TOTAL FACTOR PRODUCTIVITY ANALYSIS ACROSS THE DEVELOPING WORLD: EVIDENCE FROM ENTERPRISE SURVEYS

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What Performance Measures can be Computed with Enterprise Surveys?

□ Data collected by Enterprise Surveys (ES) allow us to compute variety of performance measures.

➤ Total factor productivity (TFP)

➤ Labor productivity measured as sales per worker

➤ Labor productivity measured as value added per worker

➤ Growth of size: measured in sales or employment levels

➤ Growth of labor productivity

Possible Analyses with Enterprise Surveys

- The performance measures can be analyzed across
  - Firm characteristics
    - Size and age groups of firms
    - Export/Non-Export
    - Gender
  - Sectors (manufacturing vs. services)
  - Two-digit manufacturing industries

Such in-dept analysis is possible for countries with large sample sizes.

Survey Questions Used to Measure TFP

Variable	Description
d2	Total annual sales in the last fiscal year (Y)
n3	Total annual sales three fiscal years ago
n2a	Annual cost of labor (wages, salaries, bonuses, etc.) in the last fiscal year (L)
n7a	Cost to re-purchase all machinery, vehicles, and equipment (K)
n2b	Annual cost of electricity in the last fiscal year (E)
n2e	Annual costs of raw materials and intermediate goods used in production in the last fiscal year(M)
l1	# of permanent, full-time employees at end of last fiscal year
l2	# of permanent, full-time employees three fiscal years ago

Computation of TFP

- Data collected in the surveys is presented in nominal local currencies.

- To compute productivity, all relevant variables are converted into US dollars and then deflated by GDP deflator in US dollars (base year 2000).

- Exchange rates and GDP deflators are obtained from World Development Indicators.

- Alternatively, producer price index obtained from IMF is used. However, PPI is available for a smaller number of countries than GDP deflator.

- Results with PPI are in accordance with those obtained with GDP deflator.

Manufacturing Industries Classification

- Enterprise surveys cover major 2-digit manufacturing industries according to ISIC rev 3.1 classification.

- Industries are determined according to the 4-digit industry code of firm's main product.

- Industry coverage of the data used in TFP analysis for 2005-2009 period:

Industry	ISIC Code	TFP Sample	Whole Sample
Food	15	4,481	6,415
Textile	17	1,890	2,665
Garments	18	3,247	4,429
Chemicals	24	1,797	2,672
Non-metallic mineral and basic metals	26,27	1,539	2,241
Fabricated Metal and Machinery	28,29	2,635	3,680
Others	-	5,823	8,172
Total		21,412	30,274

Regional Coverage of Data for 2005-2009 period

Region	# of Countries	# of Firms *
Sub-Saharan Africa (AFR)	25	5,582
South Asia and East Asia and Pacific (Asia)	9	5,439
Eastern Europe and Central Asia (ECA)	25	2872
Latin America and the Caribbean (LAC)	15	5,514
Middle East and North Africa (MENA)	6	2,005
Total	80	21,412

* Shows the number of firms used in productivity analysis. Excludes the countries in Latin America and Caribbean region that were surveyed in 2010.

List of Countries Analyzed

- **Eastern Europe and Central Asia (ECA):** Armenia; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Czech Rep.; Estonia; Macedonia, FYR; Georgia; Hungary; Kazakhstan; Kyrgyz Rep.; Latvia; Lithuania; Moldova; Poland; Romania; Russian Federation; Serbia; Slovak Rep.; Tajikistan; Turkey; Ukraine; Uzbekistan;

- **Middle East and North Africa (MENA):** Algeria; Egypt, Arab Rep.; Jordan; Morocco; Syrian Arab Rep.; Yemen Rep.;

- **Latin America and the Caribbean (LAC):** Argentina; Bolivia; Brazil; Chile; Colombia; Ecuador; El Salvador; Guatemala; Honduras; México; Nicaragua; Panama; Paraguay; Peru; Uruguay;

- **South and East Asia and Pacific (ASIA):** India; Indonesia; Malaysia; Mongolia; Nepal; Pakistan; Philippines; Thailand; Vietnam;

- **Sub-Saharan Africa (AFR):** Angola; Botswana; Burundi; Cameroon; Côte d'Ivoire; Congo; Dem. Rep.; Ethiopia; Ghana; Guinea; Guinea-Bissau; Kenya; Madagascar; Mali; Mauritania; Mauritius; Mozambique; Namibia; Nigeria; Rwanda; Senegal; South Africa; Swaziland; Tanzania; Uganda; Zambia

Data Cleaning

- Certain codes (like -9) are used in the survey when the respondent does not know the answer. They are replaced with missing values.

- Outlier test for all variables used in computation of TFP
  - Compute log values of each variable.
  - Exclude observations that are three standard deviation above or below the mean in each country/manufacturing sector.

- In addition, compute ratios of cost of labor to sales, cost of material to sales. Exclude firms that have any of these ratios that are above or below three standard deviation from the mean.

Production Function Specifications

- The data is cross-sectional, thus use various specifications of neoclassical production function.

- Estimate TFP separately for each country (including only manufacturing firms).

- In the estimations, control for 2-digit industry fixed effects.

- For countries where the sample size is large, TFP analysis can be performed at 2-digit industry level.

Production Functions (I)

- The production function used in YAKLM specification is
$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} M_{it}^{\phi}$$ where A_{it} is the TFP term.

- TFP is estimated as the residual term from this production function once log values of the variables in both sides of the equation are obtained
$$\log A_{it} = \log Y_{it} - \hat{\alpha} \log K_{it} - \hat{\beta} \log L_{it} - \hat{\phi} \log M_{it}$$

- The coefficients can be interpreted as the elasticity of each input factor.

Production Functions (II)

□ Four other versions of this production function are used:

➢ YAKLEM specification adds energy costs in YAKLM.

➢ YAKL specification only uses capital and labor as input factors.

➢ VAKL specification uses value added instead of sales as the dependent variable where VA=Y-M-E.

➢ Trans-log specification allows interaction between input factors.

$$\log A_{it} = \log Y_{it} - \hat{\alpha}_K \log K_{it} - \hat{\alpha}_L \log L_{it} - \hat{\alpha}_M \log M_{it}$$
$$- \frac{1}{2}\hat{\alpha}_{KK}\left(\log K_{it}\right)^2 - \frac{1}{2}\hat{\alpha}_{LL}\left(\log L_{it}\right)^2 - \frac{1}{2}\hat{\alpha}_{MM}\left(\log M_{it}\right)^2$$
$$- \hat{\alpha}_{KL}\left(K_{it} * L_{it}\right) - \hat{\alpha}_{KM}\left(K_{it} * M_{it}\right) - \hat{\alpha}_{LM}\log(L_{it} * M_{it})$$

Production Functions (III)

- Last specification is Solow residual method which uses a non-parametric approach.

- Elasticity of each input factor is calculated as the cost share of that input in total cost.

