Price Levels, Size, Distribution and Growth of the World Economy: Insights from recent International Comparisons of Prices and Real Product

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Background

1. Make the 2017 report better known to researchers whose focus may have been diverted by covid-19.

2. Focus on report sections like geographic regions and comparable results for 2011 and 2017 making the report especially important.

3. Compare received results from previous ICPs with the 2017 report and especially the 1975 ICP.

Order of Talk

- We will not try to cover all of the paper since much known to you.

  - Prasada will begin with
    - improved descriptive measures of real growth, inflation and exchange rate changes
    - Income distribution across countries and changes from 2011 to 2017
    - Structural changes and international prices

  - Heston will discuss
    - Price level – GDP relationship, Balassa-Samuelson research, and tradeables and non-tradeables price levels.
    - Post-2017 trends

Decomposing Real GDP of a Country

Suppose we have real GDP of a country in 2011 and 2017. What are the components that explain the difference?

Countries	RGDP 2011	RGDP 2017	Change from 2011 to 2017
	(billion $)	(billion $)	(2)/(1)
	(1)	(2)	(3)
United States	15542.58	19519.42	1.256
China	13882.96	19617.38	1.413
India	5482.87	8050.53	1.468
Germany	3415.02	4381.79	1.283
South Africa	639.19	733.69	1.148
World	93463	119089	1.274

Decomposing Real GDP of a Country

$$\frac{RGDP^{USA}_{2017,j}}{RGDP^{USA}_{2011,j}} = \frac{GDP_{2017,j} / PPP^{USA}_{2017,j}}{GDP_{2011,j} / PPP^{USA}_{2011,j}}$$

$$= \frac{\dfrac{GDP_{2017,j}}{PPP^{USA}_{2017,j}} \Big/ Def_{2011,2017,j}}{\dfrac{GDP_{2011,j}}{PPP^{USA}_{2011,j}} \Big/ Def_{2011,2017,j}} \times \frac{Def_{2011,2017,j}}{Def_{2011,2011,j}}$$

$$= \frac{GDP_{2017,j} / Def_{2011,2017,j}}{GDP_{2011,j} / Def_{2011,2011,j}} \times \frac{Def_{2011,2017,j}}{Def_{2011,2011,j}} \times \frac{PPP^{USA}_{2011,j}}{PPP^{USA}_{2017,j}}$$

$$= \frac{CGDP_{2011,2017,j}}{CGDP_{2011,2011,j}} \times Def_{2011,2017,j} \times \frac{PPP^{USA}_{2011,j}}{PPP^{USA}_{2017,j}}$$

$$= GR_{2011,2017,j} \times Def_{2011,2017,j} \times \frac{PPP^{USA}_{2011,j}}{PPP^{USA}_{2017,j}} = \text{country growth rate} \times \text{domestic price change} \times \text{effect of PPP change}$$

Decomposing Real GDP of a Country

Countries	RGDP 2011	RGDP 2017	Change from 2011 to 2017	Real Growth	Inflation	Exchange Rate change effect	National Inflation Rate
	(billion $)	(billion $)	(2)/(1)		(3)/(4)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
United States	15542.58	19519.42	1.256	1.140	1.102	1.000	1.102
China	13882.96	19617.38	1.413	1.519	0.930	0.842	1.104
India	5482.87	8050.53	1.468	1.509	0.973	0.753	1.292
Germany	3415.02	4381.79	1.283	1.099	1.168	1.065	1.096
South Africa	639.19	733.69	1.148	1.099	1.044	0.743	1.405
World	93463	119089	1.274	1.223	1.042	0.879	1.185

Decomposing Regional and Global Real GDP

ICP Region	RGDP 2011	RGDP 2017	Change from 2011 to 2017
	(billion $)	(billion $)	(2)/(1)
Panel A: Geographic Regions	(1)	(2)	(3)
East Asia & Pacific	27925	37235	1.333
Europe & Central Asia	24027	30362	1.264
Latin America & Caribbean	7675	9198	1.198
Middle East & North Africa	6943	7131	1.027
North America	16973	21297	1.255
South Asia	6923	10123	1.462
Sub-Saharan Africa	2997	3743	1.249
World	**93463**	**119089**	**1.274**

Decomposing Regional and Global Real GDP

$$\frac{RGDP_{2017,W}}{RGDP_{2011,W}} = \frac{\sum_{j=1}^{176} GDP_{2017,j} / PPP_{2017,j}^{USA}}{\sum_{j=1}^{176} GDP_{2011,j} / PPP_{2011,j}^{USA}}$$

Following Balk, Rambaldi and Rao (2020), we can rewrite this as:

$$\frac{RGDP_{2017,W}}{RGDP_{2011,W}} = \prod_{j=1}^{176} \left[GR_{2011,2017,j} \right]^{w_j} \times \prod_{j=1}^{176} \left[Def_{2011,2017,j} \right]^{w_j} \times \prod_{j=1}^{176} \left[\frac{PPP_{2011,j}^{USA}}{PPP_{2017,j}^{USA}} \right]^{w_j}$$

$$= \text{Global growth} \times \text{Average of domestic inflation rates} \times \text{PPP change effect}$$

$$= \text{Global growth} \times \text{Global inflation}$$

$$w_j = \frac{L\left(s_{2011,j}, s_{2017,j}\right)}{\sum_{j=1}^{176} L\left(s_{2011,j}, s_{2017,j}\right)} \quad where\ s_{t,j} = \frac{RGDP_{t,j}}{RGDP_{W,j}};\ t = 2011, 2017$$

Decomposing Regional and Global Real GDP (geographic regions)

ICP Region	RGDP 2011	RGDP 2017	Change from 2011 to 2017	Real Growth	Inflation	Exchange Rate change effect	National Inflation Rate
	(billion $)	(billion $)	(2)/(1)		(3)/(4)		
Panel A: Geographic Regions	(1)	(2)	(3)	(4)	(5)	(6)	(7)
East Asia & Pacific	27925	37235	1.333	1.363	0.979	0.887	1.104
Europe & Central Asia	24027	30362	1.264	1.104	1.145	0.975	1.174
Latin America & Caribbean	7675	9198	1.198	1.103	1.087	0.703	1.545
Middle East & North Africa	6943	7131	1.027	1.195	0.859	0.700	1.227
North America	16973	21297	1.255	1.138	1.102	1.002	1.100
South Asia	6923	10123	1.462	1.478	0.989	0.756	1.308
Sub-Saharan Africa	2997	3743	1.249	1.244	1.004	0.692	1.451
World	**93463**	**119089**	**1.274**	**1.223**	**1.042**	**0.879**	**1.185**

