- The International Comparison Program (ICP) collects the price series used in the PWT.
  - ICP benchmark studies are pricing exercises.
- The data are generated by an elaborate system of surveys: exercise not easy.
  - The ICP program collects the prices of between 500 and 1,500 individual goods and services in each participating country.
- For a given year, countries for which the ICP has price data are “benchmark” countries in the PWT tables.
  - The number of benchmark countries has increased from 16 in 1970 to 115 in 1996, and 146 in 2005.

ICP Data: Collection

- ICP surveys conducted for base years 1970, 1973, and 1975 were global exercises that included in one set of simultaneous comparisons all countries in all regions.
- Since 1980, the ICP has been regionalized (i.e., the participating countries are first grouped by region) and comparisons are carried out independently in each region.
  - Simplified administration but increased the complexity:
    - Regions have differed in the number of basic headings, selection of items, frequency and timing of surveys, methods of estimation and aggregation, etc.
      - Caution in exercising comparisons across regions, Deaton and Heston, 2008 (and across time; see Johnson et al., 2009).

ICP Data: Issues

- By the ICP's own documentations, the accuracy and quality of the data for most developing countries included in its benchmark surveys for are low.
  - Many countries have not been part of benchmark surveys for as many as 30 years.
- Regionalization limits comparisons.
- Pricing capital presents additional challenges (comparison resistant area).

The 2005-ICP Round

- Acknowledging the many issues that attended the collection of individual prices, the methodology used for the 2005 ICP round differed considerably from that used in previous rounds (and the 2011 round targets further improvements).
- Although many issues and concerns persist (as we show later), the new data available exhibit significant discrepancies with the data obtained in previous rounds.
  - Sub-Saharan Africa: 13 countries' PPP-based GDPs were revised up and 33 revised down (including previously benchmarked countries).
    - Revisions ranged from a 139% for the Republic of Congo to –77% for Zimbabwe.

Capital Goods: Additional Challenges

- “Capital goods can be much more complex and variable than consumer goods. For this reason, it may be more difficult to obtain perfect matches between the capital goods purchased in different countries than for consumer goods. ..
- The complexity of many capital goods is so great that the expertise required to draw up appropriate specifications for the products to be priced and to obtain average prices for them are not to be found within most statistical offices. (World Bank, 2006, Ch. 9, p. 2).”

ICP: PK Methodology, 2005 Round

- First Stage: the Global Office decides on a core list of equipment goods.
- 2005 survey: 108 core equipment goods.
  - BUT, regional offices price K goods considered to be representative of their countries (expected to consult the core list and provide prices for at least 80 of the specified items.)
- Countries are required to price K goods consistent with its valuation as fixed capital assets in the national accounts, i.e., prices must include trade, transport, and delivery and installation costs, all (including import duties) paid by the *purchaser*, and be reduced by any discounts generally made available to producers.
  - BUT prices can be collected from any of a variety sources including directly from producers, importers, or distributors or their catalogs.
  - AND countries are free to collect prices using whatever method or combination of methods they find most convenient: personal visit, telephone, letter, Internet, etc.
- Regional coordinators “edit” the prices to ensure that products that share the same technical characteristics can be compared.

Table 2. Core list of Equipment Goods for ICP 2005		
Basic Heading	Description	Number of products
15.01.11.1	FABRICATED METAL PRODUCTS	5
15.01.12.1	GENERAL PURPOSE MACHINERY	15
	A. Engines and Turbines, Pumps & Compressors	10
	B. Other General Purpose Machinery	5
15.01.13.1	SPECIAL PURPOSE MACHINERY	39
	A. Agricultural and Forestry Machinery	2
	B. Machine Tools	6
	C. Machinery for Metallurgy, Mining, Quarrying & Construction	22
	D. Machinery for Food, Beverages and Tobacco Processing	4
	E. Machinery for Textile, Apparel and Leather Production	0
	F. Other Special Purpose Machinery	5
15.01.14.1	ELECTRICAL & OPTICAL EQUIPMENT	29
	A. Office Machinery	5
	B. Computers and Other Information Processing Equipment	9
	C. Electrical Machinery and Apparatus	2
	D. Radio, Television and Communications Equipment & Apparatus	3
	E. Medical, Precision and Optical Instruments, Watches and Clocks	10
15.01.15.1	OTHER MANUFACTURED GOODS n.e.c.	0
15.01.21.1	MOTOR VEHICLES, TRAILERS and SEMI-TRAILERS	11
15.03.11.1	SOFTWARE	9
TOTAL		108