- Cost shares for capital, labor, and material are computed in respective order as:

$$\alpha_K = \frac{rK}{rK + wL + p_m M}, \alpha_L = \frac{wL}{rK + wL + p_m M}, \alpha_M = \frac{p_M M}{rK + wL + p_m M}.$$

Countries Included in the Analysis

Country	# of Firms in TFP Sample (in YAKLM spec.)	Total # of Firms	% Coverage
Argentina2010	471	791	60
Brazil2009	1,037	1,339	77
Chile2010	589	775	76
Colombia2010	583	757	77
Croatia2007	189	345	55
Egypt2008	998	1,147	87
Indonesia2009	591	1,176	50
Mexico2010	998	1,152	87
Philippines2009	347	958	36
Poland2009	65	152	43
Russia2009	271	603	45
Syria2009	230	337	68
Turkey2008	469	860	55

Excluded Countries

- Czech Republic had a negative coefficient on capital in YAKLM.
- Coefficient of capital in Romania was very close to zero.
- Hungary had biased sample towards large size firms and a small sample.
- India is excluded as the data is from 2004-2005.
- A new survey is currently being implemented in China and all East Europe and Central Asia region.

Country	Total # of Firms	# in TFP Sample
Czech2009	94	55
Hungary2009	103	74
India2005	2,218	1,474
Romania2009	193	62

Survey Weights in TFP Estimates

- [ ] When data is collected, each firm is assigned a survey-weight in order to allow the data be representative at country level.

- [ ] These weights are not used in the TFP analysis because in some countries variables to measure TFP are missing for many firms.

- [ ] Distribution of productivity sample without survey weights is compared to the distribution of the population of firms using survey weights.

Size Distribution Comparison (Employment Levels)

|	SIZE DIST(POPULATION)			SIZE DIST(TFP-SAMPLE)		
	Small	Medium	Large	Small	Medium	Large
Argentina2010	40.9	44.3	14.8	27.8	40.6	31.6
Brazil2009	28.5	47.9	23.6	34.3	46.0	19.7
Chile2010	28.8	50.7	20.5	31.1	41.1	27.8
Colombia2010	46.7	31.5	21.8	37.9	35.9	26.2
Croatia2007	53.8	34.9	11.3	40.2	30.7	29.1
Egypt2008	31.2	32.3	36.5	31.7	33.2	35.2
Indonesia2009	87.5	9.9	2.6	50.1	28.6	21.3
Mexico2010	59.5	27.7	12.8	34.7	33.2	32.2
Philippines2009	34.9	46.6	18.5	26.5	47.8	25.7
Poland2009	51.4	25.9	22.7	52.3	21.5	26.2
Russia2009	20.4	35.3	44.4	18.8	41.3	39.9
Syria2009	27.4	41.7	31.0	27.4	45.7	27.0
Turkey2008	46.9	38.3	14.8	26.0	40.9	33.1
Total	42.9	35.9	21.2	33.8	37.4	28.8

Factor Elasticities

☐ Raw and intermediate materials have the highest elasticity in 52 of the 80 countries.

☐ In 51 countries, labor has the second highest level of elasticity after material.

☐ The average elasticity values across countries are 0.10 for capital, 0.46 for labor, and 0.54 for materials.

		K	L	E	M
Colombia	Eslava et al. (2004)	0.08	0.24	0.12	0.59
Colombia	ES (2006)	0.09	0.48	0.07	0.46
Malaysia	Hallward et al. (2002)	0.15	0.30	0.24	0.31
Malaysia	ES (2007)	0.03	0.48	0.10	0.51

Factor Elasticities
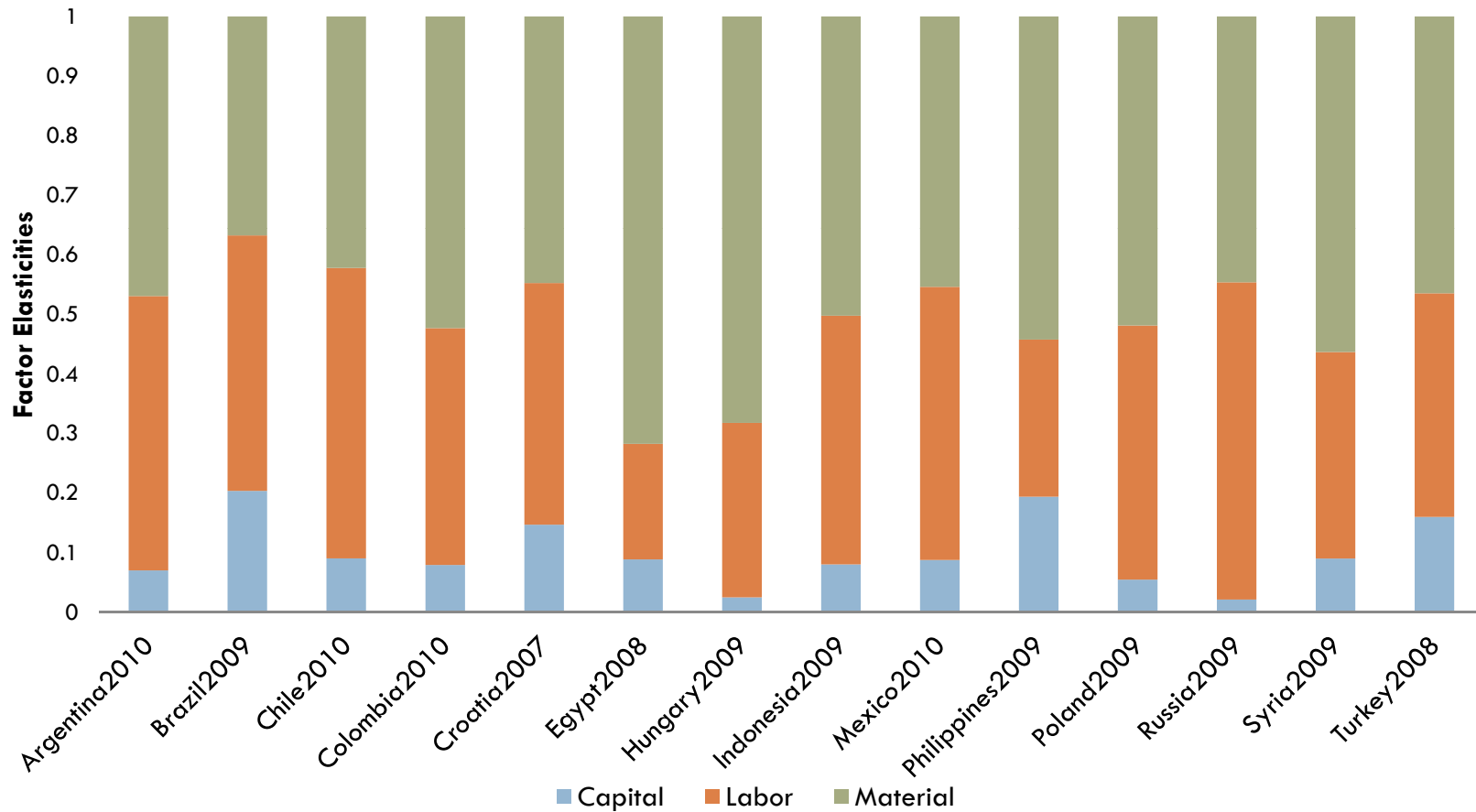
Factor elasticities add up to around 1.09 across countries

