Assessing competitiveness and long-run growth: origins of technological changes in G7 and BRIC countries

Konstantīns Beņkovskis (Bank of Latvia)

Ludmila Fadejeva (Bank of Latvia)

Robert Stehrer (Wiener Institut für Internationale Wirtschaftsvergleiche)

Julia Wörz (Oesterreichische Nationalbank)

Competitiveness and productivity

- Competitiveness and productivity are close synonyms
  - World Economic Forum "... defines competitiveness as the set of institutions, policies and factors that determine the level of productivity of a country."
- Here we analyse the contributions from TFP (interpreted as technological progress) at the industry level to an economy's long-term growth potential
- Improvements over traditional Solow residual approach
  - allow for non-constant returns to scale and changes in utilization of inputs
  - evaluate TFP at industry level and aggregate via input-output framework
  - take into account open economy characteristics

- Follow Basu and Kimball (1997)

- Allows for non-constant returns to scale

- Cost minimization problem of a representative firm:
  - adjustment costs for changes in capital and labour
  - may change utilization of inputs (capital, labour)

$$\min_{S,E,H,N,I,R} E\left(\sum_{\tau=0}^{\infty} \beta^{\tau}\left(wLG(E,H)V(S) + wL\Psi(R/L) + P^{I}K\Phi(I/K) + P^{N}N\right)\right)$$

$$Y = F(KS, LHE, N, Z) = Z\left((KS)^{s_{K}}(LHE)^{s_{L}}N^{s_{N}}\right)^{\gamma}$$

$$\dot{K} = (1 - \delta(S))K + I$$

$$\dot{L} = R$$

- Changes in output are given by:

$$dy = \gamma^* d\chi + \gamma^* du + \boxed{dz}$$

changes in output

changes in inputs

changes in utilization

changes in technology

- inputs contain capital, total hours worked and intermediate inputs

$$d\chi = s_K dk + s_L (dl + dh) + s_N dn$$

changes in input

changes in capital

changes in total hours worked

changes in intermediate input

- unobserved changes in utilisation is a function of observables

$$du = \beta_1 dh + \beta_2 (dp^N + dn - dp^I - dk) + \beta_3 (di - dk)$$

changes in utilization

changes in hours per head

changes in intermediate consumption to capital

changes in investments to capital

Aggregation of TFP
Direct and indirect effects

- Industry specific TFP growth informs about direct effects from technological change on the economy
  - However, technological changes in one industry is multiplied through interlinkages among sectors
  - Depending on strength and type of interlinkages (i.e. structure of intermediate use) aggregate TFP is affected differently by technology shocks in different industries
- Final use analysis allows to study the full effect of TFP on different GDP components
  - Theory postulates that TFP shocks affecting consumption have a different impact than TFP shocks affecting investment
- In addition – analysis of ToT shocks, which are important for open economies

		Product 1	Product 2	Trade product	Consumption	Total input
Domestic	Product 1	$P_1 N_{11}$	$P_1 N_{21}$	$P_1 X_1$	$P_1 C_1$	$P_1 Y_1$
	Product 2	$P_2 N_{12}$	$P_2 N_{22}$	$P_2 X_2$	$P_2 C_2$	$P_2 Y_2$
Trade product		$P^M_1 M_1$	$P^M_2 M_2$	...	$P^M_C C^M$	$P^M M$
Value added		VA_1	VA_2	...	...	VA
Financial account		...	...	$P^M M - P^X X$	...	...
Total output		$P_1 Y_1$	$P_2 Y_2$	$P^M M$	$P^C C$	

Matrix **B**

Represents shares of intermediate inputs in total output

Matrix $\mathbf{s_C}$

Represents structure of final consumption

- Some mathematical transformations:

$$dy_i = \gamma_i^* \left(s_{Ki} dk_i + s_{Li} (dl_i + dh_i) + \sum_j s_{Nij} dn_{ij} \right) + \gamma_i^* du_i + dz_i$$

$$dc_i = \gamma_i^* \left(s_{Ki} dk_i + s_{Li} (dl_i + dh_i) + \sum_j s_{Nij} dc_j \right) + \gamma_i^* du_i + dz_i$$

