THEORIES OF ECONOMIC GROWTH AND SOME APPLICATIONS

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Course materials at

paginaspersonales.deusto.es/ineraus/PhD.htm

For inspiration

- "Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, what, exactly? If not, what is it about the "nature of India" that makes it so? The consequences for human welfare involved in questions like this are staggering: once one starts to think about them, it is hard to think about anything else".

Robert E. Lucas Jr. (1988) "The mechanics of economic development", *Journal of Monetary Economics*, 22:3-42 (p. 5). Nobel Prize winner in Economics 1995.

For inspiration

- "Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker."

  Paul Krugman (1994; p. 9), *The Age of Diminishing Expectations.* Nobel Prize winner in Economics 2008.

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   - Financial globalization/Openness
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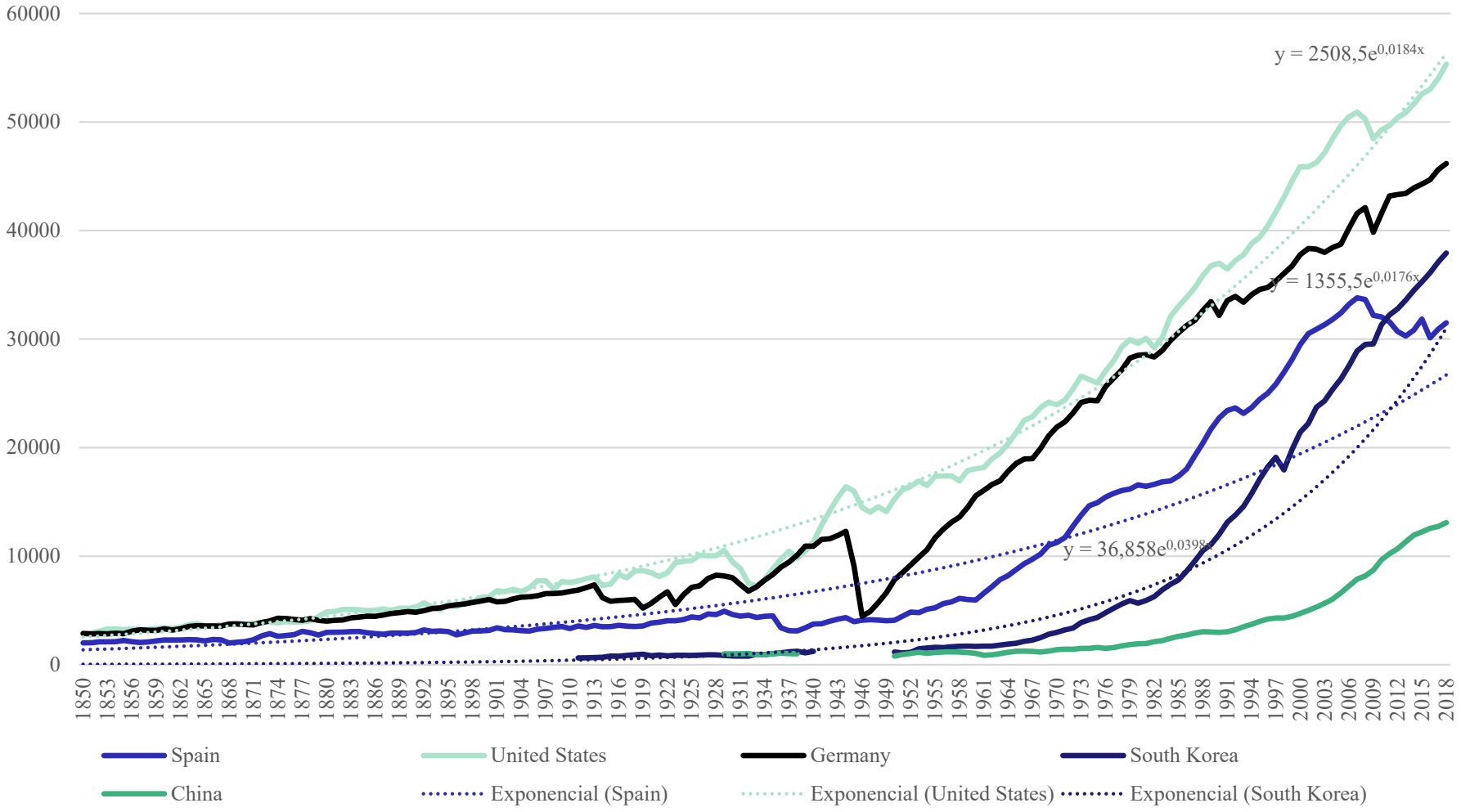
1. INTRODUCTION

INTRODUCTION

- Economic growth is a fundamental branch of (macro)economics.
- It focuses on the long-run trend performance of GDP growth (as opposed to business cycles).
- The literature is vast, intuitively quite simple, but mathematically very demanding.

Real GDP per capita, 1850-2018

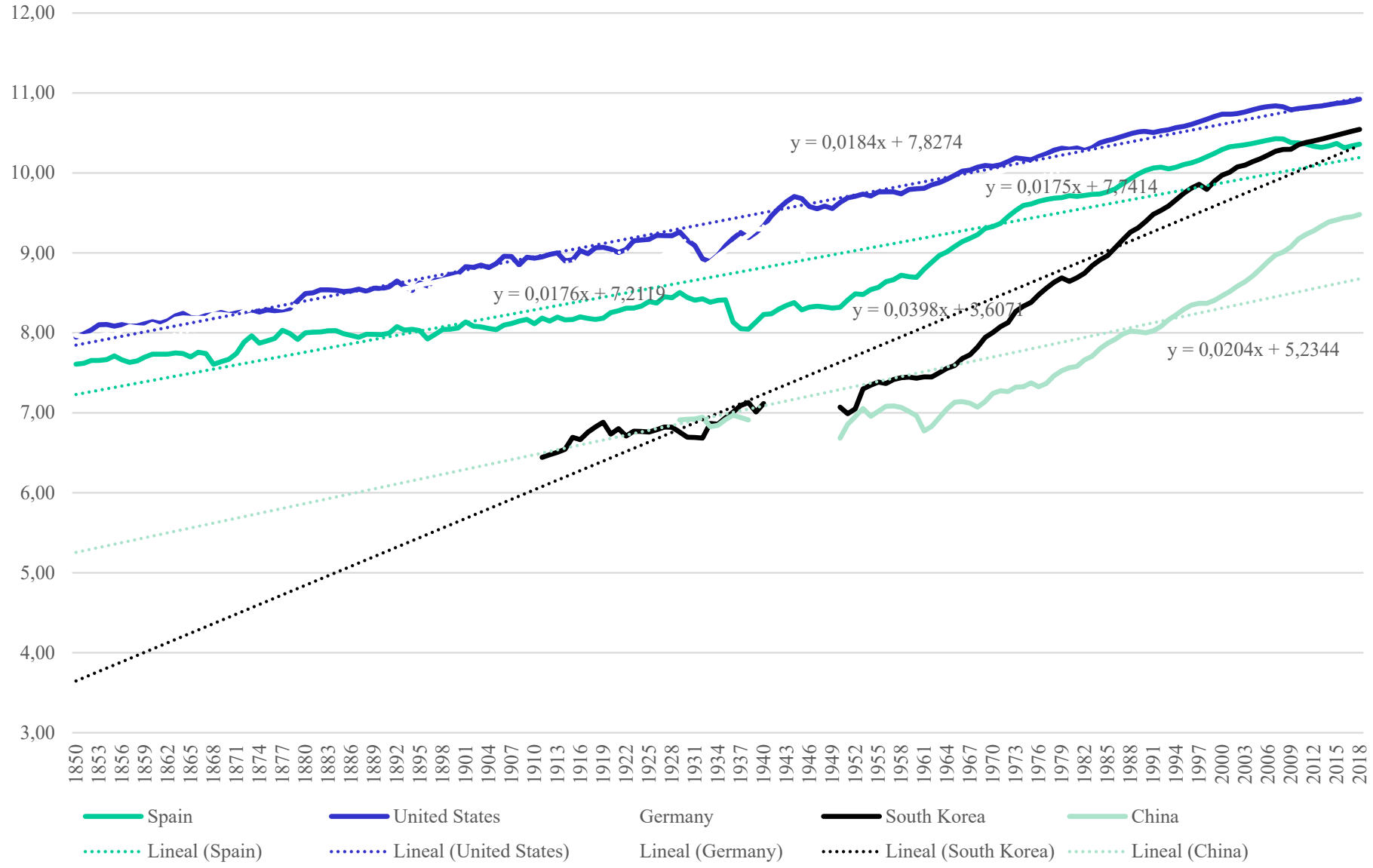
Figure. Real GDP per capita in $2011, 1850-2018



Source: Angus Maddison Project Database 2021.

Real GDP per capita, 1850-2018

Figure. GDP per capita in $2011 in logs, 1850-2018



Source: Angus Maddison Project Database 2021.

2. SOME MOTIVATION AND FACTS

Angus Maddison 1926-2010

Angus Maddison 1926 - 2010

Angus Maddison was a world scholar on quantitative macroeconomic history, including the measurement and analysis development. He was professor at the University of Groningen from 1978 to 1997, and a founder of the Groningen Gro Center.
This website provides access to major parts of Angus' work as well as to new work that is being conducted in his spirit.

' Original Homepage Angus Maddison'– this page was kept up to date until Angus passed away in April 2010. It pro writings and data series.

'The Maddison Project' – in March 2010, was launched by a group of close colleagues of Angus Maddison, with the a effective way of cooperation between scholars to continue Maddison's work on measuring economic performance fo periods and subtopics.

'Memorial Conference for Angus Maddison', 6-7 November, Amsterdam – about 70 close colleagues, friends and fami Amsterdam to celebrate Angus' work and life.

In Memoriam

Angus Maddison
(1926-2010)

Emeritus Professor

Faculty of Economics

University of Groningen

This is the last version of the Angus Maddison homepage, last updated on March 2010. Further information can be found on the Maddison-Project Website

TABLE OF CONTENTS

Personal information

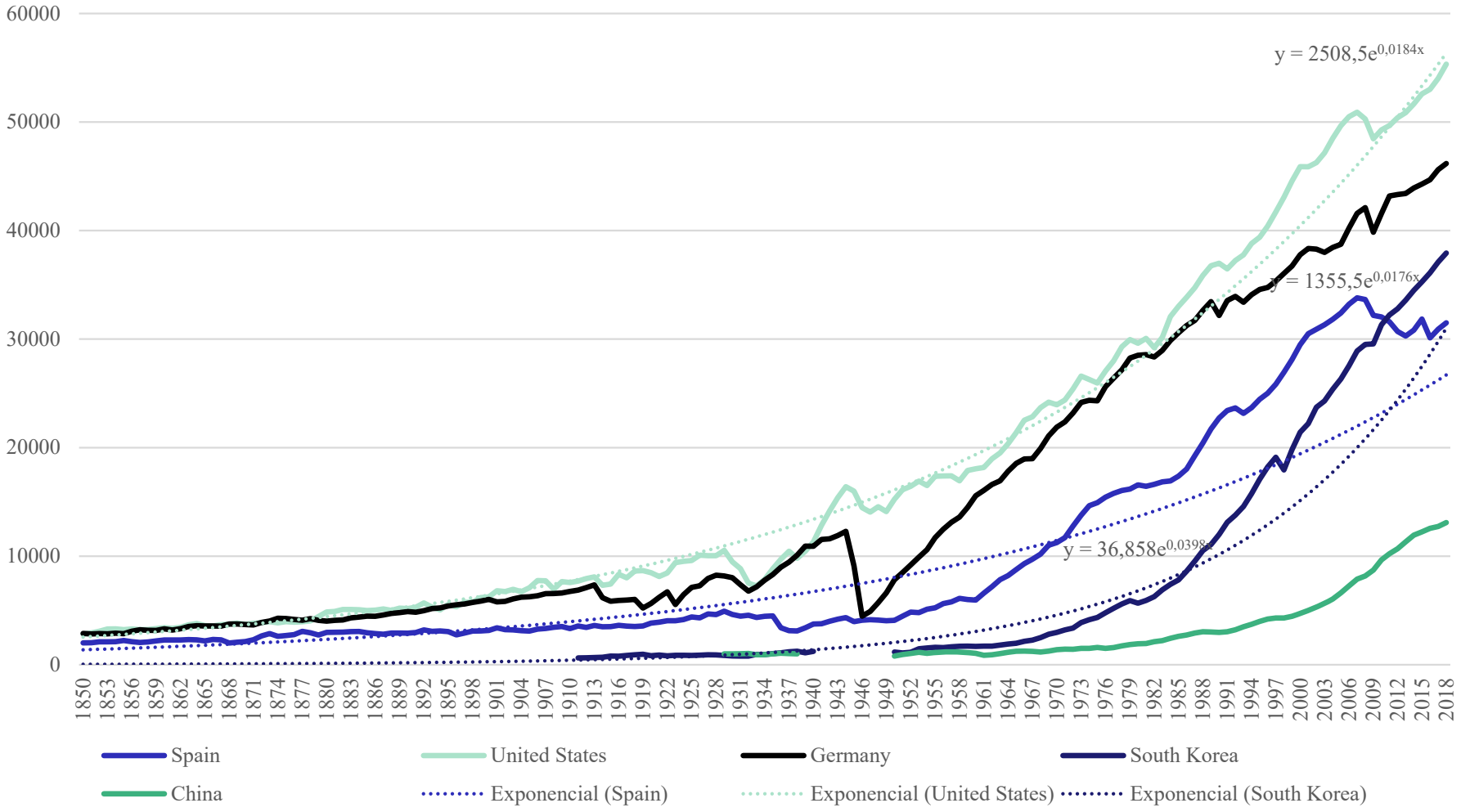
New Books:(1) Contours of the world Economy, 1-2030 AD; Essays in Macroeconomic History, Oxford University Press, September 2007
(2) Chinese Economic Performance in the Long Run, 960-2030, OECD, Paris, October 2007
Royal Decoration, October 2006
Honorary Doctorate, Hitotsubashi University, Japan, October, 2007

For discussion

- Please look at the data provided by Maddison historical statistics.
  - https://www.rug.nl/ggdc/historicaldevelopment/maddison/
  - Angus Maddison died in 2010.
- Which are the main trends shown by the data?
- Please note "The rule of 70": a country growing at a g rate on a per capita basis, will double GDP per capita in $70/g$ years.
  - This is true for any variable and magnitude, of course.

Real GDP per capita, 1850-2018

Figure. Real GDP per capita in $2011, 1850-2018



Source: Angus Maddison Project Database 2021.

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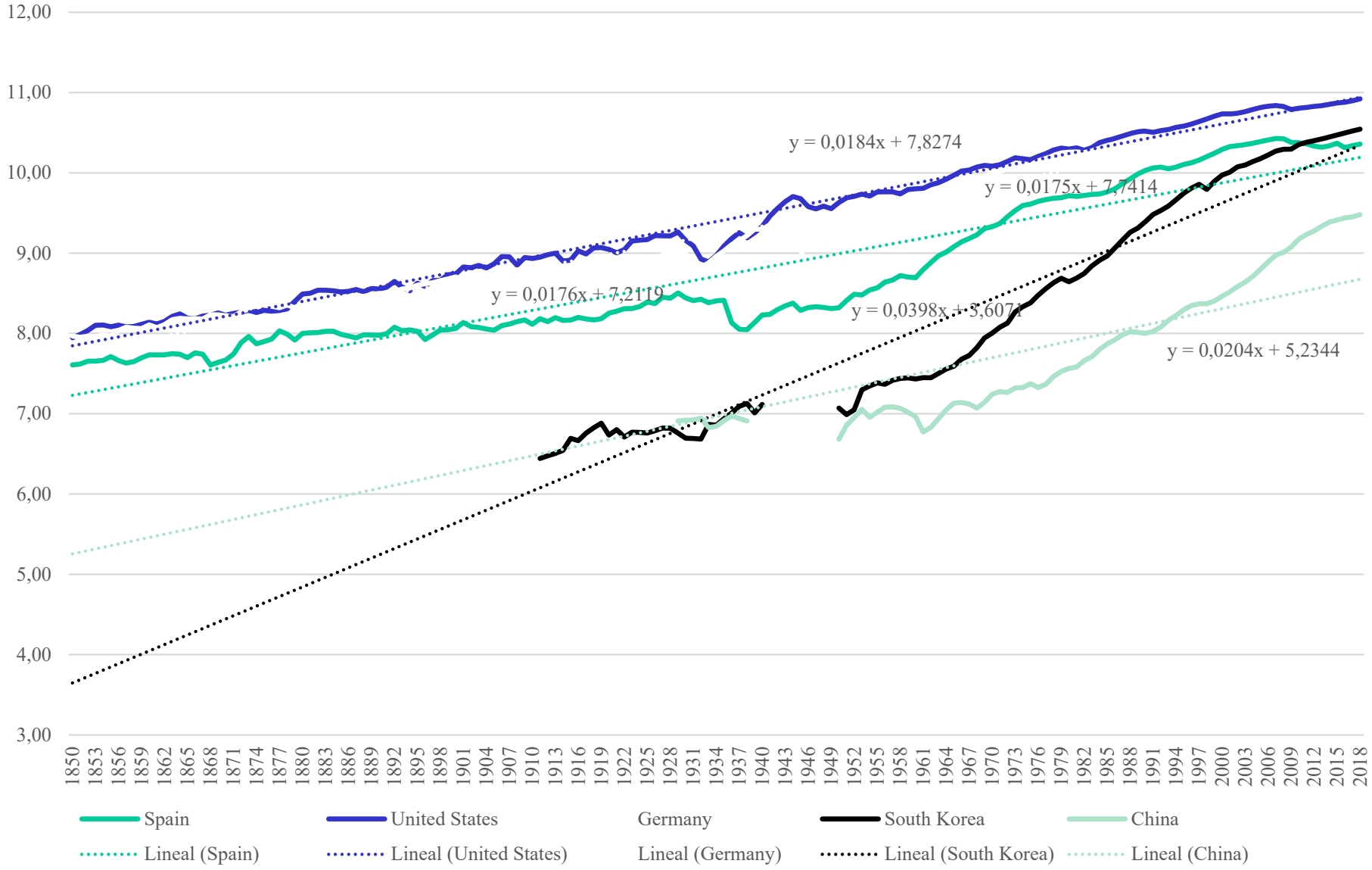


Source: Angus Maddison Project Database 2021.

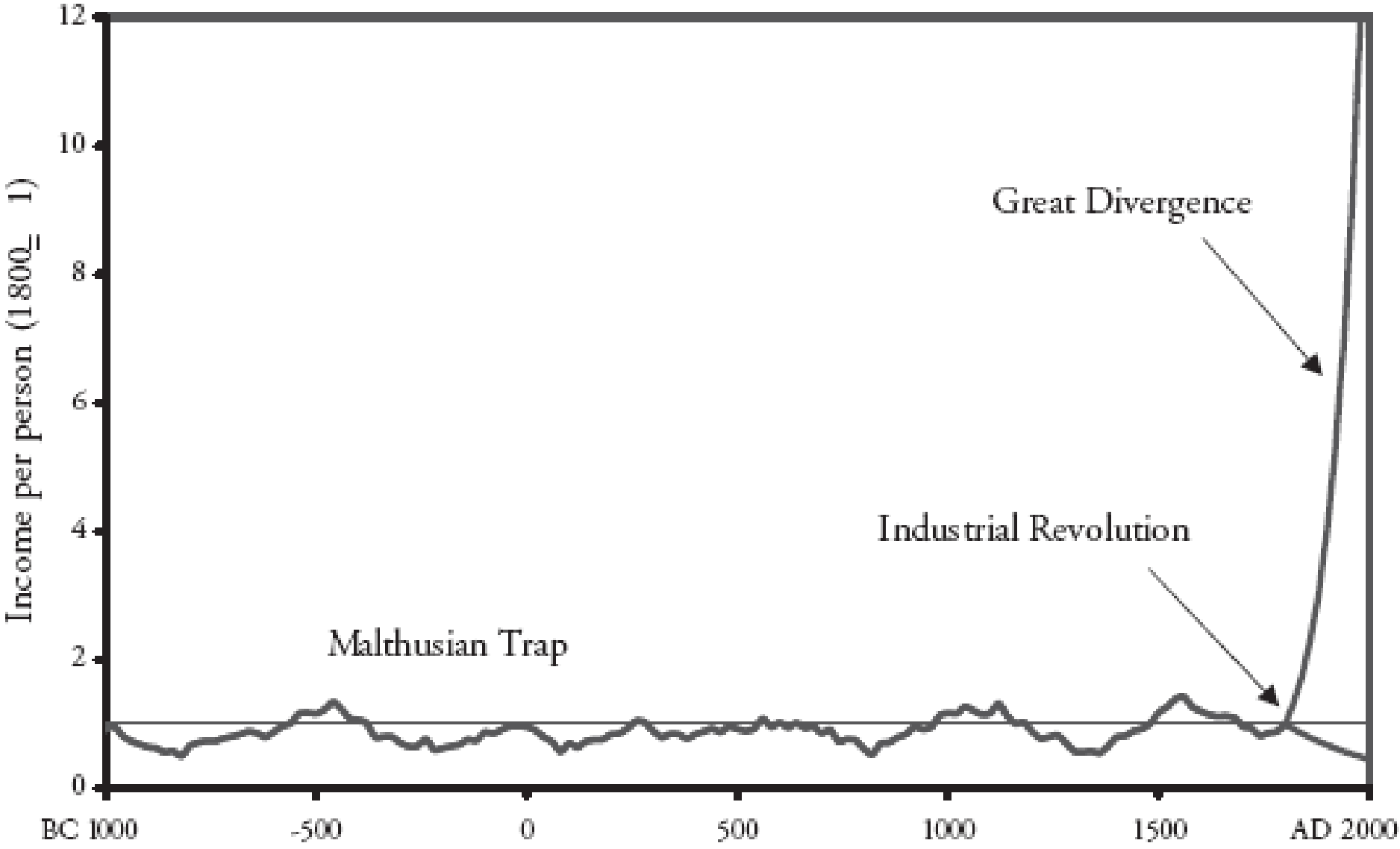


Figure 1.1 World economic history in one picture. Incomes rose sharply in many countries after 1800 but declined in others.

Source: Clark, Gregory (2008). *A farewell to alms. A brief economic history of the world*. Princeton University Press.

Important sources of data

- OECD: http://www.oecd.org/
- IMF: http://www.imf.org/
- World Bank: http://www.worldbank.org/
- Eurostat: ec.europa.eu/eurostat
- National Statistical Offices.
  - For instance, Instituto Nacional de España (INE) for Spain: http://www.ine.es/

Important sources of data

- Central Banks.
  - For instance, European Central Bank: www.ecb.int
- EUKLEMS growth and productivity accounts: http://www.euklems.net/
  - WorldKLEMS: http://www.worldklems.net/

Important sources of data

- Penn World Table: https://www.rug.nl/ggdc/productivity/pwt/?lang=en
- The Conference Board: http://www.conference-board.org/

Motivation

- OECD November 2012: “Looking to 2060: Long term global growth prospects?”
  - Main Paper: http://www.oecd-ilibrary.org/economics/looking-to-2060-long-term-global-growth-prospects_5k8zxpjsggf0-en
  - Short paper (policy note): http://www.oecd.org/economy/economicoutlookanalysisandforecasts/2060policynote.pdf
  - Video: http://youtu.be/fnIl212tBPk
- What is your opinion, based on the data?

Motivation

- Robert J. Gordon: "Is US economic growth over? Faltering innovation confronts the six headwinds" (2012)
  - Paper: http://www.nber.org/papers/w18315
  - Shorter reference: http://www.voxeu.org/article/us-economic-growth-over
- Book: "The rise and fall of American growth: The US standard of living since the Civil War" (2016).
- "Growth pessimist"
  - What do you think about his views?

Motivation

A thought experiment helps to illustrate the fundamental importance of the inventions of IR #2 compared to the subset of IR #3 inventions that have occurred since 2002. You are required to make a choice between option A and option B. With option A you are allowed to keep 2002 electronic technology, including your Windows 98 laptop accessing Amazon, and you can keep running water and indoor toilets; but you can't use anything invented since 2002.

Option B is that you get everything invented in the past decade right up to Facebook, Twitter, and the iPad, but you have to give up running water and indoor toilets. You have to haul the water into your dwelling and carry out the waste. Even at 3am on a rainy night, your only toilet option is a wet and perhaps muddy walk to the outhouse. Which option do you choose?