Decomposing Regional and Global Real GDP (income groups)

Country Groups by per capita real GDP	RGDP 2011	RGDP 2017	Change from 2011 to 2017	Real Growth	Inflation	Exchange Rate change effect	National Inflation Rate
	(billion $)	(billion $)	(2)/(1)		(3)/(4)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
High income	47587	58383	1.227	1.123	1.092	1.024	1.067
Lower middle income	13528	18991	1.404	1.383	1.015	0.732	1.386
Upper middle income	31610	40739	1.289	1.306	0.987	0.767	1.287
Low income	738	976	1.324	1.412	0.937	0.717	1.307
World	**93463**	**119089**	**1.274**	**1.223**	**1.042**	**0.879**	**1.185**

Real per capita GDP and inequality

As the level of per capita GDP and inequality in the distribution of income are two aspects of welfare, we look at Sen's (1976, 1979) measure of welfare:

$$W = \mu \times (1 - G)$$

where G is the Gini coefficient.

Gini is computed as population weighted inequality – Concept 2 international inequality in Milanovic (2002).

Sen's Measure of Welfare

	2011		2017	
Per capita real GDP in 2017 $	14551		16575	
Gini	0.4848		0.4721	
Sen's Welfare Measure	7497		8750	
Theil's measure	0.4364		0.4169	
Decomposition of Theil's measure - Geographic Regions		%		%
Within region	0.1274	29.19	0.1091	26.17
Between region	0.3090	70.81	0.3078	73.83
Decomposition of Theil's measure - Income groups				
Within region	0.0514	11.78	0.0406	9.71
Between region	0.3850	88.22	0.3765	90.29

Inequality in GDP and its components

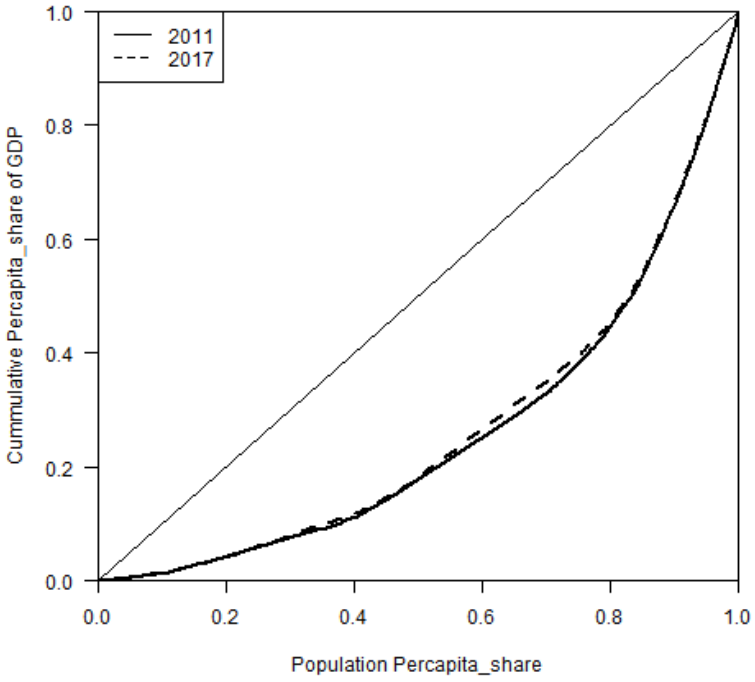
Inequality Measure	GDP		Individual Consumption Expenditure by Households (ICEH)		Actual Consumption Expenditure by Households (ACEH)		Government Expenditure		Gross Capital formation	
	2011	**2017**	**2011**	**2017**	**2011**	**2017**	**2011**	**2017**	**2011**	**2017**
per capita real expenditure	14551	16575	7335	8934	8881	10797	2970	3352	3504	4204
Gini	0.4848	0.4721	0.5100	0.4701	0.5063	0.4770	0.5318	0.5415	0.4524	0.4779
Theil	0.4364	0.4169	0.4559	0.3859	0.4541	0.4013	0.5728	0.6064	0.4404	0.4940
Within	0.1274	0.1091	0.1318	0.0997	0.1289	0.1021	0.1624	0.1553	0.1596	0.1492
Between	0.3090	0.3078	0.3241	0.2862	0.3251	0.2993	0.4104	0.4510	0.2808	0.3448
% share of inequality between	70.81	73.83	71.09	74.16	71.60	74.57	71.65	74.37	63.76	69.80

Note: Per capita expenditures are expressed in constant 2017 US dollars.

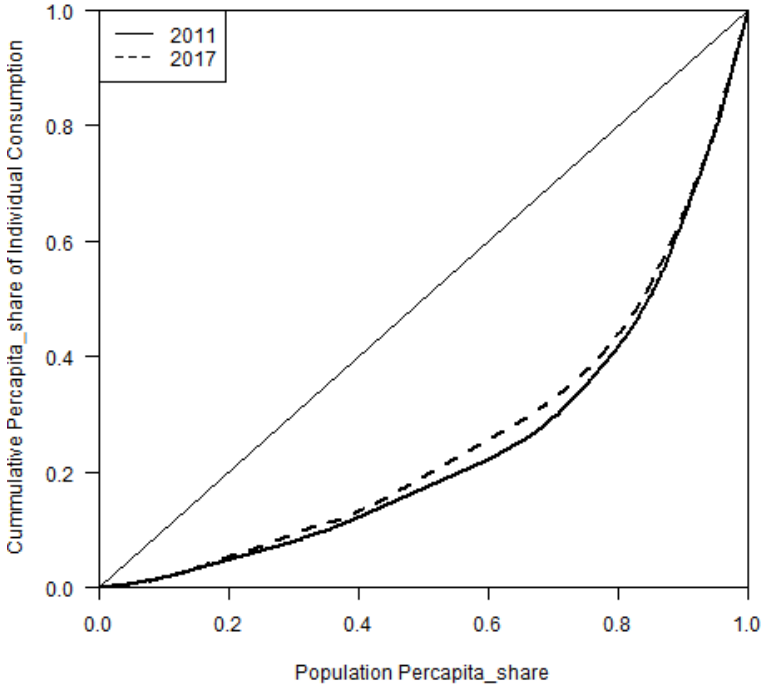
- Gini and Theil's inequality measures are population weighted. No account of inequality within countries is made.
- Within region and between region inequalities are for geographical regions.