$$dc = \gamma s_K dk + \gamma s_L (dl + dh) + \gamma B^T dc + \gamma du + dz$$
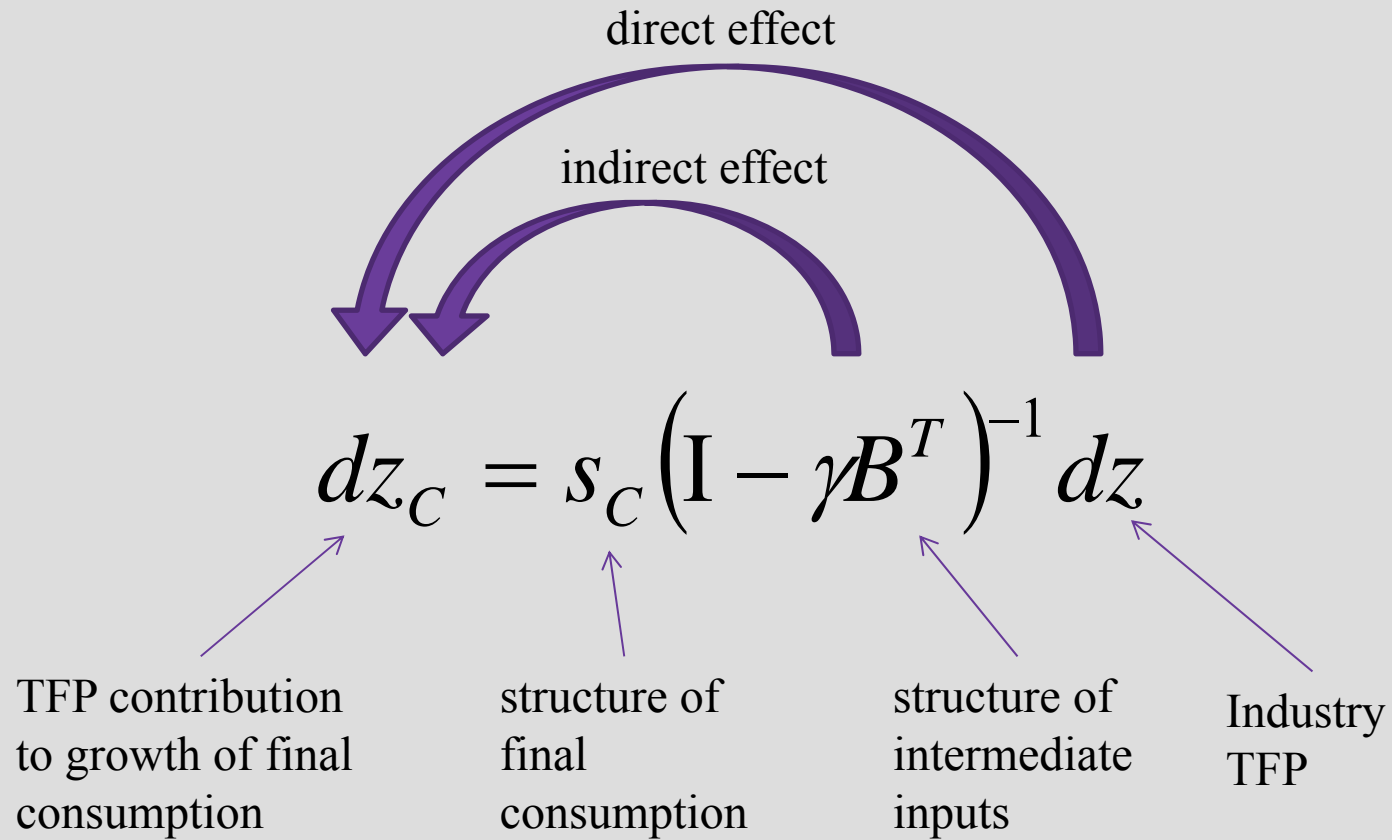
$$dc = \left(I - \gamma B^T \right)^{-1} \gamma s_K dk + \left(I - \gamma B^T \right)^{-1} \gamma s_L (dl + dh) + \left(I - \gamma B^T \right)^{-1} \gamma du + \left(I - \gamma B^T \right)^{-1} dz$$