Robert J. Gordon (2012)

IR #1 (1750-1830): Steam machines, railroads, …

IR #2 (1870-1970): Electricity, internal combustion engines, running water, …

IR #3 (1980-): Computers, internet, ICT, …

Motivation

Instalaciones y características de las viviendas (miles)
Fuente: Albert Carreras y Xavier Tafunell (Coords.) (2005). "Estadísticas históricas de España. Siglos XIX-XX". Fundación BBVA (p. 493)

	1950	1991
Agua corriente	2.150,0	11.659,1
Retrete	3.330,4	11.402,9
Baño o ducha	576,3	11.206,6
Energía eléctrica	5.061,7	11.696,9
Teléfono	257,6	8.827,6
Calefacción (instalación fija)	166,1	9.809,8
Refrigeración		621,6
Gas distribuido por tubería	334,7	2.576,4
Total de viviendas familiares	6.370,3	11.736,4

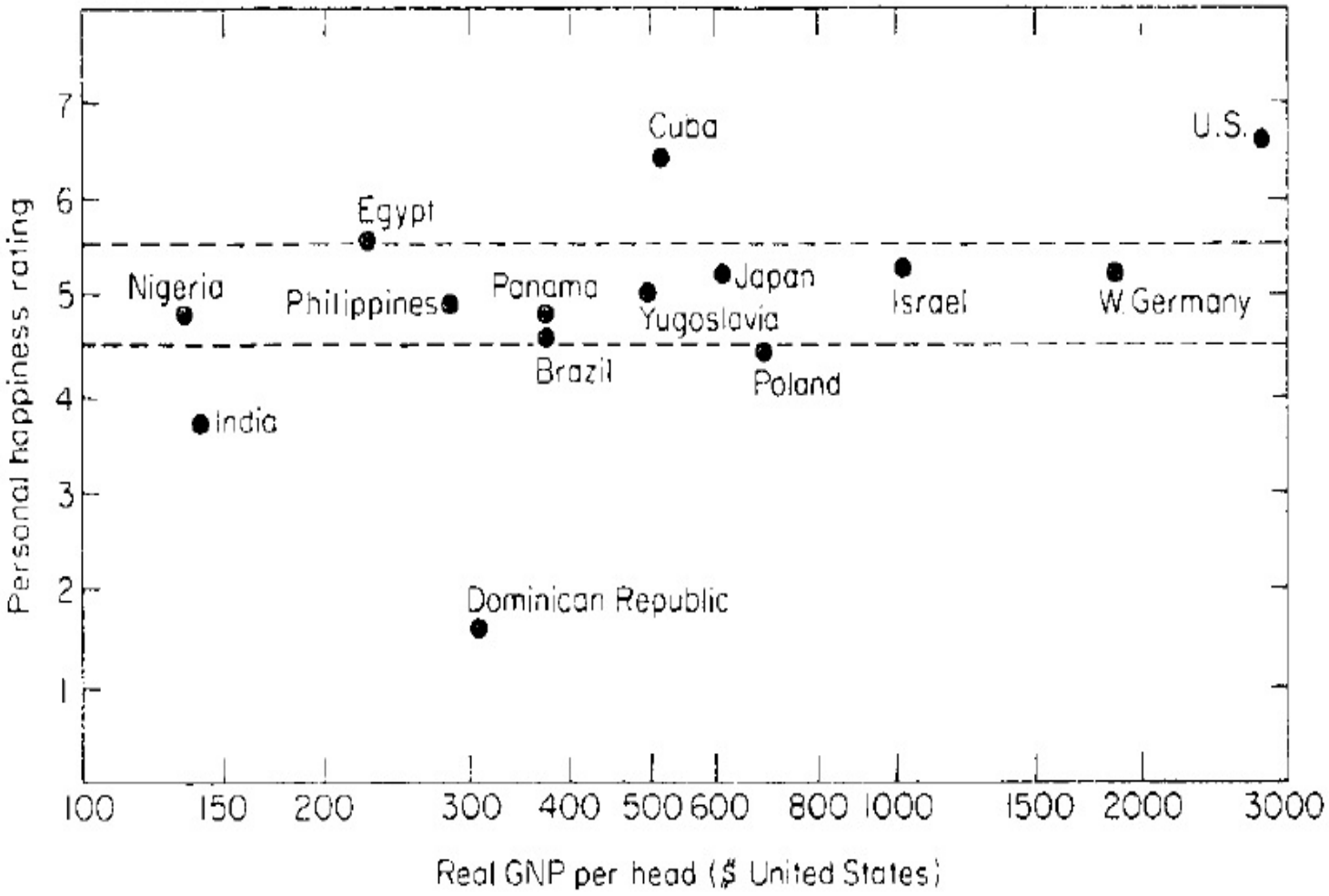
Motivation

- Peter C. Evans & Marco Annunziata (2012) “Industrial internet: Pushing the boundaries of minds and machines”
  - Paper: http://files.gereports.com/wp-content/uploads/2012/11/ge-industrial-internet-vision-paper.pdf
  - Shorter reference: http://www.voxeu.org/article/next-productivity-revolution-industrial-internet
- Erik Brynjolfsson, & Andrew McAfee (2014) “The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies”. Andrew McAfee (2019), “MORE FROM LESS: The surprising story of how we learned to prosper using fewer resources-And what happens next”
  - https://www.pairagraph.com/dialogue/9301beaf3a5b4a14868c682a36402474
- These are “growth optimists”.

Motivation

- Kenneth Rogoff: “Rethinking the growth imperative” (2012)
  - Opinion: http://www.project-syndicate.org/commentary/rogoff88/English
- Growth is “compulsory”.
- What do you think about his views?

Easterlin´s paradox



Source: Easterlin (1974). http://graphics8.nytimes.com/images/2008/04/16/business/Easterlin1974.pdf

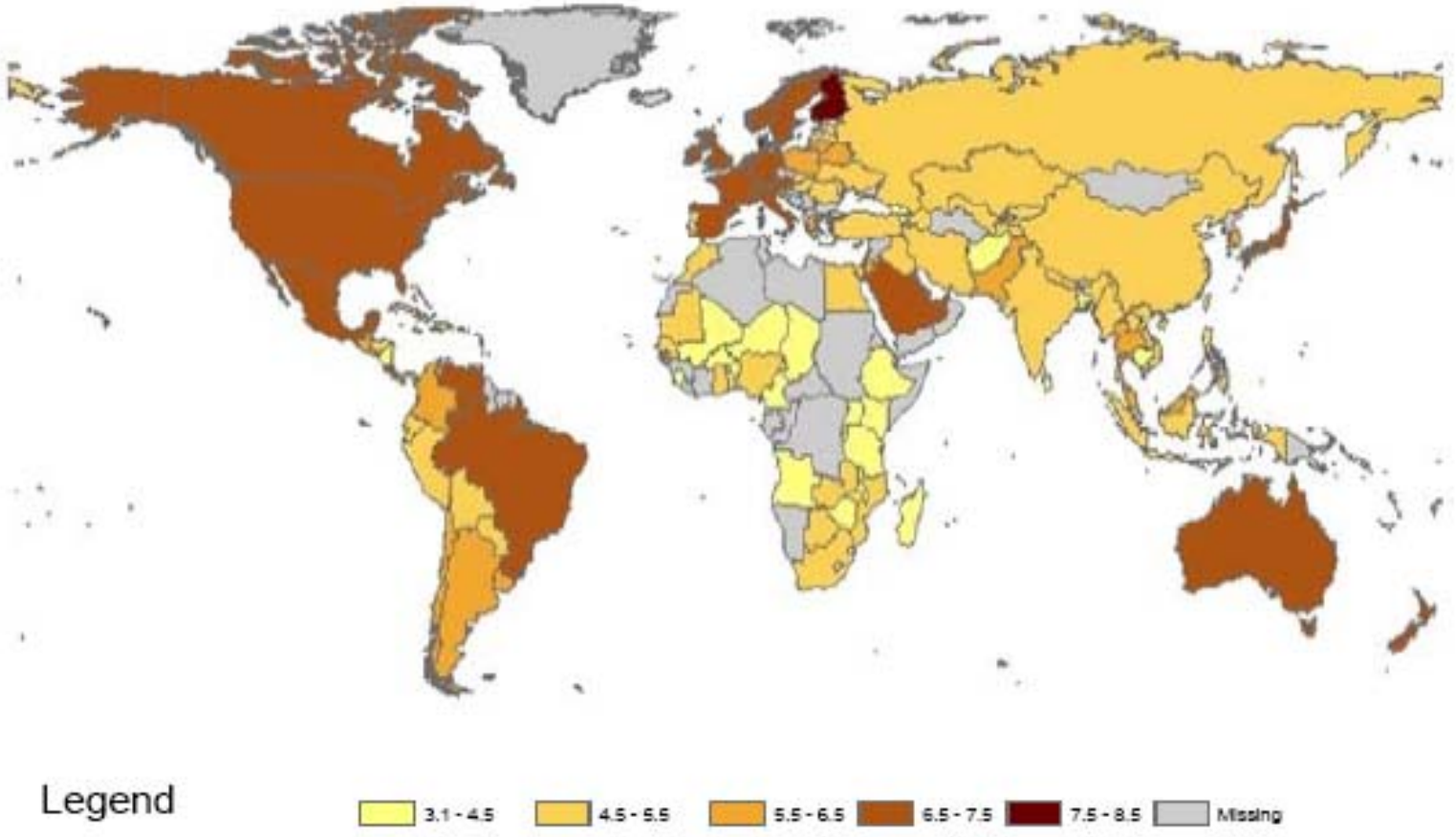


Figure 1: Life satisfaction around the world: population means of 0 to 10

Source: Deaton, Angus. "Income, aging, health, and wellbeing around the world. Evidence from the Gallup World Poll. Working paper.

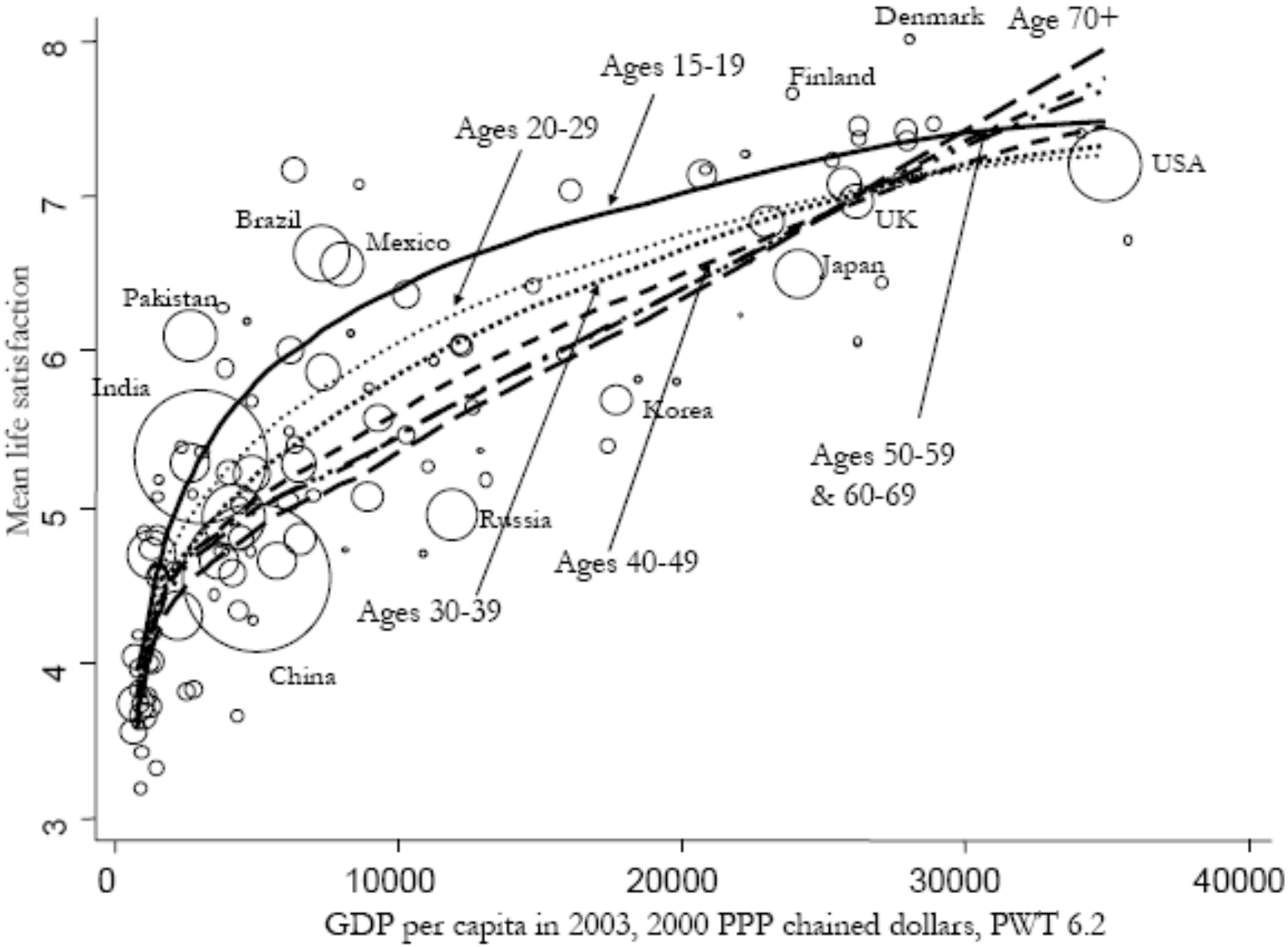
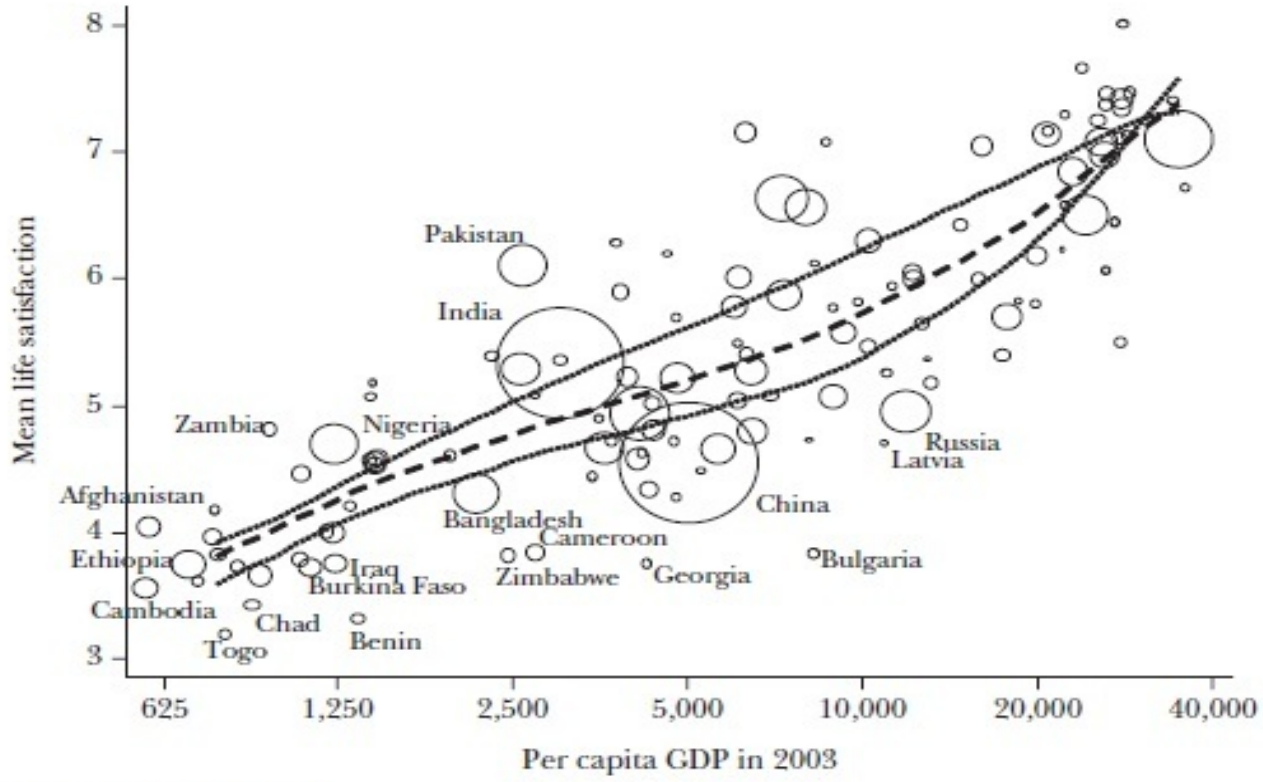


Figure 2: Life satisfaction, per capita GDP, and age

Source: Deaton, Angus. "Income, aging, health, and wellbeing around the world. Evidence from the Gallup World Poll. Working paper.

Figure 2

Each Doubling of GDP is Associated with a Constant Increase in Life Satisfaction



Source: Penn World Table 6.2.

Note: Each circle is a country, with diameter proportional to population. The scale on the x-axis is logarithmic. The middle line shows average life satisfaction for each level of per capita GDP while the outer two lines show the same thing, but for two age groups, ages 15 to 25—the upper line for most of the figure—and ages 60 and over—which is usually the lower line. GDP per capita in 2003 is measured in purchasing power parity chained dollars at 2000 prices.

Source: Deaton, Angus. "Income, aging, health, and wellbeing around the world. Evidence from the Gallup World Poll. Working paper.

Motivation

- Kenneth Arrow, Partha Dasgupta and others "Sustainability and the measurement of wealth" (2012)
  - https://www.cambridge.org/core/services/aop-cambridge-core/content/view/DF1D0473AD397311143DB1033B50A7E6/S1355770X12000137a.pdf/div-class-title-sustainability-and-the-measurement-of-wealth-div.pdf
- An empirical application.
- What do you think about their views?

Motivation

- Growth versus degrowth: “Living better with less”
  - My own paper (2012): http://paginaspersonales.deusto.es/ineraus/Files/ArticuloI%C3%B1akiErauskin_Decrecimiento_Completo.pdf
  - Kallis, Kerschner, and Martinez-Alier: “The economics of degrowth” (2012): http://www.sciencedirect.com/science/article/pii/S0921800912003333

Motivation

- Growth versus degrowth: “Living better with less”
  - Recent post by Milanovic: https://braveneweurope.com/branko-milanovic-degrowth-solving-the-impasse-by-magical-thinking .

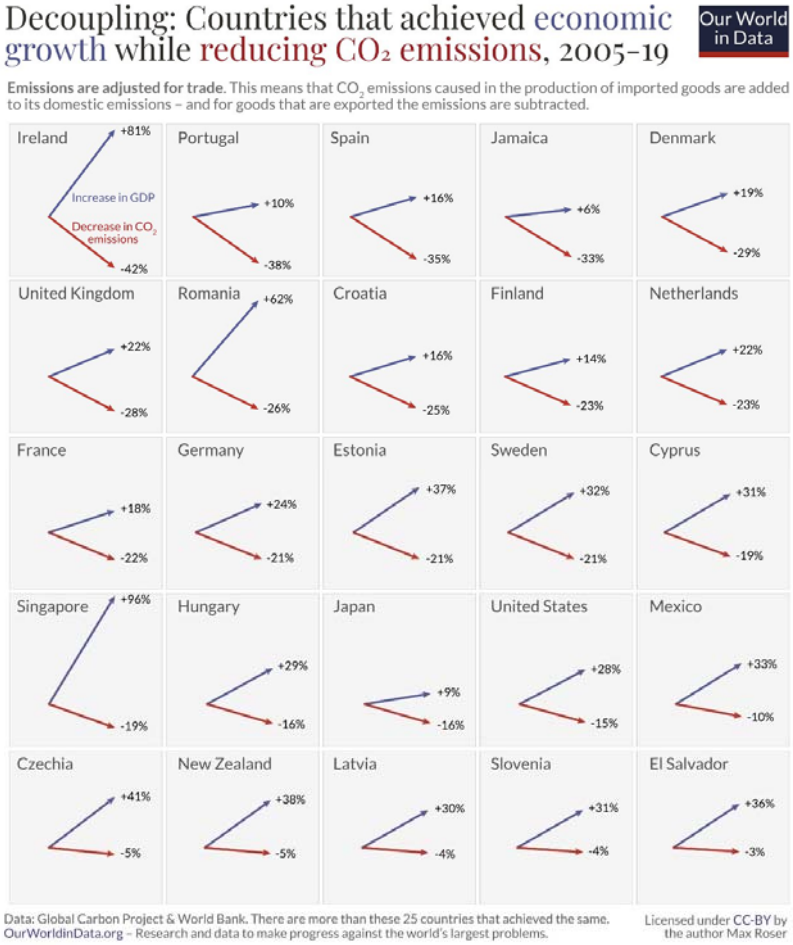
    To keep World GDP as it is:

    - Scenario A: “Freeze” today´s global income distribution so that 10-15% of the world population continue to live below absolute poverty line and 50% of world population below $PPP 7 dollars per day (around 2.500 dollars). Unacceptable.
    - Scenario B: Introduce a different distribution where everybody who is above the current mean world income ($PPP 16 dollars per day; around 6.000 dollars) is driven down to this mean and poor countries are allowed to continue growing until reaching the mean. ¿Unfeasible?

Motivation

- Future (Jesús Fernández Villaverde):
  - https://blogs.elconfidencial.com/economia/la-mano-visible/2021-10-09/el-futuro-demografico-de-la-humanidad-los-retos-economicos_3303868/
  - World population will be 9.500 million in 2050-2060 and then it will decay:
    - Less pressure for resources.
    - Decoupling: less resources for higher GDP levels. But developing world needs more resources still.

Decoupling



Source: Our world in data, Twitter-Julia K Steinberger, https://twitter.com/JKSteinberger/status/1587562407920123911

Motivation

- Future:
  - GDP will grow more slowly.
    - So far: GDP growth (3%)=Labor productivity growth (2%)+Labor growth (1%).
    - Future: GDP growth (1%)=Labor productivity growth (2%)+Labor growth (-1%).
    - But future labor productivity growth =2% (Gordon vs. others debate)?

Motivation

- ¿Is climate change compatible with growth? Transition to a carbon-free economy.
  - If no measures are taken, great impact on GDP and the environment.
  - If measures are taken:
    - Improving efficiency in the use of energy is not enough.
    - Objective: Decouple economic activity from GHG emissions. Some keys:
      - Innovation.
      - Correct externalities. Taxation.

SOME FACTS

- Some facts (there are many):
  - Differences in the level of income, and differences in the rate of income growth among countries.
  - Growth is a recent phenomenon.
  - Poverty reduction.
  - Inequality reduction, for the world as a whole.
    - But more inequality in some developed world (Milanovic, Piketty).
  - Trend in labor shares and mark-ups.
  - Climate change.

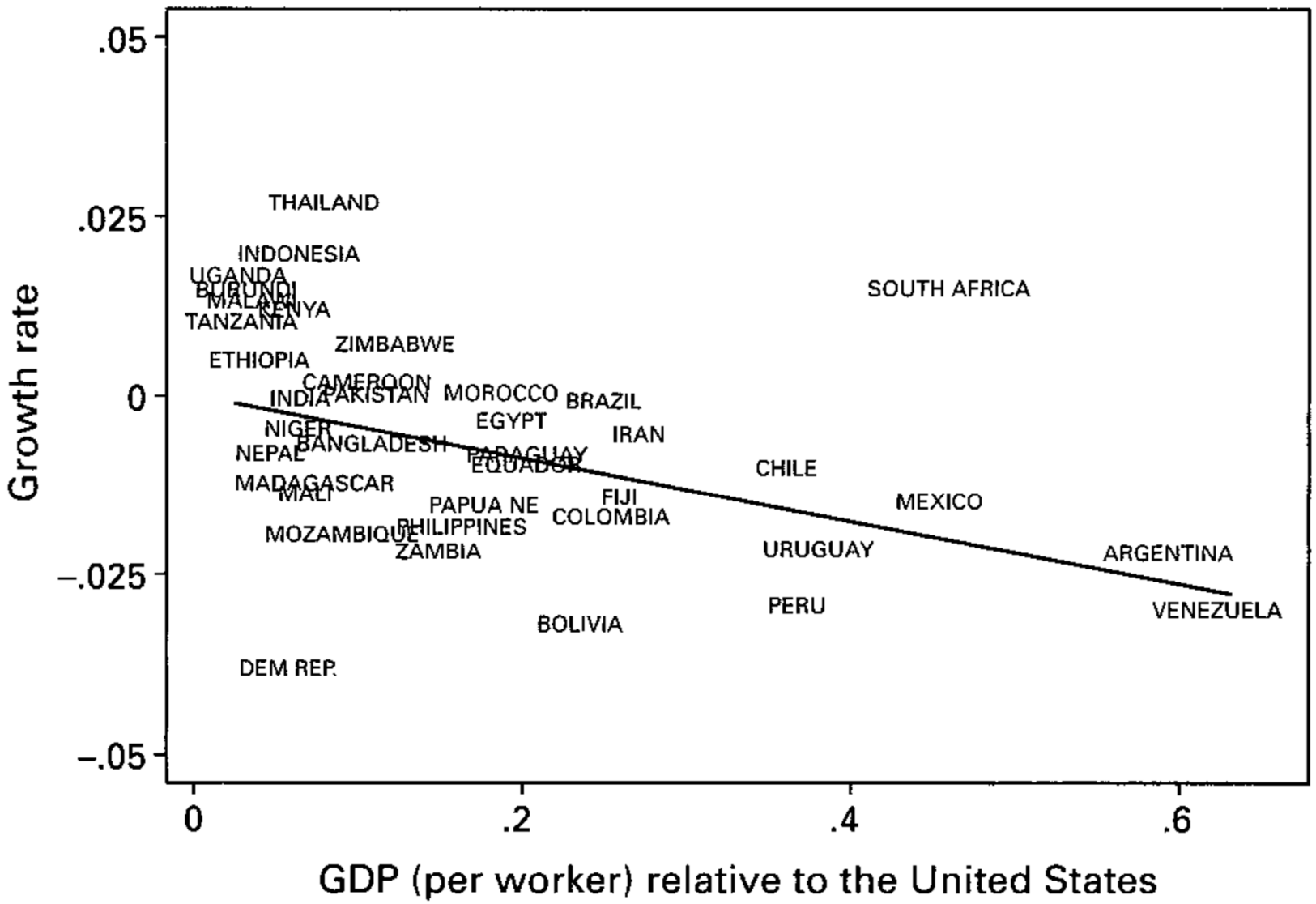


Figure I.1
Cross-country convergence

Source: Aghion, Philippe, and Peter Howitt (2009). *The economics of growth.* MIT Press.