ICP Ring List: Example

Annex 1. ICP Equipment Ring List

BH Code	Basic Heading Title	Product Name	Pr. Code	No. of Prod ts
15.01.11.1	**FABRICATED METAL PRODUCTS**			
		Horizontal Cylindrical Storage Tank (5,000 Liters)	1	
		Horizontal Cylindrical Storage Tank 10,.000 Liters)	2	
		Tank for Storing Liquid Food & Beverage Products (1,000 Liters)	3	
		Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	4	
		Pressurized Gas StorageTank	5	**5**
15.01.12.1	**GENERAL PURPOSE MACHINERY**			
	A. Engines & Turbines, Pumps & Compressors			
		Air Compressor - Small	1	
		Air Compressor - Towed	2	
		Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	3	
		Industrial Diesel Engine (Heavy Duty) - Tier3 Stage3A	4	
		Light Industrial Diesel Engine	5	
		Marine Diesel Engine (Commercial)	6	
		Marine Diesel Engine (Pleasure)	7	
		On-Highway Commercial Diesel Engine (Heavy Duty)	8	
		Water Pump - Centrifugal	9	
		Water Pump - Jet	10	**10**
	B. Other General Purpose Machinery			
		Air Conditioner - Residential	11	
		Air Conditioner - Room	12	
		Rough Terrain Forklift - Extendable Boom	13	
		Rough Terrain Crane – Hydraulic Extendable Boom	14	

Poking Around the ICP data

- Obtain the 2005 ICP raw data from the World Bank
  - This is the country level data for each subheading
  - Cannot get the original census takers' data (?)
  - ICP uses unusual "ring" technique to link regions
  - Cannot get OECD data except ring = GBR,JPN,EST,SVN
  - Example:

isocode	spdcode	spdname	Price Local Currency (PLCU)
arg	150112105	Light Industrial Diesel Engine	
arg	150114102	FAX	x
arg	150121110	Pickup Truck	x
arg	150113132	Mincing Machine (1 KW Power)	x
arg	150114115	Electric Motor	x
arg	150311103	MS Office 2003 Standard (10)	x
arg	150112115	Rough Terrain Forklift - Extendable Boom	x
arg	150311102	Adobe Photoshop (100)	x
arg	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	x
arg	150121103	Diesel Minibus - 15 Passengers	x
	…		

ICP Data Example (cont.)

- Note: substantial missing prices

isocode	spdcode	spdname	plcu
arg	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	x
bol	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	
bra	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	
chl	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	x
col	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	
ecu	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	
per	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	
pry	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	
ury	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	x
ven	150111101	Horizontal Cylindrical Storage Tank (5,000 Liters)	
arg	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	x
bol	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	
bra	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	
chl	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	x
col	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	
ecu	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	
per	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	
pry	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	
ury	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	x
ven	150111104	Tank for Storing Liquid Food & Beverage Products (5,000 Liters)	
arg	150112101	Air Compressor - Small	x
bol	150112101	Air Compressor - Small	
bra	150112101	Air Compressor - Small	
chl	150112101	Air Compressor - Small	x
col	150112101	Air Compressor - Small	
ecu	150112101	Air Compressor - Small	
per	150112101	Air Compressor - Small	x
pry	150112101	Air Compressor - Small	x
ury	150112101	Air Compressor - Small	
ven	150112101	Air Compressor - Small	x
arg	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	
bol	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	
bra	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	
chl	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	
col	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	
ecu	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	
per	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	x
pry	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	
ury	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	x
ven	150112103	Industrial Diesel Engine (Heavy Duty) -Tier2 Stage2	
...			