- Aggregated TFP contribution to final consumption growth:

$$dz_C = s_C \left(I - \gamma B^T \right)^{-1} dz$$

direct effect

indirect effect

$$dz_C = s_C\left(\mathrm{I} - \gamma B^T\right)^{-1} dz$$

TFP contribution
to growth of final
consumption

structure of
final
consumption

structure of
intermediate
inputs

Industry
TFP

Description of the database

- WIOD (World Input-Output Database):
  - Harmonized input-output tables
  - Industry level data on output, capital, labour
  - 35 industries (NACE, rev.1)
  - 40 countries:
    - 27 EU members
    - 13 major countries
  - Annual data for 1995-2009

Estimation of TFP at industry level
Estimation strategy

- Regression to estimate:

$$dy_{it} = b_0 + \gamma^* d\chi_{it} + b_1 dh_{it} + b_2\left(dp_{it}^N + dn_{it} - dp_{it}^I - dk_{it}\right) + b_3\left(di_{it} - dk_{it}\right) + \xi_{it}$$

$$dz_{it} = b_0 + \xi_{it}$$

- Data organized in industry-specific panel datasets
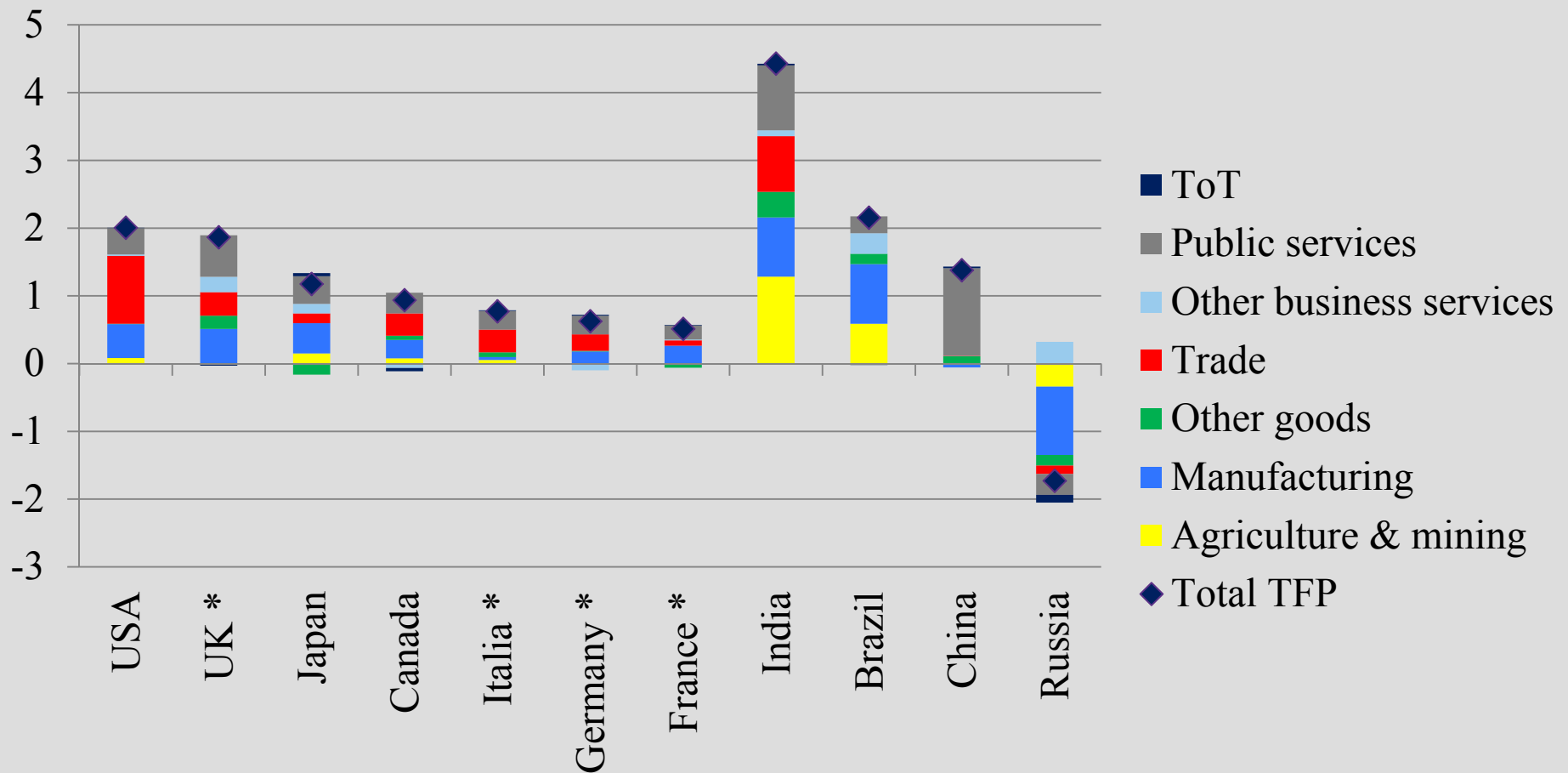- Country-specific fixed effects
- Estimated by TSLS