Correlation between different TFP estimates

Correlation Coefficients

	YAKLM	YAKLEM	YAKL	VAKL	Translog
YAKLEM	0.96				
YAKL	0.83	0.79			
VAKL	0.87	0.89	0.86		
Translog	0.73	0.75	0.51	0.73	
Solow	0.64	0.62	0.44	0.63	0.80

All coefficients are significant at 1%

Spearman Rank Correlations

|	YAKLM	YAKLEM	YAKL	VAKL	Translog
YAKLEM	0.92				
YAKL	0.73	0.73			
VAKL	0.74	0.79	0.81		
Translog	0.57	0.55	0.28*	0.47	
Solow	0.51	0.41	0.23*	0.34	0.66

* significant at 5%, all other significant at 1%
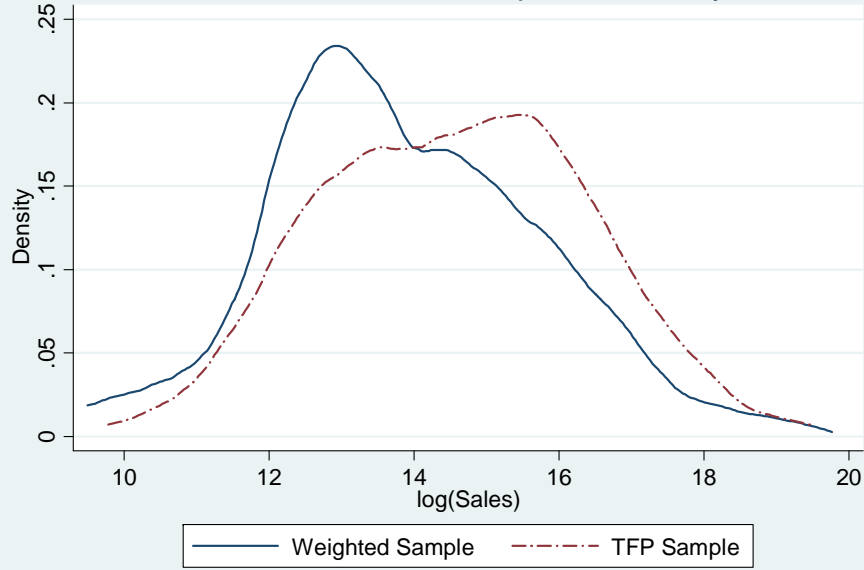
Aggregate vs. Average Productivity

- Using factor elasticities obtain TFP estimates for each firm.

- Weight TFP values with firms' output shares to obtain aggregate TFP.

- Output share is computed as the ratio of each firm's sale to aggregate sale in that country.

- Firms with higher sales have larger contribution to aggregate TFP.

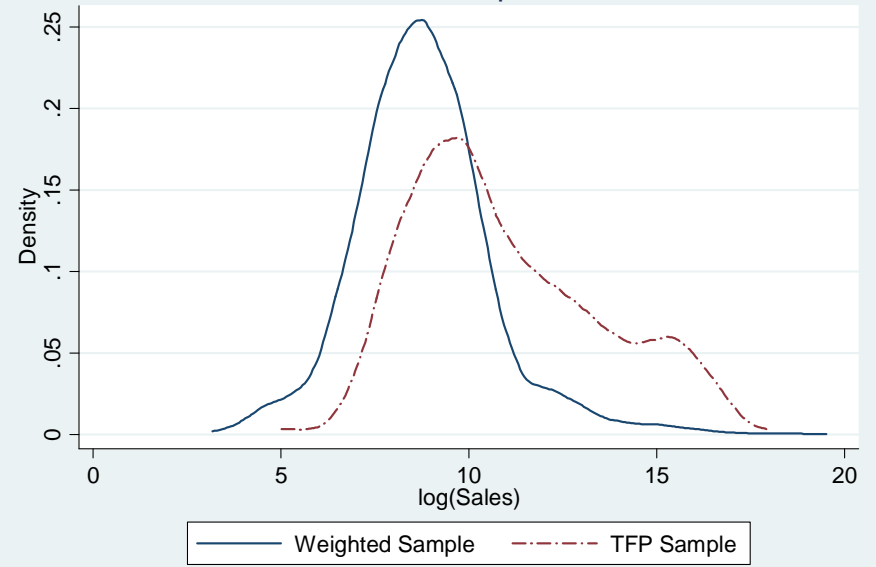- Average TFP shows how an average firm performs in each country.

