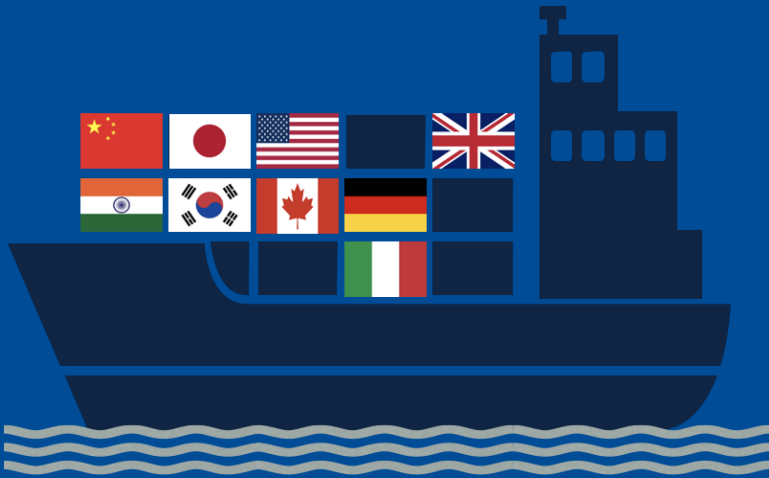




Sources of Long-Term Growth and Productivity Developments: A Comparative Analysis, 1950-2023

SWISS STATA CONFERENCE 2025

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Research sponsored by the International Monetary Fund (IMF)