The Country-Product-Dummy Method

- Multilateral approach in which PPPs are estimated simultaneously for all products and countries within a region, (the method accommodates the fact that not all countries report all products).
- One country is chosen as a base.
- Observed price is p_{ij}, for $i=1, 2, \ldots m$ countries and for j=1,2… n products, are expressed in each country's national currencies,
- CPD multiplicative method: $p_{ij} = \alpha_i \beta_j v_{ij}$, where v_{ij} is the error term, converted from a multiplicative one to an additive one by taking logs.
- Dummy variables used to represent each country (i) and product (j). The regression coefficients are estimated by ordinary least squares.
- We estimate mark-ups using CPD to calculate deviations from the LOOP, and analyze whether they systematically co-vary with income, etc.

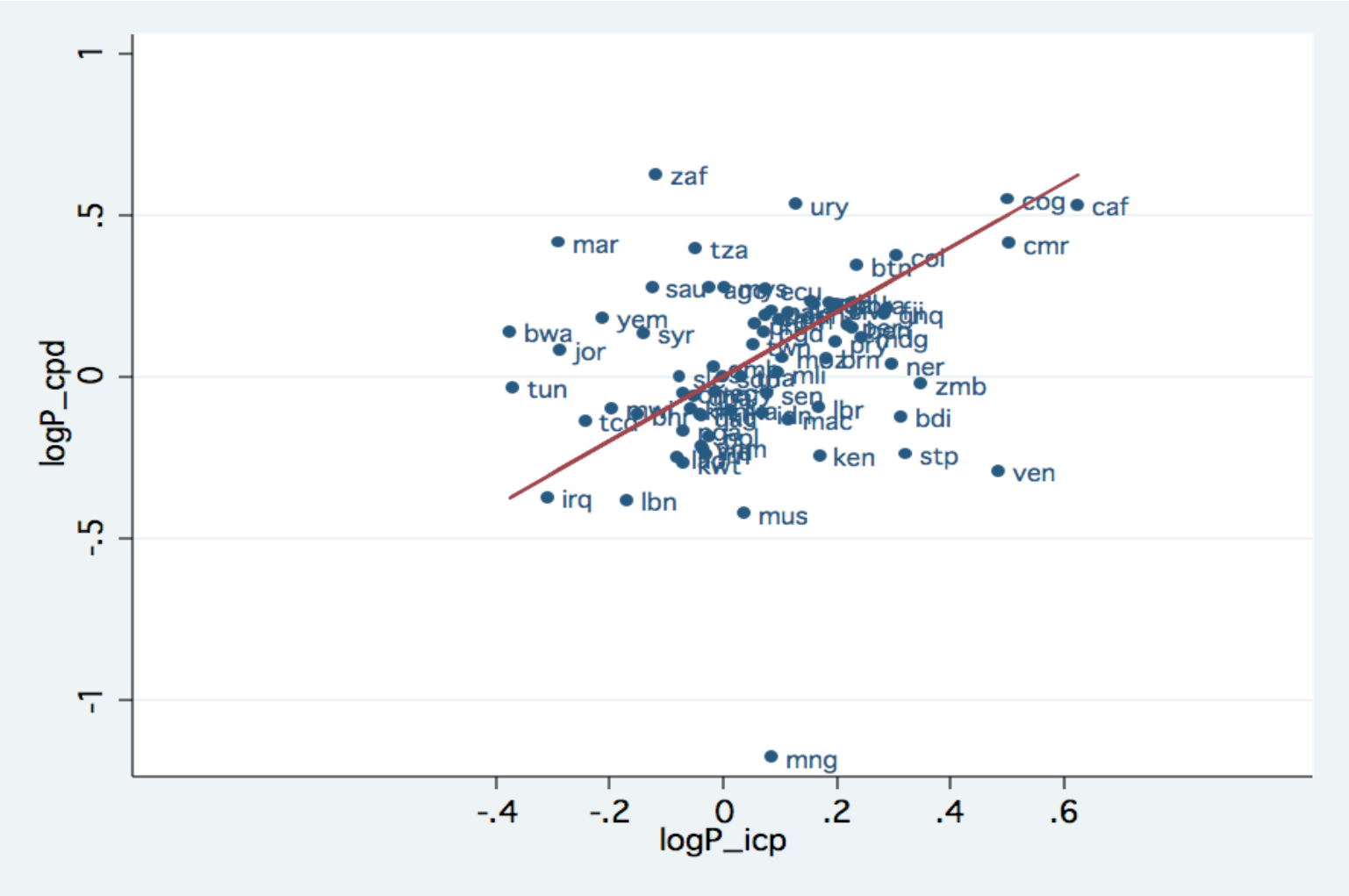
CPD extracts PK (Equipment)