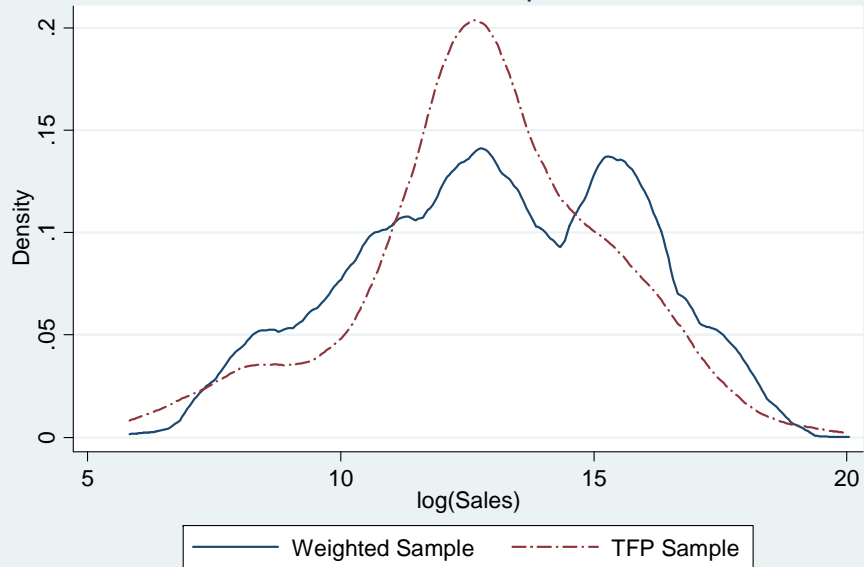# Aggregate and Average TFP with YAKLM Specification
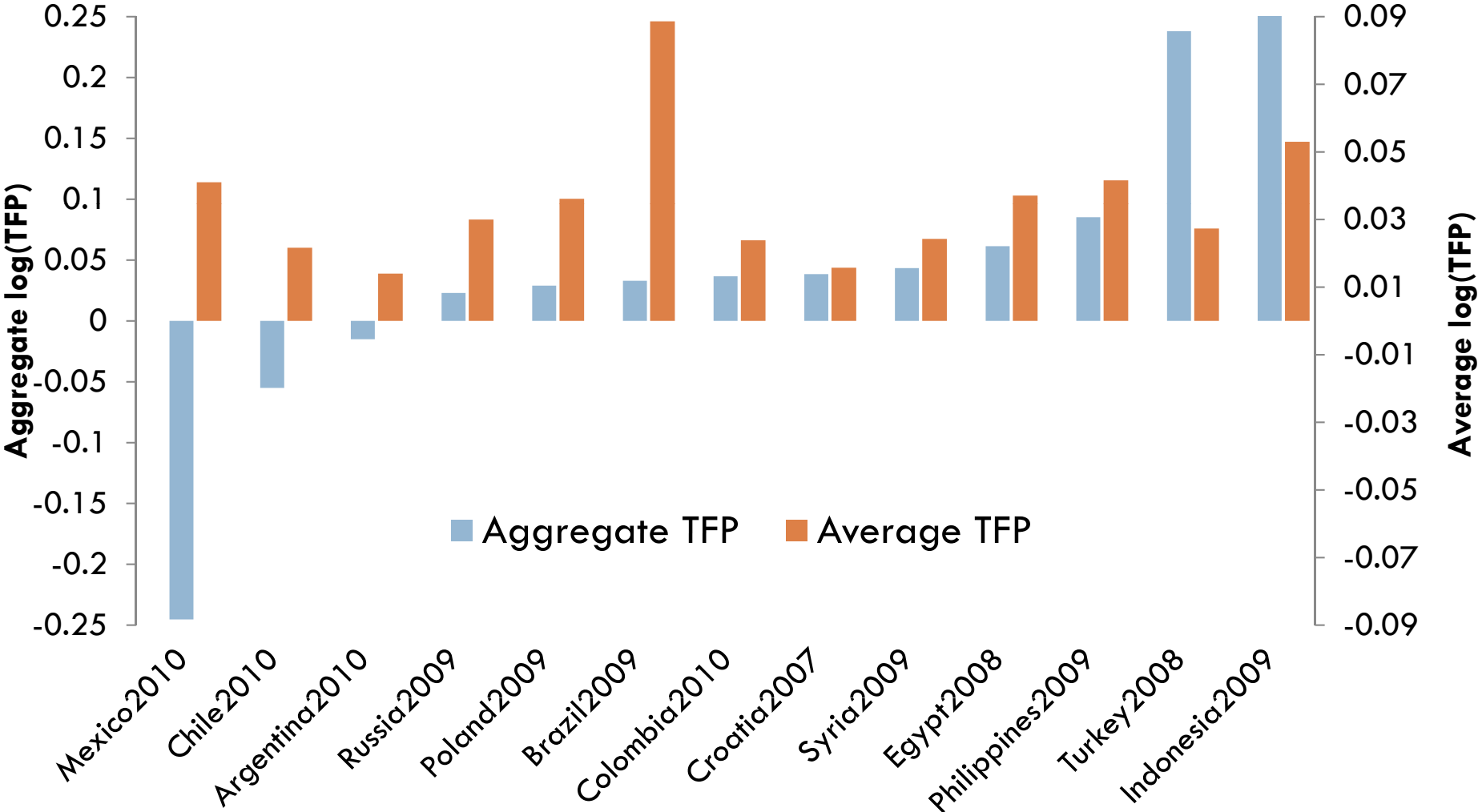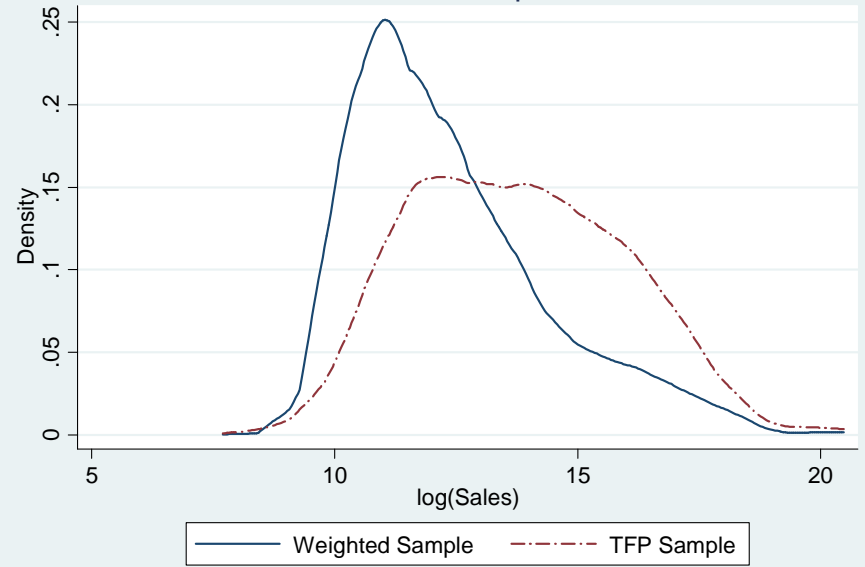
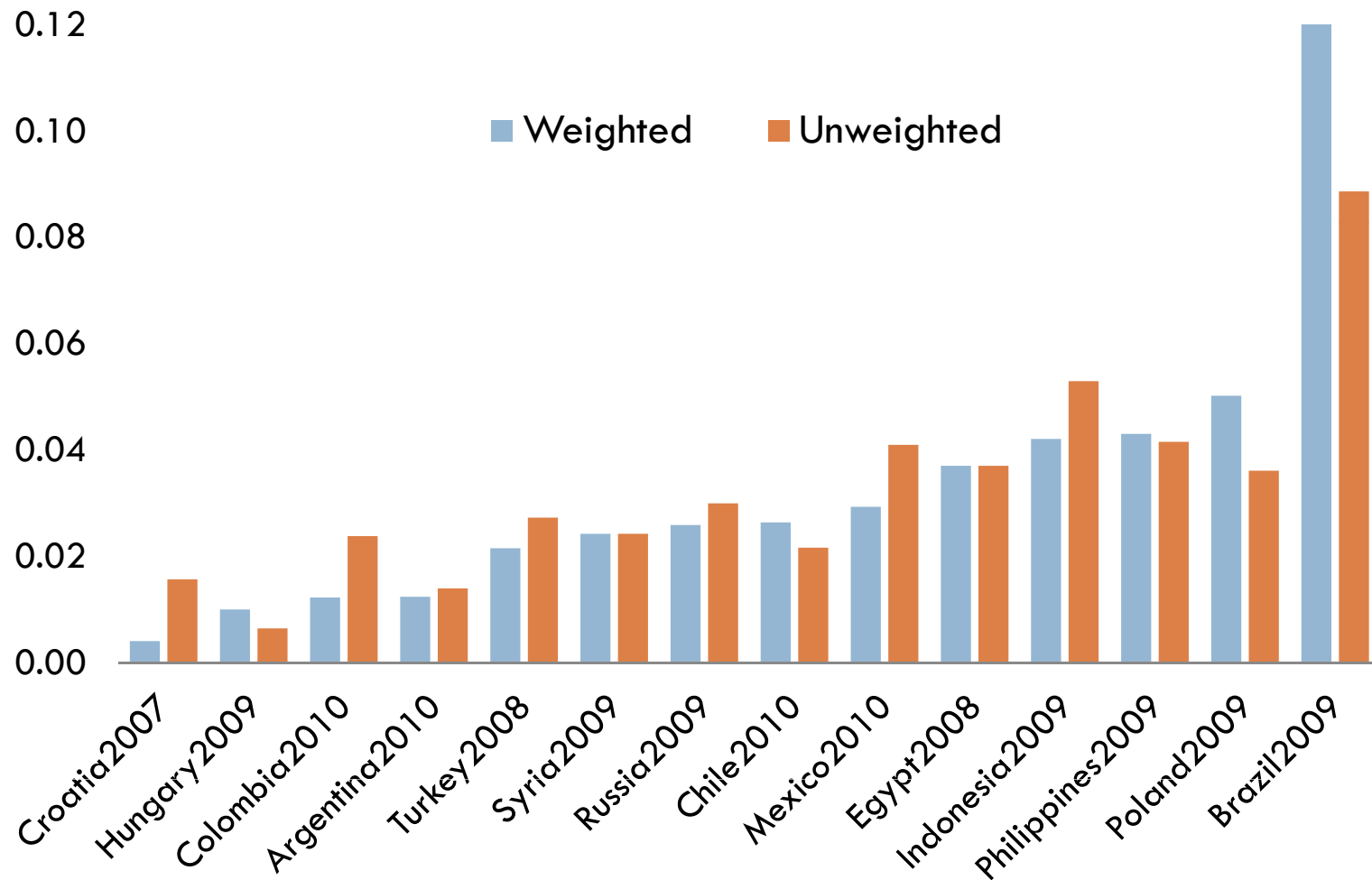Size