Estimation of TFP at industry level
Estimation results

Industry	Coefficients				No. of countries	No. of obs.	Sargan-test (p-value)
	$d\chi$	dh	$dn+dp^N-$ $-dk-dp^I$	di-dk			
Agriculture, Forestry and Fishing	0.032	-0.029	0.928***	0.018	40	360	0.620
Mining and Quarrying	0.548***	0.171	0.121	-0.019	40	393	0.684
Food, Beverages and Tobacco	1.076***	0.155	-0.049	0.012	40	407	0.017
Textiles and Textile Products	0.909***	0.052	0.122	-0.004	40	398	0.254
Leather and Footwear	0.940***	0.040	0.180*	0.021	39	350	0.463
Wood and Products of Wood and Cork	0.975***	0.296	0.199	-0.034	40	394	0.669
Pulp, Paper, Printing and Publishing	1.001***	0.103	0.031	0.003	40	407	0.080
Refined Petroleum, Chemical Products	0.998***	0.007	-0.082	0.012	40	404	0.019
Rubber and Plastics	0.936***	0.112***	0.120*	-0.007	40	407	0.705
Other Non-Metallic Mineral	0.997***	0.398	0.087	-0.018	40	404	0.226
Basic Metals and Fabricated Metal	0.841***	0.275	0.132	-0.009	40	407	0.327
Machinery, n.e.c.	0.852***	0.447**	0.230	-0.051**	40	407	0.112
Electrical and Optical Equipment	1.159***	0.099	-0.113	-0.009	40	401	0.685
Transport Equipment	0.497***	-0.073	0.734***	-0.069	40	399	0.599
Manufacturing, n.e.c; Recycling	0.924***	0.281	0.147	-0.034	40	396	0.479
Electricity, Gas and Water Supply	0.572***	-0.036	0.305**	0.011	40	403	0.134
Construction	0.942***	0.132	0.163*	-0.030	40	404	0.983
Trade	0.745***	0.110	0.360**	0.005	40	407	0.169
Hotels and Restaurants	0.919***	0.038	0.419	-0.026	40	394	0.508
Transport	0.909***	0.189	0.155*	0.004	40	402	0.494
Post and Telecommunications	1.168***	0.075	-0.028	-0.015	40	404	0.392
Financial Intermediation	1.131***	0.174	-0.154	-0.015	40	401	0.504
Real Estate Activities	1.103***	0.015	-0.083	-0.012	40	407	0.925
Other Business Activities	1.177***	0.527**	-0.180	0.006	40	405	0.562
Public Administration and Defence	0.773***	0.137	0.088	0.006	39	392	0.463
Education	-0.684	-0.065	0.502	0.055	40	401	0.908
Health and Social Work	0.021	0.439	0.160	-0.084*	40	394	0.649
Other Social Services; Employed Persons	1.377*	-0.827	0.073	-0.088	40	401	0.346