Lorenz curves for GDP and its components – 2011, 2017

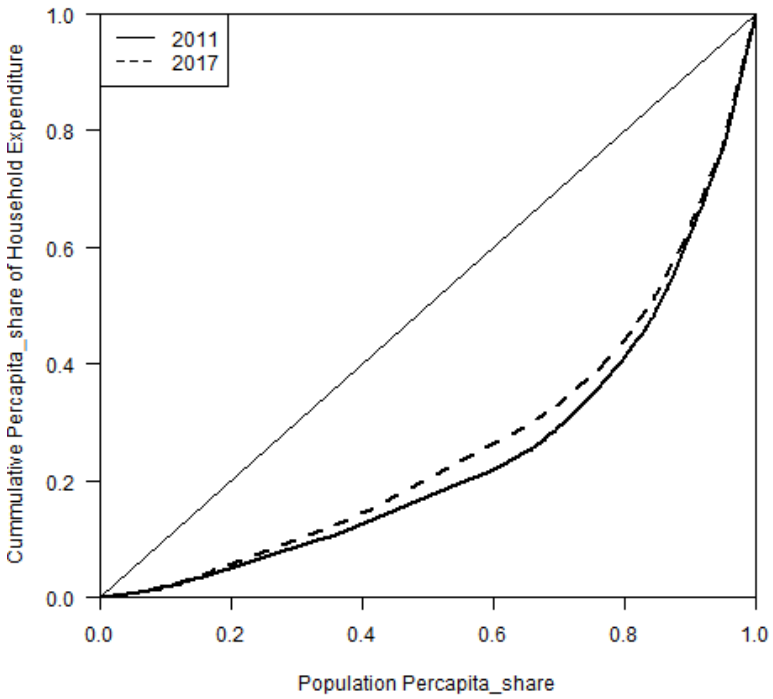
GDP



ICEH

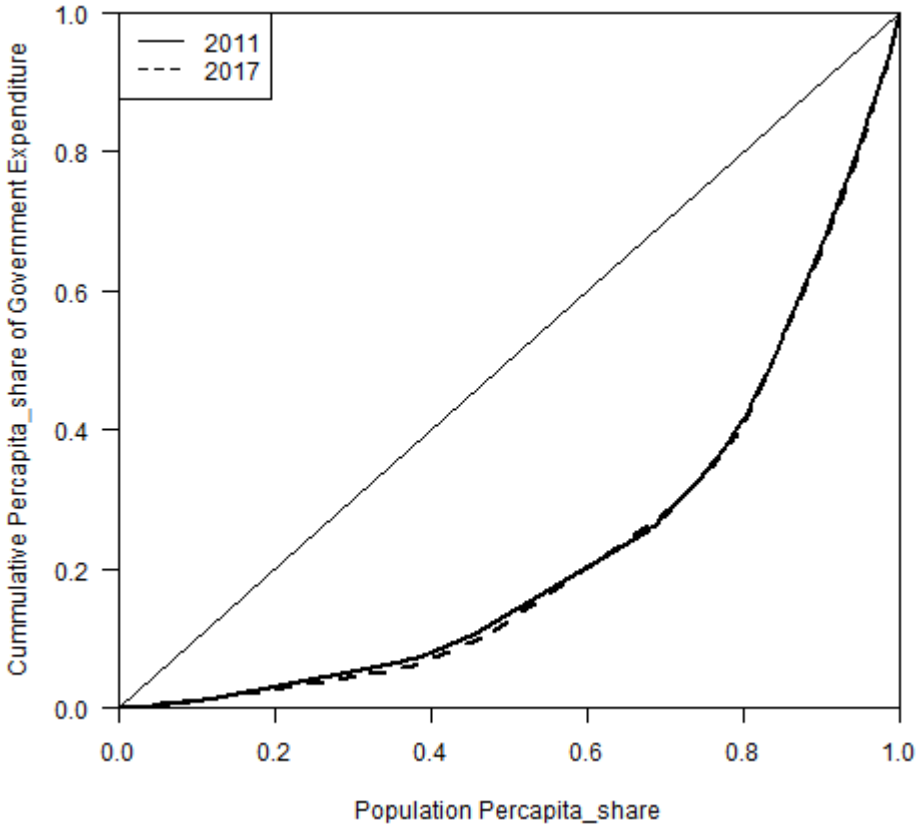


ACEH

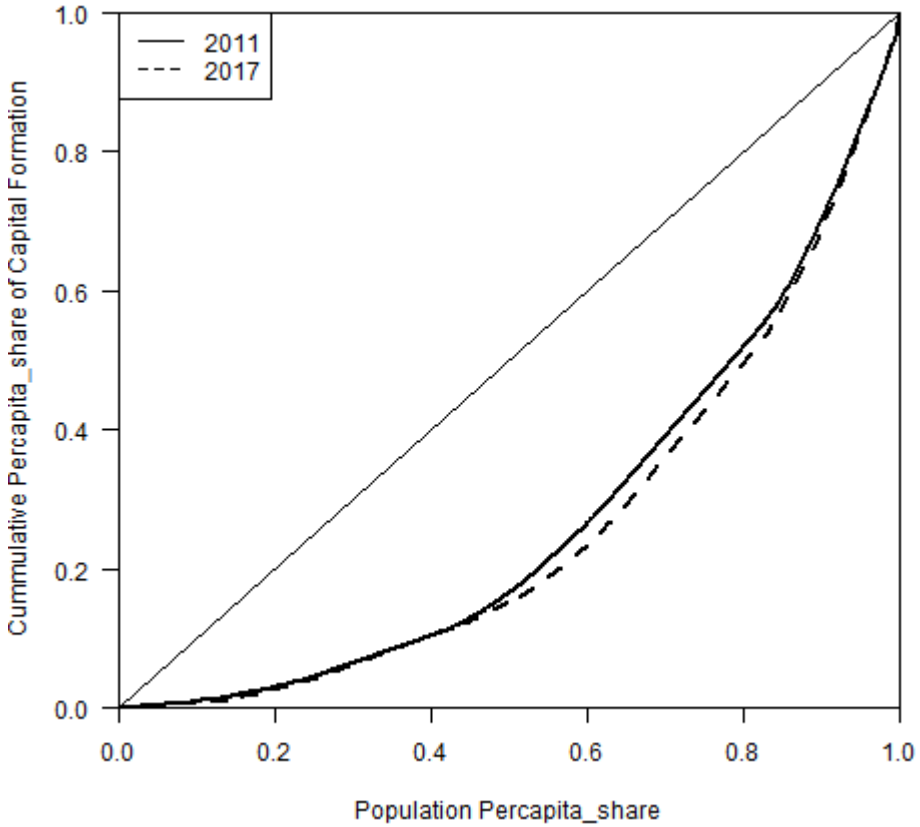


Lorenz curves for GDP and its components – 2011, 2017

Gov. Exp

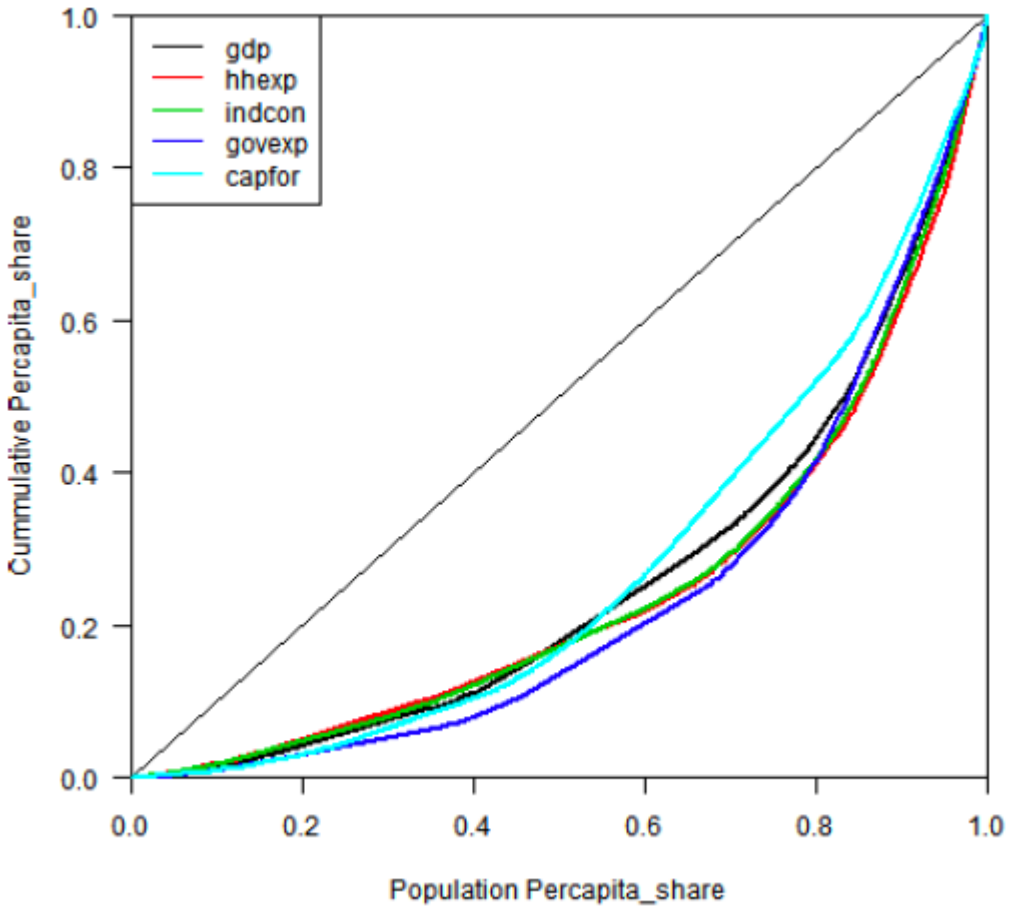


GFCF

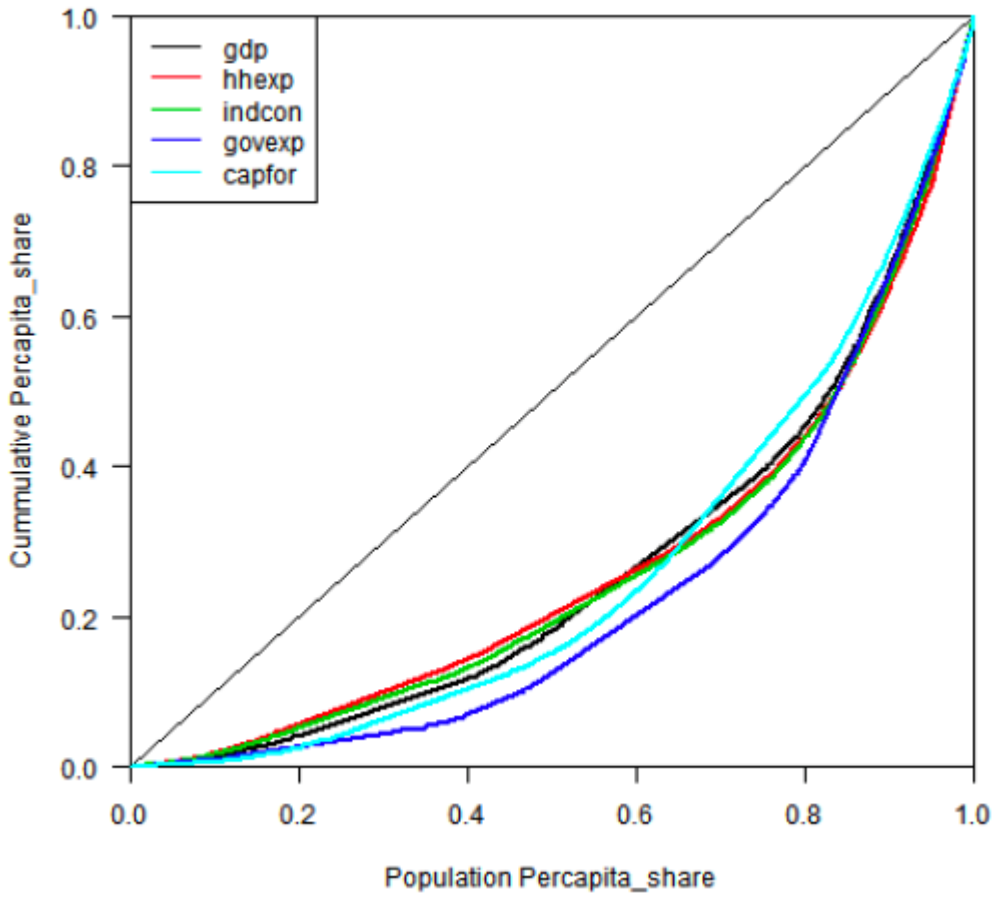


Lorenz curves for GDP and its components – 2011, 2017

2011



2017



Price Level Indexes (PLI) and Relative Price Structures

- Price level indexes from the ICP have been a well-researched component of the output of the ICP.
- Presentation by Angus and Paul touched on empirical regularities in the relationship between PLI and real per capita GDP.
- Alan will present additional findings on this aspect.
- PLI's for specific aggregates are traditionally used for comparisons across countries. In what follows we will look at possible use of PLI's for the analysis of relative price levels.