Table I.1
Poverty Reduction in India Headcount Ratios (Percentage)

	Official Methodology			Adjusted Estimates		
	1987–88	1993–94	1999–2000	1987–88	1993–94	1999–2000
Rural	39.4	37.1	26.9	39	33	26.3
Urban	39.1	32.9	24.1	22.5	17.8	12

Official: Consumption data from Planning Commission Sample Survey
Adjusted: Consumption data from improved comparability and price indices

Table I.2
India in Cross Section: Mean of Growth Rate of Output per Worker, 1970–2000

	1970–80	1980–90	1990–2000
Mean of growth rate	0.77	3.91	3.22

Source: Aghion, Philippe, and Peter Howitt (2009). *The economics of growth.* MIT Press.

Parametric estimations of the world distribution of income

Maxim Pinkovskiy Xavier Sala-i-Martin

22 January 2010

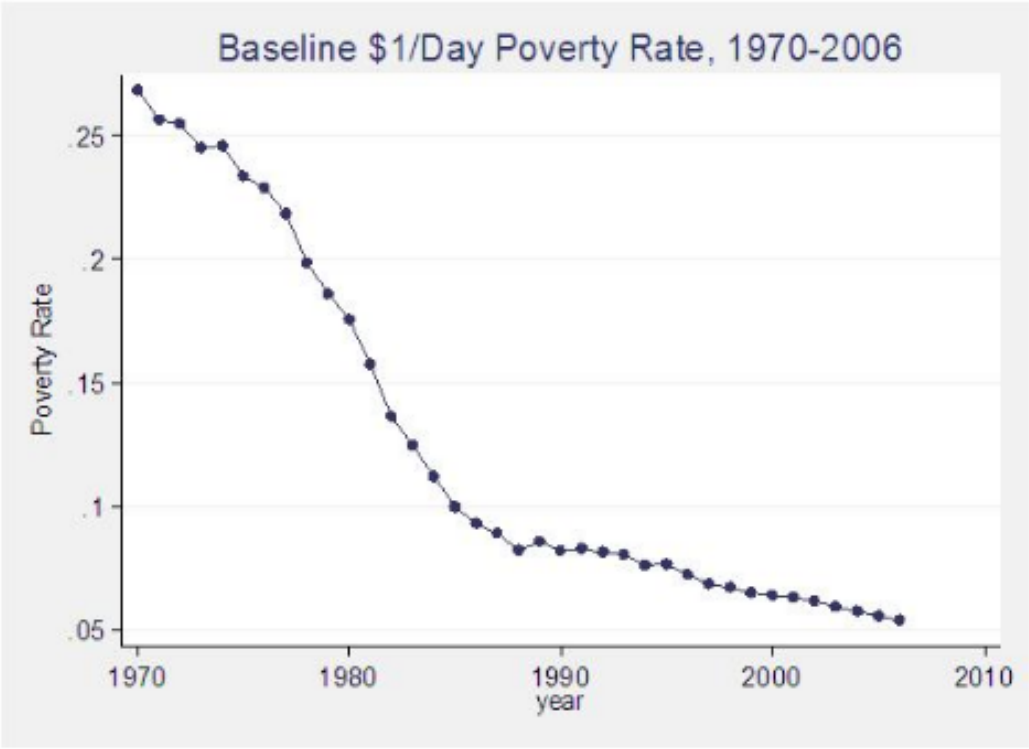
World poverty is falling. This column presents new estimates of the world's income distribution and suggests that world poverty is disappearing faster than previously thought. From 1970 to 2006, poverty fell by 86% in South Asia, 73% in Latin America, 39% in the Middle East, and 20% in Africa. Barring a catastrophe, there will never be more than a billion people in poverty in the future history of the world.

Maxim Pinkovskiy
Department of Economics,
MIT

Xavier Sala-i-Martin
Professor of Economics,
Columbia University

World poverty is falling. Between 1970 and 2006, the global poverty rate has been cut by nearly three quarters. The percentage of the world population living on less than $1 a day (in PPP-adjusted 2000 dollars) went from 26.8% in 1970 to 5.4% in 2006 (Figure 1).

Figure 1. World poverty rates



Although world population has increased by about 80% over this time (World Bank 2009), the number of people

The Developing World Is Poorer Than We Thought, But No Less Successful in the Fight against Poverty

Shaohua Chen
Martin Ravallion

Abstract

The paper presents a major overhaul to the World Bank's past estimates of global poverty, incorporating new and better data. Extreme poverty—as judged by what "poverty" means in the world's poorest countries—is found to be more pervasive than we thought. Yet the data also provide robust evidence of continually declining poverty incidence and depth since the early 1980s. For 2005 we estimate that 1.4 billion people, or one quarter of the population of the developing world, lived below our international line of $1.25 a day in 2005 prices; 25 years earlier there were 1.9 billion poor, or one half of the population. Progress was uneven across regions. The poverty rate in East Asia fell from almost 80 percent to under 20 percent over this period. By contrast it stayed at around 50 percent in Sub-Saharan Africa, though with signs of progress since the mid 1990s. Because of lags in survey data availability, these estimates do not yet reflect the sharp rise in food prices since 2005.

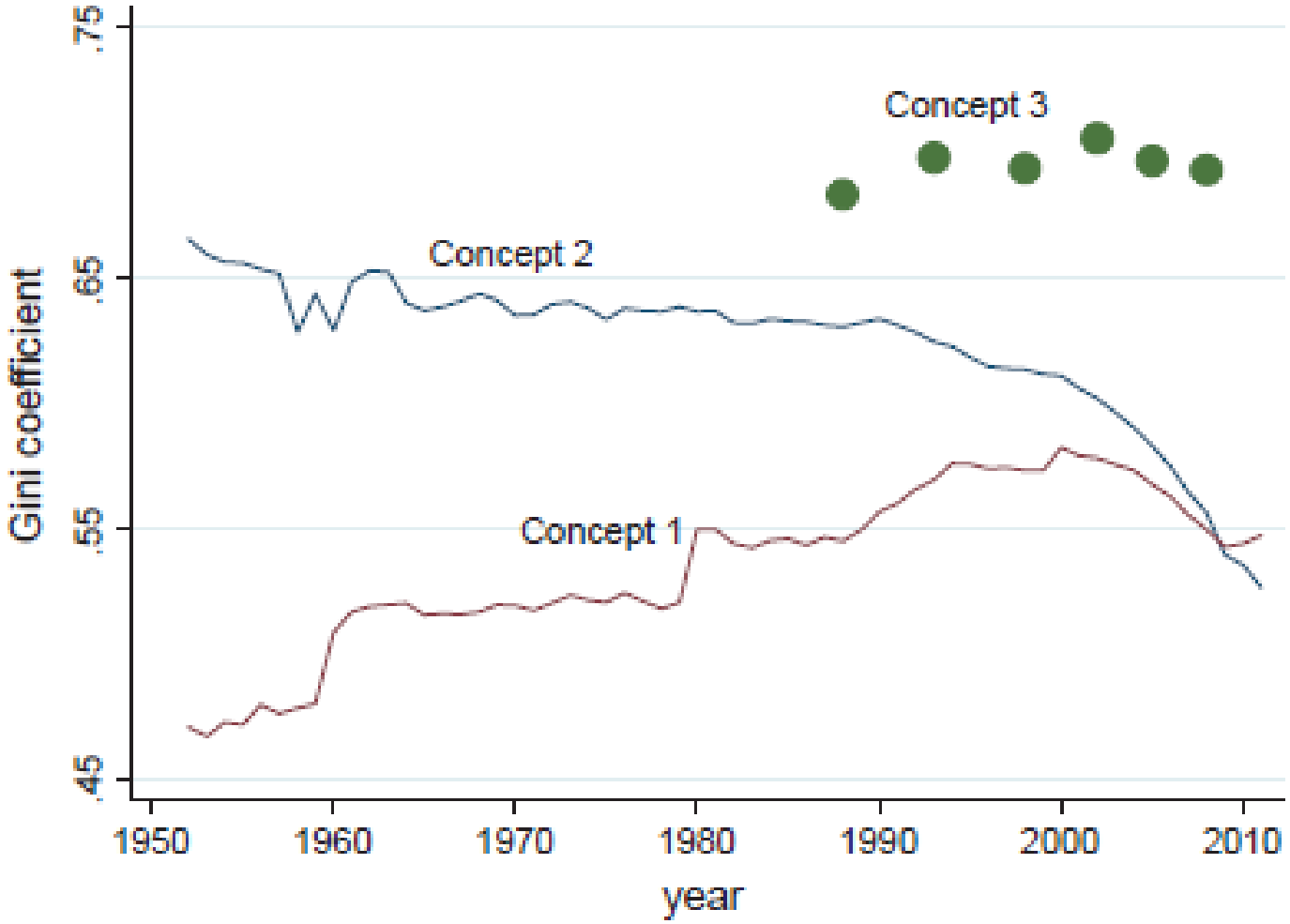
Table 7: Regional breakdown of number of poor (millions) for international poverty lines of $1.00-$2.50 a day over 1981-2005

(a) Number living below $1.00 a day

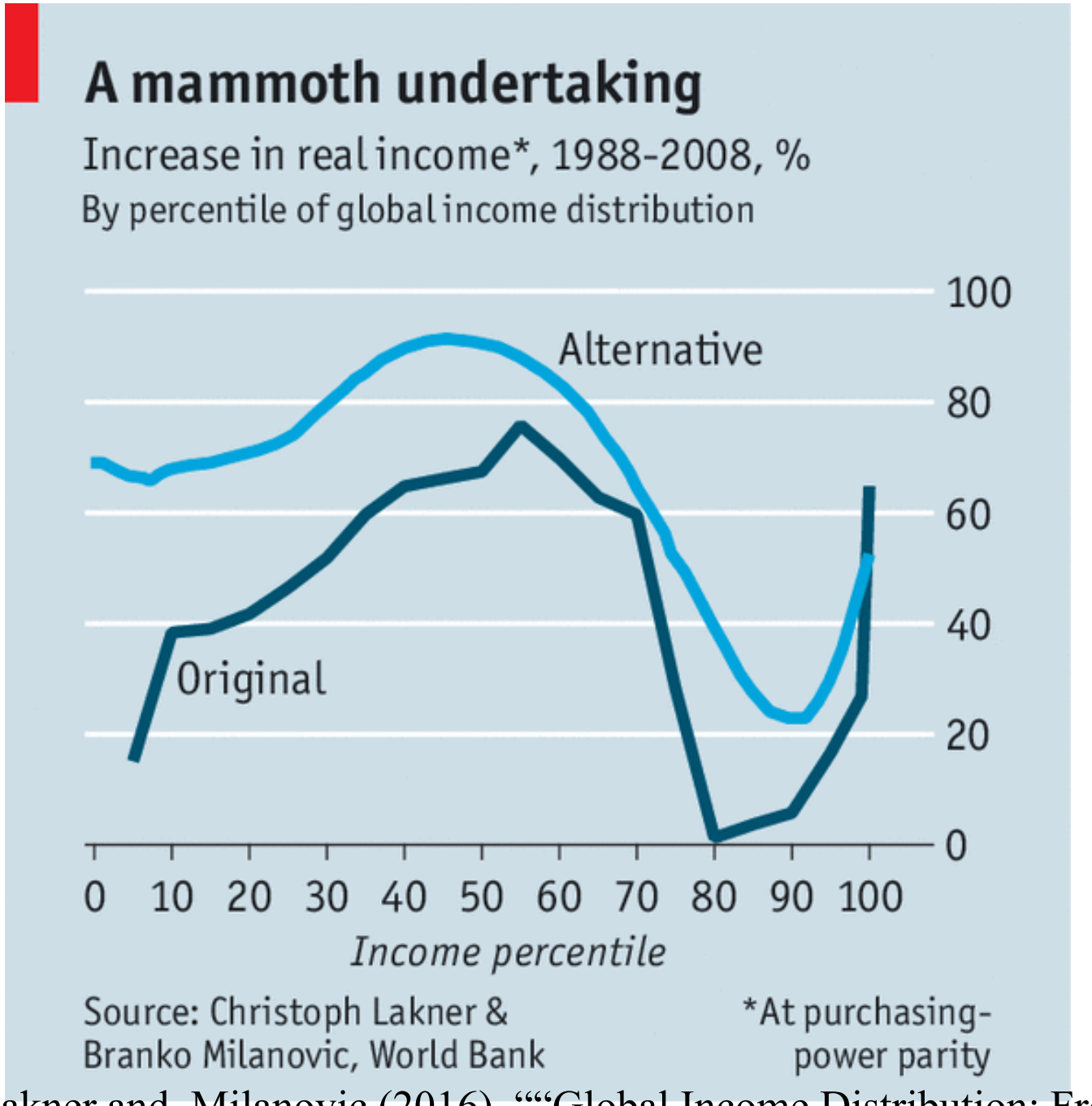
Region	1981	1984	1987	1990	1993	1996	1999	2002	2005
East Asia and Pacific	921.7	721.8	590.2	623.4	588.7	404.9	420.8	326.8	175.6
Of which China	730.4	548.5	412.4	499.1	444.4	288.7	302.4	244.7	106.1
Eastern Europe and Central Asia	3.0	2.4	2.1	4.1	10.1	11.7	14.4	12.6	10.2
Latin America and Caribbean	28.0	35.8	36.9	29.0	27.6	35.6	37.8	40.7	30.7
Middle East and North Africa	5.6	4.6	4.7	3.8	3.7	4.1	4.7	3.9	4.7
South Asia	387.3	374.3	384.4	381.2	348.8	368.0	359.5	372.5	350.5
Of which India	296.1	282.2	285.3	282.5	280.1	271.3	270.1	276.1	266.5
Sub-Saharan Africa	169.4	195.9	209.0	245.2	259.0	287.6	308.4	310.1	304.2
Total	**1515.0**	**1334.7**	**1227.2**	**1286.7**	**1237.9**	**1111.9**	**1145.6**	**1066.6**	**876.0**
(b) Number living below $1.25 a day									
East Asia and Pacific	1071.5	947.3	822.4	873.3	845.3	622.3	635.1	506.8	316.2
Of which China	835.1	719.9	585.7	683.2	632.7	442.8	446.7	363.2	207.7
Eastern Europe and Central Asia	7.1	5.7	4.8	9.1	20.1	21.8	24.3	21.7	17.3
Latin America and Caribbean	42.0	52.3	52.3	42.9	41.8	52.2	54.8	58.4	46.1
Middle East and North Africa	13.7	11.6	11.9	9.7	9.8	10.6	11.5	10.3	11.0
South Asia	548.3	547.6	569.1	579.2	559.4	594.4	588.9	615.9	595.6
Of which India	420.5	416.0	428.0	435.5	444.3	441.8	447.2	460.5	455.8
Sub-Saharan Africa	213.7	243.8	259.6	299.1	318.5	355.0	381.6	390.0	390.6
Total	**1896.2**	**1808.2**	**1720.0**	**1813.4**	**1794.9**	**1656.2**	**1696.2**	**1603.1**	**1376.7**

Source: Chen and Ravallion (2008). "The developing world is poorer than we thought, but no successful in the fight against poverty"

Figure 2. International and global inequality, 1952–2011: 'the mother of all inequality disputes'.

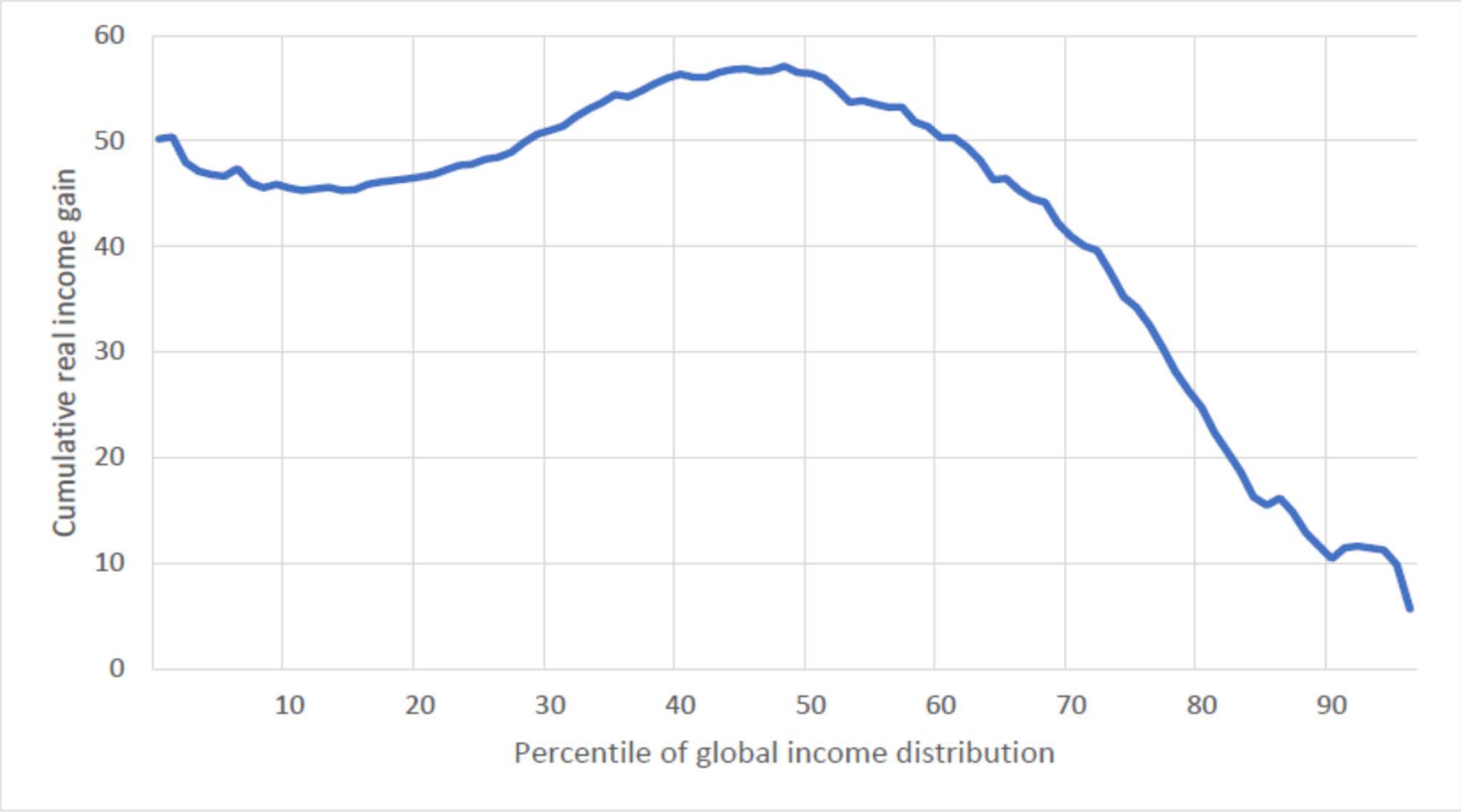


Source: Milanovic (2012). "Global income inequality by the numbers: In history and now. An overview".



Source: Lakner and Milanovic (2016). ""Global Income Distribution: From the Fall of the Berlin Wall to the Great Recession." World Bank Economic Review.

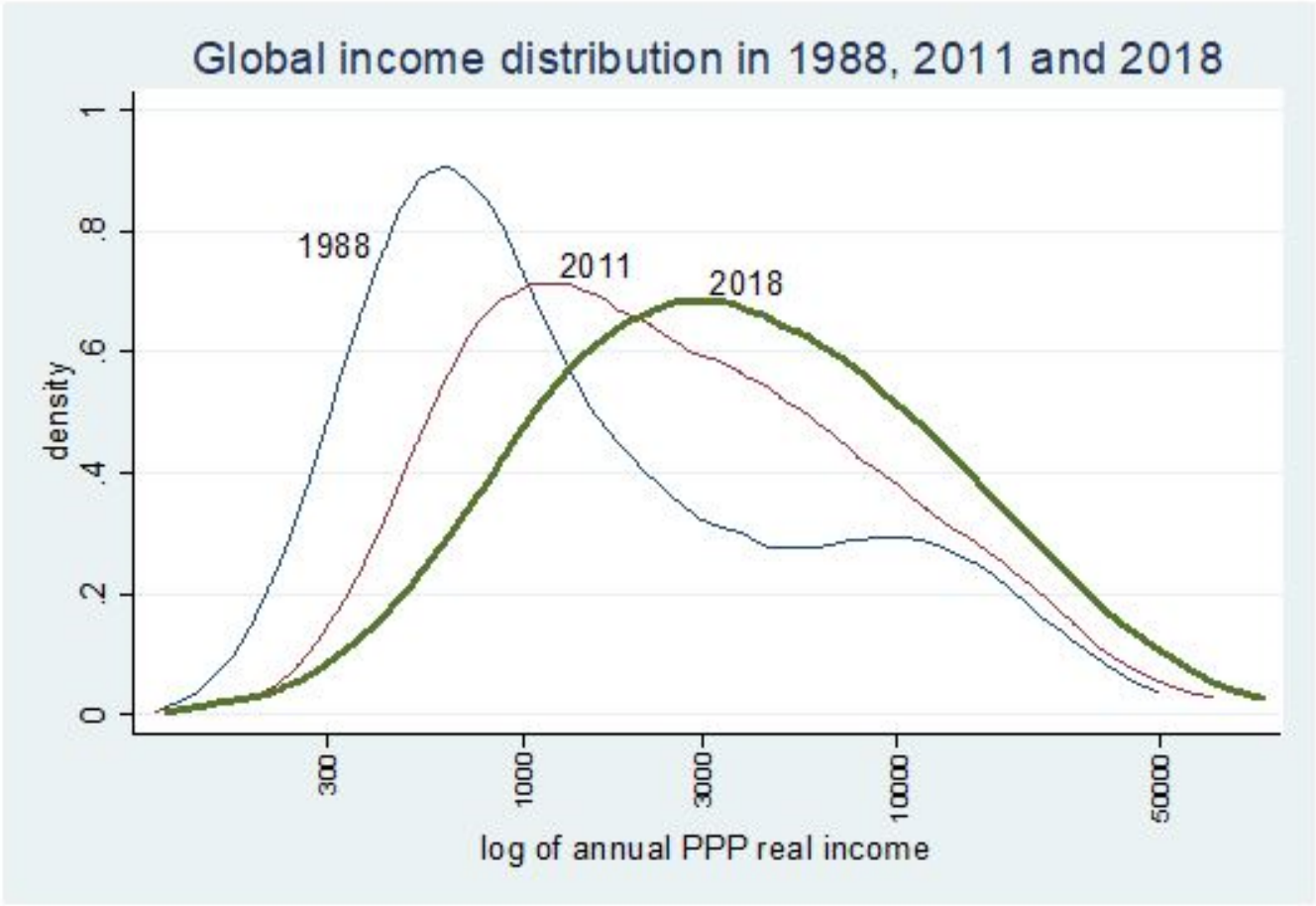
Not an elephant anymore



Source: Milanovic, B (2020), "After the crisis: the evolution of the global income distribution between 2008 and 2013", Stone Center on Socio-Economic Inequality Working Paper No. 18.