Distribution Comparison:Turkey · Size Distribution Comparison:Indonesia · Size Distribution Comparison:Brazil · Size Distribution Comparison:Mexico
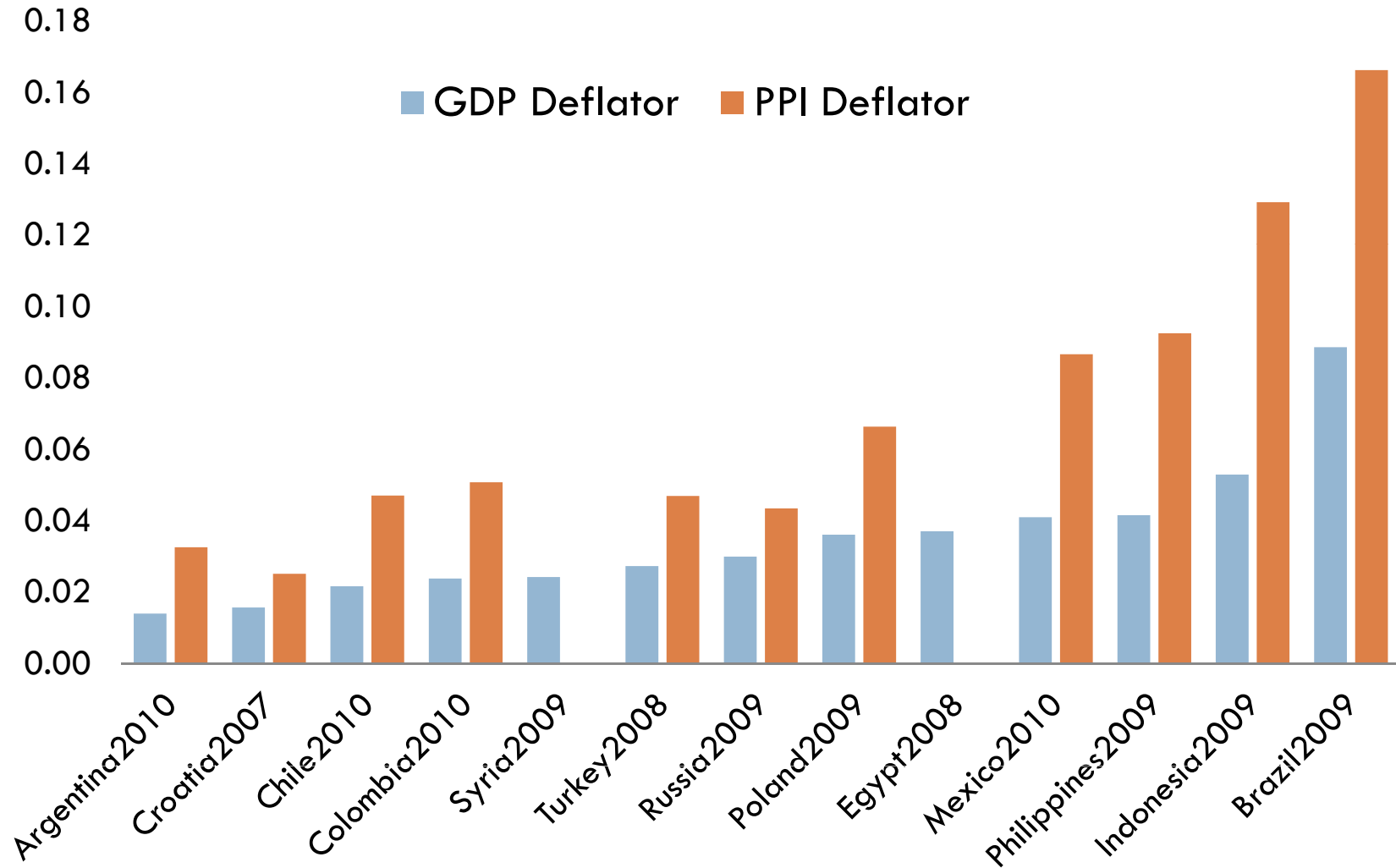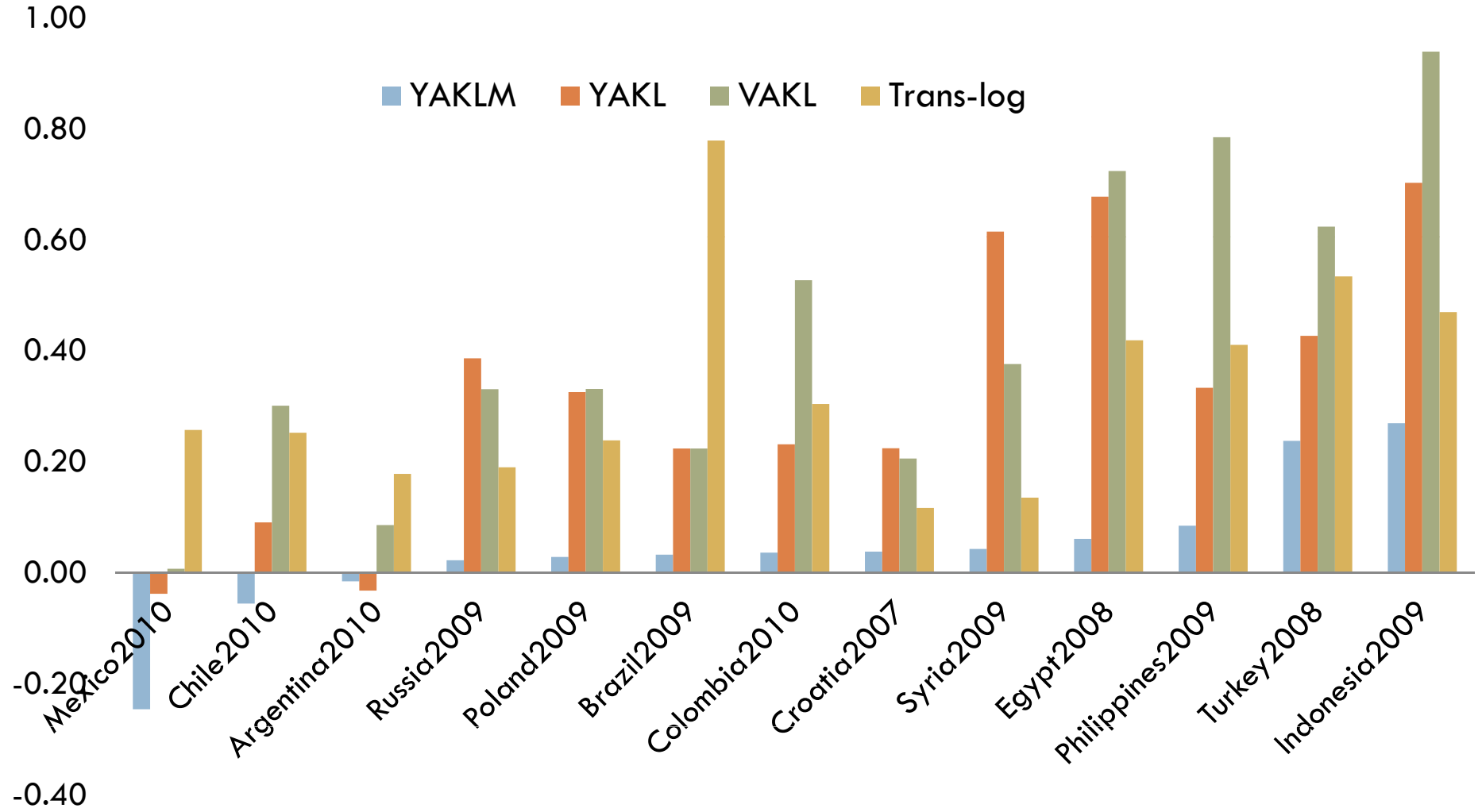