Agenda

■ Part 1

- Research Setting, Motivation & Literature
- A New Dataset, 1950-2023

■ Part 2

- Growth Decomposition in the Long Term
- “Escapers” of the Income Trap

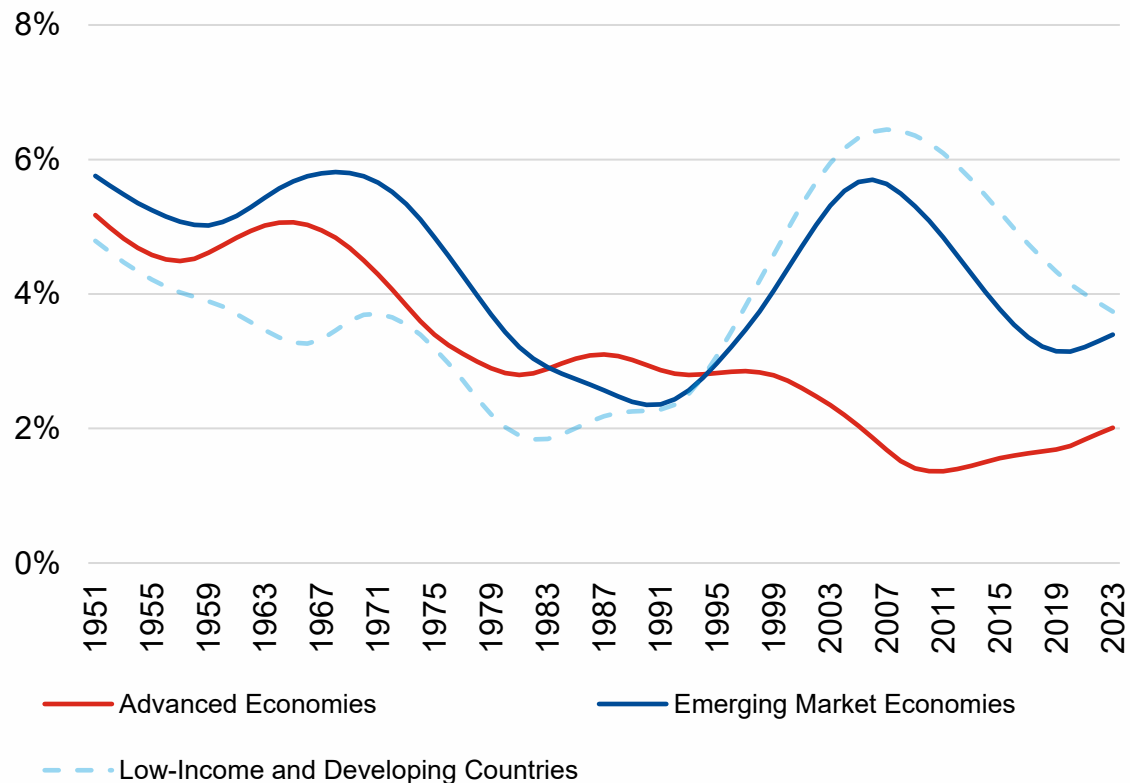
■ Part 3

- Drivers of growth components and policy implications

Slowing Down in Growth and Significant Productivity Gaps Continue

Trend Growth of GDP, 1951-2023

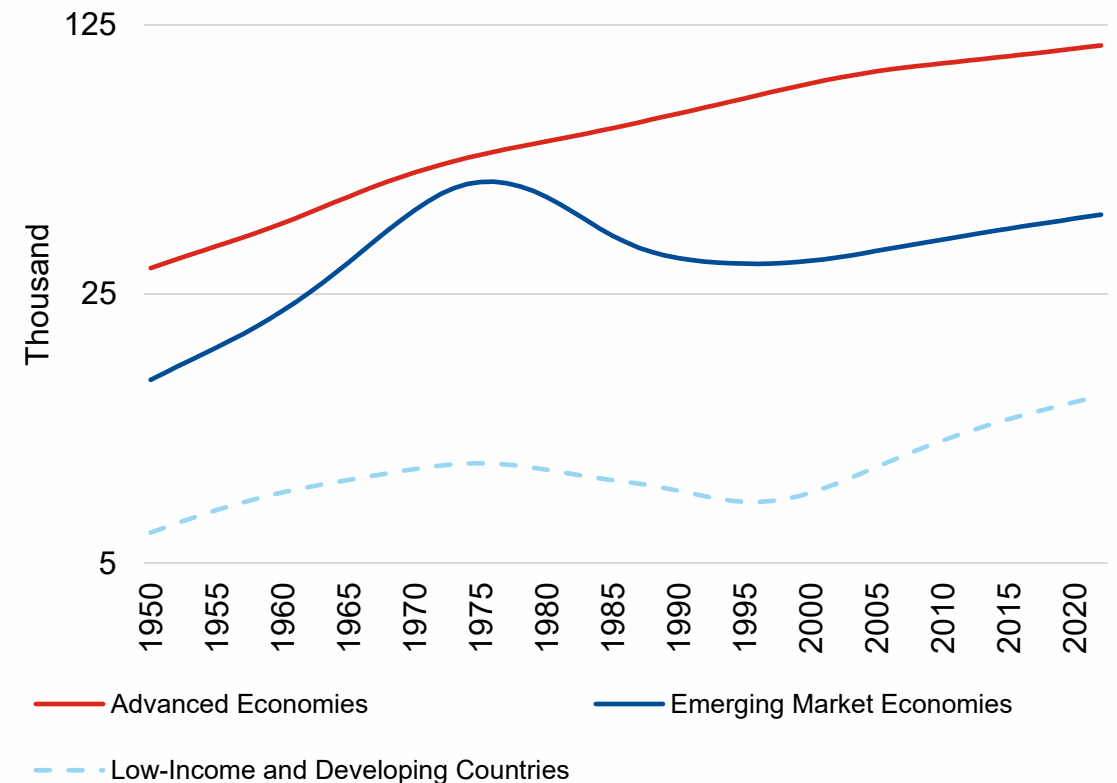
using HP filter, lambda=100



Sources: PWT 10.01, Conference Board TED; Maddison's Project Database, Author's Calculation

Labor Productivity, 1950-2023 (GDP per Person Employed, in constant 2017US\$)

using HP filter, lambda=100



Sources: Author's Calculation

Motivation & Literature Review

Problems Identified with Literature

Restricted Time and Geographical Scope

- Mostly on AEs, East Asia and Latin America Countries
 - ▶ Cette et al. (2022); Bosworth & Collins (2008); Misra et al. (2015)
- After the late 1970s

An Evolving Definition of TFP

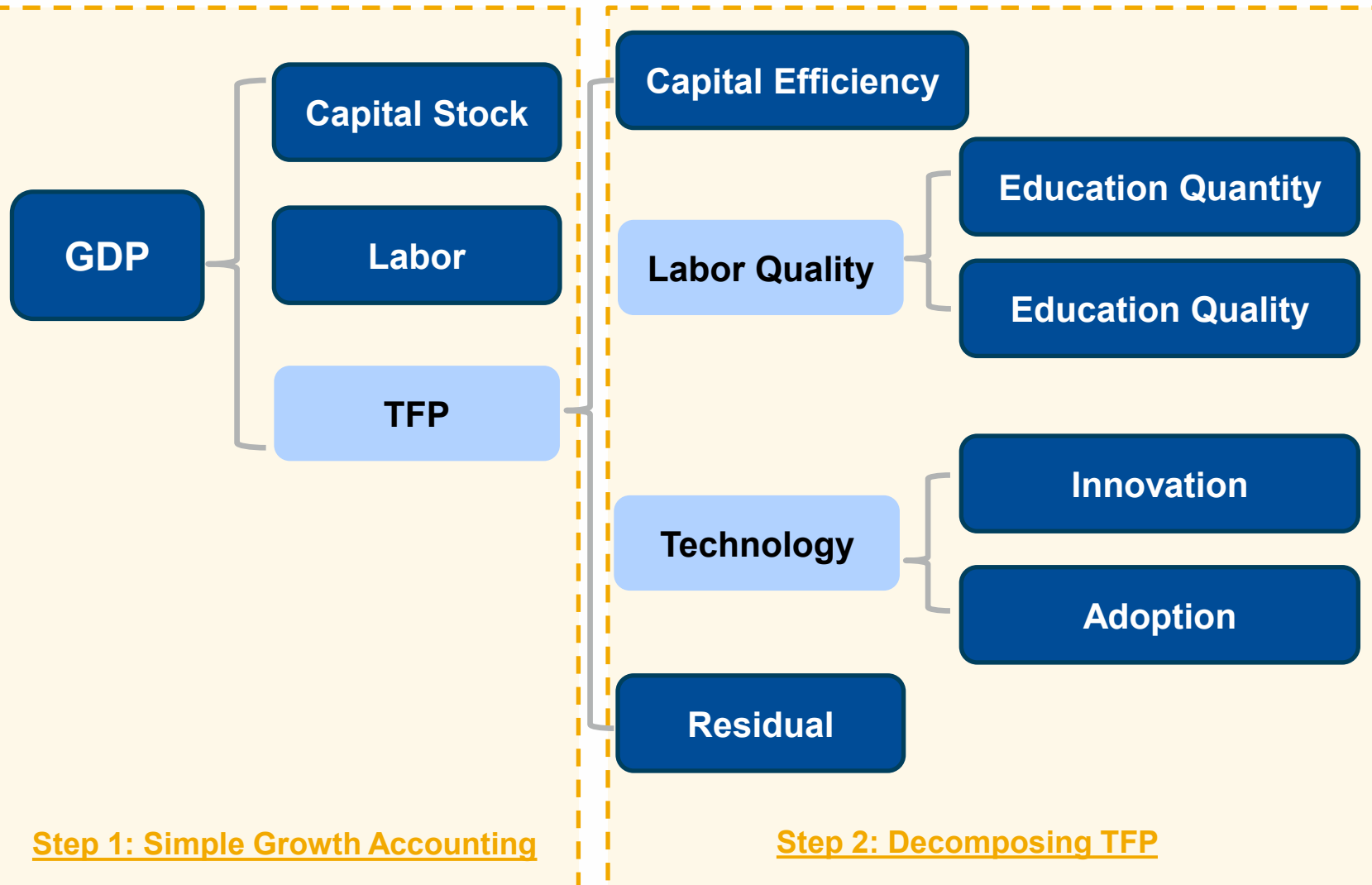
- Factor Inputs: Capital Stock and Labor
- TFP as a residual
 - ▶ Quality of Capital Stock and Labor
 - ▶ Innovation & Technology



Contributions of My Study

- Using a new and original dataset, this study covers a larger set of 130 economies and takes a longer-term perspective from 1950 to 2023
 - ▶ Including 37 AEs, 62 EEs, and 31 LIDCs (Groupings from the 2023 IMF Fiscal Monitor)
- Developed an augmented growth accounting framework which singles out the contribution of factor inputs, factor efficiency, innovation, technology adoption
- Identified the drivers of growth components from a set of policy variables

A New Dataset, 1950-2023



GDP

- ▶ PWT 10.01, Conference Board TED, 2024; Maddison's Project Database for former USSR and Czechoslovakia, 1950-1969; Milanovic (2011) for former Yugoslavia, 1952-1969