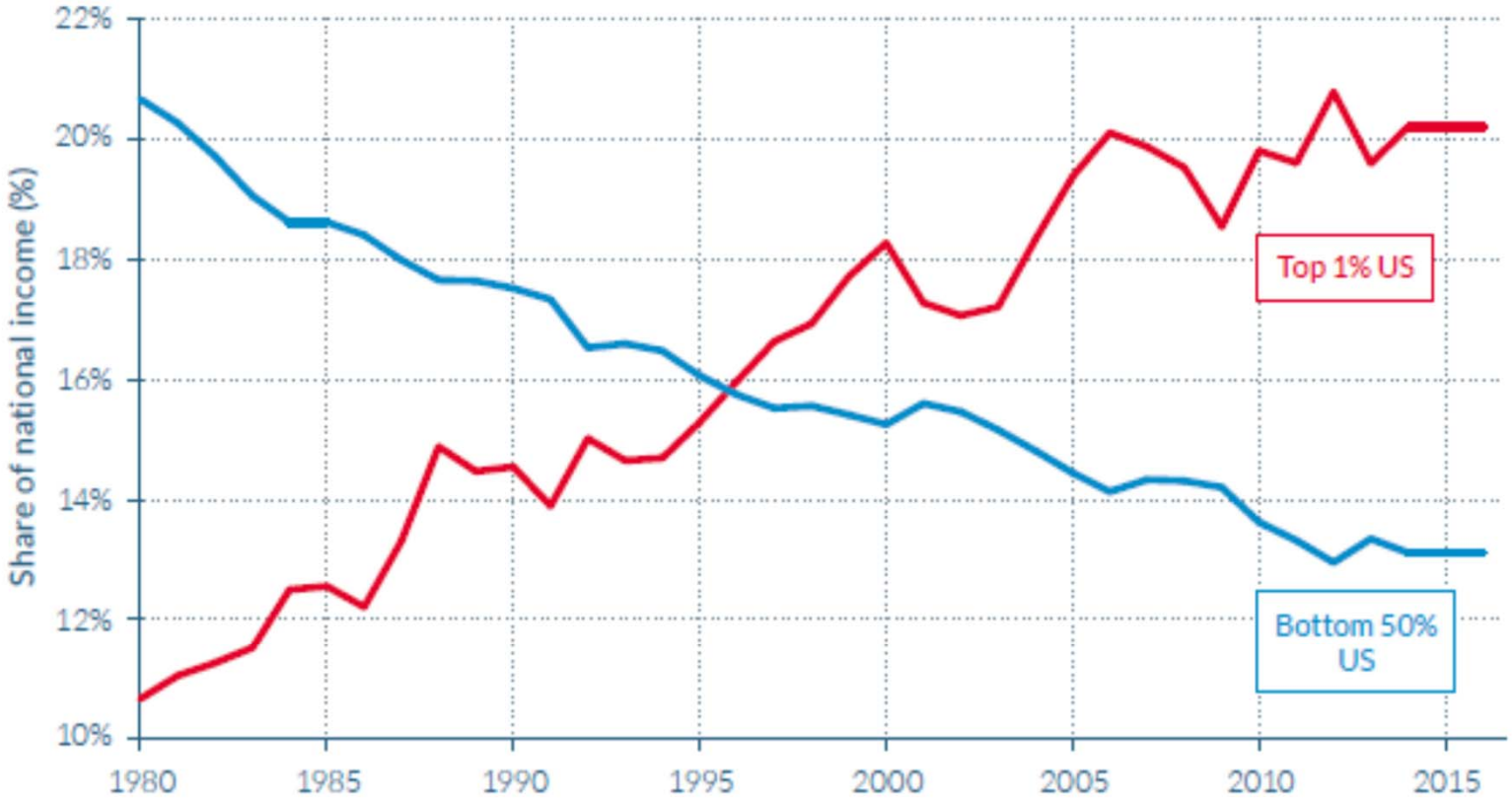
Global income distribution

The emergence of the global median or middle class



Source: Milanovic, B (2022), Twitter: https://twitter.com/BrankoMilan/status/1583990254117474304

Inequality, United States



Source: WID.world (2017). See wir2018.wid.world for data series and notes.

In 2016, 12% of national income was received by the top 1% in Western Europe, compared to 20% in the United States. In 1980, 10% of national income was received by the top 1% in Western Europe, compared to 11% in the United States.

Source: World Inequality Lab (2017). "World Inequality Report 2018".

Inequality, Western Europe

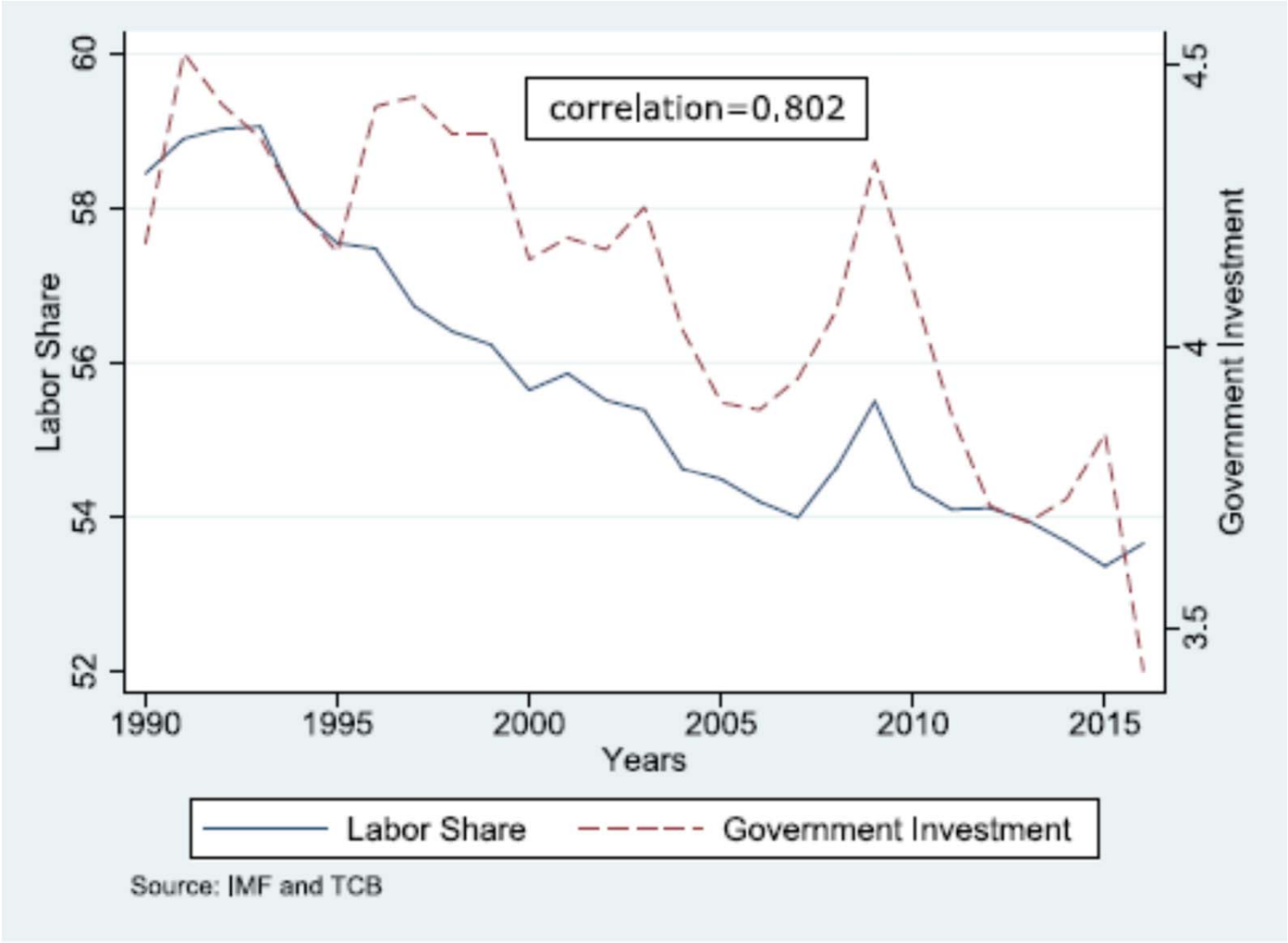
Source: World Inequality Lab (2017). "World Inequality Report 2018".

Decline in the labor share

Year	Labor share	Average Gini
1990	55.6	36.7
1995	54.3	37.5
2000	53.5	38.4
2005	51.3	38.3
2010	50.2	39.0
2015	49.9	40.1

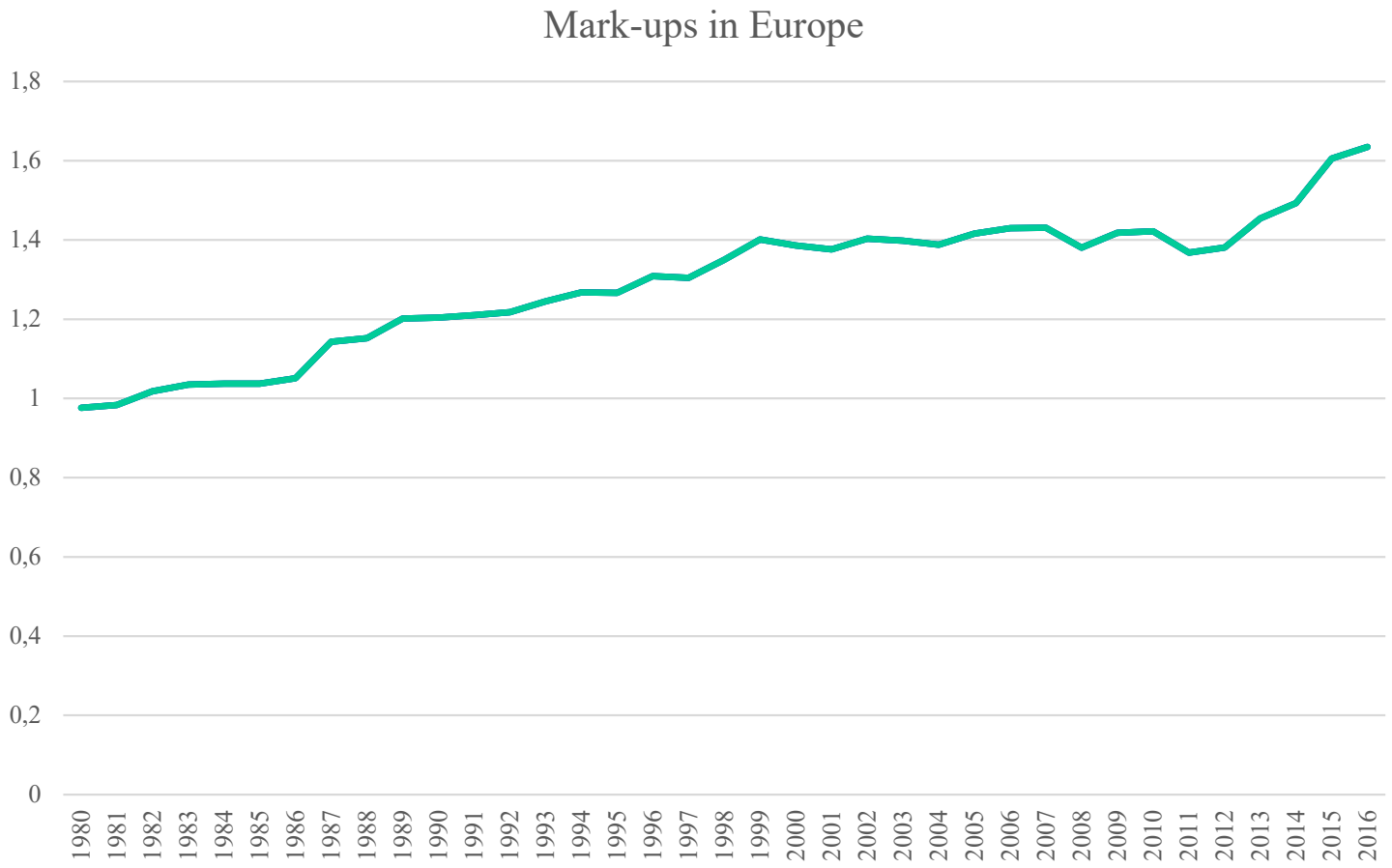
Source: Erauskin (2020). "The labor share and income inequality: some empirical evidence for the period 1990-2015", *Applied Economic Analysis*

Decline in the labor share



Source: Bom & Erauskin (2022). "Productive government investment and the labor share", *International Review of Economics and Finance.*

Increase in mark-ups

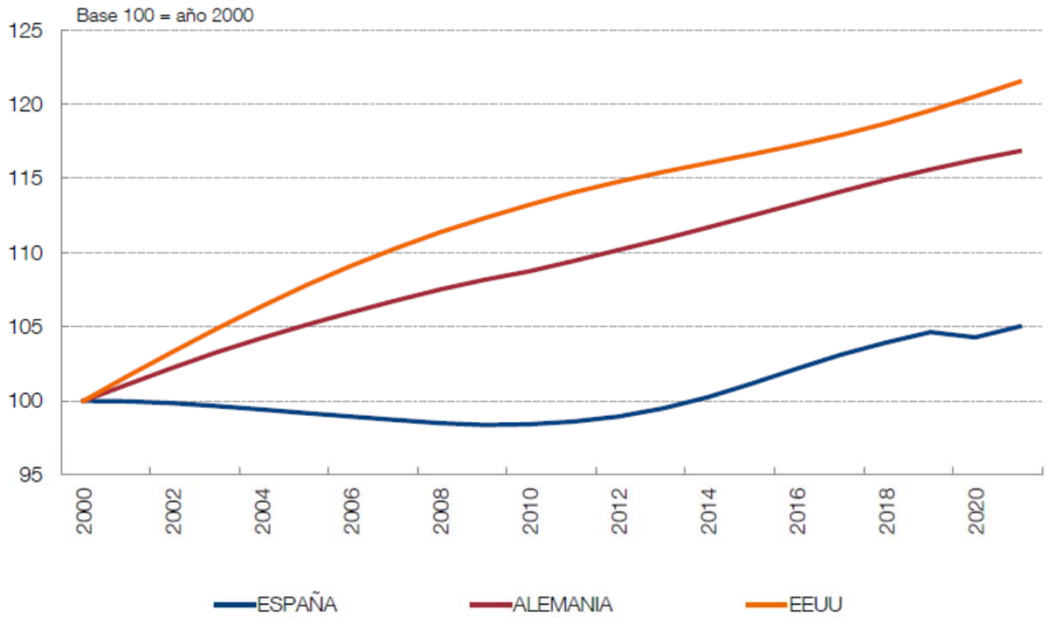


Source: Jan Eeckhout “The profit paradox” (2021).

Spain and Productivity

EN LAS DOS ÚLTIMAS DÉCADAS, LA TASA DE CRECIMIENTO DE LA PRODUCTIVIDAD EN ESPAÑA HA SIDO MUY REDUCIDA Y HA ESTADO MUY POR DEBAJO DE LA DE OTRAS ECONOMÍAS DE REFERENCIA

PRODUCTIVIDAD TOTAL DE LOS FACTORES



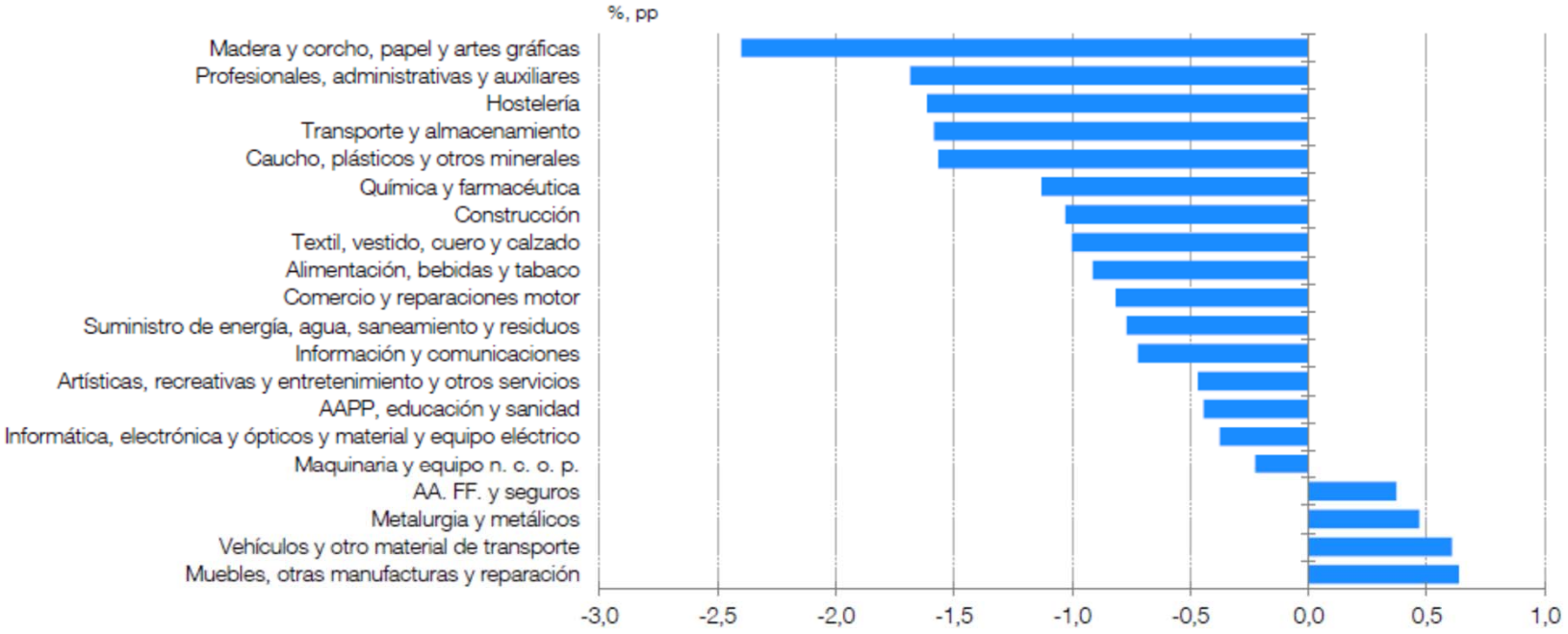
Fuente: Comisión Europea.

Source: Angel Gavilán (2022). "El crecimiento de la productividad en la economía española: ¿Síntoma o problema?". Banco de España.

Spain and Productivity

LA MENOR PRODUCTIVIDAD FRENTE A OTROS PAÍSES EUROPEOS SE OBSERVA EN PRÁCTICAMENTE TODAS LAS RAMAS DE ACTIVIDAD, NO ES UNA CUESTIÓN DE ESPECIALIZACIÓN SECTORIAL

DIFERENCIAL EN EL CRECIMIENTO ANUAL DE LA PTF ENTRE ESPAÑA Y LA UE-12 (2000-2016)



Fuente: EUKLEMS.

Source: Angel Gavilán (2022). "El crecimiento de la productividad en la economía española: ¿Síntoma o problema?". Banco de España.

Spain and Productivity

LA BAJA PRODUCTIVIDAD AGREGADA EN NUESTRO PAÍS NO ES UN "PROBLEMA", ES EL "SÍNTOMA" DE MÚLTIPLES DEFICIENCIAS/ANOMALÍAS QUE INTERACCIONAN ENTRE SÍ

- Tamaño empresarial
- (Re-) Asignación de recursos
- Capital humano
- Capital tecnológico / Innovación
- Marco regulatorio / institucional

Source: Angel Gavilán (2022). "El crecimiento de la productividad en la economía española: ¿Síntoma o problema?". Banco de España.

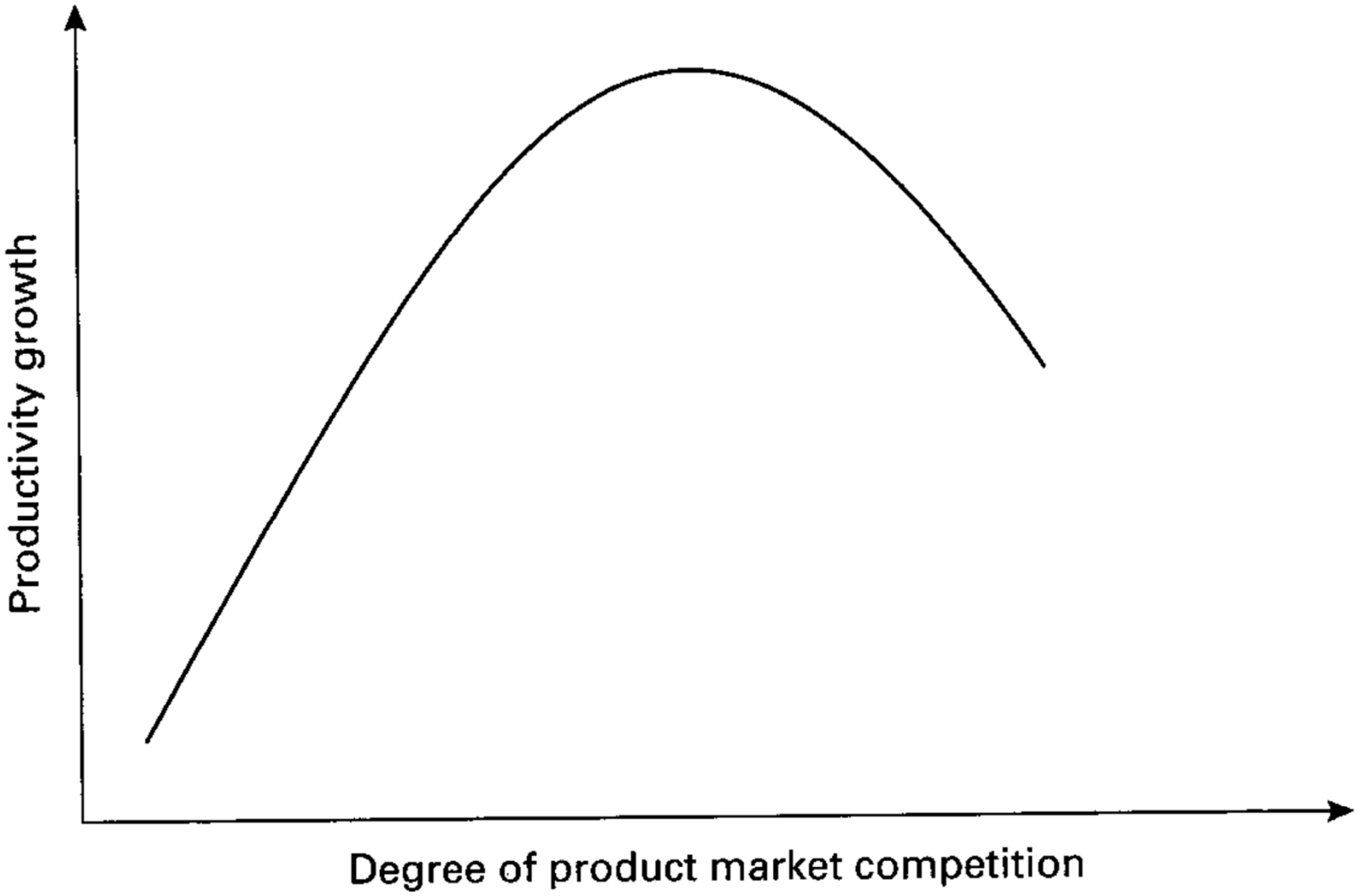


Figure I.4
Innovation and product market competition

Source: Aghion, Philippe, and Peter Howitt (2009). *The economics of growth.* MIT Press.

3. THREE WAVES (FIVE MODELS)

THREE WAVES
FIVE MODELS

- There are many frameworks to analyze economic growth. The “correct” model depends on the issue one wants to focus on.
- This course will be focused on the five main (mathematical) models.
- Aghion and Howitt (2009; mainly Introduction and Part I) will be the main reference in Sections 3 and 4 in this presentation.

THREE WAVES
FIVE MODELS

- The three waves (Five models) are:
  - *1st wave:* The Harrod-Domar model (1)
  - *2nd wave:* The neoclassical model (2)
  - *3rd wave:* Endogenous models
    - Investment based: The AK endogenous model (3)
    - Innovation based:
      - The product variety model (4)
      - The Schumpeterian model (5)

3.1: THE HARROD-DOMAR MODEL

THE HARROD-DOMAR MODEL

- This pertains to the "first wave" in modern economic growth (Harrod 1939, Domar 1946).
- It is a Keynesian inspired growth model.
  - "Domar was writing in the aftermath of the Great Depression that made many people running the machines lose jobs. Domar and many other economists expected a repeat of the Depression after World War II unless the government did something to avoid it. Domar took high unemployment as a given, so there were always people available to run any additional machines that you built." (Easterly, 2001)

THE HARROD-DOMAR MODEL

- According to Easterly (2001), even though it is ignored on a theoretical basis nowadays, it is still used on a practical basis:
  - "The Harrod-Domar growth model supposedly died long ago. But for over 40 years, economists working on developing countries have applied (and still today apply) the Harrod-Domar model to calculate short-run investment requirements for a target growth rate. They then calculate a "Financing Gap" between the required investment and available resources, and often fill the "Financing Gap" with foreign aid."
  - Remember: Savings (private+public+foreign) = Investment

THE HARROD-DOMAR MODEL

- The main prediction of the Harrod-Domar model is that "GDP growth is proportional to the ratio of investment over GDP".
- Since output *Y* was assumed to be proportional to the stock of capital *K*:

$$Y_t = \alpha K_{t-1}$$

THE HARROD-DOMAR MODEL

$$Y_t = \alpha K_{t-1}$$

- Then

$$Y_t - Y_{t-1} = \alpha(K_{t-1} - K_{t-2}) = \alpha I_{t-1}$$

- And the main prediction is given by:

$$\frac{Y_t - Y_{t-1}}{Y_{t-1}} = \alpha \frac{I_{t-1}}{Y_{t-1}}$$

THE HARROD-DOMAR MODEL

- "The problem of balancing aggregate demand and supply was Domar's concern. Investment in building new machines had a dual character -- it added to desired purchases of goods (demand) and it also added capacity (supply). These two effects would not necessarily be equal, Domar argued, and so the economy would spiral off into either chronic overproduction or chronic underproduction. This was the Harrod-Domar model."
  - "Knife-edge" condition.