- Countries (80)
  - Africa (33) [*omit Zimbabwe*]; W Asia (11); Asia (22); Latin America (10)
  - OECD (4) [“*ring*” countries only]
- Products (about 100 SPD codes; exclude software--not included for all countries).
  - But only 41 for Latin America
  - Exclude software (not included for all countries).
- Regression with country and product dummies (CPD):

$$log\ PK_{cp} = Country_c + Product_p + e_{cp}$$

- Take the country effect $Country_c$ as representing the average capital price level for country c
- Normalize price to 1 (log=0) in SGP [common to all datasets]

log PK: CPD v ICP Method



The correlation between CPD and ICP prices for the sample of 75 countries over which we have data is only 0.25

CPD v ICP Method

- Reactions
  - Why so different?
  - Results do not line up at all, which raises questions about construction of ICP data
    - Correlation = 0.25
  - There appears to be a lot of noise
    - Many countries with suspiciously low capital goods prices

The Eaton-Kortum (2001)Trade-Based Prices

- The model predicts that the equipment price index in a country would depend on its productivity/costs in producing equipment goods and on the barriers in importing equipment goods from all other producers.

- In particular their assumptions imply that the equipment price index in a country is smaller the larger the productivity of the home country in those goods. That will also imply a large share of those goods produced and consumed domestically.

- Plus, for given domestic productivity it is smaller the smaller the barriers to import of those goods.

Empirical strategy

- From a trade equation we can obtain estimates of domestic productivity and barriers to import. For importer-country n the model implies the following import equation (relative to local production):

$$x_{ni}^{k} = \ln \frac{X_{ni}^{k}}{X_{nn}^{k}} = \ln \frac{T_i c_i^{-\theta}}{T_n c_n^{-\theta}} - \theta \ln d_{ni}$$

  - X_{ni}^{k} is the total import of capital good of country n from country i
  - X_{nn}^{k} is the total sales of capital good of country n to itself
  - T_i is a measure of productivity of country i
  - C_i is a measure of costs of production in country I
  - D_{ni} is a measure of trade costs between country n and i.

  - Define:

$$S_i = \ln T_i - \theta \ln c_i$$

  - And assume that transport costs depend on barriers, distance, contiguity and common language.

The equation empirically implementable is:

$$x_{ni}^{k} = S_i - S_n - \theta m_n - \theta d_k - \theta b - \theta l + \theta \delta_{ni}$$

- where

S_i =competitiveness of exporter I

S_n competitiveness of n as exporter

m_n = importer n barriers

d_k = logarithm of distance between i and n

b = i-n common border

l = i-n common language

θ is a parameter measuring the variability of quality and is calibrated by EK to be 8.3 (the value however is relative to 1985 data).

The exact capital price index from the model is

$$P_n^k = \gamma[\sum_{i=1}^{N} T_i c_i^{-\theta} d_{ni}^{-\theta}]^{-\frac{1}{\theta}}$$

And the estimated counterpart (in logs) is:

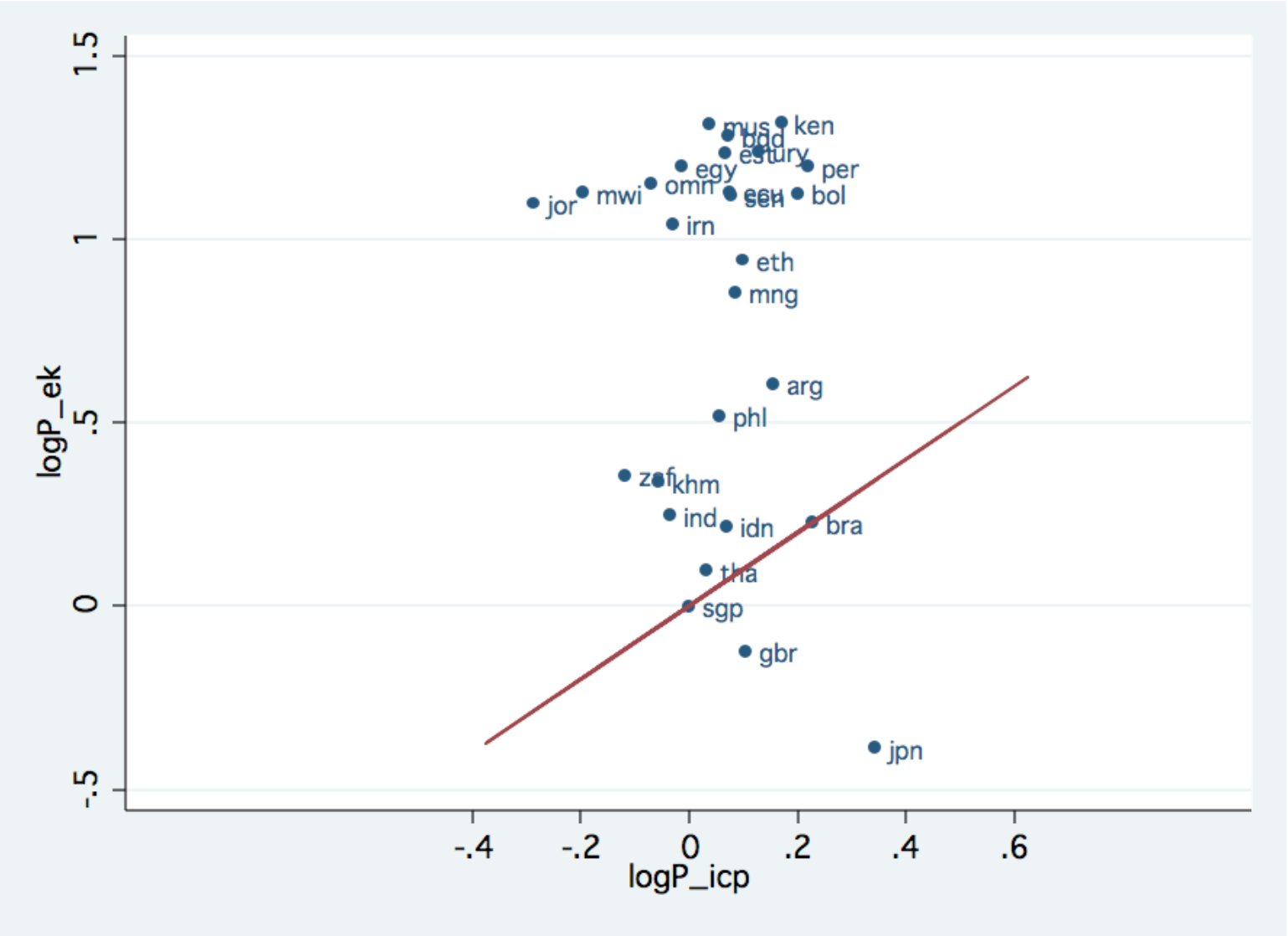
$$\ln \hat{P}_n^k = -\frac{1}{\theta}\ln\left(\sum_{i=1}^{N}\exp(\hat{S}_i - \theta\hat{m}_n - \theta\hat{d}_k - \theta\hat{b} - \theta\hat{l})\right)$$

The index decreases with estimated competitiveness of the importer and increases with increased barriers