Price Level Indexes (PLI) at the Country Level

The price level index for a country *j* with respect to a reference country, say country 1, is the ratio of PPP to exchange rate:

$$PLI_{1j} = \frac{PPP_{1j}}{XR_{1j}} \qquad j = 1, 2, \ldots, M$$

We focus here on GDP but discussion applies for other aggregates. PLI can be equivalently expressed as the ratio of nominal GDP to real GDP:

$$PLI_{1,j} = \frac{PPP_{1,j}}{XR_{1,j}} = \frac{GDP_j / XR_{1,j}}{GDP_j / PPP_{1,j}} = \frac{\text{nominal GDP}}{\text{real GDP}}$$

Price Level Indexes (PLI) at the Global level

Defining price level index for the world is a little bit tricky as there are no PPPs or exchange rates at the global level. The current practice is to extend the equivalence of PLI and the ratio of nominal to real GDP. Then PLI at the world level is given by:

$$\mathrm{PLI}_{1,\mathrm{W}} = \frac{\mathrm{Nominal\,GDP}_{1,W}}{\mathrm{Real\,GDP}_{1,W}} = \frac{\sum_{j=1}^{M} NGDP_{1,j}}{\sum_{j=1}^{M} RGDP_{1,j}} = \frac{\sum_{j=1}^{M} GDP_j / XR_{1,j}}{\sum_{j=1}^{M} GDP_j / PPP_{1,j}}$$

The Global and Regional ICP reports publish country-level PLIs expressed relative to world level = 1 (or 100). The World PLI is a weighted average of country-specific PLIs.

$$\mathrm{PLI}_{1,\mathrm{W}} = \frac{\sum_{j=1}^{M} GDP_j / XR_{1,j}}{\sum_{j=1}^{M} GDP_j / PPP_{1,j}} = \frac{\sum_{j=1}^{M} \frac{GDP_j}{PPP_{1,j}} \times \frac{PPP_{1,j}}{XR_{1,j}}}{\sum_{j=1}^{M} GDP_j / PPP_{1,j}}$$

$$= \sum_{j=1}^{M} \frac{GDP_j / PPP_{1,j}}{\sum_{j=1}^{M} GDP_j / PPP_{1,j}} \times \frac{PPP_{1,j}}{XR_{1,j}} = \sum_{j=1}^{M} s_j \cdot \frac{PPP_{1,j}}{XR_{1,j}} = \sum_{j=1}^{M} s_j \cdot PLI_{1,j}$$

Comparing World Price Levels across Commodities/Basic Headings

Here we compare world price level of a basic heading with world price level at GDP.

$$\mathrm{PLI}_{\mathrm{GDP,1,W}} = \frac{\sum_{j=1}^{M} GDP_j / XR_{1,j}}{\sum_{j=1}^{M} GDP_j / PPP_{GDP,1,j}} = \sum_{j=1}^{M} s_{GDP,j} \cdot \frac{PPP_{GDP,1,j}}{XR_{1,j}} = \sum_{j=1}^{M} s_{GDP,j} \cdot PLI_{GDP,1,j}$$

$$\mathrm{PLI}_{\mathrm{i,1,W}} = \frac{\sum_{j=1}^{M} \exp_{i,j} / XR_{1,j}}{\sum_{j=1}^{M} \exp_{i,j} / PPP_{GDP,1,j}} = \sum_{j=1}^{M} s_{\mathrm{i},j} \cdot \frac{PPP_{\mathrm{i},1,j}}{XR_{1,j}} = \sum_{j=1}^{M} s_{\mathrm{i},j} \cdot PLI_{i,1,j} \qquad j = 1,2,\ldots,155$$

Differences between world price levels here are driven by: (i) differences in GDP and basic-heading specific PLI's; and (ii) expenditure shares used in computing global level PLI's. We can decompose this into PPP difference component and expenditure share component.,

Comparing World Price Levels across Commodities/Basic Headings

To address the problem of differences in weights, we re-compute world PLI for each basic heading using GDP share weights. Relative price levels are defined with respect to world GDP level PLI.

$$\mathrm{PLI}^*_{\mathrm{i,1,W}} = \frac{\sum_{j=1}^{M} \exp_{i,j} / XR_{1,j}}{\sum_{j=1}^{M} \exp_{i,j} / PPP_{GDP,1,j}} = \sum_{j=1}^{M} s_{\mathrm{GDP},j} \cdot \frac{PPP_{\mathrm{i},1,j}}{XR_{1,j}} = \sum_{j=1}^{M} s_{\mathrm{GDP},j} \cdot PLI_{i,1,j} \qquad j = 1,2,\ldots,155$$

$$RPLI_{i,W} = \frac{PLI^*_{i,1,W}}{PLI_{GDP,1,W}}$$

	Normalized World PLI with GDP Weights, 2011	Normalized World PLI with GDP Weights, 2017
	(5)	(6)
GROSS DOMESTIC PRODUCT	1.000	1.000
INDIVIDUAL CONSUMPTION EXPENDITURE BY HOUSEHOLDS	1.058	1.053
FOOD AND NON-ALCOHOLIC BEVERAGES	1.279	1.349
FOOD	1.281	1.354
NON-ALCOHOLIC BEVERAGES	1.263	1.313
ALCOHOLIC BEVERAGES, TOBACCO AND NARCOTICS	1.055	1.299
TOBACCO	0.857	1.079
CLOTHING AND FOOTWEAR	1.146	1.257
CLOTHING	1.162	1.292
FOOTWEAR	1.105	1.176
HOUSING, WATER, ELECTRICITY, GAS AND OTHER FUELS (Category)	0.965	0.933
ACTUAL RENTALS FOR HOUSING	0.834	0.831
ELECTRICITY, GAS AND OTHER FUELS	1.391	1.413
FURNISHINGS, HOUSEHOLD EQUIPMENT AND ROUTINE HOUSEHOLD MAINTENANCE	1.240	1.266
GOODS AND SERVICES FOR ROUTINE HOUSEHOLD MAINTENANCE	1.356	1.119
HEALTH - HHC (Category)	0.777	0.745
TRANSPORT	1.335	1.330
OPERATION OF PERSONAL TRANSPORT EQUIPMENT	1.497	1.537
TRANSPORT SERVICES	1.121	1.214
COMMUNICATION	0.974	0.840
RECREATION AND CULTURE - HHC (Category)	1.132	1.148
EDUCATION - HHC (Category)	0.699	0.683
RESTAURANTS AND HOTELS	1.132	1.109
MISCELLANEOUS GOODS AND SERVICES (Category)	1.058	1.083
PERSONAL CARE	1.008	1.140
INDIVIDUAL CONSUMPTION EXPENDITURE BY GOVERNMENT	0.709	0.740
COLLECTIVE CONSUMPTION EXPENDITURE BY GOVERNMENT	0.903	0.960
GROSS CAPITAL FORMATION	1.062	1.044
GROSS FIXED CAPITAL FORMATION	1.056	1.041
MACHINERY AND EQUIPMENT	1.493	1.673
CONSTRUCTION	0.839	0.741
OTHER PRODUCTS	1.276	1.367

World PLI's for different aggregates expressed relative to World GDP PLI 2011, 2017

Comparing World Relative Price Levels Pseudo Geary-Khamis International Average prices

We explore an alternative to world PLIs's discussed above to compare relative price levels in 2011, 2017 with results reported in KHS (1982) for 1975.