THE HARROD-DOMAR MODEL

- As we will show below, the Harrod-Domar model can also be seen as a special case of the AK model.
- The empirical evidence is at odds with the main predictions of the model.

3.2: THE NEOCLASSICAL MODEL

THE NEOCLASSICAL MODEL

- This is the “second wave” in modern economic growth.
- Today it is the most important benchmark model.
- It has become known as the Solow-Swan model (1956).
  - Solow is Nobel Prize winner in Economics 1987.

Economics

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1987

"for his contributions to the theory of economic growth"

Robert M. Solow

USA

Massachusetts Institute
of Technology (MIT)
Cambridge, MA, USA

b. 1924

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Robert Solow

From Wikipedia, the free encyclopedia

Robert Merton Solow (born August 23, 1924) is an American economist particularly known for his work on the theory of economic growth. He was awarded the John Bates Clark Medal (in 1961) and the 1987 Nobel Memorial Prize in Economics.

Contents [hide]

Biography [edit]

Robert Solow was born in Brooklyn, New York on August 23, 1924, the oldest of three children. He was well educated in the neighborhood public schools of New York City and excelled academically early in life.

In September 1940, Solow went to the Harvard College with a scholarship. At Harvard, his first studies were in sociology and anthropology as well as elementary economics.

By the end of 1942, Solow left the university and joined the U.S. Army. He served briefly in North Africa and Sicily, and later served in Italy during World War II until he was discharged in August 1945.

He returned to Harvard in 1945, and studied under Wassily Leontief. As his research assistant he produced the first set of capital-coefficients for the input-output model. Then he became interested in statistics and probability models. From 1949-50, he spent a fellowship year at Columbia University to study statistics more intensively. During that year he was also working on his Ph.D. thesis, an exploratory attempt to model changes in the size distribution of wage income using interacting Markov processes for employment-

Robert Solow

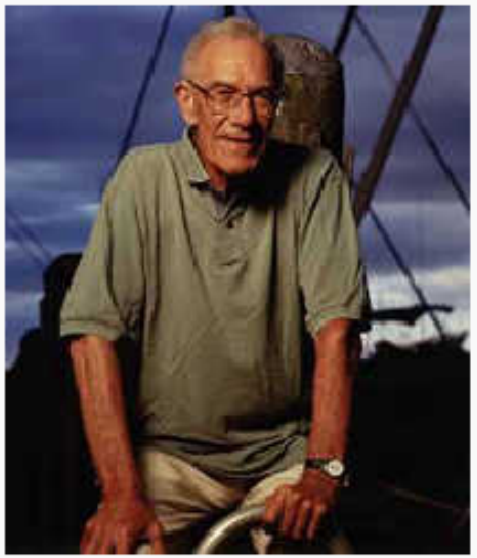


Photo: Minneapolis Fed, 2002

Born	August 23, 1924 New York
Residence	USA
Nationality	US
Field	Economics
Institution	MIT
Alma Mater	Harvard University
Academic Advisor	Wassily Leontief
Notable Students	George Akerlof Ben Bernanke Robert J. Gordon Joseph Stiglitz

Solow, a genius, and a very good-humored person

- Said by him, presumably: "*Everything reminds Milton [Friedman] of the money supply. Well, everything reminds me of sex, but I keep it out of the paper" (*taken from Baldwin and Wyplosz, 2004, Economics of the European Integration, p. 163).

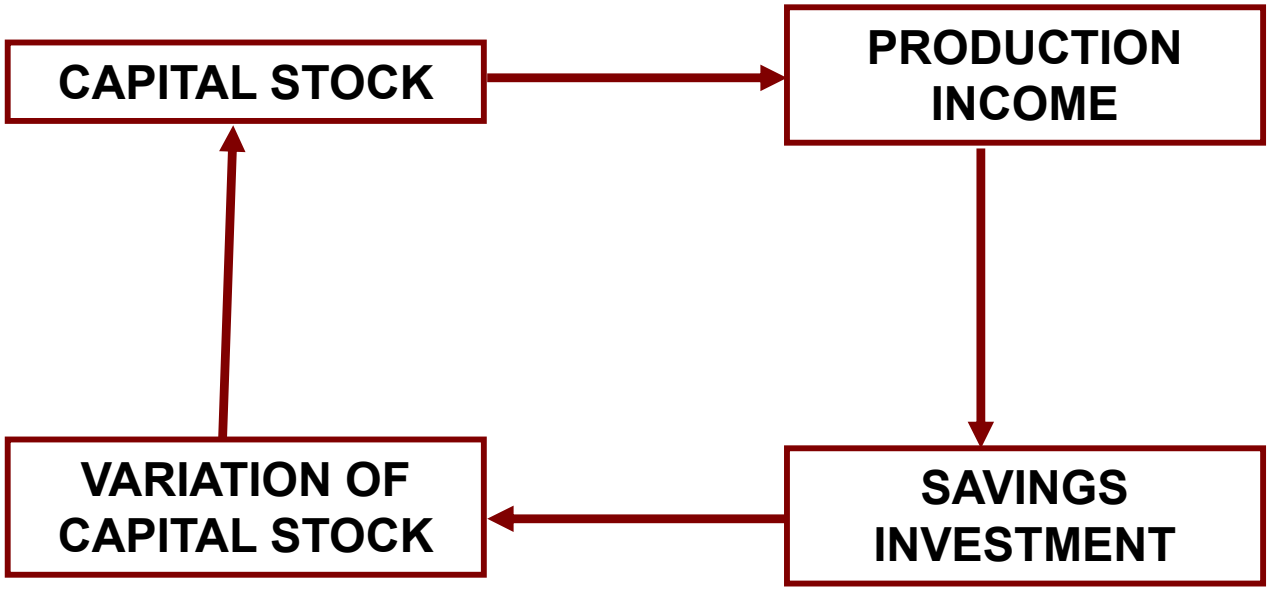
Solow, a genius, and a very good-humored person

- “Suppose someone sits down where you are sitting right now and announces to me that he is Napoleon Bonaparte. The last thing I want to do with him is to get involved in a technical discussion of cavalry tactics at the battle of Austerlitz.”

THE NEOCLASSICAL MODEL

- In the simplest model, increasing savings increases growth (temporarily), but it cannot last indefinitely.
- In the long run, growth rate is determined by the growth rate of technological progress, which is taken to be EXOGENOUS (independent of economic forces). This exogeneity is an important limitation of the model.
- **Underlying principle: diminishing returns or declining marginal product of capital.** As more capital is being added, the marginal return eventually falls.

Please note the dynamics in a standard growth model



THE NEOCLASSICAL MODEL

- **Objective:** explaining the evolution of output per worker *L* (*Y/L or Y/(EL)*).
- **Four elements** of the model:

1. Standard (Cobb-Douglas) production function, with **constant returns to scale**.

$$Y = (K)^{\alpha} \times (LE)^{1-\alpha}$$

α = Capital share
$1 - \alpha$ = Labor share
Y = Output
K = Stock of capital
L = Labor
E = Efficiency of labor = The skills and education of the labor force, the ability of the labor force to handle modern technologies, and the efficiency with which the economy's businessess and markets function

Diminishing marginal product is a key element of the model. Additionally, Inada condition, perfect competition, substitutability of factors, and full employment.

THE NEOCLASSICAL MODEL

- **Four elements** of the model:

2. Savings S is a fraction of output: $S=sY$
3. Savings=Investment: $S=I$
4. Solow-Swan equation: increase in capital K depends on investment I minus depreciation δK.

$$K_{t+1} - K_t = I_t - Depreciation$$
$$K_{t+1} - K_t = sY_t - \delta K_t$$

3.1: First model: NO technological progress. E is constant

$$K_{t+1} - K_t = sY_t - \delta K_t$$

- Then, ***in intensive terms,*** dividing by the number of workers, L_t, we get, after some algebra, that

$$k_{t+1} - k_t = sy_t - (\delta + n)k_t$$

where n is growth rate of population N.

$$y_t = \frac{Y_t}{L_t}$$

$$k_t = \frac{K_t}{L_t}$$

Capital letters denote the level of a variable, while lowercase letters denote a variable in intensive terms, i.e., divided by the number of workers.

Digression: Maths on Solow-Swan equation

- Note that:

$$\frac{k_{t+1}-k_t}{k_t}=\frac{K_{t+1}-K_t}{K_t}-\frac{L_{t+1}-L_t}{L_t}$$

$$k_{t+1}-k_t=k_t\times\frac{K_{t+1}-K_t}{K_t}-k_t\times\frac{L_{t+1}-L_t}{L_t}$$

$$k_{t+1}-k_t=\frac{K_{t+1}-K_t}{L_t}-k_t\times\frac{L_{t+1}-L_t}{L_t}$$

$$\frac{K_{t+1}-K_t}{L_t}=k_{t+1}-k_t+k_t\times\frac{L_{t+1}-L_t}{L_t}$$

Digression: Maths on Solow-Swan equation

$$\frac{K_{t+1} - K_t}{L_t} = sy_t - \delta k_t$$

$$\frac{K_{t+1} - K_t}{L_t} = k_{t+1} - k_t + k_t \times \frac{L_{t+1} - L_t}{L_t}$$

- Therefore:

$$k_{t+1} - k_t + k_t \times \frac{L_{t+1} - L_t}{L_t} = sy_t - \delta k_t$$

$$k_{t+1} - k_t = sy_t - \left(\delta + \frac{L_{t+1} - L_t}{L_t}\right) \times k_t$$

$$k_{t+1} - k_t = sy_t - (\delta + n) \times k_t$$

Digression: Maths on Solow-Swan equation

$$k_{t+1} - k_t = sy_t - (\delta + n) \times k_t$$

- This expression is known as **the basic Solow-Swan equation**: it shows the variation in the stock of capital per worker (K/L). This, of course, will show the evolution of income per capita (Y/L).

$$Y_t = (K_t)^{\alpha} \times (L_t E_t)^{1-\alpha}$$

$$\frac{Y_t}{L_t} = \left(\frac{K_t}{L_t}\right)^{\alpha} \times \left(\frac{L_t}{L_t} E_t\right)^{1-\alpha}$$

$$y_t = (k_t)^{\alpha} \times (E_t)^{1-\alpha}$$

THE NEOCLASSICAL MODEL

$$k_{t+1} - k_t = sy_t - (\delta + n)k_t$$

is known as the ***Solow-Swan equation***

- Interpretation:
  - Capital stock per worker increases with the difference between gross savings of the economy and the term *(δ+n)k.*
  - When savings increases investment increases, and capital stock rises.
  - *(δ+n)k:* the higher the depreciation rate *δ*, and populacion growth *n*, the lower the increase of capital stock per worker.

Figure- Depreciation plus …

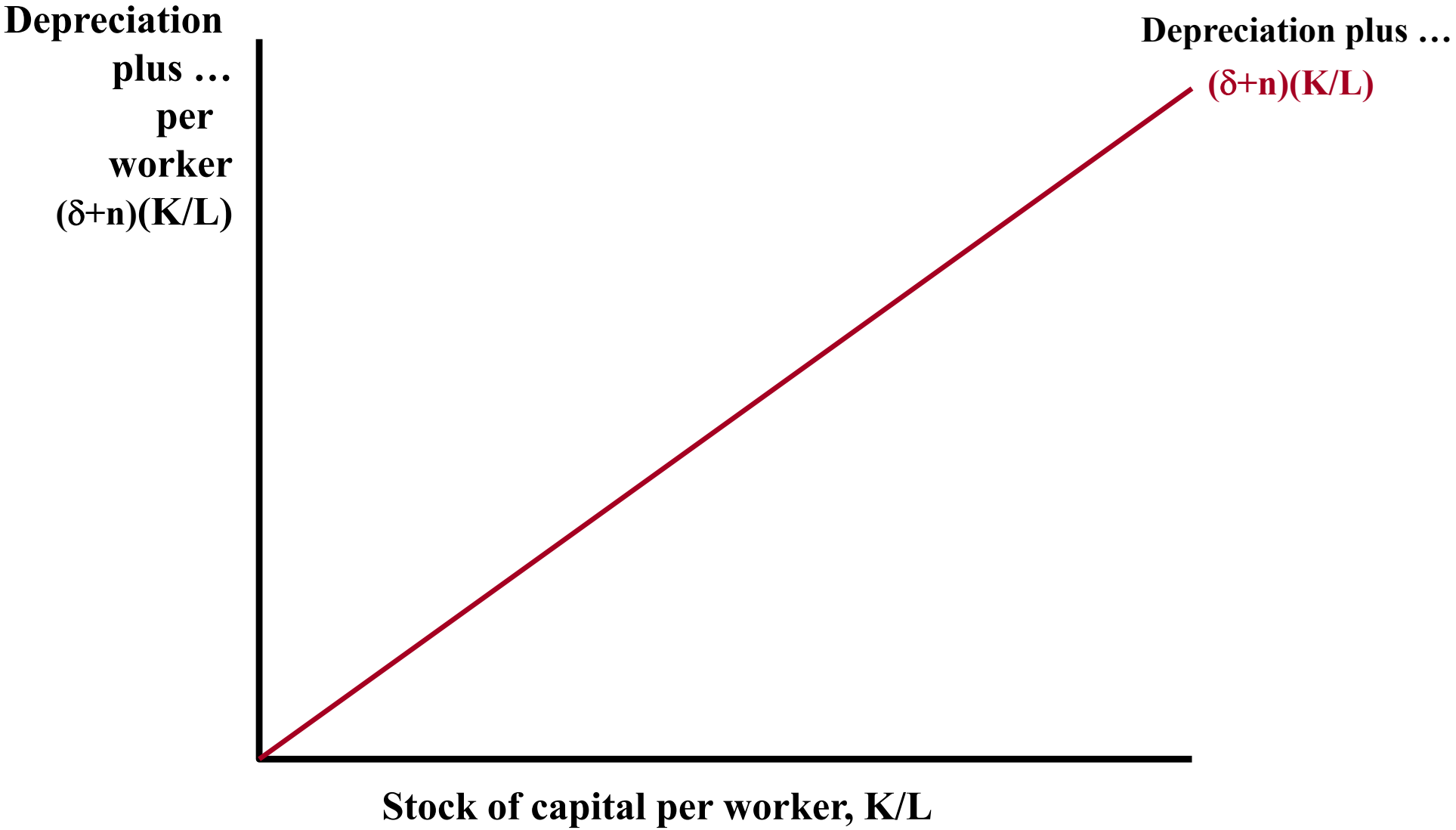


Figure- Production and savings

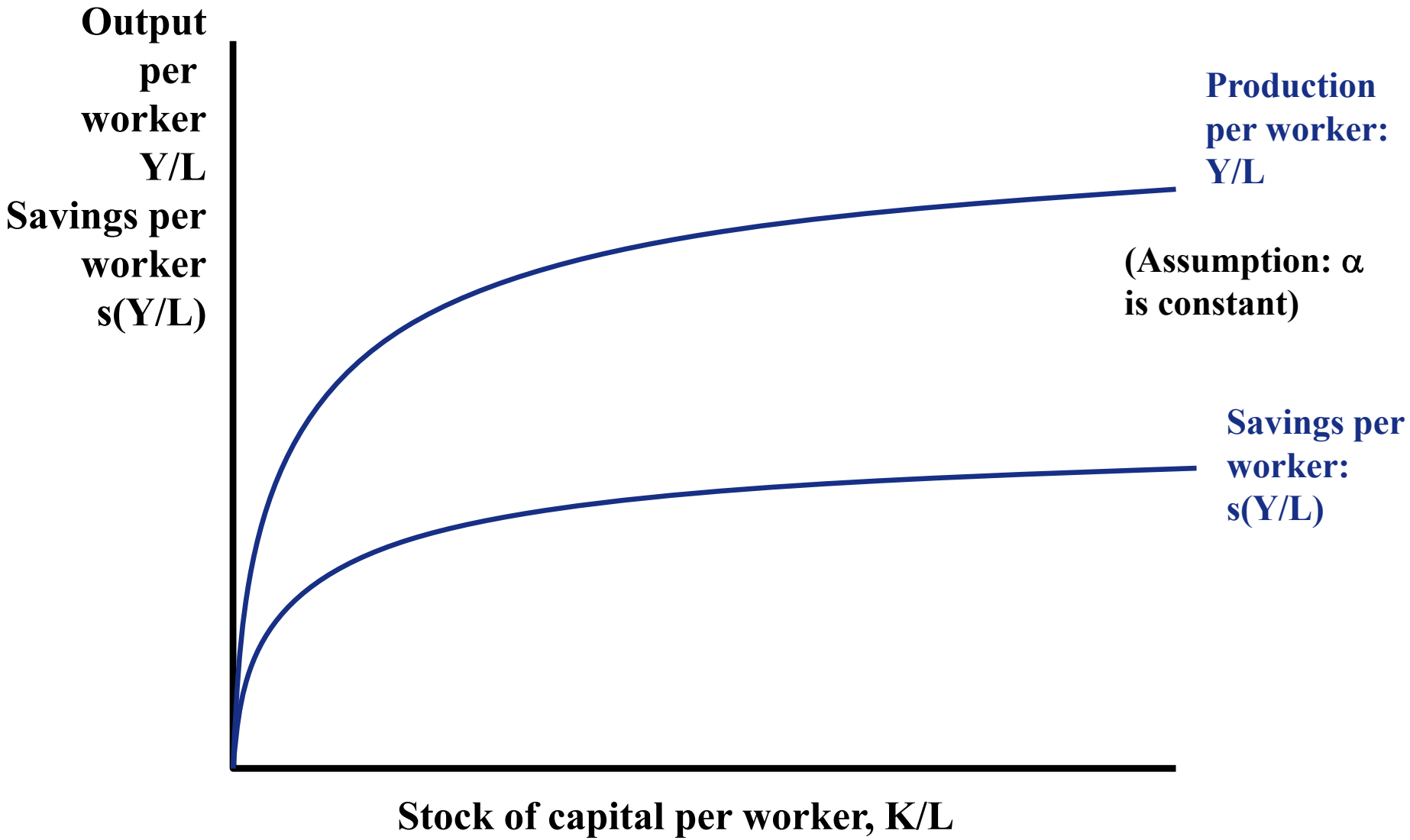
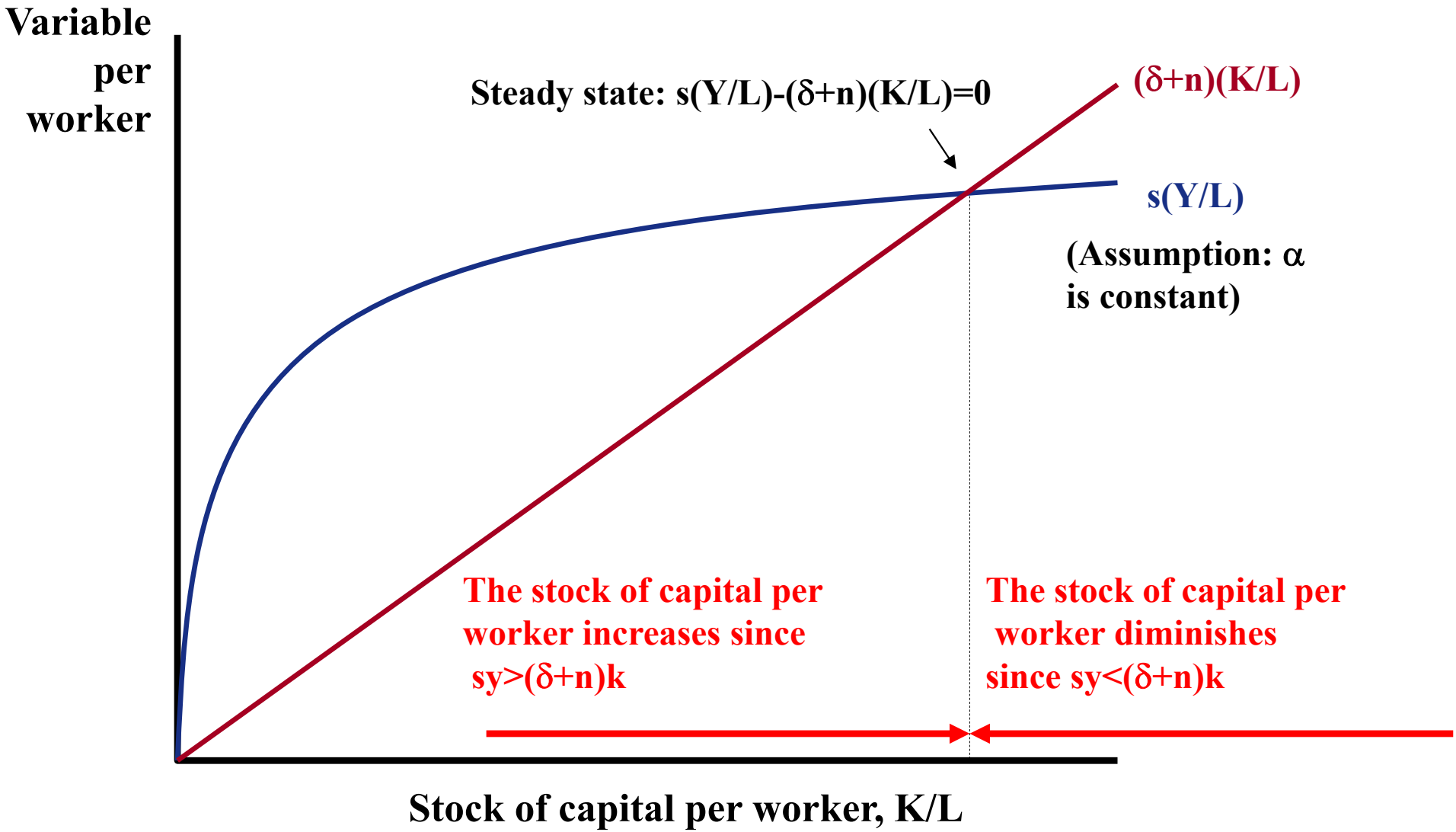


Figure – The whole picture



THE NEOCLASSICAL MODEL

- In a balanced equilibrium (steady state):

$$k_{t+1} = k_t \Rightarrow sy_t = (\delta + n)k_t$$

- This implies that, after some algebra, the stock of capital per worker and capital-output ratio reach a steady state:

$$\frac{K}{Y} = \frac{s}{\delta + n}$$

THE NEOCLASSICAL MODEL

- For a Cobb-Douglas production function (in intensive terms):

$$\frac{Y}{L} = (K/L)^{\alpha} E^{1-\alpha}$$

- The level of output per worker is given by

$$\frac{Y}{L} = \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} E$$

$$\frac{K}{Y} = \frac{s}{\delta + n}$$

THE NEOCLASSICAL MODEL

- This implies that:
  - An increase in savings can increase the rate of growth transitorily, but not permanently. However, the level of output increases permanently.
  - An increase in population growth can reduce the rate of growth transitorily, but not permanently. However, the level of output decreases permanently.
  - THERE IS NOT SUSTAINED GROWTH IN THE LONG RUN.

3.2. The complete model. There is technological progress: E increases

$$K_{t+1} - K_t = sY_t - \delta K_t$$

- Then, in intensive terms (dividing by the units of effective workers, $E \times L$), we get, after some algebra, that

$$\hat{k}_{t+1} - \hat{k}_t = s\hat{y}_t - (\delta + n + g)\hat{k}_t$$

$$\hat{k}_t = \frac{K_t}{E_t L_t}$$

$$\hat{y}_t = \frac{Y_t}{E_t L_t}$$

where n is population growth and g is the rate of technological progress.

n denotes the growth rate of population *N* and *g* the growth rate of the level of technology (or efficiency of labor) *E*. A "hat" denotes the level of a variable in intensive terms, divided by the units of effective workers.