Extending the data to more countries

- We use the same method as EK, but we use more recent data on trade flows, aggregating 1995-1999.
  - This produces estimates more comparable with 2000 prices
  - Reduces the number of zero-trade cells in the gravity equation
- We also extend the number of importing countries (to 63) and we include all the available exporters.
- We include among the equipment goods the following BEA sectors:
  - Farm and garden Machinery, Mining and construction equipment. Computer and office equipment, Other non-electric machinery, Household appliances, Household audio and Video, electronic components, Other electric machinery, Instruments and Apparatus.

log PK: EK v ICP Method



EK v ICP Method

- Reactions
  - EK results extend to a newer and wider sample
  - The average distortion using this method is very large (lnPK on average 0.82). Using the ICP it is small (average lnPK is 0.03)
  - Now EK generates wider range of PK, with much higher prices in some countries, compared to ICP
    - This was *not* true in original EK paper for 1985 data, when variance of EK and ICP PKs was similar.
  - However, restricting the comparison to the 24 countries for which we have data to perform the EK calculations, the CPD and the ICP, we see that the CPD standard deviation across countries and its range of variation is similar to the one obtained using EK method, and much larger than from ICP.

Price index	mean	Std. dev.	min	max
Ln(P_icp)	0.03	012	-0.28	0.22
Ln(P_cpd)	0.003	0.34	-1.17	0.62
Ln(P_EK)	0.82	0.44	0	1.13

Possible Explanations

- Why?
  - The variation is due in large part to the assumed θ (quality dispersion). If it has decreased (quality convergence) the variation could be smaller
  - No sign of convergence to LOOP when we use the EK method, but ICP price dispersion seems to have fallen in relative terms.

- Trade-related indices emphasize a much larger disparity that ICP, can it be that inappropriate quality adjustment is responsible for this?
- Is it a composition issue?

Correlation with barriers

- Examine whether the different price measures correlate with measures of trade barriers

1. Policy, given by log(1+average tariffs) and an index of regulatory barriers (lower=more freedom) from the Economic Freedom in the World Database (EFW 2006)
2. Distance, using a remoteness index, log distance weighted by partner GDP (Engel Rose)

Correlation with barriers: EK fits

Expected sign

	COEFFICIENT	logP_icp	logP_cpd	logP_ek
+	ltar	-1.116**	-0.343	2.787*
		-0.52	-0.7	-1.45
–	regbarriers	-0.0491***	-0.0207	-0.155***
		-0.016	-0.02	-0.049
+	lremote	0.279**	0.376**	-0.169
		-0.12	-0.18	-0.25
	Constant	-1.907*	-2.973*	2.808
		-1	-1.6	-2.11
	Observations	57	53	57
	R-squared	0.24	0.1	0.37
	Standard errors in parentheses			
	*** p<0.01, ** p<0.05, * p<0.1			