We compute international average prices similar to those computed in Geary-Khamis method with the difference that these average prices depend on GDP level PPPs but not the converse.

This means that PPPs computed using GEKS for ICP are retained but used as conversion factors for computing international average prices.

Comparing World Relative Price Levels Pseudo Geary-Khamis International Average prices

For the all the basic headings, pseudo-GK international prices are defined as (equation A3.3):

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_{GDP,j}\right)}{\sum_{j=1}^{M} q_{ij}} \qquad i = 1,2,....,M$$

We recall that, from the standard ICP framework:

$$q_{ij} = \frac{e_{ij}}{p_{ij}} = \frac{e_{ij}}{PPP_{ij}} \quad i = 1,2,...,155;\ \mathrm{j} = 1,2,...,\mathrm{M}$$

where PPP_{ij} *'s* are basic heading PPPs. Therefore,

$$\Pi_i = \frac{\sum_{j=1}^{M}\left(e_{ij}/PPP_{GDP,j}\right)}{\sum_{j=1}^{M}\left(e_{ij}/PPP_{i,j}\right)} \qquad i = 1,2,....,155$$

Properties of Pseudo Geary-Khamis International Average prices

1. The pseudo-international prices ensure that world real expenditure on *i-th* commodity is the same whether it is obtained by summing deflated country level expenditures using GDP level PPPs or by simply evaluating the total world consumption at international prices (equation A 3.6).

$$\sum_{i=1}^{155}\left(\Pi_i \cdot \sum_{j=1}^{M} q_{ij}\right) = \sum_{i=1}^{N}\sum_{j=1}^{M}\left(e_{ij} / PPP_{GDP,j}\right)$$

2. It is clear that these international prices can be used to study the global expenditure structure at international prices. Share of *i-th* commodity in world real; GDP is simply:

$$S_i = \frac{\Pi_i \cdot \sum_{j=1}^{M} q_{ij}}{\sum_{i=1}^{155}\left(\Pi_i \cdot \sum_{j=1}^{M} q_{ij}\right)} \quad i = 1, 2, \ldots, 155$$

Comparison of International Average Prices for selected Basic Headings, 1975, 2011 and 2017

Item - ICP 2011, 2017	International Average Prices, 2011	International Average Prices, 2017	GK International Prices , 1975	Name of item in 1975
Rice	0.8936	1.2771	1.09	Rice
Beef and veal	1.4987	1.3117	0.93	Fresh beef and veal
Mineral waters, soft drinks, fruit and vegetable juices	1.2616	1.2957	1.35	non-alcoholic beverages
Garments	1.1826	1.2837	1.1	Men's clotjhing; Women's clothing - 1.29; Boys and girls clothing - 1.32; men's and boys' underwear - 1.48; women's and girls' underwear - 1.13; Haberdashery, millinery - 0.97; clothing rental and repair
Major household appliances whether electric or not	1.2293	1.3741	1.44	Refigerators and freezers; Washing appliances - 1.49; cooking appliances - 1.24; heating appliances - 1.33; cleaning appliances - 1.5; other household appliances - 2.01
Medical services	0.8666	0.8384	0.54	Physicians' services
Passenger transport by railway	0.9248	1.0982	0.26	Rail transport
Pharmaceutical products	1.1061	1.0812	0.93	Drugs, medical prepartions
Hairdressing salons and personal grooming establishments	0.5554	0.5029	0.56	Barber and beauty shops
Intermediate consumption, government	1.2533	1.2655	1.21	Commodities of government
Road transport equipment	0.446	0.9513	1.53	Trucks, buses, trailers
Residential buildings	0.5336	0.5302	1.09	one and two-family dwellings; multi-family dwellings - 1.07
Non-residential buildings	1.6198	1.92	1.49	Industrial buildings; commercial buildings - 1.15; office buildings - 1.12;
Civil engineering works	0.9845	0.8229	0.86	Roads, streets, highways

Comparison of International Average Prices for selected Basic Headings, 1975, 2011 and 2017

- We have been able to find 93 matches (some times rough) between 2011/2017 BHs and 1975 BHs. The last column shows details.

- The international average prices remained similar in the case of a number of basic headings but have shown dramatic shifts for others.

- International average prices remained similar for non-residential buildings and civil engineering works but show a dramatic reduction, by almost 50 percent, since 1975.

- Road transport equipment raises questions across all three years although the decline from 1975 is consistent with the general decline in trade barriers during the period.

Price, Quantity and Income Similarity Indices

- We tried to replicate KHS (1982) results on price, quantity and income similarity indices – but had no success.
- We computed KHS measures of price and quantity similarity and found:
    - A small degree of convergence in price similarity indices
    - Divergence in quantity similarity indices
    - Found that the regression relationships between the quantity similarity indices and price and income similarity indices to be considerably weaker than what was reported by KHS (1982)
- We explored cluster analysis to form country groupings based on price similarity indices
    - As expected clusters identified are not stable over the years 2011 and 2017.
    - When four clusters are formed, the membership was similar to income group memberships.

Over to Alan …..