Digression: Maths on Solow-Swan equation

$$K_{t+1} - K_t = sY_t - \delta K_t$$

- If we divide by (E×L) we express variables per ***effective*** worker (indicated by a "hat" above the variable):

$$\frac{K_{t+1} - K_t}{E_t L_t} = s\frac{Y_t}{E_t L_t} - \delta\frac{K_t}{E_t L_t}$$

$$\frac{K_{t+1} - K_t}{E_t L_t} = s\hat{y}_t - \delta\hat{k}_t$$

BUT WE DO NOT KNOW WHAT $\frac{K_{t+1} - K_t}{E_t L_t}$ IS EQUAL TO

Digression: Maths on Solow-Swan equation

- Note that:

$$\frac{\hat{k}_{t+1} - \hat{k}_t}{\hat{k}_t} = \frac{K_{t+1} - K_t}{K_t} - \frac{L_{t+1} - L_t}{L_t} - \frac{E_{t+1} - E_t}{E_t}$$

$$\hat{k}_{t+1} - \hat{k}_t$$

$$= \hat{k}_t \times \frac{K_{t+1} - K_t}{K_t} - \hat{k}_t \times \left(\frac{L_{t+1} - L_t}{L_t} + \frac{E_{t+1} - E_t}{E_t} \right)$$

$$\hat{k}_{t+1} - \hat{k}_t = \frac{K_{t+1} - K_t}{E_t L_t} - \hat{k}_t \times \left(\frac{L_{t+1} - L_t}{L_t} + \frac{E_{t+1} - E_t}{E_t} \right)$$

$$\frac{K_{t+1} - K_t}{E_t L_t} = \hat{k}_{t+1} - \hat{k}_t + \hat{k}_t \times \left(\frac{L_{t+1} - L_t}{L_t} + \frac{E_{t+1} - E_t}{E_t} \right)$$

Digression: Maths on Solow-Swan equation

$$\frac{K_{t+1} - K_t}{E_t L_t} = s\hat{y}_t - \delta\hat{k}_t$$

$$\frac{K_{t+1} - K_t}{E_t L_t} = \hat{k}_{t+1} - \hat{k}_t + \hat{k}_t \times \left(\frac{L_{t+1} - L_t}{L_t} - \frac{E_{t+1} - E_t}{E_t} \right)$$

- Therefore:

$$\hat{k}_{t+1} - \hat{k}_t + \hat{k}_t \times \left(\frac{L_{t+1} - L_t}{L_t} - \frac{E_{t+1} - E_t}{E_t} \right) = s\hat{y}_t - \delta\hat{k}_t$$

$$\hat{k}_{t+1} - \hat{k}_t = s\hat{y}_t - (\delta + n + g) \times \hat{k}_t$$

Digression: Maths on Solow-Swan equation

$$\hat{k}_{t+1} - \hat{k}_t = s\hat{y}_t - (\delta + n + g) \times \hat{k}_t$$

- This expression is also known as the **basic Solow-Swan equation** (which now also includes the growth of the efficiency of labor): it shows the variation of the stock of capital per effective worker. This shows the evolution of real income per worker, of course.

THE NEOCLASSICAL MODEL

$$\hat{k}_{t+1} - \hat{k}_t = s\hat{y}_t - (\delta + n + g)\hat{k}_t$$

is known as the ***Solow-Swan equation***

- Interpretation:
  - Capital stock per effective worker increases with the difference between gross savings of the economy and the term $(\delta+n+g)k$.
  - When savings increases investment increases, and capital stock rises.
  - $(\delta+n+g)k$: the higher the depreciation rate δ, and so on, the lower the increase of capital stock per effective worker.

Figure- Depreciation plus …

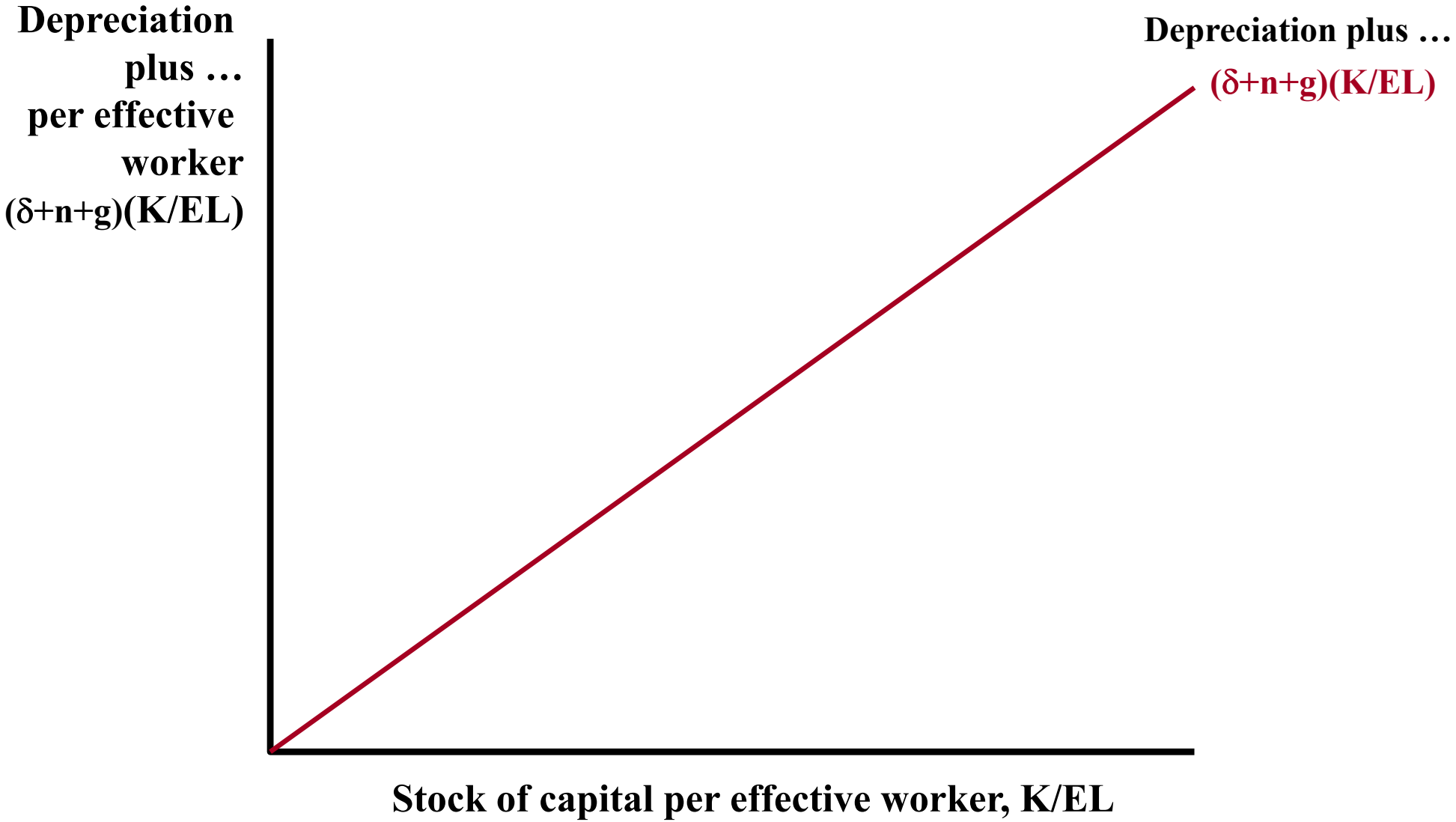


Figure- Production and savings

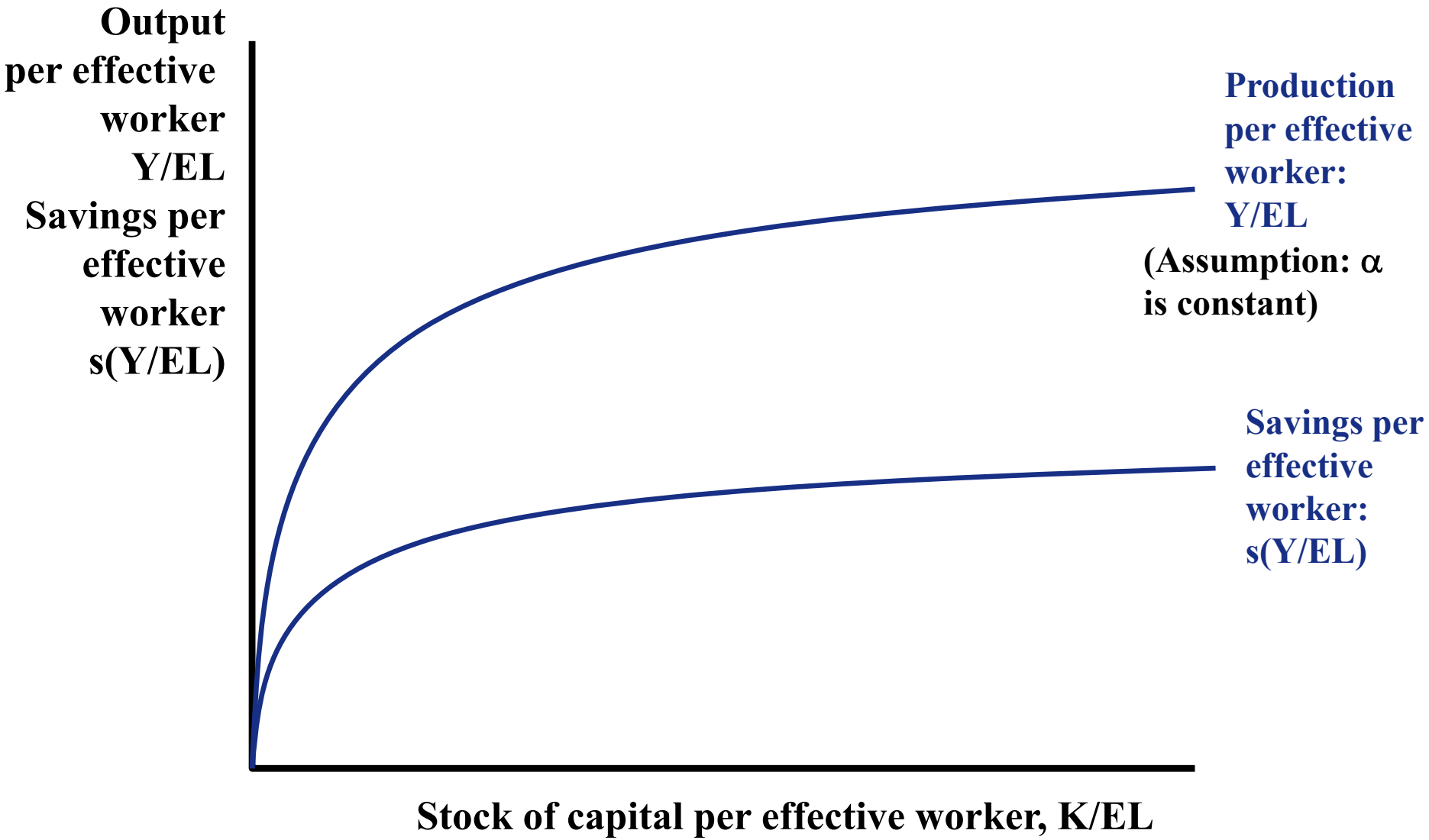
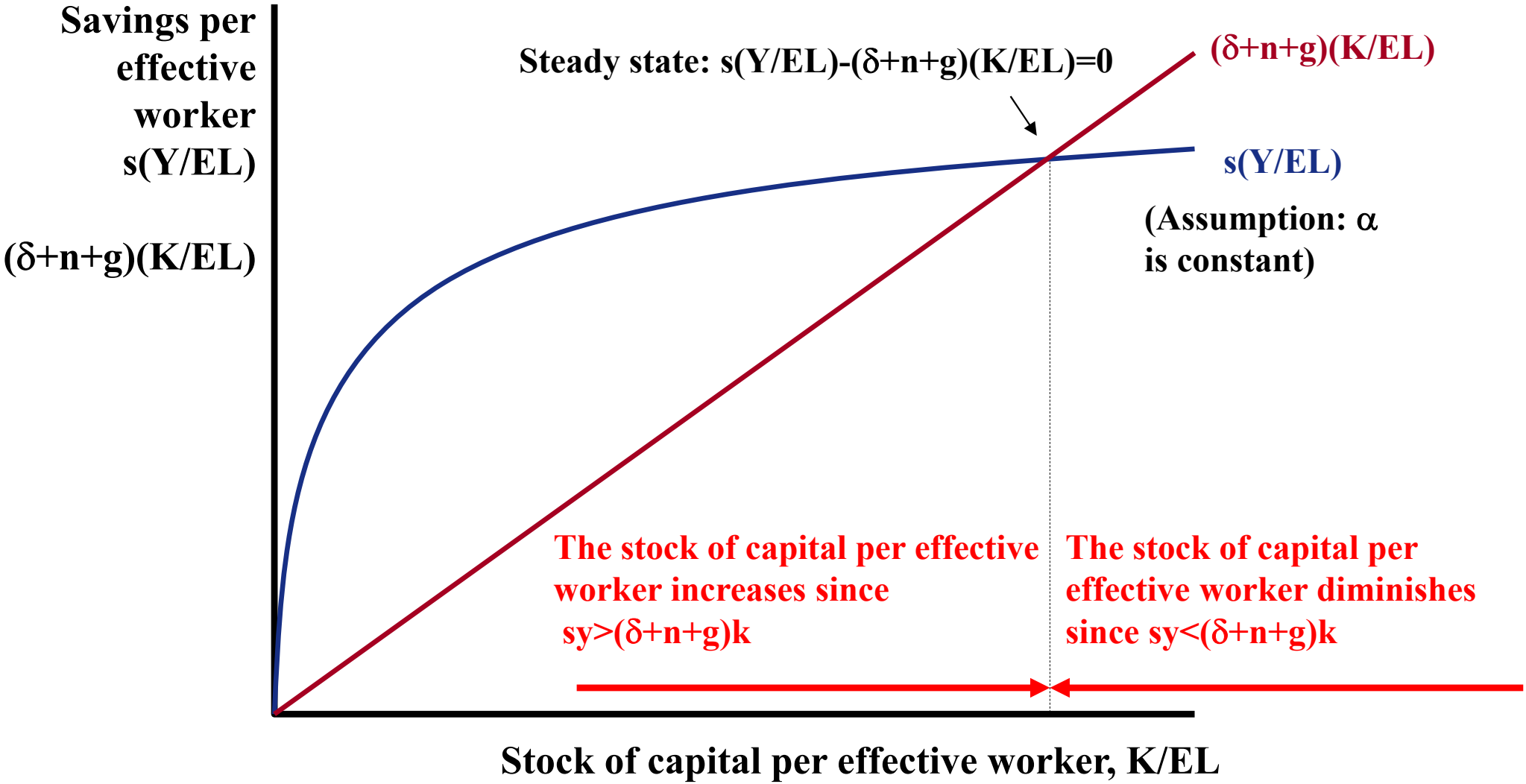


Figure – The whole picture



THE NEOCLASSICAL MODEL

- In a balanced equilibrium (steady state):

$$\hat{k}_{t+1} = \hat{k}_t \Rightarrow s\hat{y}_t = (\delta + n + g)\hat{k}_t$$

- This implies that, after some algebra, the stock of capital per effective worker and capital-output ratio reach a steady state:

$$\frac{K}{Y} = \frac{s}{\delta + n + g}$$

THE NEOCLASSICAL MODEL

- For a Cobb-Douglas production function (in intensive terms):

$$\frac{Y}{L} = \left(\frac{K}{L}\right)^{\alpha} E^{1-\alpha}$$

- The level of output per worker is given by

$$\frac{Y}{L} = \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} E$$

$$\frac{K}{Y} = \frac{s}{\delta + n + g}$$

THE NEOCLASSICAL MODEL

- This implies that:
  - Long run growth is only determined by the growth rate of technological change. However, the growth rate of the level of technology is exogenously given.
  - In the simplest case where there is no growth in technological progress, for instance, an increase in savings can increase the rate of growth transitorily, but not permanently. However, the level of output increases permanently.

THE NEOCLASSICAL MODEL

- Based on these results, the model suggests a testable prediction: Are poor countries likely to catch up with rich ones?
- This has become known as conditional convergence.
- If countries have the same characteristics (technology, ...), the answer is YES for the neoclassical growth model, since they will converge on the same steady state.

THE NEOCLASSICAL MODEL

- There is a vast literature on this issue, when compared to the AK model (more on this below).

THE NEOCLASSICAL MODEL

- Additionally, the neoclassical growth model offers a growth accounting framework to quantify the contribution of inputs to output growth (Solow, 1957). More on this will be shown below in Sections 4 and 5.

THE NEOCLASSICAL MODEL

- Please note that this model can be easily extended to incorporate an endogenous savings rate *a la Cass-Koopmans-Ramsey*. This is the benchmark model in advanced and PhD macroeconomics courses today.

3.3: THE AK MODEL

NEOCLASSICAL GROWTH MODEL

- In the neoclassical growth model the rate of technological change is assumed to be exogenously given (determined by non-economic forces).
- However, that was clearly unsatisfactory.
- Now this is endogenously derived.

ENDOGENOUS GROWTH

- Assuming exogenous technological change was not satisfactory because technological change is surely NOT exogenous.
  - Instead, it depends on economic decisions (it is endogenous) since it comes from industrial innovations made by profit-seeking firms.
    - It will depend on: the funding of science, the accumulation of human capital, and others economic activities.

ENDOGENOUS GROWTH

- In the neoclassical growth model, the fundamental reason to converge to a steady state with zero per capita growth is the diminishing returns to capital.
- **Therefore, to attain a positive per capita growth, there should not be diminishing returns to capital. This is a key feature in endogenous growth models.**

THE AK MODEL

- The AK growth model pertains to the “third wave” in modern economic growth, and, in turn, to the “first family” (investment based) of models since there are others in modern economic growth.

ENDOGENOUS GROWTH

- Incorporating endogenous technology into growth theory forces us to deal with the difficult phenomenon of increasing returns to scale: **people must be given an incentive to improve technology.**
  - With constant returns to scale, inputs are paid according to their marginal products. Then there is nothing to pay for the resources used in improving technology.
  - Endogenous theory cannot be based on the usual theory of competitive equilibrium.

ENDOGENOUS GROWTH

- Arrow (1962) proposed a solution: technological progress is supposed to be an unintended consequence of producing new capital goods, named as "learning by doing" (e.g. airframe manufacturing, shipbuilding, ...). **Knowledge creation is a side product of investment.** A firm that increases its physical capital learns simultaneously how to produce more efficiently. **This positive effect of experience on productivity** is called learning by doing (or investing).
  - Arrow is Nobel Prize winner in Economics 1972.

ENDOGENOUS GROWTH

- Learning by doing was assumed to be purely external to the firms responsible for it.
  - That is, if technological progress depends on the aggregate production function of capital and firms are all very small, they all can be assumed to take the rate of technological progress as being given independently of their own production of capital goods.
    - Each firm maximizes profits paying inputs their marginal products.
    - There is not an additional payment for their contribution to technological progress.

Kenneth Arrow - Wikipedi

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Kenneth Arrow

From Wikipedia, the free encyclopedia

Kenneth Joseph Arrow (born August 23, 1921) is an American economist and joint winner of the Nobel Memorial Prize in Economics with John Hicks in 1972. To date, he is the youngest person to have received this award, at 51.

In economics, he is considered an important figure in post-World War II neo-classical economic theory. Many of his former graduate students have gone on to win the Nobel Memorial Prize themselves. Arrow's impact on the economics profession has been tremendous. For more than fifty years he has been one of the most influential of all practicing economists.

His most significant works are his contributions to social choice theory, notably "Arrow's impossibility theorem", and his work on general equilibrium analysis. He has also provided foundational work in many other areas of economics, including endogenous growth theory and the economics of information.

Arrow remains active on the international scene through a variety of initiatives including trustee of Economists for Peace and Security and a member of the Advisory Board of Incentives for Global Health, the not-for-profit behind the Health Impact Fund.

Contents [hide]

Kenneth J. Arrow

Neoclassical economics

National Medal of Science award ceremony, 2004

Born	August 23, 1921 (age 92) New York City, USA
Nationality	United States
Institution	Stanford University
Field	Microeconomics General equilibrium theory Social choice theory
Alma mater	Columbia University City College of New York

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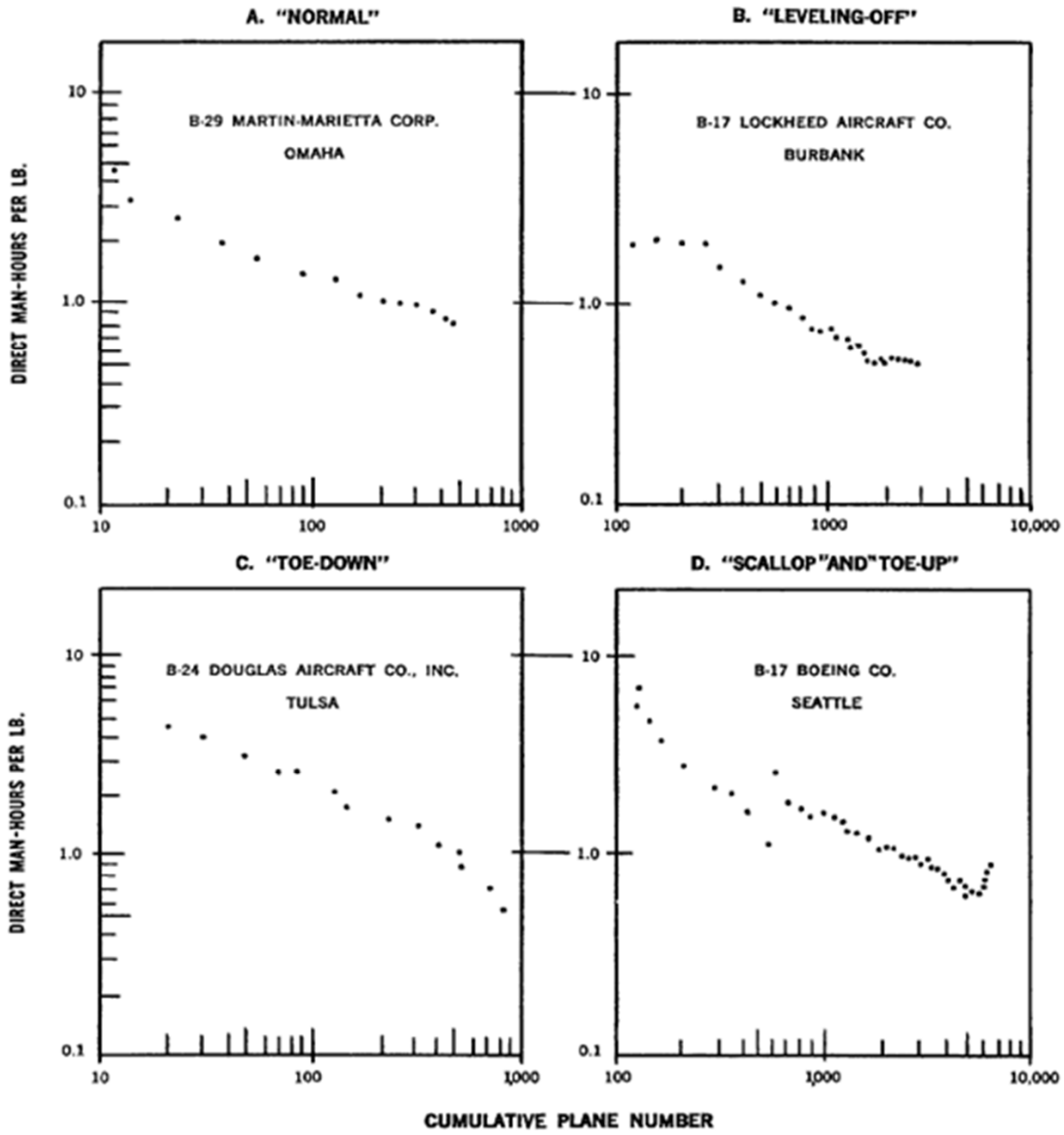
ENDOGENOUS GROWTH

- Productivity growth is based on two assumptions:
  - Learning by doing works through each firm's net investment. An increase in a firm's capital stock leads to a parallel increase in its stock of knowledge, *A*:
    - (Arrow) Knowledge and productivity gains come from investment and productivity, based on empirical evidence that large positive effects of experience on productivity in airframe manufacturing, shipbuilding, and other areas.
  - Each firm's knowledge is a public good that any other firm can access at zero cost. In other words, once discovered, a piece of knowledge spills over instantly across the whole economy.
    - The spillover assumption is natural because knowledge has a nonrival character: if one firm uses an idea, it does not prevent others from using it. Of course, firms have incentives to maintain secrecy over their discoveries and patents (then knowledge leaks out gradually). This has been modeled also.

EXHIBIT II. Data Illustrating Normal Learning Curve and Some Deviations



SOURCE: Miguel A. Reguero, "An Economic Study of the Military Airframe Industry," Wright-Patterson Air Force Base, Ohio, Department of the Air Force, October 1957, pp. 231–235.

THE AK MODEL

- The AK model assumes that when people accumulate capital, learning by doing generates technological progress that tends to raise the marginal product of capital, thus offsetting the law of diminishing marginal product (when technology is unchanged). Then the marginal product is constant, A:

$$Y = AK$$

THE AK MODEL

$$Y = AK$$

- The AK model is based on capital accumulation. Thus long run growth rate depends on economic factors such as thrift and the efficiency of resource allocation.
- Instead, other models of endogenous growth (more on this later) emphasize creativity and innovation as the main drivers of economic growth.