Correlation with development: EK fits

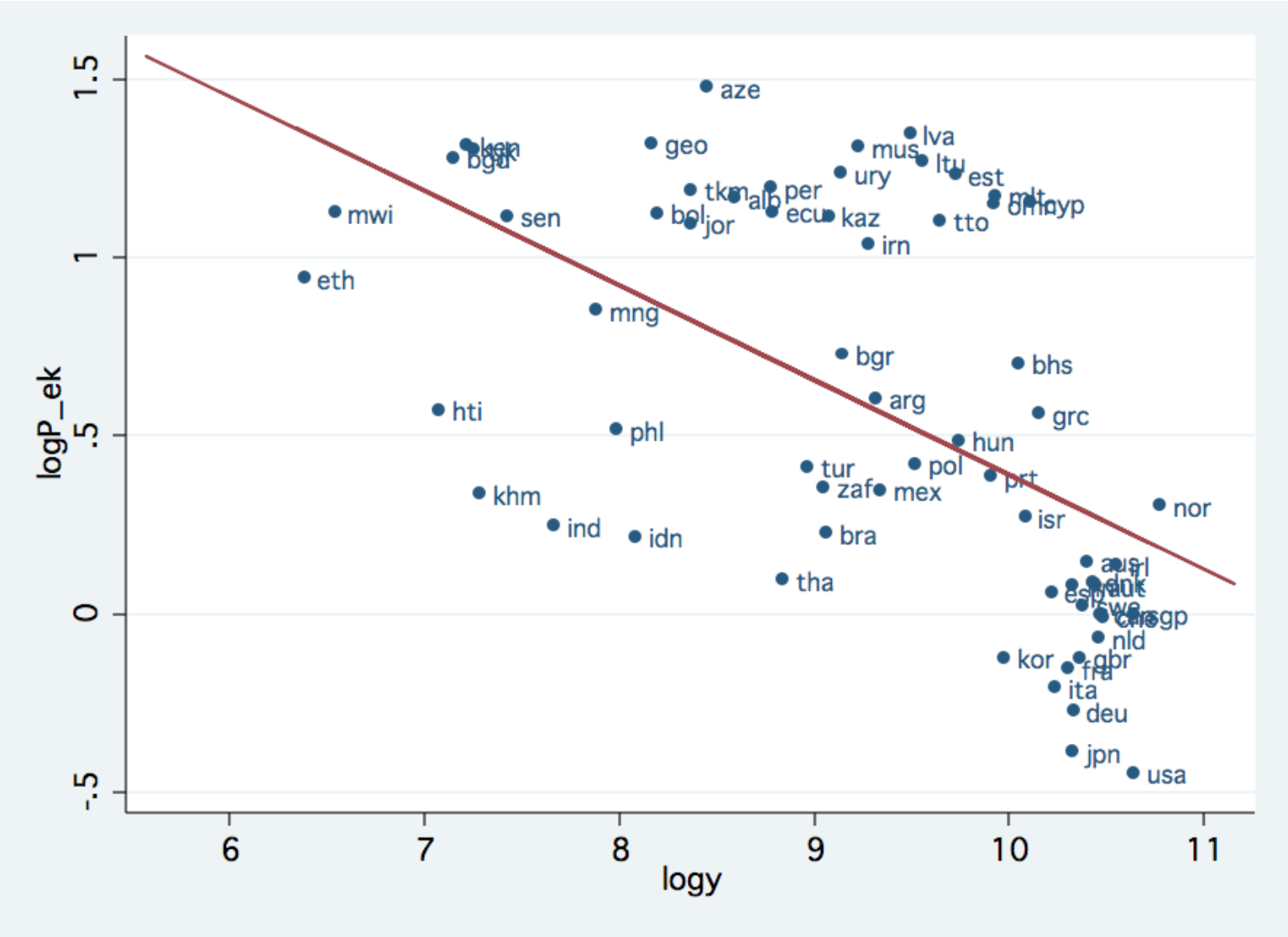
Expected sign

–

COEFFICIENT	logP_icp	logP_cpd	logP_ek
logy	-0.0194	-0.00651	-0.266***
	-0.018	-0.026	-0.05
Constant	0.225	0.102	3.053***
	-0.15	-0.22	-0.47
Observations	77	73	63
R-squared	0.02	0	0.31
Standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

A big effect, if true: if capital share is 1/3, dMPK/dy = –2/3, and coefficient "explains" -0.266/0.666 = 40% of development gaps

Correlation with development: EK fits



Summary

- Reasons to doubt IPC/PWT in general
  - Johnson et al. 2009; Ciccone and Jarocinksi, 2007.
  - Deaton and Heston (2008) warn against comparing ICP data from weak statistical capability.
- Even more doubt about ICP/PWT PK data
  - Census methods imprecise, unclear quality adjustments
  - Missing data filled by assuming **LOOP (*circularity!*)**
- EK approach extends to a larger sample of countries
  - Trade-based prices inversely correlated with development
  - Consistent with trade data (unit values); Alfaro and Ahmed, 2008.
  - Can be improved using a parameter θ obtained from 1999 data

Summary

- Understanding the large differences between the trade-based method and the ICP (or PCD) would allow us to make progress in understanding how quality matter for the trade index and how it is measured in the ICP.
- Work in progress
  - Given doubts about the ICP, we would like to start over and collect better PK data to find a definitive answer
- Immense policy implications
  - Lacking good data, current debate is more heat than light