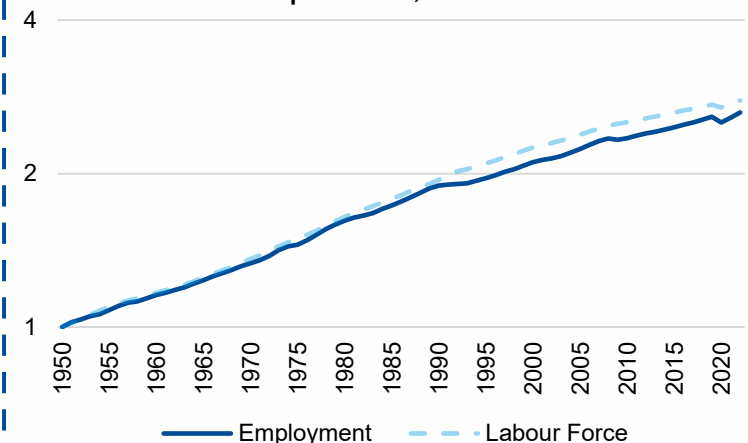
Labor

▶ Employment

- PWT 10.01 & Conference Board

▶ Labor Force

- Trend comparison, 1950=1



Capital Stock and Capital Efficiency

Capital Stock

➤ Capital Quantity (K)

- Perpetual Inventory Method

$$A_{i,t} = A_{i,t-1}(1 - \partial_i) + I_{i,t}$$

- 1970-2019: PWT
- 1960-1970: Growth rates of investment (sum of all types) from the IMF Investment and Capital Stock database
- Before 1960: investment rate (GFCF divided by GDP) kept constant
- After 2019: using trend of investment rate from OECD and WDI for extrapolation
- Countries of missing data are assumed to follow the evolution of investment rates of similar countries

Capital Efficiency

➤ Capital Composition Effect (KQ)

- User Cost Approach

$$\Delta \ln K_t = \sum_{i=1}^k \bar{v}_{i,t} \Delta \ln A_{i,t}$$

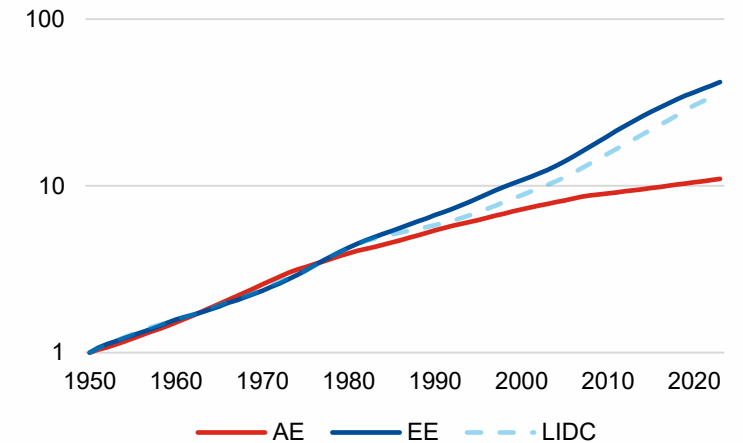
where $\bar{v}_{i,t}$ is the two-year average share of each asset in total capital compensation (M).

- Individual capital compensations are obtained as products of capital stock, and the rental price:

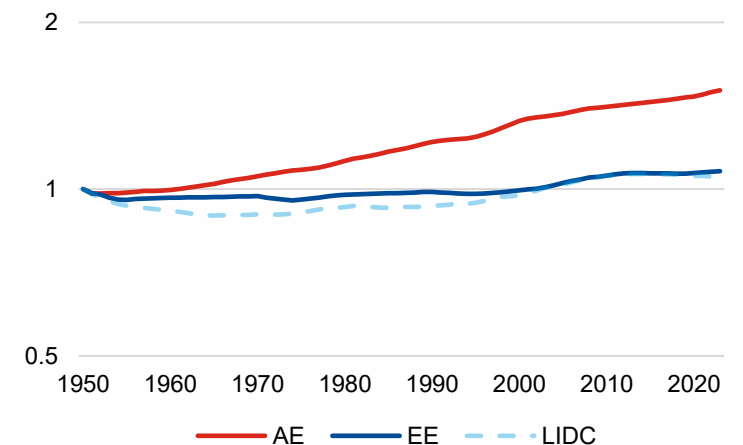
$$c_{i,t} = r_t P_{i,t-1} + \partial_i P_{i,t} - (P_{i,t} - P_{i,t-1})$$

- A measure of how fast a country is upgrading its capital by increasing the share of assets of high marginal productivity.

How fast capital stock is accumulating?



How fast capital efficiency is improving?



Labor Quality

Labor Quality

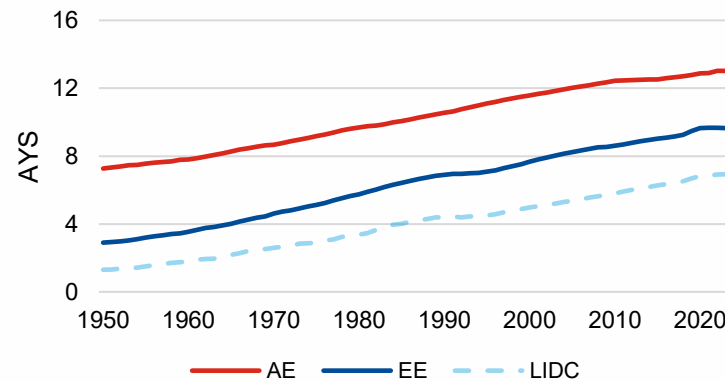
Education Quantity

- Average Years of Schooling
- 1950-2015: Barro & Lee database; OECD How Was Life II report; Didenko et al. (2013)'s Former Soviet Union dataset; van Leeuwen-Li dataset
- 2015-2023: trend from UNESCO for extrapolation

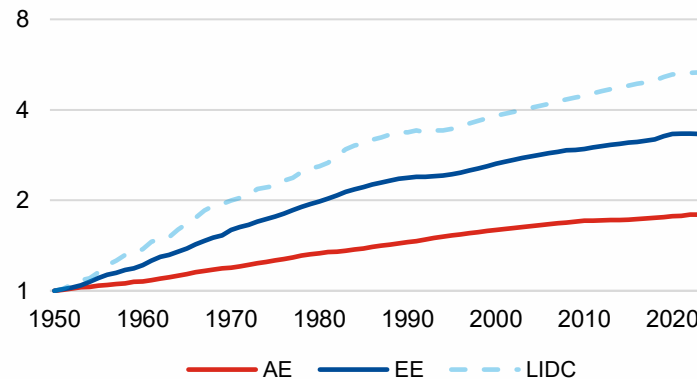
Education Quality

- Performance of secondary students on international assessments, such as TIMSS and PISA
- 1970-2015: Lee and Lee, 2024; Global Dataset on Education Quality by Altinok et al., 2018 (regional)
- 2015-2023: trend from TIMSS scores in 2015 and 2019 & PISA in 2015, 2018, and 2022
- Missing countries: machine learning