Price level – GDP relationship

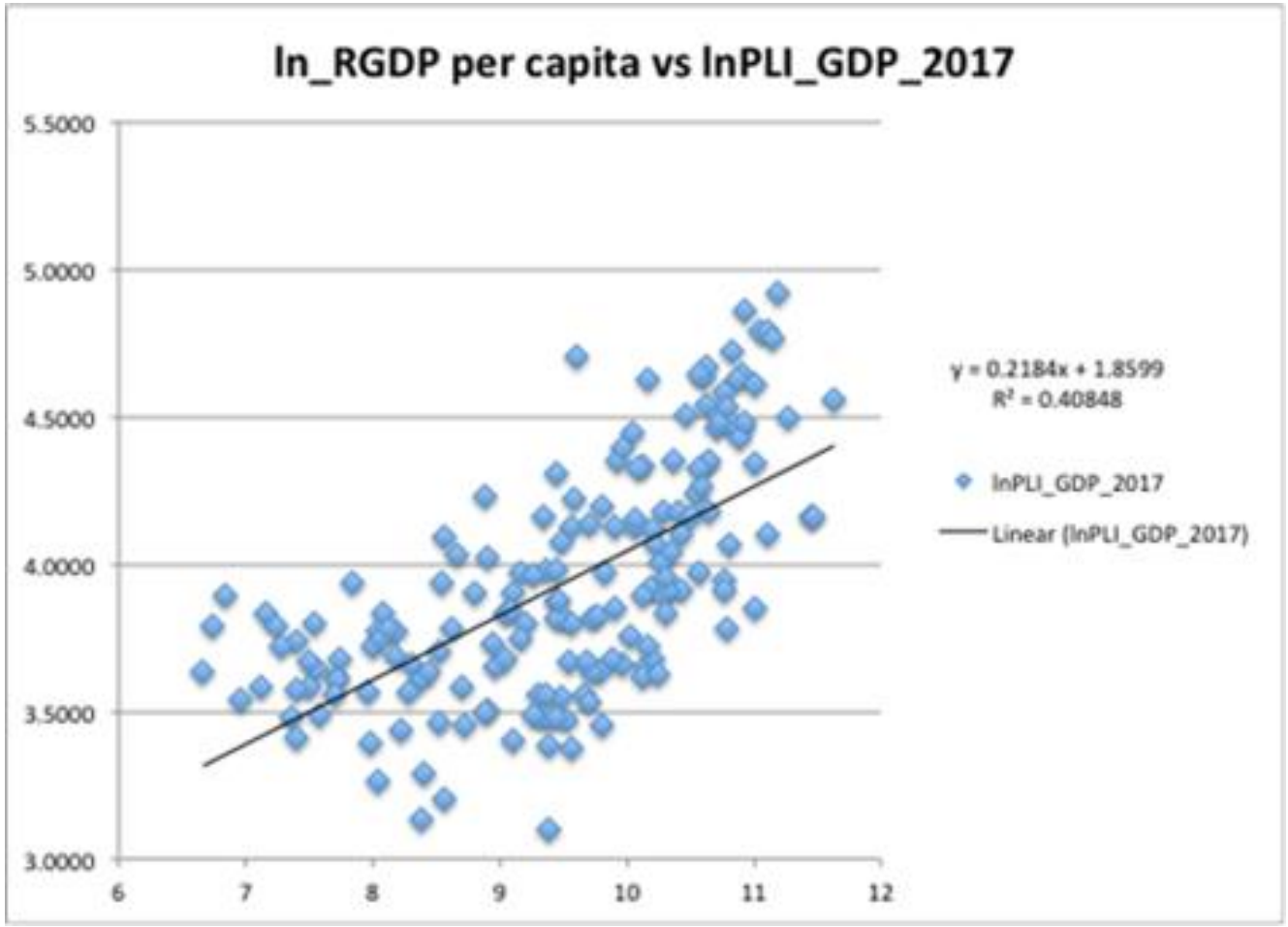
1. The major finding of the research phase of the ICP at Penn (1968-1982) was that the price level of GDP rises with per capita GDP.

2. A corollary of this result is that the income distribution in PPP terms was much narrower than in nominal terms at exchange rates. A finding that was often misunderstood early in the ICP.

3. Results are replicated in 2011 and 2017
   - Graphs of Real (RGDP) or nominal (NGDP) per capita versus PL of GDP in 2017 shown in next slides

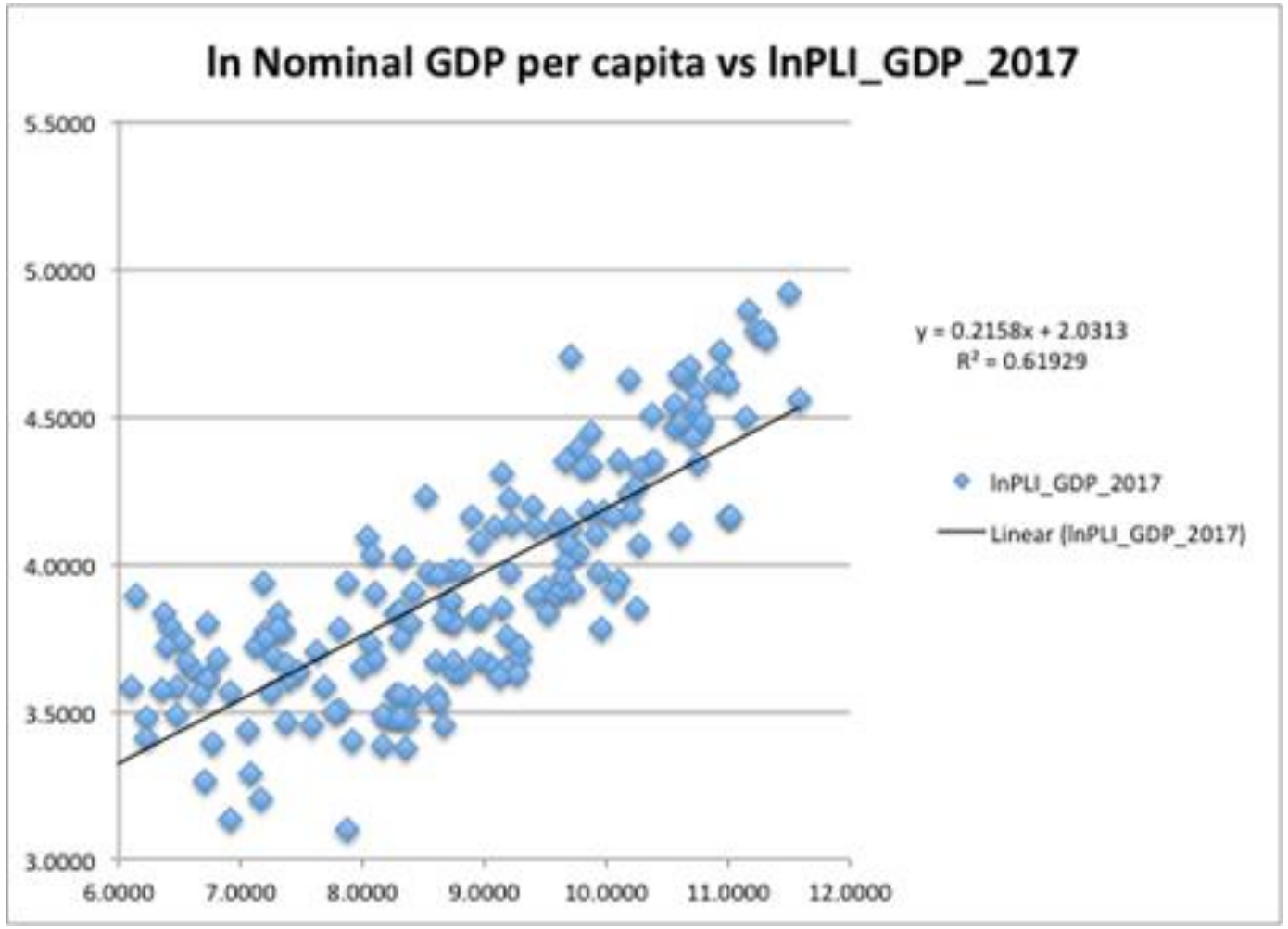
Price level GDP regressed on Real GDP pc 2017