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Weighted vs. Un-weighted Average TFP Estimates (YAKLM)
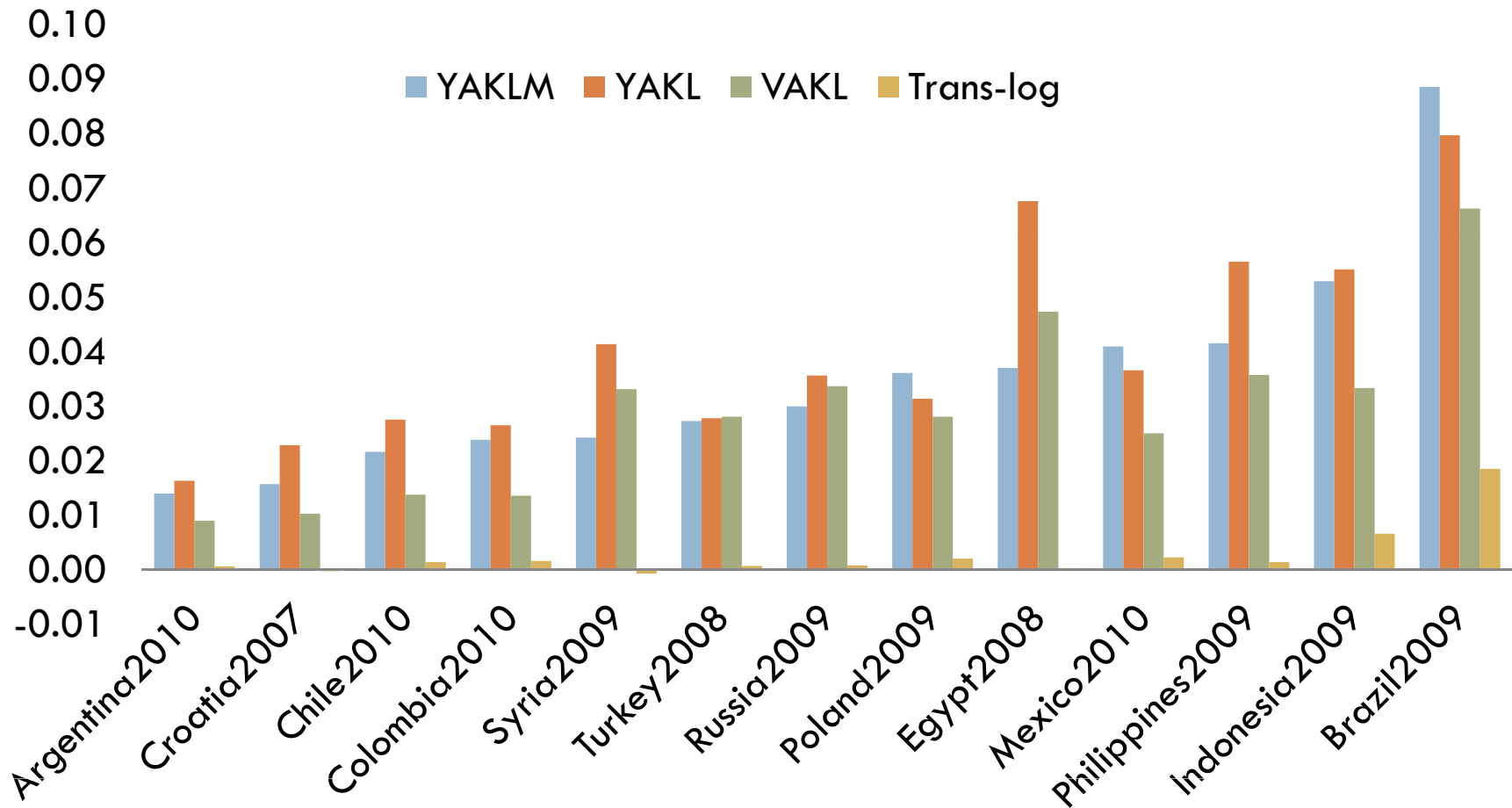
Average TFP (GDP Deflator vs. PPI) (YAKLM)