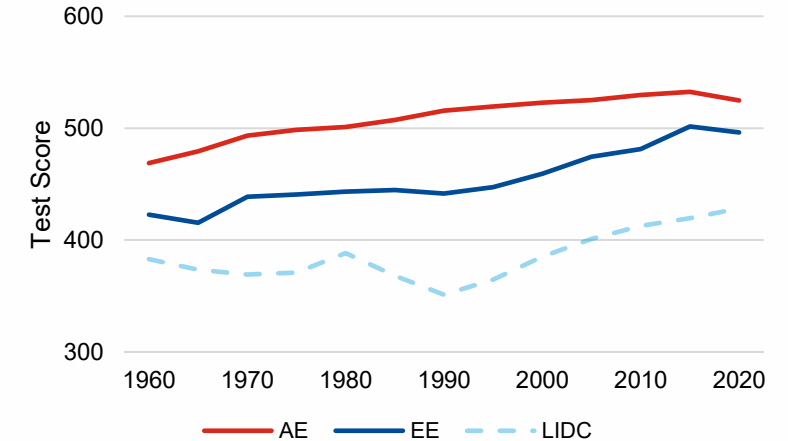
Years of Schooling, 1950-2023



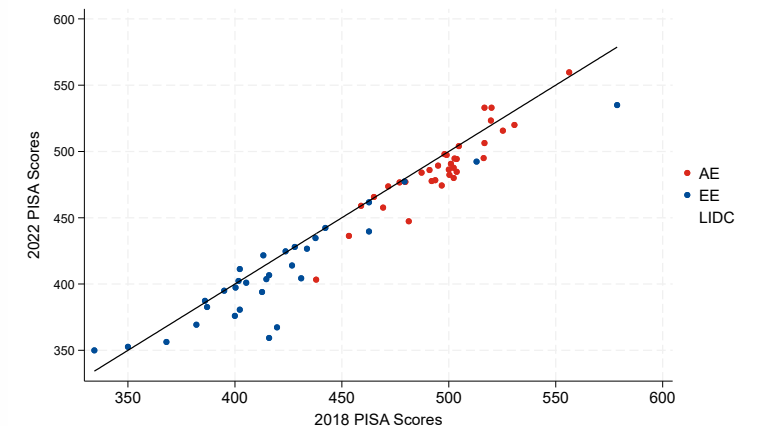
1950=1



International Test Score, 1960-2023



A Drop in 2022 PISA Scores after Covid



Innovation and Technology

Technology

Innovation Output

- Geometric mean of 2 components after they have been normalized

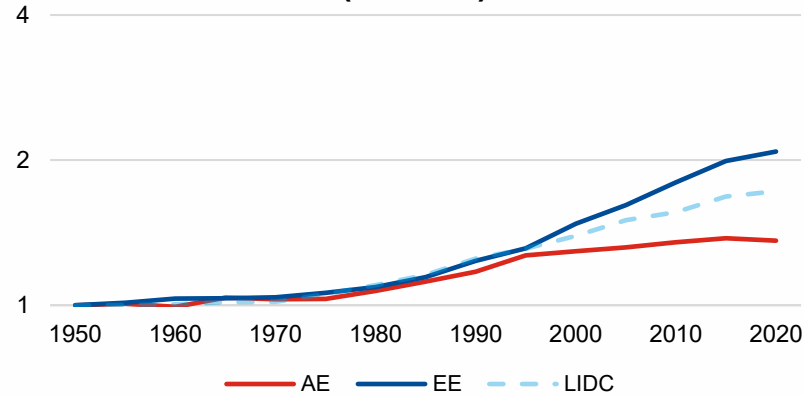
using $100 * \frac{V_i - V_{min}}{V_{max} - V_{min}}$:

- Patents by origin
 - Trademarks by origin
- Global Innovation Index; WIPO Archives; Eurostat; OECD

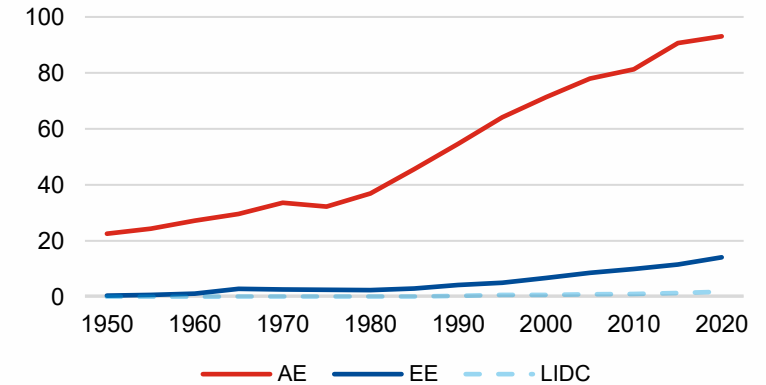
Technology Adoption

- Geometric mean of 4 components after they have been normalized
- Access to electricity (% of population)
 - Fixed broadband subscriptions
 - Fixed telephone subscriptions
 - Mobile cellular subscriptions
- World Development Indicators; RICYT

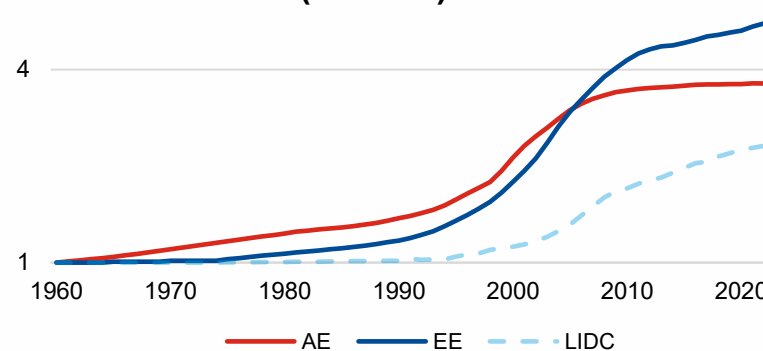
Innovation Output Growth
(1950=1)