Aggregated TFP
contributions to private consumption

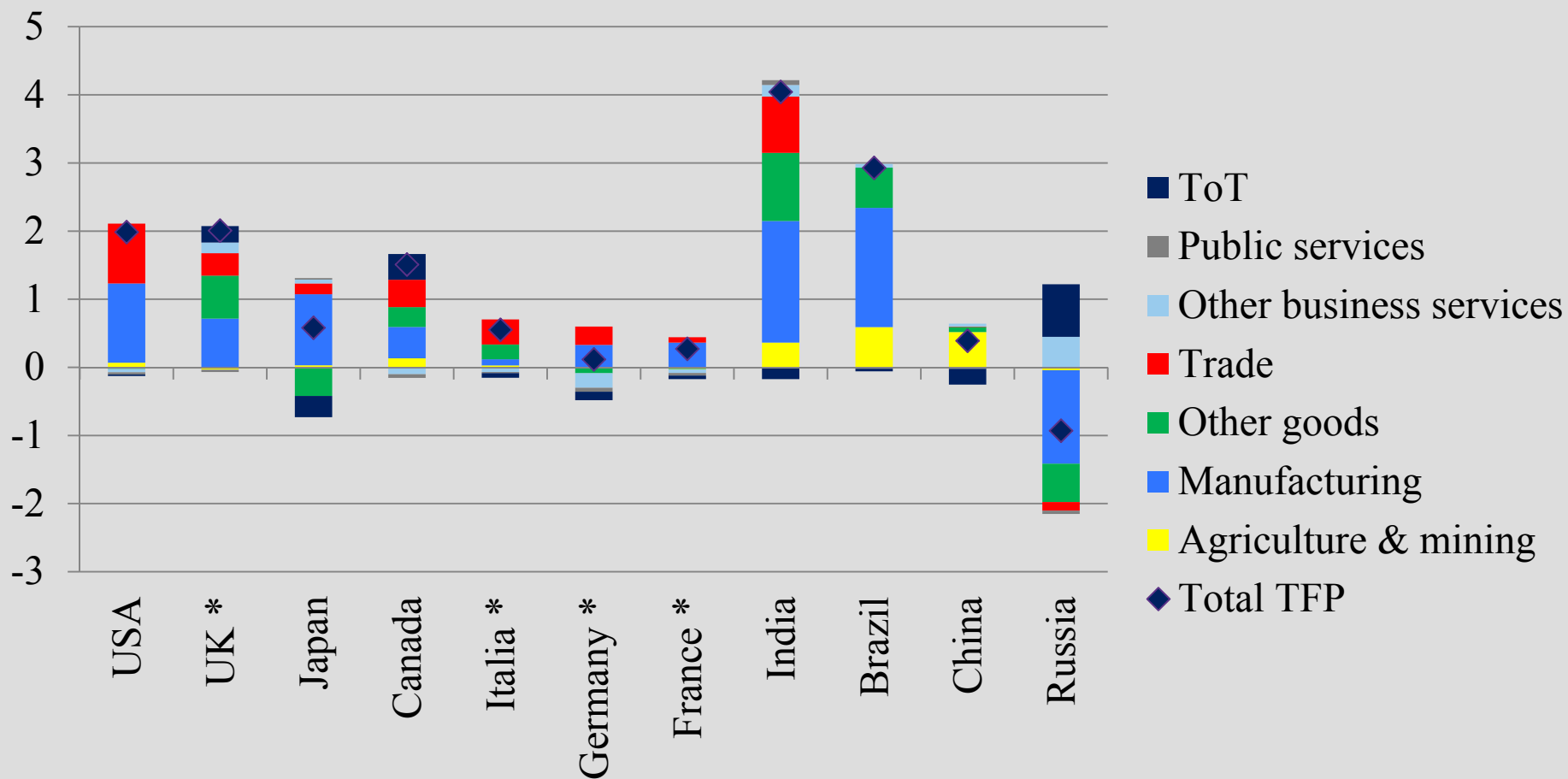**Average contributions