Aggregate TFP Across Specifications

Average TFP Across Specifications

Comparison of Solow Residual
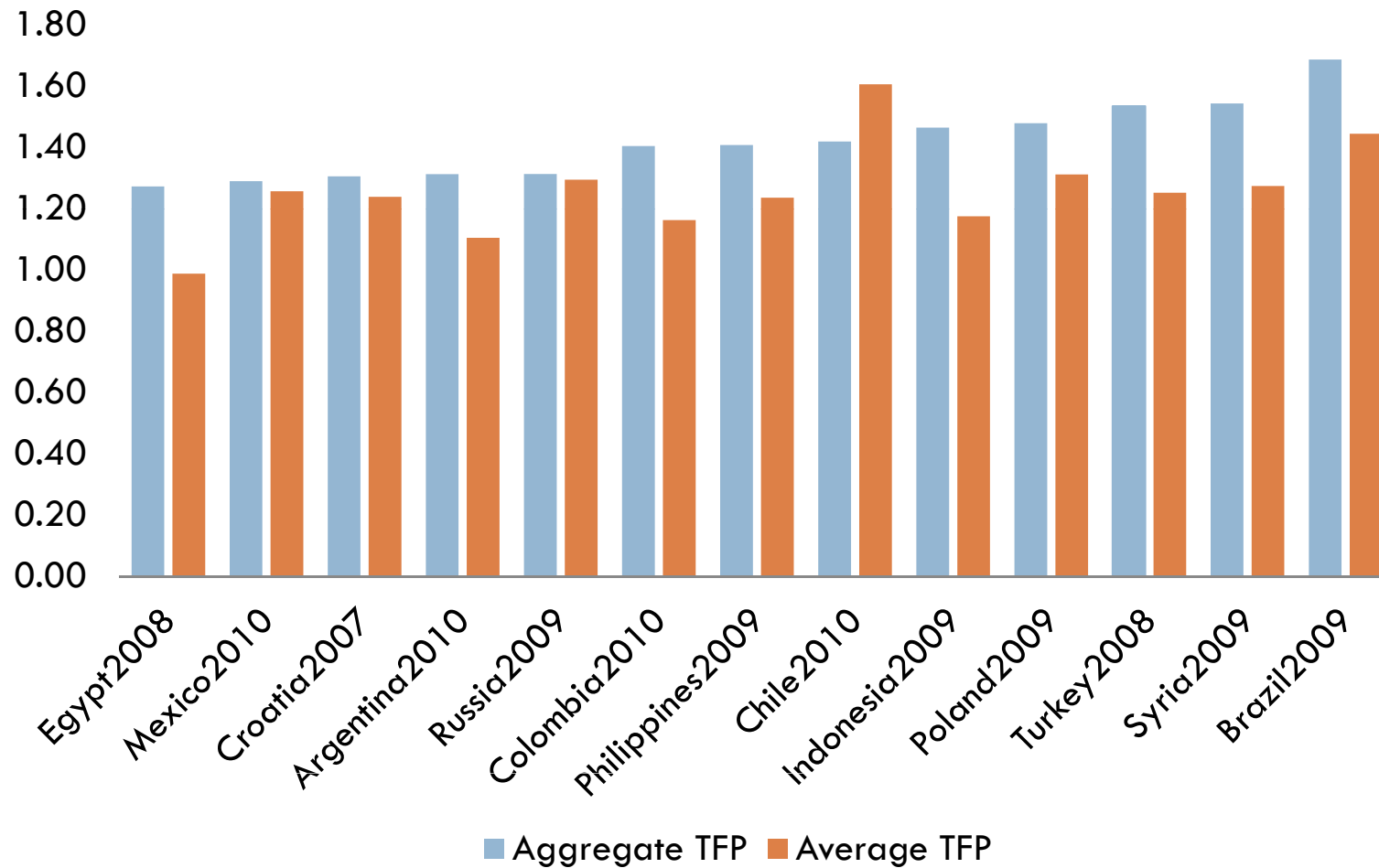
Performance Relative to Turkey in YAKLM Specification

% Difference in Actual Average TFP	Country
-1.3	Argentina2010
-1.2	Croatia2007
-0.6	Chile2010
-0.3	Colombia2010
-0.3	Syria2009
0.0	Turkey2008
0.3	Russia2009
0.9	Poland2009
1.0	Egypt2008
1.4	Mexico2010
1.4	Philippines2009
2.6	Indonesia2009
6.3	Brazil2009

% Difference in Actual Aggregate TFP	Country
-38.3	Mexico2010
-25.4	Chile2010
-22.4	Argentina2010
-19.4	Russia2009
-18.9	Poland2009
-18.5	Brazil2009
-18.2	Colombia2010
-18.1	Croatia2007
-17.7	Syria2009
-16.2	Egypt2008
-14.2	Philippines2009
0.0	Turkey2008
3.2	Indonesia2009

Aggregate TFP Comparison (with 2006 LAC Data)
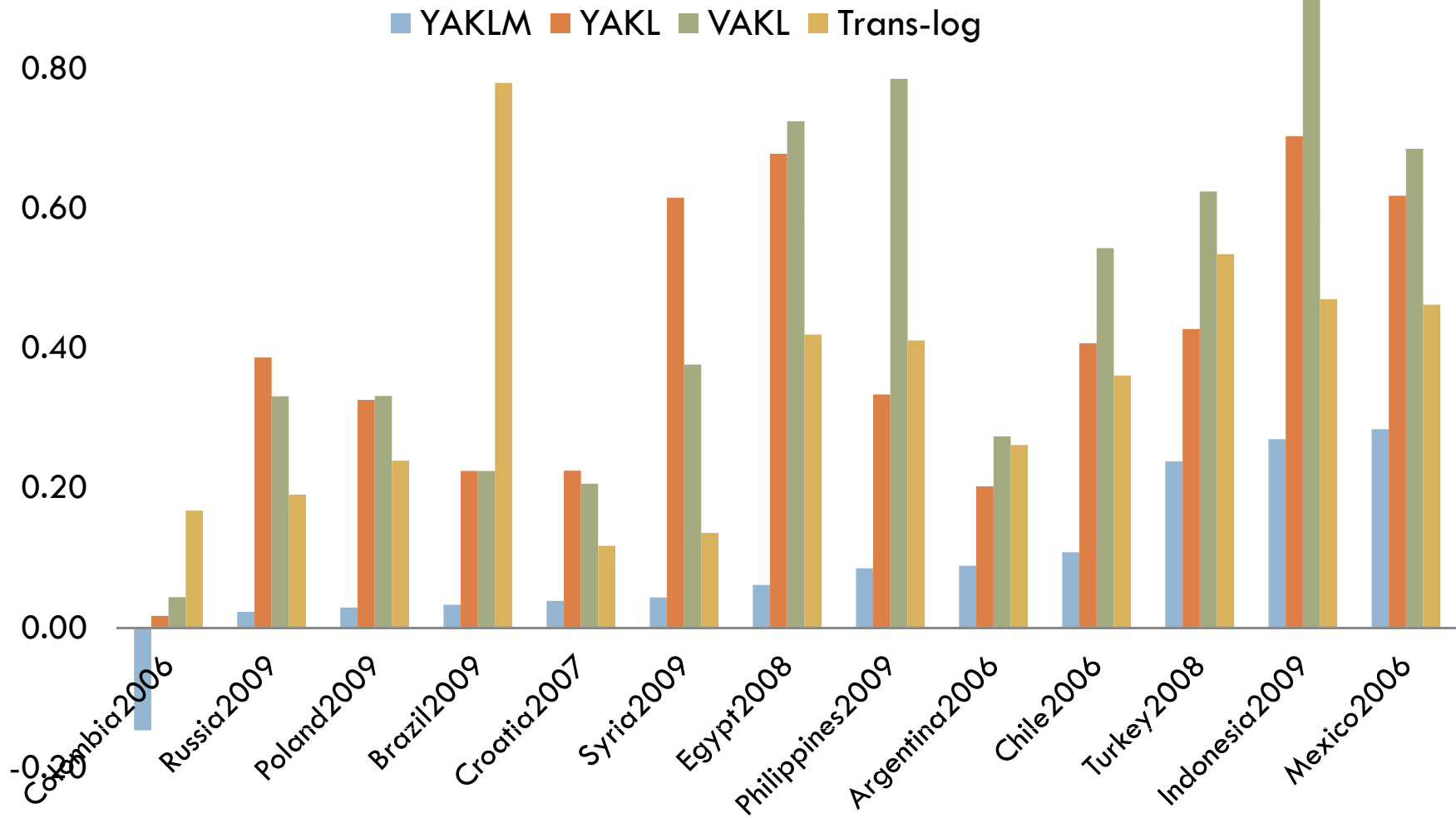
Average Productivity Comparison (with 2006 LAC Data)