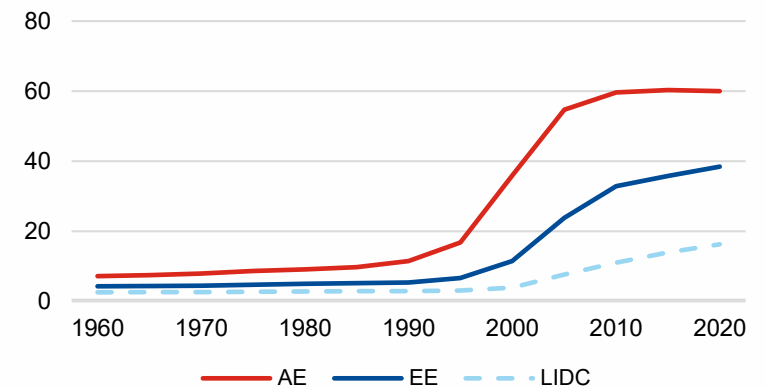
Innovation Output (per thousand population, excl. China)



Technology Adoption Growth
(1960=1)



Technology Subscriptions (per 100 people)



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- **Growth Decomposition in the Long Term**
- **“Escapers” of the Income Trap**

- Part 3

- Drivers of growth components and policy implications

Method of Growth Accounting

Output

$$Y = AK^{\alpha}L^{\beta}$$

Inputs

TFP Components

$$\log_Y_{it} = \beta_1 \log_K_{it} + \beta_2 \log_L_{it} + \beta_3 \log_KQ_{it} + \beta_4 \log_LQ_{it} + \beta_5 \log_EQ_{it} + \beta_6 \log_IO_{it} + \beta_7 \log_TA_{it} + \alpha_i + \varepsilon_{it}$$

Capital

Labor

Capital
Composition

Education
Quantity

Education
Quality

Innovation
Output

Tech
Adoption

Country
Fixed Effects

Error Term

Fix-Share Growth Accounting

Assuming $\beta_1 = 0.3$
and $\beta_2 = 0.7$

$$\Delta \log_TFP_{it} = \Delta \log_Y_{it} - 0.3 * \Delta \log_K_{it} - 0.7 * \Delta \log_L_{it}$$

$$\log_TFP_{it} = \beta_3 \log_KQ_{it} + \beta_4 \log_LQ_{it} + \beta_5 \log_EQ_{it} + \beta_6 \log_IO_{it} + \beta_7 \log_TA_{it} + \alpha_i + \varepsilon_{it}$$

	TFP, Annual	
	β	SE
Capital Composition	0.58***	0.026
Education Quantity	0.09***	0.012
Education Quality	0.46***	0.045
Innovation Output	0.04***	0.004
Technology Adoption	0.18***	0.012
Number of Observations	6350	
R-squared	0.4106	

Growth Regression

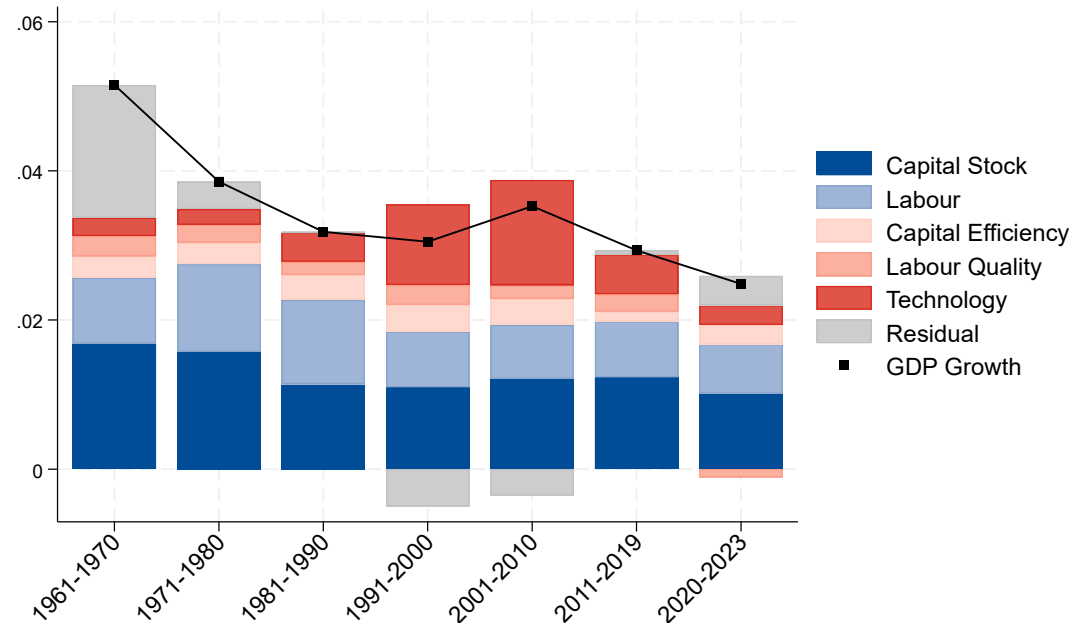
Note: ***p < .01, **p < .05, *p < .1.

	GDP, Annual		5-Year Interval	
Capital	0.56***	0.008	0.57***	0.017
Labor	0.27***	0.013	0.24***	0.027
Capital Composition	0.54***	0.024	0.52***	0.052
Education Quantity	0.09***	0.015	0.10***	0.032
Education Quality	0.44***	0.041	0.46***	0.010
Innovation Output	0.02***	0.004	0.02**	0.010
Technology Adoption	0.06***	0.011	0.05*	0.025
Number of Observations	6350		1334	
R-squared	0.9415		0.9415	

Growth Decomposition in the Long Term

Fix-Share Decomposition

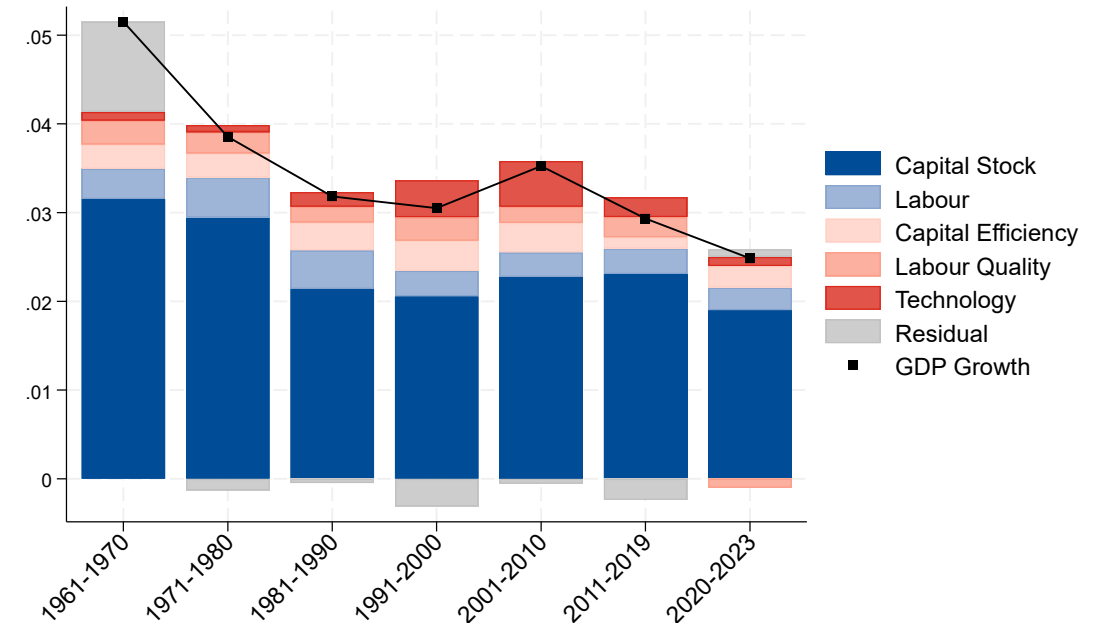
Assuming $\beta_1 = 0.3$ and $\beta_2 = 0.7$