of industry TFP to private consumption growth, 1996-2009**
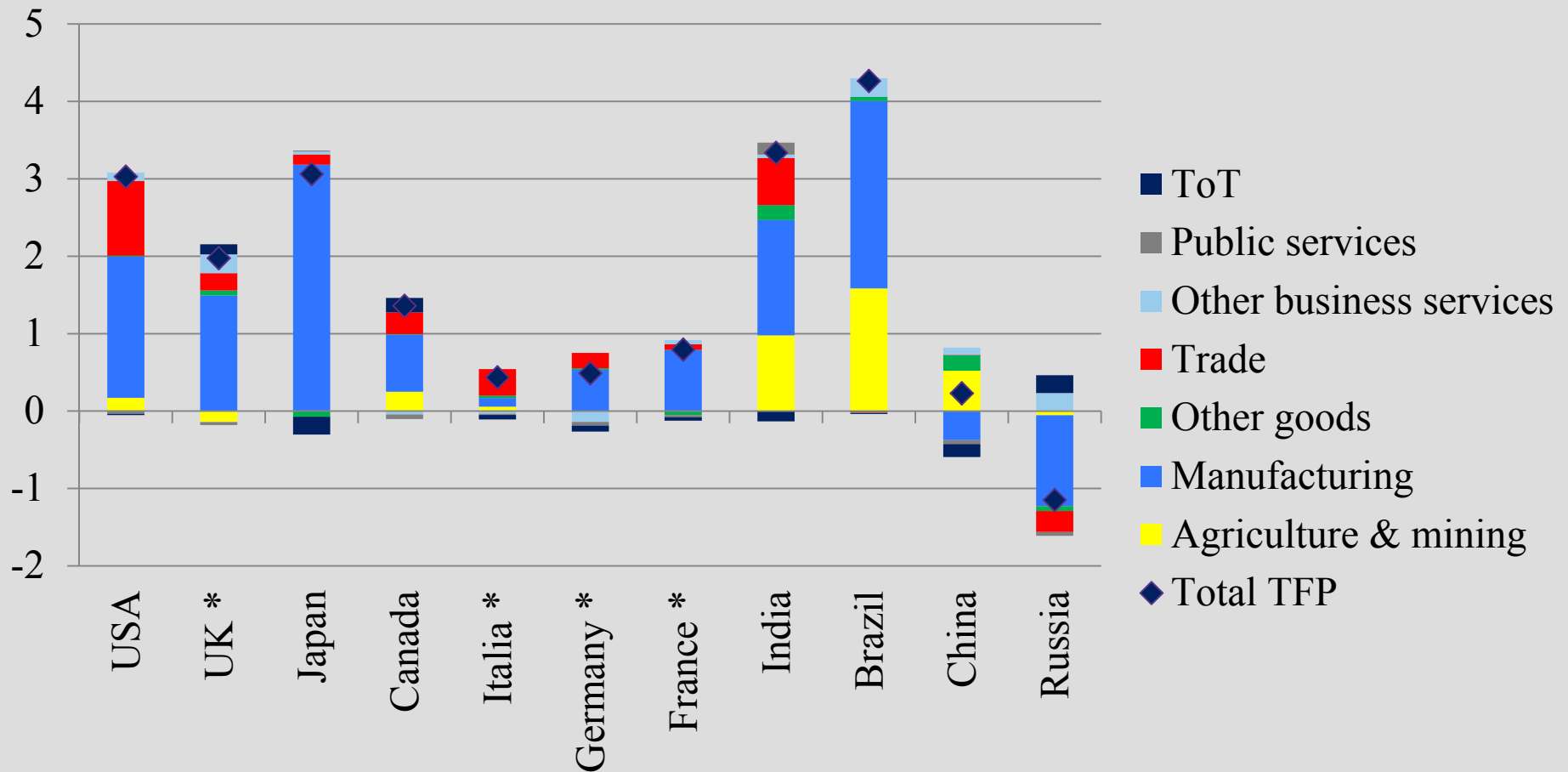
* 1996-2007