Aggregate TFP Rankings (All Measures)

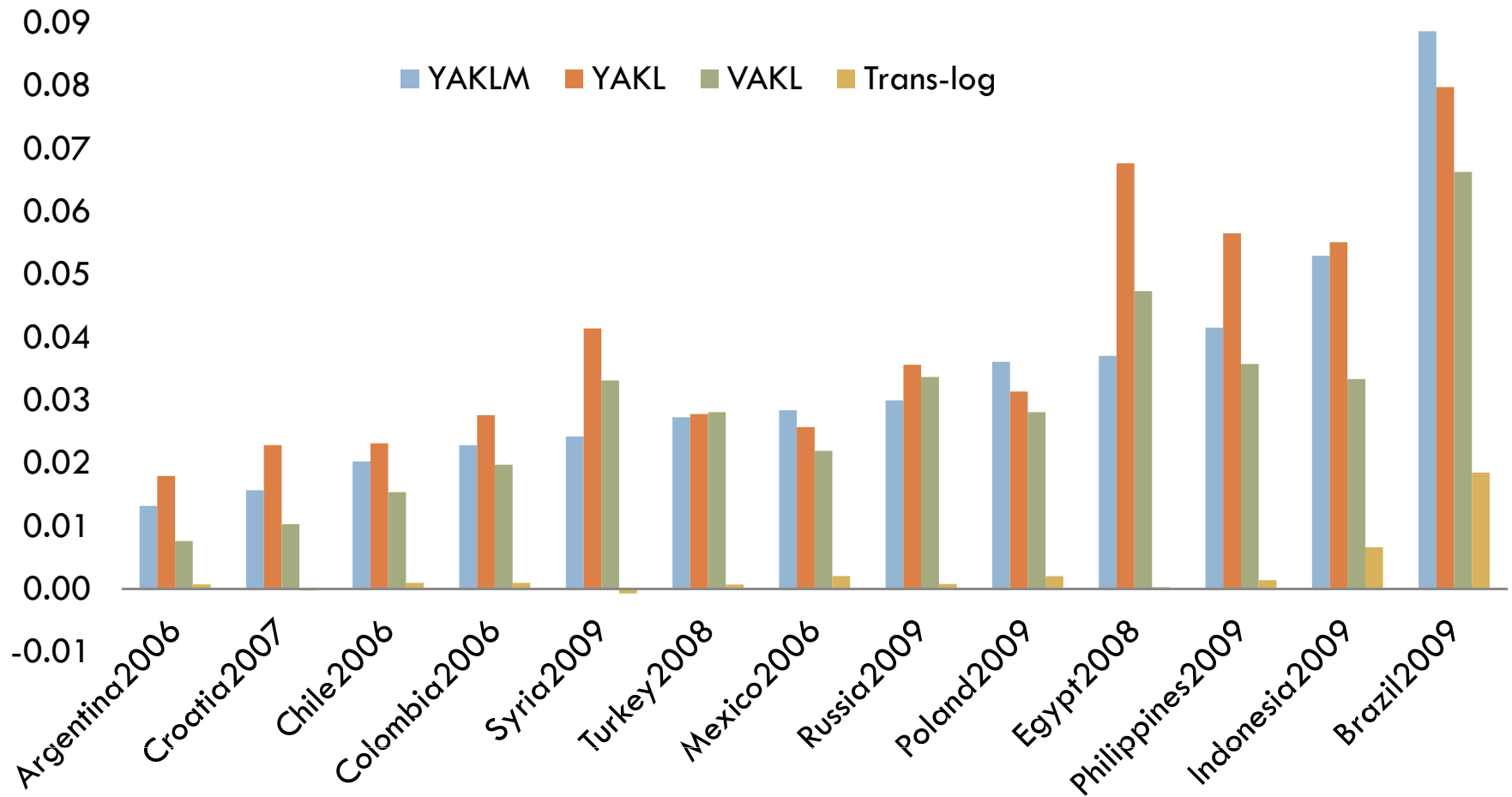| YAKLM	YAKLEM	YAKL	VAKL	Trans-log	Solow
Mexico2010	Mexico2010	Mexico2010	Mexico2010	Croatia2007	Egypt2008
Chile2010	Brazil2009	Argentina2010	Argentina2010	Syria2009	Mexico2010
Argentina2010	Chile2010	Chile2010	Croatia2007	Argentina2010	Croatia2007
Russia2009	Argentina2010	Brazil2009	Brazil2009	Russia2009	Argentina2010
Poland2009	Croatia2007	Croatia2007	Chile2010	Poland2009	Russia2009
Brazil2009	Russia2009	Colombia2010	Russia2009	Chile2010	Colombia2010
Colombia2010	Syria2009	Poland2009	Poland2009	Mexico2010	Philippines2009
Croatia2007	Poland2009	Philippines2009	Syria2009	Colombia2010	Chile2010
Syria2009	Colombia2010	Russia2009	Colombia2010	Philippines2009	Indonesia2009
Egypt2008	Egypt2008	Turkey2008	Turkey2008	Egypt2008	Poland2009
Philippines2009	Philippines2009	Syria2009	Egypt2008	Indonesia2009	Turkey2008
Turkey2008	Indonesia2009	Egypt2008	Philippines2009	Turkey2008	Syria2009
Indonesia2009	Turkey2008	Indonesia2009	Indonesia2009	Brazil2009	Brazil2009

Average TFP Rankings (All Measures)

YAKLM	YAKLEM	YAKL	VAKL	Trans-log	Solow
Argentina2010	Argentina2010	Argentina2010	Argentina2010	Syria2009	Egypt2008
Croatia2007	Croatia2007	Croatia2007	Croatia2007	Croatia2007	Argentina2010
Chile2010	Chile2010	Colombia2010	Colombia2010	Egypt2008	Colombia2010
Colombia2010	Turkey2008	Chile2010	Chile2010	Argentina2010	Indonesia2009
Syria2009	Colombia2010	Turkey2008	Mexico2010	Turkey2008	Philippines2009
Turkey2008	Syria2009	Poland2009	Poland2009	Russia2009	Croatia2007
Russia2009	Russia2009	Russia2009	Turkey2008	Chile2010	Turkey2008
Poland2009	Egypt2008	Mexico2010	Syria2009	Philippines2009	Mexico2010
Egypt2008	Poland2009	Syria2009	Indonesia2009	Colombia2010	Syria2009
Mexico2010	Mexico2010	Indonesia2009	Russia2009	Poland2009	Russia2009
Philippines2009	Philippines2009	Philippines2009	Philippines2009	Mexico2010	Poland2009
Indonesia2009	Indonesia2009	Egypt2008	Egypt2008	Indonesia2009	Brazil2009
Brazil2009	Brazil2009	Brazil2009	Brazil2009	Brazil2009	Chile2010