Sources: Author's Calculation

Growth Regression Decomposition

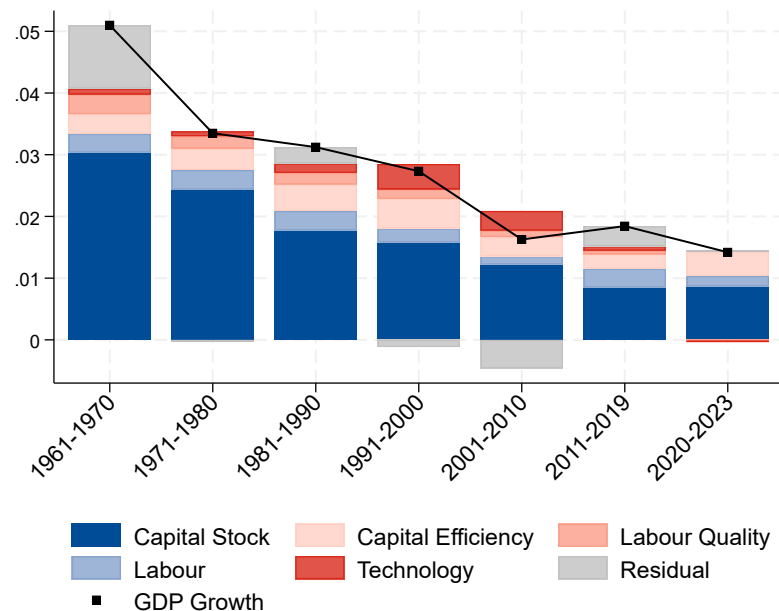
Estimating $\beta_1 - \beta_7$ in panel regression



Sources: Author's Calculation

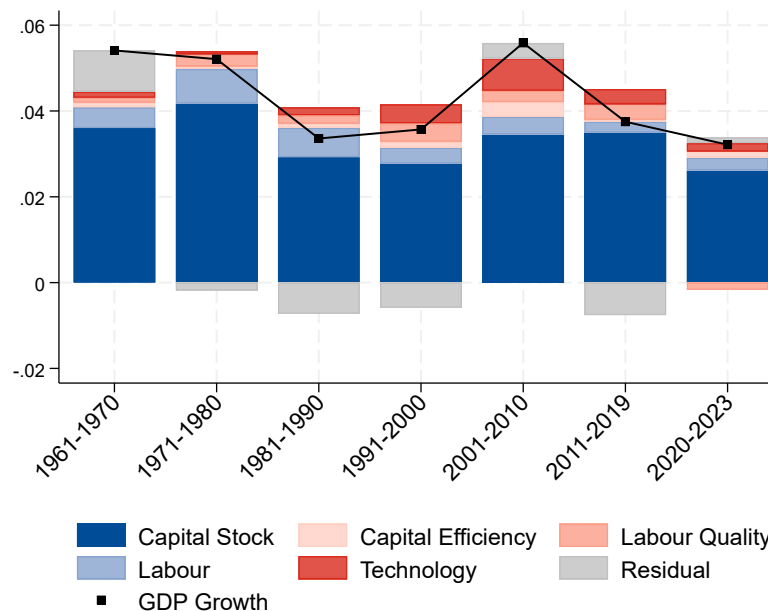
Decomposition in the Advanced Economies, Emerging Economies, and Low-Income Developing Countries

Advanced Economies



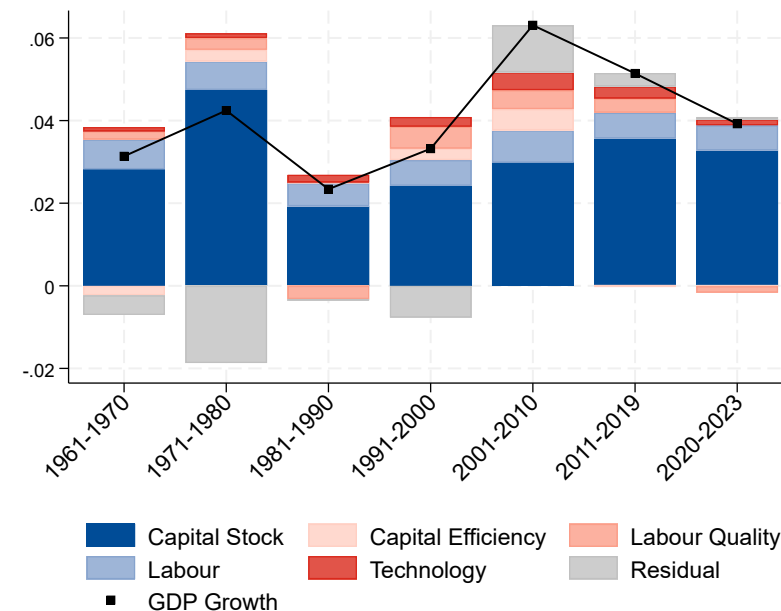
- Growth slowdown since the 1950s
- Higher capital efficiency share
- TFP share highest in the 1990s
- Slowdown in tech expansion

Emerging Economies



- Both EE and LIDC have peak GDP growth in the 2000s, driven by improved factor efficiency and technological advancement
- Either small or neglectful capital efficiency compared to AEs
- Slowing down capital stock and tech expansion

Low-Income Developing Countries



“Escapers” of the Income Trap

1950: Starting



2023: Ending



International per capita levels of industrialization index from Bairoch (1982), UK 1900=100