THE AK AND THE HARROD-DOMAR MODELS

- An early precursor of the AK model was that of Harrod-Domar. If the production function has fixed technological coefficients (Leontiev):

$$Y = F(K, L) = \min\{AK, BL\}$$

- Due to the non-substitutability of inputs, there will probably be surplus capital or labor.

THE AK AND THE HARROD-DOMAR MODELS

- When capital is the limiting factor (surplus labor takes place) in Harrod-Domar's model, i.e., $AK<BL$, then the production function is "linear-in-K":

$$Y = AK$$

THE AK AND THE HARROD-DOMAR MODELS

- Then the Solow-Swan equation becomes

$$K_{t+1} - K_t = sAK_t - \delta K_t$$

- The growth rate of capital will be:

$$g = \frac{K_{t+1} - K_t}{K_t} = sA - \delta$$

- Since output is linear-in-K, then the rate of growth of output will also be g.
- The growth rate is increasing in the savings rate s.

THE AK AND THE HARROD-DOMAR MODELS

- The problem with the Harrod-Domar model is that it cannot explain the sustained growth in output per person exhibited since the industrial revolution.
  - Growth rate of output per worker = g-n
  - But if this is positive, the growth rate of capital per worker K/L, g-n, is also positive.
  - A point will be reached where capital is not the limiting factor. Then $Y=BL$, both Y and L growing at the same rate: output per worker ceases to grow.

NEOCLASSICAL VERSION OF HARROD-DOMAR

- The first AK model accounting for sustained growth in output per capita is Frankel (1962). His model encompasses:
  - Solow: perfect competition, substitutability of factors, and full employment.
  - Harrod-Domar: long run growth rate depends on the savings rate.

NEOCLASSICAL VERSION OF HARROD-DOMAR

- The model is based on "Learning by doing": individual firms contribute to the accumulation of technological knowledge (development) when they accumulate capital (spillover effects: aggregate productivity depends on firms' specific-sectoral productivity).

$$y_j = \bar{A} k_j^{\alpha} L_j^{1-\alpha}$$

$$\bar{A} = A_0 \left(\sum_{j=1}^{N} k_j \right)^{\eta}$$

η reflects the extent of the knowledge externalities generated among firms (if η =0 there are not externalities)

NEOCLASSICAL VERSION OF HARROD-DOMAR

- Once output, capital, and labor are aggregated across firms, the result is that, in equilibrium, aggregate output is given by:

$$Y = AK^{\alpha+\eta}$$

- Thus

$$K_{t+1} - K_t = sAK_t^{\alpha+\eta} - \delta K_t$$

$$\frac{K_{t+1} - K_t}{K_t} = sAK_t^{\alpha+\eta-1} - \delta$$

NEOCLASSICAL VERSION OF HARROD-DOMAR

- And the growth rate of capital is given by

$$g = \frac{K_{t+1} - K_t}{K_t} = sAK_t^{\alpha+\eta-1} - \delta$$

NEOCLASSICAL VERSION OF HARROD-DOMAR

- Depending on the impact of diminishing returns and the spillover effect:
  - Diminishing returns are stronger ($\alpha+\eta<1$): Solow-Swan results. Stable steady state. Long run growth rate is zero.
  - Spillover results are stronger ($\alpha+\eta>1$): ever increasing growth rate. Unstable steady state. Explosive growth.
  - Both impacts compensate ($\alpha+\eta=1$): AK model results, Y and K increase in the same proportion, but with substitutability of factors, full employment. Thus:

$$g = \frac{K_{t+1} - K_t}{K_t} = sA - \delta$$

NEOCLASSICAL VERSION OF HARROD-DOMAR

- Please note that intertemporal utility maximization can be easily incorporated to the model.

THE AK MODEL

- There is a vast literature on the empirical debate between between neoclassical and AK growth models:
  - Persistent positive growth rates of per capita GDP in most countries worldwide. This fact can be explained by the AK growth model, but not by the neoclassical model.
  - Cross-country or cross- regional convergence, either absolute (irrespective of their characteristics) or conditional (given similar characteristics). This runs in favor of the neoclassical model. *Club convergence*.

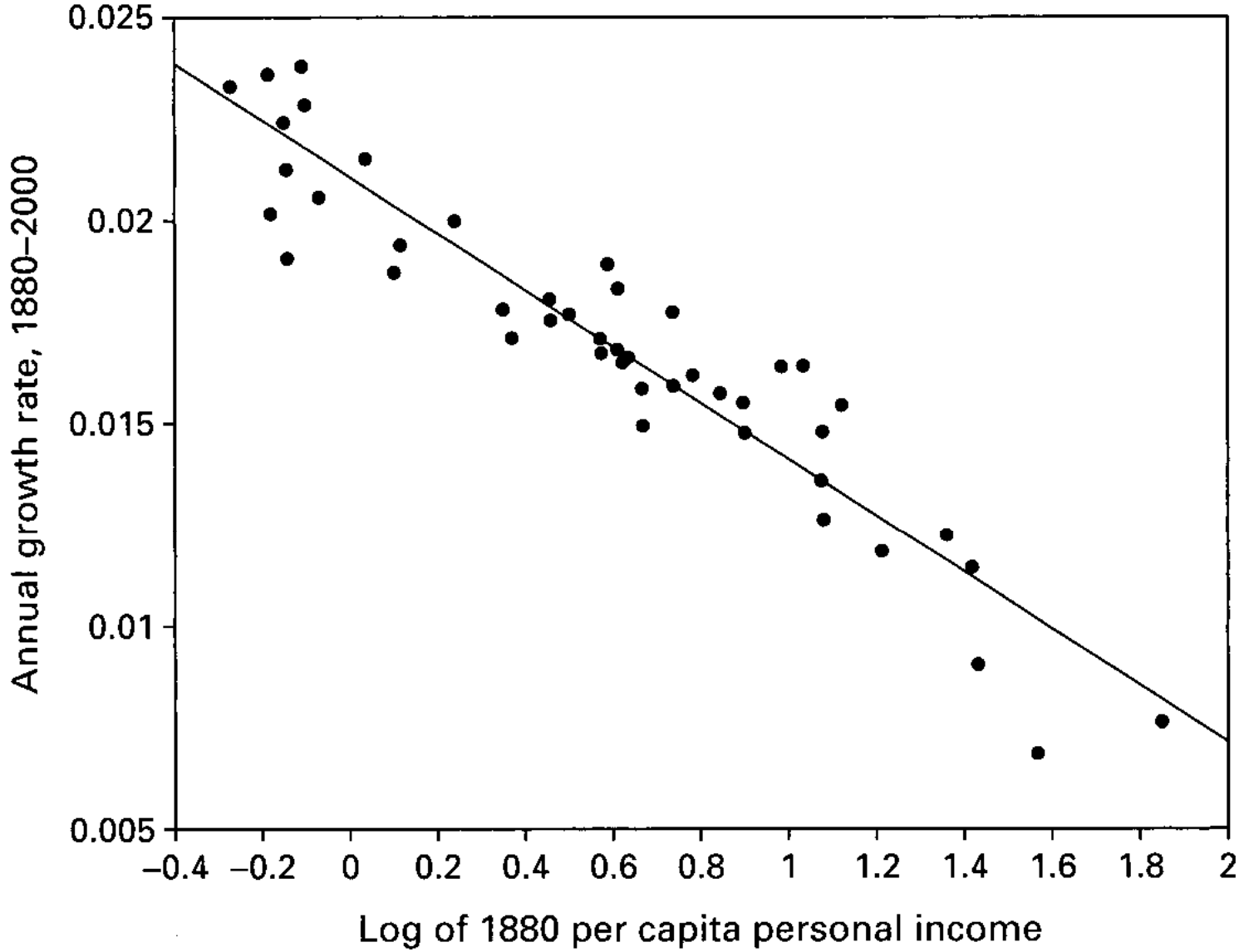


Figure 2.1
Convergence of personal income across U.S. states

Source: Aghion, Philippe, and Peter Howitt (2009). *The economics of growth.* MIT Press.

THE AK MODEL

- An underlying difficulty for the AK model is that there is no explicit distinction between capital accumulation and technological progress.
- The next models focus mainly on innovation-based models that make that distinction explicit.

3.4: THE PRODUCT VARIETY MODEL

THE PRODUCT VARIETY MODEL

- This is the third wave in modern economic growth: innovation-based ("second family") growth models related to product variety (Romer, 1990).
- Innovation causes productivity growth by creating new, but not necessarily improved, varieties of products.

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2018

William D. Nordhaus
Paul M. Romer

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William D. Nordhaus

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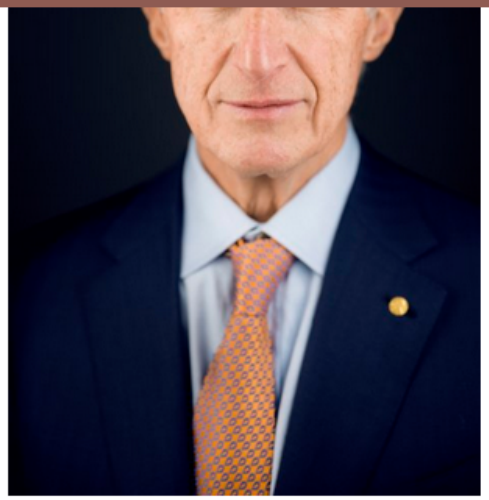


William D. Nordhaus

Prize share: 1/2

Paul M. Romer

Prize share: 1/2

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2018 was divided equally between William D. Nordhaus "for integrating climate change into long-run macroeconomic analysis" and Paul M. Romer "for integrating technological innovations into long-run macroeconomic analysis."

THE PRODUCT VARIETY MODEL

- Productivity comes from an expanding variety of specialized intermediate products. Product variety expands gradually because discovering how to produce a large range of products takes real resources, including time.
- Growth is induced and sustained by increased specialization (A.A. Young, 1928).

THE PRODUCT VARIETY MODEL

- For each new product there is a sunk cost of product innovation that must be incurred just once, when the product is first introduced, and never again. The sunk costs can be taken as costs of research, an activity that adds to the stock of technological knowledge.

THE PRODUCT VARIETY MODEL

- Technological knowledge consists of a list of blueprints, each of them describing how to produce a different product, and every innovation adds one more blueprint to the list (understood as basic innovation, as if a new industry were opened up). Identifying the state of the technology with the number of varieties should be seen as a metaphor.

THE PRODUCT VARIETY MODEL

- Differences with AK model:
  - Sunk cost of product development, AND
  - Fixed costs make product markets monopolistically competitive rather than perfectly competitive. Imperfect competition creates profits, and these profits act as a reward for the creation of new products.
- This allows to "solve" the problem created by Euler's theorem (given that perfect competition exhausts income).

THE PRODUCT VARIETY MODEL

- Elements of the basic model:
  - Consumers. Utility maximizers.
  - Firms. Profit maximizers.
    - Research sector. Perfect competition. Spending on research creates new blueprints (that is, expands the number of varieties). A blueprint has a value for its inventor.
    - Producers of intermediate goods, which are different from each other. Each interm. good is monopolized by the person who created the blueprint.
    - Producers of final goods. Perfect competition. Intermediate goods are used as inputs. The final good is devoted to consumption, production of blueprints, and production of interm. goods.

THE PRODUCT VARIETY MODEL

- Final output is produced under perfect competition using labor and a range of intermediate inputs . The final goods production function is:

$$Y_t = L_t^{1-\alpha} \sum_{i=0}^{N_t} x_{it}^{\alpha}$$

- There are N varieties of intermediate products, and x_{it} refers to units of intermediate input (capital).

THE PRODUCT VARIETY MODEL

$$Y_t = L_t^{1-\alpha} \sum_{i=0}^{N_t} x_{it}^{\alpha}$$

- The production function exhibits diminishing marginal products of each input but constant returns to scale in all inputs together.
- The function is additively separable: marginal products of intermediate goods are independent. New discoveries do not convert others obsolete.

THE PRODUCT VARIETY MODEL

$$Y_t = L_t^{1-\alpha} \sum_{i=0}^{N_t} x_{it}^{\alpha}$$

- Each intermediate product is produced using the final good as input, one for one. That is, each unit of intermediate product *i* produced requires the input of one unit of final good.

THE PRODUCT VARIETY MODEL

Adding up:

$$Y_t = L_t^{1-\alpha} N_t x_t^{\alpha}$$

Thus product variety *N* enhances overall productivity in the economy. **Technological change in the form of continuous increases in N avoids the tendency for diminishing marginal returns. This is the basis for endogenous growth.**

THE PRODUCT VARIETY MODEL

$$X_t = \sum_{i=0}^{N_t} x_i$$

X_t is the total amount of final good used in producing intermediate products.

- Suppose that each intermediate product is produced in the same amount x (in equilibrium). Then

  By symmetry, aggregate stock of capital X_t is divided into the N_t varieties evenly.

$$x = \frac{X_t}{N_t}$$

THE PRODUCT VARIETY MODEL

- Substituting $x = \frac{X_t}{N_t}$

into $Y_t = L_t^{1-\alpha} \sum_{i=0}^{N_t} x_{it}^{\alpha}$

we get $Y_t = N_t^{1-\alpha} L_t^{1-\alpha} X_t^{\alpha}$

THE PRODUCT VARIETY MODEL

$$Y_t = N_t^{1-\alpha} L_t^{1-\alpha} X_t^{\alpha} = N_t^{1-\alpha} L_t^{1-\alpha} (N_t x_t)^{\alpha}$$

- Given *L*, if intermediates *Nx* expand:
  - Taking the form of increases in *x*, diminishing returns are found.
  - However, with increases in *N* diminishing returns do not arise.
- Increasing *N* encompasses technological change: diminishing returns do not take place. Endogenous growth occurs.

THE PRODUCT VARIETY MODEL

$$Y_t = N_t^{1-\alpha} L_t^{1-\alpha} X_t^{\alpha} = N_t^{1-\alpha} L_t^{1-\alpha} (N_t x_t)^{\alpha}$$

- The degree of product variety is the economy's aggregate productivity parameter, and its growth is the long-run growth rate of per capita worker.
- More product variety raises output potential because a given capital stock is spread over a large number of uses, each of which shows diminishing returns.

THE PRODUCT VARIETY MODEL

- Increasing product variety sustains growth.
- New varieties (new innovations) themselves result from R&D investments by research-entrepreneurs, who are motivated by the prospect of (perpetual) monopoly rents if they successfully innovate.
- There is only one kind of innovation, which always results in the same kind of new product.

THE PRODUCT VARIETY MODEL

- The empirical evidence does not seem to provide a strong support for this model.
- In addition, there is no role for exit and turnover in the economy.

3.5: THE SCHUMPETERIAN MODEL

Joseph Schumpeter

From Wikipedia, the free encyclopedia

Joseph Alois Schumpeter (8 February 1883 – 8 January 1950)[1] was an Austrian-American economist and political scientist. He popularized the term "creative destruction" in economics.[2]

Contents [show]

Life [edit]

Born in Třešť, Moravia (now Czech Republic, then part of Austria-Hungary) in 1883 to Catholic ethnic German parents, Schumpeter began his career studying law at the University of Vienna under the Austrian capital theorist Eugen von Böhm-Bawerk, taking his PhD in 1906. In 1909, after some study trips, he became a professor of economics and government at the University of Czernowitz. In 1911 he joined the University of Graz, where he remained until World War I. In 1919-1920, he served as the Austrian Minister of Finance, with some success, and in 1920-1924, as president of the private Biedermann Bank. That bank, along with a great part of that regional economy, collapsed in 1924 leaving Schumpeter bankrupt.

From 1925-1932, he held a chair at the University of Bonn, Germany. He lectured at Harvard in 1927-1928 and 1930. Because of the rise of Nazism in Germany he moved to the United States where he would teach from 1932 until his death in 1950.

During his Harvard years he was not generally considered a good classroom teacher, but he acquired a school of loyal followers. His prestige among colleagues was likewise not very high because his views seemed outdated and not in synch with the then-fashionable Keynesianism. This period of his life was characterized by hard work but little recognition of his core ideas.

Although Schumpeter encouraged some young mathematical economists and was even the president of the Econometric Society (1940–41), Schumpeter was not a mathematician but rather an economist and tried instead to integrate sociological understanding into his economic theories. From current thought it has been argued that Schumpeter's ideas on business cycles and economic development could not be captured in the mathematics of his day - they need the language of non-linear dynamical systems to be partially formalized.

Schumpeter claimed that he had set himself three goals in life: to be the greatest economist in the world, to be the best horseman in all of Austria and the greatest lover in all of Vienna. He said he had reached two of his goals, but he never said which two.[3][4] Although, he is reported to have said that there were too many fine horseman in Austria for him to succeed in all his aspirations! (P.A. Samuelson and W.D. Nordhaus, Economics (1998, p. 178)

Most important work [edit]

Joseph Schumpeter

Birth	8 February 1883 Třešť, Moravia, Austria–Hungary (now Czech Republic)
Death	8 January 1950 (aged 66) Taconic, Connecticut, U.S.
Institution	Harvard University 1932-50 University of Bonn 1925-32 Biedermann Bank 1921-24 University of Graz 1912-14 University of Czernowitz 1909-11
Field	Economics
Alma mater	University of Vienna
Influences	Böhm-Bawerk, Wieser, Menger, Walras, Juglar

THE SCHUMPETERIAN MODEL

- This is the third wave ("third family") in modern economic growth. Again this is an innovation-based growth model, also known as the Schumpeterian model since it involves "creative destruction" (Schumpeter, 1942): quality-improving innovations created by new technologies render old products obsolete (Aghion and Howitt, 1992, 1998).

portrayed as *Shiva Nataraja* (Lord of the Dance), which is proposed as the source of the Western notion of "creative destruction".[1]

Other nineteenth-century formulations of this idea include Russian anarchist Mikhail Bakunin, who wrote in 1842, "The passion for destruction is a creative passion, too!"[16] Note, however, that this earlier formulation might more accurately be termed "destructive creation", and differs sharply from Marx's and Schumpeter's formulations in its focus on the active destruction of the existing social and political order by human agents (as opposed to systemic forces or contradictions in the case of both Marx and Schumpeter).

Schumpeter [edit]

Joseph Schumpeter [edit]

The expression "creative destruction" was popularized by and is most associated with Joseph Schumpeter, particularly in his book *Capitalism, Socialism and Democracy*, first published in 1942. Already in his 1939 book *Business Cycles*, he attempted to refine the innovative ideas of Nikolai Kondratieff and his long-wave cycle which Schumpeter believed was driven by technological innovation.[17] Three years later, in *Capitalism, Socialism and Democracy*, Schumpeter introduced the term "creative destruction", which he explicitly derived from Marxist thought (analysed extensively in Part I of the book) and used it to describe the disruptive process of transformation that accompanies such innovation:

> Capitalism [...] is by nature a form or method of economic change and not only never is but never can be stationary. [...] The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates. [...] The opening up of new markets, foreign or domestic, and the organizational development from the craft shop and factory to such concerns as U.S. Steel illustrate the same process of industrial mutation [...] that incessantly revolutionizes the economic structure *from within*, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism. It is what capitalism consists in and what every capitalist concern has got to live in.[18]

In Schumpeter's vision of capitalism, innovative entry by entrepreneurs was the disruptive force that sustained economic growth, even as it destroyed the value of established companies and laborers that enjoyed some degree of monopoly power derived from previous technological, organizational, regulatory, and economic paradigms. However, Schumpeter was pessimistic about the sustainability of this process, seeing it as leading eventually to the undermining of capitalism's own institutional frameworks:

> In breaking down the pre-capitalist framework of society, capitalism thus broke not only barriers that impeded its progress but also flying buttresses that prevented its collapse. That process, impressive in its relentless necessity, was not merely a matter of removing institutional deadwood, but of removing partners of the capitalist stratum, symbiosis with whom was an essential element of the capitalist schema. [... T]he capitalist process in much the same way in which it destroyed the institutional framework of feudal society also undermines its own.[6]

Schumpeter nevertheless elaborated the concept, making it central to his economic theory, and it was later taken up as a major doctrine of the so-called Austrian School of free-market economic thought.[*citation needed*]

Examples [edit]

Schumpeter (1949) in one of his examples used "the railroadization of the Middle West as it was initiated by the Illinois Central." He wrote, "The Illinois Central not only meant very good business whilst it was built and whilst new cities were built around it and land was cultivated, but it spelled the death sentence for the [old] agriculture of the West."[19]

THE SCHUMPETERIAN MODEL

- The model begins with a Cobb-Douglas type of production function at the industry level

$$Y_{it} = A_{it}^{1-\alpha} K_{it}^{\alpha}$$

- *K* represents the flow of a unique **intermediate** product used in this sector, each unit of which is produced one-for one by final output (or capital).

THE SCHUMPETERIAN MODEL

- Each **intermediate** product is produced and sold exclusively by the most recent innovator (a monopolist). A successful innovator in sector *i* improves the technology parameter A_{it} and is thus able to displace the previous product in that sector, until it is displaced in turn by the next innovator.

THE SCHUMPETERIAN MODEL

- First implication of the model: faster growth generally implies a higher rate of firm turnover, because this process of creative destruction generates entry of new innovators and exit of former innovators.

THE SCHUMPETERIAN MODEL

- Even though the focus is on individual industries, the assumption that all industries are equal *ex ante* offers a simple (Cobb-Douglas) structure.

$$Y_t = A_t^{1-\alpha} K_t^{\alpha}$$

- As in the neoclassical model, the long run growth rate is given by the growth rate of the factor productivity *A*, which here depends endogenously on the economy-wide rate of innovation.

THE SCHUMPETERIAN MODEL

$$Y_t = A_t^{1-\alpha} K_t^{\alpha}$$

- There are two main inputs to innovation:
  - The private expenditures made by the prospective innovator, and
  - The stock of innovations that have already been made by past innovators: publicly available stock of knowledge (current innovators can add to it).

THE SCHUMPETERIAN MODEL

$$Y_t = A_t^{1-\alpha} K_t^{\alpha}$$

- (Cont.) Stock of innovations available:
  - An innovation that leapfrogs *("salto de rana")* the best available technology available before the innovation, resulting in a new technology parameter A_{it} in the innovating sector i, which is some multiple γ of its preexisting value: LEADING-EDGE INNOVATION.
  - An innovation that catches up to a global technology frontier $\hat{A}_t$ (the stock of global technological knowledge available to innovators in all sectors in all countries). IMPLEMENTING (IMITATING) INNOVATION

THE SCHUMPETERIAN MODEL

- If leading-edge innovations take place at the frequency μ_n and implementation innovations (or imitations) at the frequency μ_m, then the aggregate productivity parameter evolves as

$$A_{t+1} - A_t = \mu_n(\gamma - 1)A_t + \mu_m(\bar{A}_t - A_t)$$

$\bar{A}_t$ refers to a global technology frontier

Frequency = Probability of an innovation in each period (also the long-run frequency of innovations , that is, the fraction of periods in which an innovation will occur).

γ-1= The proportional increase in productivity resulting from each innovation.

THE SCHUMPETERIAN MODEL

$$A_{t+1} - A_t = \mu_n(\gamma - 1)A_t + \mu_m(\bar{A}_t - A_t)$$

- And the growth rate will be given by

$$g_t = \frac{A_{t+1} - A_t}{A_t} = \mu_n(\gamma - 1) + \mu_m(a_t^{-1} - 1)$$

where

$$a_t = \frac{A_t}{\bar{A}_t}$$

is an inverse measure of "distance to the frontier"

THE SCHUMPETERIAN MODEL

$$g_t = \frac{A_{t+1} - A_t}{A_t} = \mu_n(\gamma - 1) + \mu_m(a_t^{-1} - 1)$$

- Growth policies are highly context-dependent:

$$a_t = \frac{A_t}{\bar{A}_t}$$

  - How does country performance vary with its proximity to the technological frontier a_t?
  - To what extent will the country converge to the technological frontier a_t?
  - What kinds of policy changes are needed to sustain convergence as the country approaches the technological frontier a_t?

THE SCHUMPETERIAN MODEL

- The critical innovation frequencies could be:
  - Taken as given, or,
  - Derived endogenously from profit maximization strategies. They will depend on:
    - Economic institutions, such as property right protection, the financial system, ...
    - Government policy.
- The equilibrium intensity and mix of innovation will depend on the institutions and policies, and this in turn from the country´s distance to the technological frontier.

THE SCHUMPETERIAN MODEL

$$g_t = \frac{A_{t+1} - A_t}{A_t} = \mu_n(\gamma - 1) + \mu_m(a_t^{-1} - 1)$$

- This is Gerschenkron´s "advantage from backwardness" (1962): the further the distance, the faster the growth rate, given the frequencies.
- Appropriate institutions can also be easily incorporated in the framework. If institutions favoring imitation are not the same as those favoring leading-edge innovation:
  - If far from the frontier: imitation.
  - If close to the frontier: leading-edge innovation.