Average contributions of industry TFP to gross fixed capital formation growth, 1996-2009

Legend:
- ToT
- Public services
- Other business services
- Trade
- Other goods
- Manufacturing
- Agriculture & mining
- Total TFP

Categories: USA, UK *, Japan, Canada, Italia *, Germany *, France *, India, Brazil, China, Russia
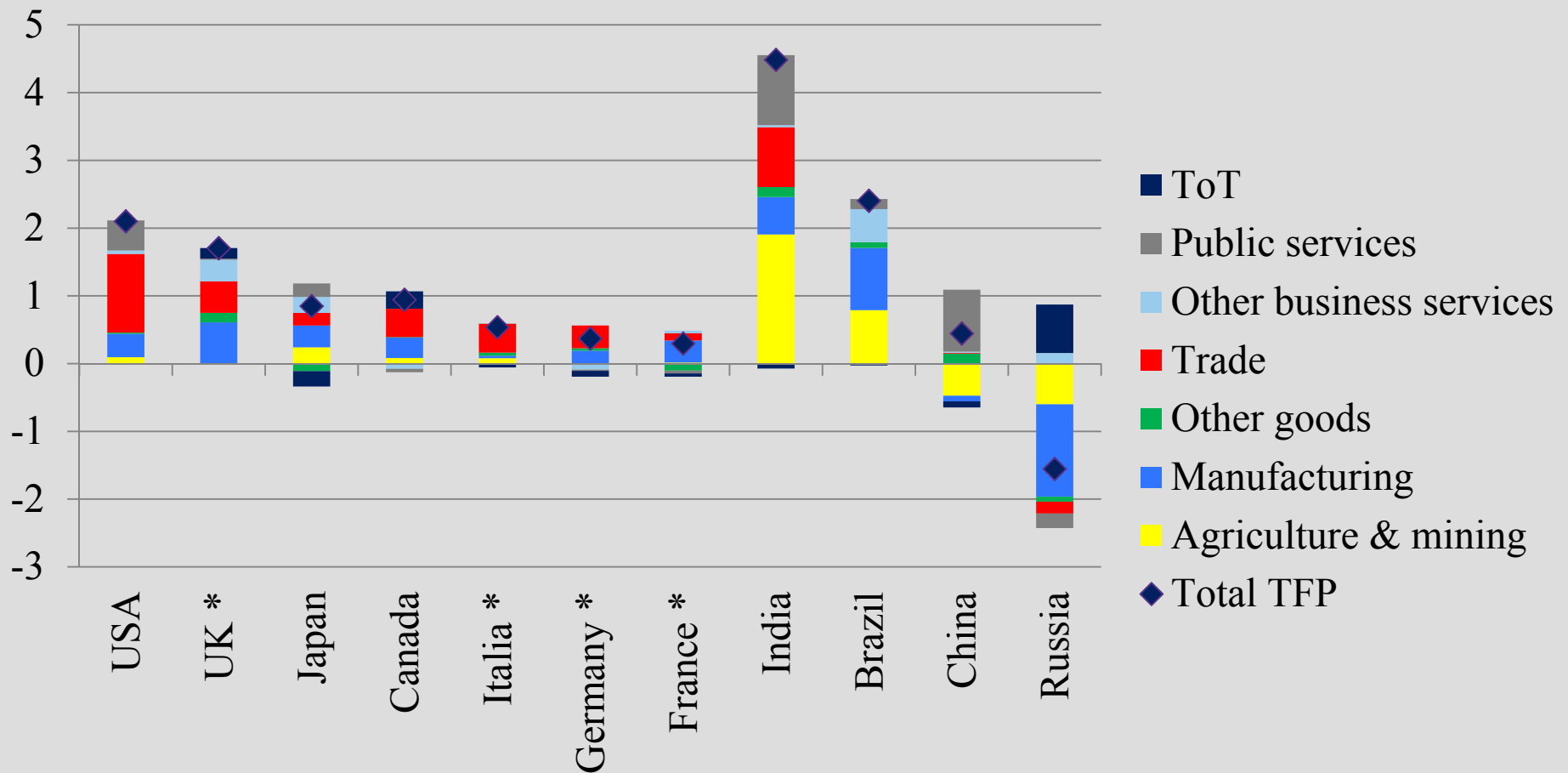
* 1996-2007

Aggregated TFP contributions to exports

Average contributions of industry TFP to export growth, 1996-2009

Legend:
- ToT
- Public services
- Other business services
- Trade
- Other goods
- Manufacturing
- Agriculture & mining
- Total TFP

Categories (x-axis): USA, UK *, Japan, Canada, Italia *, Germany *, France *, India, Brazil, China, Russia

* 1996-2007

Some very preliminary conclusions

- Contribution of technological shocks is very heterogenous within G7 and BRIC countries:
  - EU countries are lagging behind other G7 countries
  - India and Brazil shows very dynamic TFP growth
  - Surprisingly, TFP contribution for China is very moderate – much of growth is explained by increasing utilization of factors
  - Negative contribution from technology shocks for Russia
- Some differences in sectoral composition as well:
  - Important role of manufacturing for India and Brazil
  - Significant contribution of trade for G7 countries
- A lot of additional in-depth analysis is needed