Low-Income Trap

Middle-Income Trap

	Low-Income Trap			Middle-Income Trap		
	GDP per capita < 7,000 (2017US\$)			GDP per capita >= 7,000 (2017US\$)		
				Industrialization Index<100	Industrialization index>=100	
	LIDC	EE	AE	EE	AE	AE
	Group1	Group2	Group3	Group4	Group5	Group6
Capital	2.2%	2.5%	1.8%	3.0%	1.8%	1.8%
Labor	0.7%	0.5%	0.3%	1.0%	0.3%	0.3%
Capital Efficiency	0.0%	0.1%	0.4%	-0.1%	0.2%	0.3%
Labor Quality	0.2%	0.2%	0.3%	0.1%	0.3%	0.1%
Technology	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%
Residual	0.1%	0.4%	1.2%	-0.3%	0.3%	0.3%
GDP	3.4%	3.9%	4.2%	3.9%	3.0%	2.9%
GDP/capita	1.0%	2.3%	3.3%	0.6%	2.5%	2.0%

“Escapers” of the Income Trap

1950: Starting



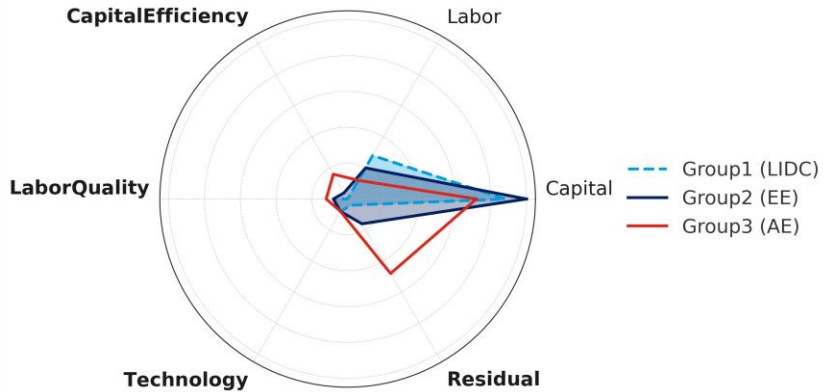
2023: Ending



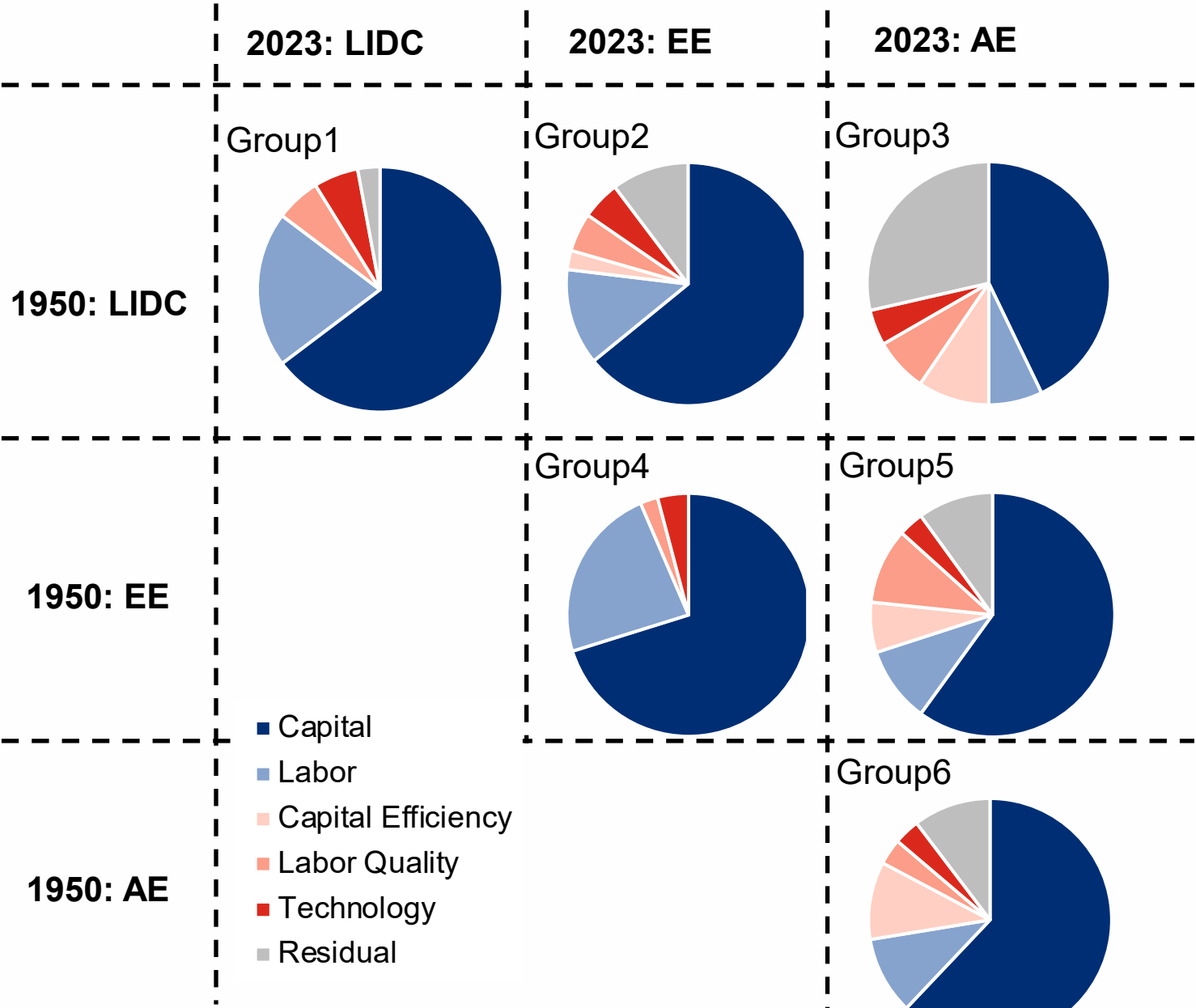
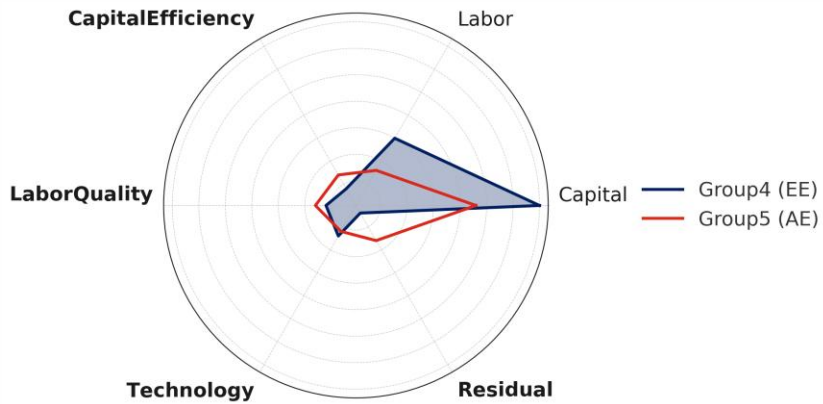
AEs are having
very different
patterns