Figure 3a



Price level GPD regressed on Nominal GDP pc 2017

Figure 3b



Balassa-Samuelson

1. Balassa-Samuelson
   - Productivity differences in *tradeables* lead to wage and income differences across countries
   - Productivity differences for *non-tradeables* across countries are narrower than for tradeables so overall price levels are lower in low-income countries

2. Alternative explanations of the Penn effect were forthcoming after *Phase I* of the ICP was published in 1975, including that of Bhagwati and others

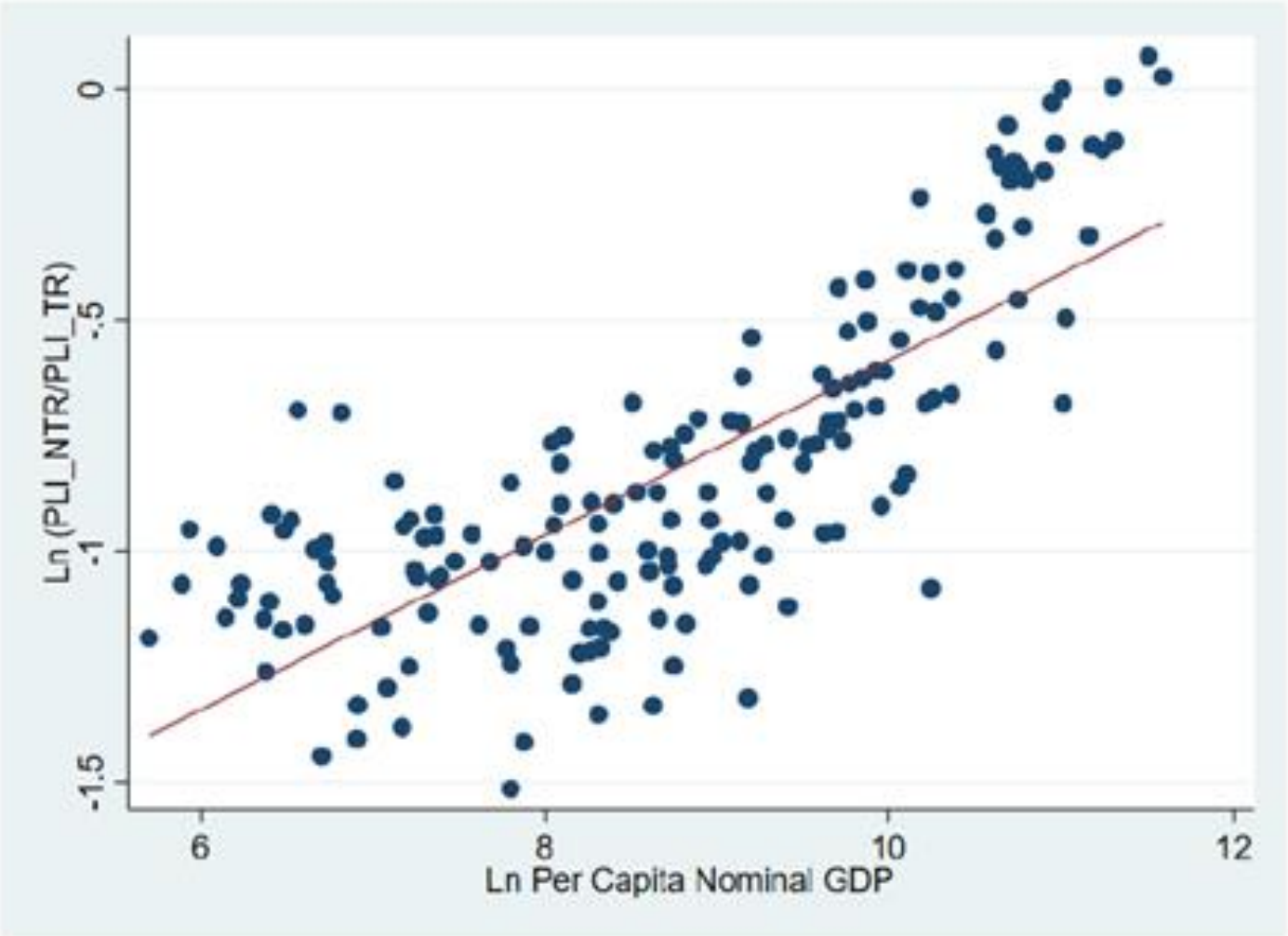
3. Contrary to Balassa-Samuelson, and the law of one price, the PL of *tradeables* rises with per-capita income of countries, a theme in the work of Kravis and Lipsey

PL of tradeables and Non-tradeables vs Nominal GDP per capita in 2017

1. Ln PL_TR = 0.0855 * ln NGDP_PC - 0.8409 *(Rsq = .480)*
   (0.0067) (0.0617)

2. Ln PL_NTR = 0.2745 * ln NGDP_PC - 3.3185 *(Rsq = .603)*
   (0.0166) (0.1497)

Ratio of PL of non-tradeables to tradeables vs Nominal GDP per capita 2017



2017 Benchmark

1. Research using core item prices (Zhang 2017, Vo 2021) to examine the '*law of one price*'
   - See also Harrod (1939)
2. Regressions explaining national price levels:
   - Flurry of interest after first three ICPs (1970, 1973 and 1975)
   - Variables such as openness to trade and share of tradeables are no longer important
   - Nominal GDP and Nominal GDP squared much more significant
3. Relative size of largest economies: China, the U.S. and India, have substantially changed since early ICP rounds
4. Pivotal as a pre-pandemic benchmark