		Low-Income Trap			Middle-Income Trap		
		GDP per capita < 7,000 (2017US\$)			GDP per capita >= 7,000 (2017US\$)		
					Industrialization Index<100	Industrialization index>=100	
		LIDC	EE	AE	EE	AE	AE
		Group1	Group2	Group3	Group4	Group5	Group6
Capital		2.2%	2.5%	1.8%	3.0%	1.8%	1.8%
Labor		0.7%	0.5%	0.3%	1.0%	0.3%	0.3%
TFP Components		0.5%	0.9%	2.1%	0.0%	0.9%	0.8%
GDP		3.4%	3.9%	4.2%	3.9%	3.0%	2.9%
GDP/capita		1.0%	2.3%	3.3%	0.6%	2.5%	2.0%

Escaping the “Low-Income Trap”



Escaping the “Middle-Income Trap”



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- **Part 3**

- **Drivers of growth components and policy implications**

Drivers (1-Market Openness)

Policy Indicator	Construction	Sources
Trade Openness	$TradePolicy_{i,t} = 100 * \frac{Tariff_{max} - Tariff_{i,t}}{Tariff_{max} - Tariff_{min}} - NTB_{i,t}$ <i>Tariff_{i,t}</i> represents the mean tariff rate. The max and mean values were set at 0% and 50%, respectively. If applicable, a non-tariff barriers (NTB) penalty of 5, 10, 15, or 20 percentage points is then subtracted from the base score. NTB is based on the Global Competitiveness Report survey : “In your country, tariff and non-tariff barriers significantly reduce the ability of imported goods to compete in the domestic market. 1–7 (best)”.	WTO, World Tariff Profiles; World Economic Forum, Global Competitiveness Report; Heritage Foundation, Trade Freedom; Fraser Institute, Economic Freedom Dataset, Area 4 A2 & B1; Gwartney, Lawson & Block, 1995
Capital Movement	I. Chinn-Ito Index of de jure financial openness. Composed of a series of dummy variables that “codify the tabulation of restrictions on cross-border financial transactions reported in the IMF’s Annual Report on Exchange Arrangements and Exchange Restrictions”. II. IMF reports on up to 13 types of international capital controls. Used the percentage of capital controls not levied as a share of the total number of capital controls listed.	Chinn & Ito, 2006; Menzi & Ito, 2008; IMF, Annual Report on Exchange Arrangements and Exchange Restrictions; Fraser Institute, Economic Freedom Dataset, Area 4 D1 & 2

Deep Drivers (2-Effective Regulations)

Policy Indicator	Construction	Sources
Labor Market Regulation	I. Hiring regulations and minimum wage II. Hiring and firing regulations III. Centralized collective bargaining IV. Hours regulations V. Mandated cost of worker dismissal VI. Conscription	Fraser Institute, Economic Freedom Dataset, Area 5B
Business Regulation	I. Administrative requirements II. Bureaucracy costs III. Starting a business IV. Impartial public administration V. Licensing restrictions VI. Cost of tax compliance	Fraser Institute, Economic Freedom Dataset, Area 5C
Property Rights	Using two sources, Global Competitiveness Report question: “Property rights, including over financial assets, are poorly defined and not protected by law (= 1) or are clearly defined and well protected by law (= 7)”. Second, Property Rights and Rule-Based Governance from Country Policy and Institutional Assessment data from the World Bank. For years before 2000, trend follow the Legal System and Property Rights data.	World Economic Forum, Global Competitiveness Report; Fraser Institute, Economic Freedom Dataset, Area 2 & 2C

Deep Drivers (3-Others)

Policy Indicator	Construction	Sources
Size of Government	I. Government consumption II. Transfers and subsidies III. Government investment IV. Top marginal tax rate V. State ownership of assets	Fraser Institute, Economic Freedom Dataset, Area 1
Debt/GDP Ratio	Central Government Debt as % of GDP	IMF Global Debt Database
Disasters	Disaster dummy. The aggregate data for Czechoslovakia, the former USSR, and the former Yugoslavia is employed for member countries.	EM-DAT International Disaster Database

Results

		Capital Stock		Capital Composition		Innovation Output		Technology Adoption	
		β	SE	β	SE	β	SE	β	SE
Market Openness	Trade Openness	0.15***	0.031	0.01*	0.006	0.31***	0.045	0.26***	0.017
	Capital Movement	0.68***	0.021	0.07***	0.005	0.70***	0.038	0.38***	0.013
Effective Regulations	Labor Market Regulation	0.07	0.048	0.12***	0.010	0.43***	0.079	0.20***	0.028
	Business Regulation	0.01**	0.035	0.03*	0.008	0.08**	0.056	0.07***	0.020
	Property Rights	0.16***	0.072	0.02	0.015	0.40***	0.106	-0.09	0.039
Controls	Size of Government	0.28***	0.054	-0.05*	0.012	0.07	0.103	-0.02	0.036
	Debt/GDP Ratio	0.16***	0.013	0.02*	0.003	0.16***	0.045	0.06***	0.016
	Debt/GDP Ratio squared	-0.01**	0.008	0.00	0.002	-0.02**	0.019	-0.02***	0.007
	Disasters	-0.01	0.016	-0.00	0.003	-0.01	0.003	-0.00	0.001
Number of Observations		2985		2985		2908		2956	
R-squared		0.3410		0.1566		0.2300		0.3643	

Note: ***p < .01, **p < .05, *p < .1. Standard errors are in parentheses.

Summary

- Constructed a novel and original database of growth contributors (including capital, labor, capital efficiency, labor quality, innovation and technology) for 130 countries covering for a long period 1950-2023
- The decomposition shows that major growth contributors in Low-Income Countries and Emerging Economies are capital and labor, whereas efficiency and technology are contributing significantly more to growth in the “escapers” group.
- Market openness, effective labor market regulations, business regulations, and the protection of property rights, as well as government expenditures and an appropriate level of debt, are essential for driving capital accumulation, efficiency, innovation, and technology.
- Next Steps: improved measurement of technology; other potential drivers for growth components; simulating analysis for LIDC or EE that strives to develop into a more advanced economy using different scenarios