SAPIR REPORT

Contrary to the post-war period where growth and catching-up with the US could largely be achieved through factor accumulation and imitation, once European countries had moved closer to the technology frontier and also with the occurrence of new technological revolutions in communication and information, innovation at the frontier has become the main engine of growth (see Box 4.1). This in turn called for new organisational forms, less vertically integrated firms, greater mobility both intra- and inter-firm, greater flexibility of labour markets, a greater reliance on market finance and a higher demand for both R&D and higher education. However, these necessary changes in economic institutions and organisations have not yet occurred on a large scale in Europe and it is this delay in adjusting our institutions, which accounts to a large extent for our growth deficit.

Source: *An agenda for a growing Europe. Making the EU Economic System Deliver*. Chaired by André Sapir (2003). European Commission.

SAPIR REPORT

Key requirements for innovation

The balance between imitation and innovation has thus shifted decisively in favour of the second. In addition, a greater proportion of that innovation is radical rather than elemental. Growth becomes driven by innovation at the frontier and fast adaptation to technical progress.

Now, as new growth theories suggest, most innovations result from entrepreneurial activities or investments - typically, investments in R&D - which involve risky experimentation and learning. The incentive to engage in innovative investments is itself affected by the economic environment. In particular research investment is encouraged by:

- a good system to protect intellectual property rights on innovations;
- a high productivity of R&D, which itself requires a good education and research subsidy system;
- low interest rates as R&D investments are forward-looking; this in turn calls for a stable macroeconomy;
- product market competition, low entry costs, and market openness to stimulate innovation by incumbents;
- good access to risk capital by new start-up firms;
- more flexible labour market institutions, so that new innovators can quickly find workers that match their new technologies.

Source: *An agenda for a growing Europe. Making the EU Economic System Deliver*. Chaired by André Sapir (2003). European Commission.

TO RECAP: MODELS

- First wave: Harrod-Domar (capital accum.).
- Second wave: Solow-Swan (capital accum.).
- Third wave:
  - First family: AK model (based on capital accumulation).
  - Second family: Product variety (innovation based).
  - Third family: Schumpeterian model (innovation based).

4. EMPIRICAL EVIDENCE

EMPIRICAL EVIDENCE

- Neoclassical and AK growth models focus on capital accumulation, while product-variety and Schumpeterian models focus on innovations that raise productivity.
- Two have been the main strands of empirical analysis:
  - Convergence (econometric). Mentioned for neoclassical vs. AK.
  - Growth accounting (non-econometric and econometric). This is the topic I will analyze now.

EMPIRICAL EVIDENCE

- Growth accounting. Solow (1957).
  - Which is the contribution of inputs to output? Which are the sources of growth?
  - General framework based on Solow (1956). First results focus on total factor productivity (TFP) growth. Capital accumulation is also an important factor.
  - Measuring capital is difficult.
  - Accounting for vs. Causation.

Table 5.1
Growth Accounting in OECD Countries: 1960–2000

Country	Growth Rate	TFP Growth	Capital Deepening	TFP Share	Capital Share
Australia	1.67	1.26	0.41	0.75	0.25
Austria	2.99	2.03	0.96	0.68	0.32
Belgium	2.58	1.74	0.84	0.67	0.33
Canada	1.57	0.95	0.63	0.60	0.40
Denmark	1.87	1.32	0.55	0.70	0.30
Finland	2.72	2.03	0.69	0.75	0.25
France	2.50	1.54	0.95	0.62	0.38
Germany	3.09	1.96	1.12	0.64	0.36
Greece	1.93	1.66	0.27	0.86	0.14
Iceland	4.02	2.33	1.69	0.58	0.42
Ireland	2.93	2.26	0.67	0.77	0.23
Italy	4.04	2.10	1.94	0.52	0.48
Japan	3.28	2.73	0.56	0.83	0.17
Netherlands	1.74	1.25	0.49	0.72	0.28
New Zealand	0.61	0.45	0.16	0.74	0.26
Norway	2.36	1.70	0.66	0.72	0.28
Portugal	3.42	2.06	1.36	0.60	0.40
Spain	3.22	1.79	1.44	0.55	0.45
Sweden	1.68	1.24	0.44	0.74	0.26
Switzerland	0.98	0.69	0.29	0.70	0.30
United Kingdom	1.90	1.31	0.58	0.69	0.31
United States	1.89	1.09	0.80	0.58	0.42
Average	2.41	1.61	0.80	0.68	0.32

Source: Aghion, Philippe, and Peter Howitt (2009). *The economics of growth.* MIT Press.

EMPIRICAL EVIDENCE

- Directions of new research in growth accounting:
  - Human capital,
  - Information and Communication Technologies capital, and
  - Intangible assets.
- I will focus on the basic framework in the next section in more detail.

5. THREE (PERSONAL) PRACTICAL EXAMPLES

THREE (PERSONAL) PRACTICAL EXAMPLES

- Broad recommendation for research: provide a coherent mix of theory and empirical evidence. It makes it much easier to “sell”.

5.1: GROWTH ACCOUNTING

GROWTH ACCOUNTING

- What follows is mostly based on Erauskin (2011): "ACCOUNTING FOR GROWTH IN SPAIN, THE BASQUE COUNTRY (AND ITS THREE HISTORIC TERRITORIES), NAVARRE, AND MADRID SINCE 1965".
  - I have an older paper (2008) on this issue as well.

Introduction

- Motivation:
  - Post-war period has been a fruitful period as far as economic progress is concerned.
  - However, growth did not proceed at a steady pace.
  - Territories throughout Spain have performed unevenly.
  - Few studies on the whole period 1965-2008.

Introduction

- This paper provides a long term analysis on the proximate causes of economic growth for 1965-2008.
  - Spain, the Basque Country, Navarre, Madrid, the EU, and the US.

The growth accounting methodology

- How does it work? Proximate sources of economic growth (vs. Deep determinants of growth).
- Growth accounting decomposes the growth rate of output into:
  - Contribution of labor growth.
  - Contribution of capital growth.
  - Everything else: “black box”; “measure of our ignorance”, growth in total factor productivity, …
- Origins: Solow (1957).

The growth accounting methodology

- Neoclassical production function:

$$Y_t = A_t \cdot F\left(L_t, K_{INF,t}, K_{ICT,t}, K_{O,t}\right),$$

Y=Output

A=Level of technology (TFP)

L=Labor

K=Services of capital

- Infrastructures (INF),
- Information and Communication Technologies (ICT): hardware, software, and communications,
- Others (O).

The growth accounting methodology

K=Services of capital

- Infrastructures (INF): road, water, railway, airport, port, and urban.
- Information and Communication Technologies (ICT):
  - Hardware: office machinery and computer equipment,
  - Software, and
  - Communications
- Other (O) type of non-residential capital:
  - Constructions other than dwellings and the infraestructures referred to earlier,
  - Transport equipment.
  - Machinery, equipment and other products, except ICT.

The growth accounting methodology

- Under usual assumptions, the growth rate of output is:

$$\Delta \ln Y_t = \Delta \ln A_t + \bar{\alpha}_{L,t} \cdot \Delta \ln L_t + \bar{\alpha}_{KINF,t} \cdot \Delta \ln K_{INF,t} + \bar{\alpha}_{KICT,t} \cdot \Delta \ln K_{ICT,t} + \bar{\alpha}_{KO,t} \cdot \Delta \ln K_{O,t}$$

where α denotes input shares.

- If we have data on Y, L, and K, and input shares...

The growth accounting methodology

Then ...

$$\Delta \ln A_t = \Delta \ln Y_t - \bar{\alpha}_{L,t} \cdot \Delta \ln L_t - \bar{\alpha}_{KINF,t} \cdot \Delta \ln K_{INF,t} - \bar{\alpha}_{KICT,t} \cdot \Delta \ln K_{ICT,t} - \bar{\alpha}_{KO,t} \cdot \Delta \ln K_{O,t}$$

= **the growth rate of output that cannot be attributed to the (weighted) growth rate of inputs="Solow residual"="a measure of our ignorance"=technical innovations, organizational and institutional changes, changes in societal attitudes, fluctuations in demand, changes in factor shares, omitted variables, and errors of measurement.**

The growth accounting methodology

- Alternatively:

$$\Delta \ln Y_t - \Delta \ln L_t = \Delta \ln A_t + \bar{\alpha}_{KINF,t} \cdot \left(\Delta \ln K_{INF,t} - \Delta \ln L_t\right) + \bar{\alpha}_{KICT,t} \cdot \left(\Delta \ln K_{ICT,t} - \Delta \ln L_t\right) + \bar{\alpha}_{KO,t} \cdot \left(\Delta \ln K_{O,t} - \Delta \ln L_t\right)$$

which is very useful to analyze the growth rate of output per hour (or per worker).

The growth accounting methodology

- The above equations have been obtained using non-econometric procedures:
  - They are the most frequently used.
  - Important advantages over econometric procedures.

Results of previous studies

- Several studies for Spain, but very few for the Autonomous Communities, or provinces in Spain.
- Escriba and Murgui (1998). Growth in TFP and private capital were the sources of growth (1980-1993).
- Gallastegui (2000). Period 1985-1994. 60% was explained by the evolution of private and public capital, employment, training of workers, and expenditure in R+D. 30% was explained by technological change.

Results of previous studies

- Goerlich and Mas (2001). Growth in TFP was the main source of growth, followed by private capital (1965-1996).
- Timmer, Ypma and van Ark (2003). 1980-2001
  - EU: Growth in TFP and capital during 1980-1995. Increasing contribution of labor during 1995-2001. ICT contribution increased, but not much.
  - US: Growth in labor and capital during 1980-1995, and capital and labor during 1995-2001. ICT contribution increased notably.
  - Spain: similar sources to those of the EU. Growth in TFP during 1980-1995, and labor during 1995-2001. ICT contribution did not increase.

Results of previous studies

- Mas and Quesada (2005). Similar results to those of Timmer et al. (1985-2002).
  - Labor and capital were the main sources of growth.
  - The contribution of labor increased enormously, while that of TFP declined.
  - Increasing contribution of ICT capital.
- Erauskin (2005). 1986-2000. Private capital and TFP growth fuelled output growth in the Basque Country.

Table 1. **SOURCES OF GROSS VALUE ADDED GROWTH MARKET ECONOMY. 1980-1995**

	Japan	US	EU-15ex	Spain
GVA growth. (1)	3.87	2.97	2.06	2.42
Total contribution of labor. (2)=(3)+(4)	0.39	1.19	0.02	0.31
Hours worked. (3)	0.11	0.95	-0.28	-0.01
Changes in the composition of labor. (4)	0.27	0.24	0.30	0.32
Contribution of capital, Total. (5)=(6)+(7)	1.98	1.12	1.06	1.44
Contribution of capital, Non-ICT. (6)	1.52	0.60	0.67	0.98
Contribution of capital, ICT. (7)	0.46	0.52	0.38	0.47
Contribution of TFP. (8)=(1)-(2)-(5)	1.51	0.65	0.98	0.66

Source: Mas and Robledo (2010, pp. 109-110).

Table 2. **SOURCES OF GROSS VALUE ADDED GROWTH MARKET ECONOMY. 1995-2005**

	Japan	US	EU-15ex	Spain
GVA growth. (1)	0.99	3.69	2.20	3.61
Total contribution of labor. (2)=(3)+(4)	-0.52	0.66	0.64	2.55
Hours worked. (3)	-0.94	0.37	0.42	2.15
Changes in the composition of labor. (4)	0.42	0.28	0.21	0.40
Contribution of capital, Total. (5)=(6)+(7)	1.06	1.34	1.19	1.91
Contribution of capital, Non-ICT. (6)	0.61	0.57	0.62	1.44
Contribution of capital, ICT. (7)	0.46	0.77	0.57	0.47
Contribution of TFP. (8)=(1)-(2)-(5)	0.45	1.70	0.38	-0.85

Source: Mas and Robledo (2010, pp. 112-113).

Results of previous studies

- Van Ark, O'Mahony, & Timmer (2008).
  - "the European productivity slowdown is attributable to the slower emergence of the knowledge economy in Europe compared to the United States".
    - Lower contribution of ICT capital.
    - Lower share of technology-producing industry in the EU.
    - Lower TFP.
  - Working of labor market. High product market regulation.

Results of previous studies

- Pérez & Robledo (2010). Spain, 1970-2007
  - Contribution of capital and labor.
  - Difference: Declining role of TFP growth. Causes:
    - Too much investment in the building sector.
    - Additional orientation of investment: services.
    - Deficiencies in education and inadequate working of labor market.
    - Unproductive overinvesment in productive assets.

Results of previous studies

- Erauskin (2008). Spain, the Basque Country, and Navarre, 1986-2004.
  - Higher growth rates for 1995-2004.
  - Labor and capital growth rates were the main engines of growth.
  - TFP growth was residual and it was declining, even reaching negative figures.

Table 3. **SOURCES OF GROSS VALUE ADDED GROWTH. 1986-2004**

	EU-15ex	US	Spain	The Basque Country	Navarre
GVA growth. (1)	2.21	2.89	3.14	2.50	3.15
Contribution of labor. (2)	0.55	1.02	1.48	1.17	1.41
Contribution of capital, Total. (3)=(4)+(7)	1.20	1.18	1.21	0.97	1.34
Contribution of capital, Non-ICT. (4)=(5)+(6)	0.76	0.60	0.87	0.66	0.97
Contribution of capital, Public infrastructure. (5)			0.12	0.10	0.09
Contribution of capital, Other Non-ICT. (6)			0.74	0.56	0.88
Contribution of capital, ICT. (7)=(8)+(9)+(10)	0.44	0.58	0.35	0.31	0.36
Contribution of capital, Hardware. (8)			0.18	0.17	0.20
Contribution of capital, Software. (9)			0.08	0.07	0.07
Contribution of capital, Communications. (10)			0.09	0.07	0.10
Contribution of TFP. (10)=(1)-(2)-(3)	0.47	0.68	0.44	0.36	0.40

Source: Erauskin (2008a, p. 47).

Data sources

- Data for the EU and the US: EU KLEMS. From 1970 (1980) onwards.
- Data for Spain:
  - National Accounts.
    - INE.
    - FBBVA. For data before 1986.
  - FBBVA and IVIE: new capital database from 2007 onwards (period 1964-2008).
- Data for the Basque Country (GVA, employment). Independent data from 1980 onwards.

The results

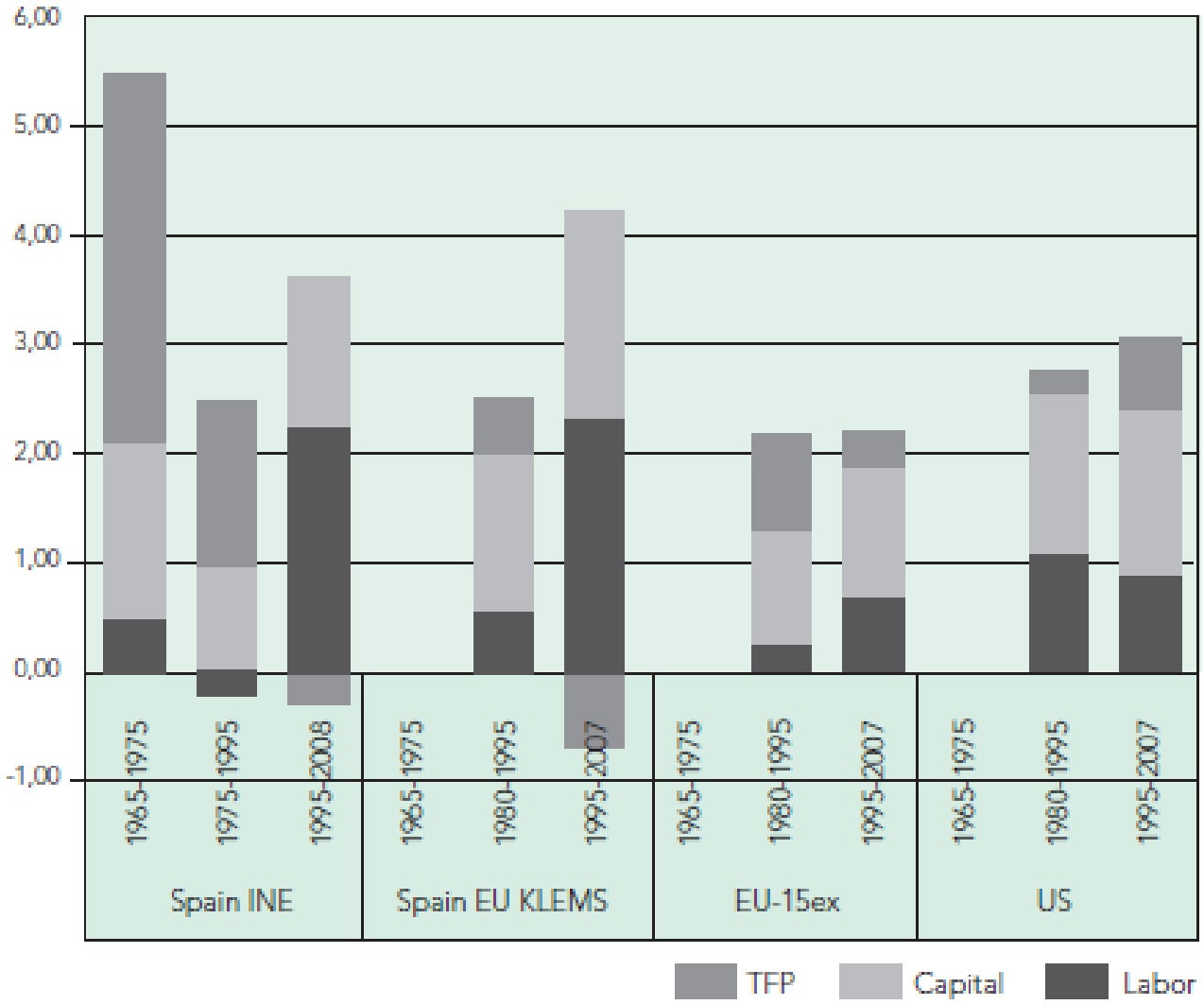
- Three periods:
  - 1965-1975: “Traditional catch-up pattern”
  - 1975-1995: “Productivity slowdown”
  - 1995-2008: “Europe’s falling behind”.

Table 4. **SOURCES OF GROSS VALUE ADDED GROWTH. 1965-2008**

	Spain INE-FBBVA-IVIE	Spain EU KLEMS 1980-2007	EU-15ex EU KLEMS 1980-2007	US EU KLEMS 1980-2007
GVA growth. (1)	3.23	2.96	2.19	2.89
Contribution of labor. (2)	0.64	1.37	0.47	1.02
Contribution of capital, Total. (3)=(4)+(7)	1.18	1.64	1.09	1.49
Contribution of capital, Non-ICT. (4)=(5)+(6)	0.86	1.21	0.71	0.82
Contribution of capital, Public infrastructure. (5)	0.10			
Contribution of capital, Other Non-ICT. (6)	0.76			
Contribution of capital, ICT. (7)=(8)+(9)+(10)	0.32	0.43	0.37	0.67
Contribution of capital, Hardware. (8)	0.17			
Contribution of capital, Software. (9)	0.07			
Contribution of capital, Communications. (10)	0.09			
Contribution of TFP. (10)=(1)-(2)-(3)	1.42	-0.04	0.64	0.39

Sources: EU KLEMS database (for Spain (1980-2007), the EU and the US), INE, FBBVA, FBBVA-IVIE database and EU KLEMS database (for Spain), and our own elaboration. The contribution of labor includes the impact of changes in the composition of the labor force for Spain (1980-2007), the EU-15ex and the US.

Figure 1. **SOURCES OF GROSS VALUE ADDED GROWTH IN SPAIN, THE EU AND THE US**



Sources: EU KLEMS database (for Spain (1980-2007), the EU and the US), INE, FBBVA, FBBVA-IVIE database and EU KLEMS database (for Spain), and our own elaboration. The contribution of labor includes the impact of changes in the composition of the labor force for Spain (1980-2007), the EU-15ex and the US.

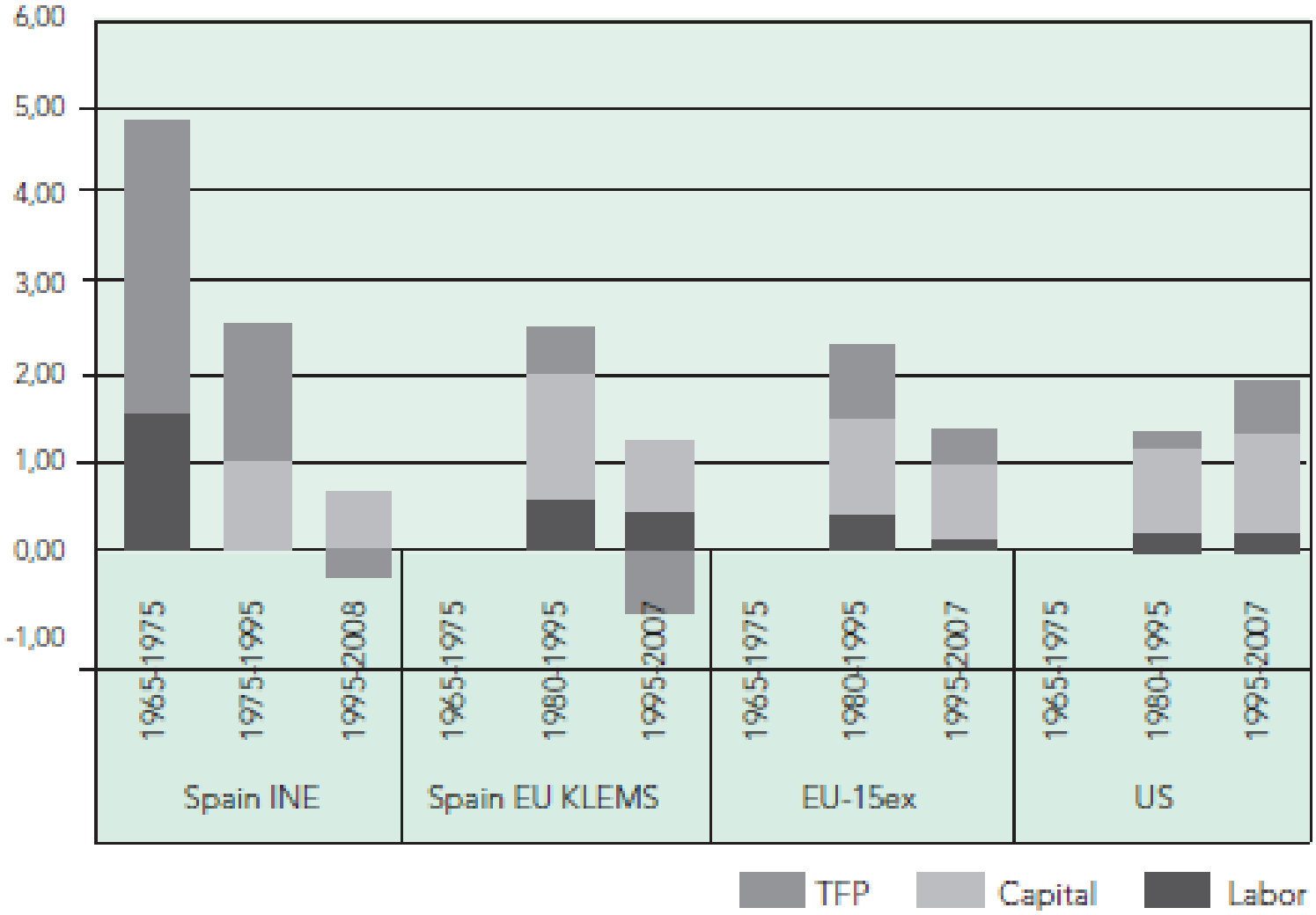
Table 5. **SOURCES OF GROSS VALUE ADDED GROWTH. 1995-2008**

	Spain INE-FBBVA -IVIE	Spain EU KLEMS 1995-2007	EU-15ex EU KLEMS 1995-2007	US EU KLEMS 1995-2007
GVA growth. (1)	3.34 (3.55)	3.52 (3.57)	2.22 (2.42)	3.05 (2.93)
Contribution of labor. (2)	2.27	2.32	0.73	0.92
Contribution of capital, Total. (3)=(4)+(7)	1.35	1.89	1.13	1.50
Contribution of capital, Non-ICT. (4)=(5)+(6)	0.89	1.43	0.69	0.76
Contribution of capital, Public infrastructure. (5)	0.11			
Contribution of capital, Other Non-ICT. (6)	0.78			
Contribution of capital, ICT. (7)=(8)+(9)+(10)	0.45	0.46	0.44	0.74
Contribution of capital, Hardware. (8)	0.22			
Contribution of capital, Software. (9)	0.10			
Contribution of capital, Communications. (10)	0.13			
Contribution of TFP. (10)=(1)-(2)-(3)	-0.27 (0.29)	-0.69 (-0.53)	0.36 (0.73)	0.63 (0.74)

The figures within parentheses show the results for Spain, the EU-15ex, and the US for the period 2003-2007.

Sources: EU KLEMS database (for Spain (1995-2007), the EU and the US), INE, FBBVA-IVIE database and EU KLEMS database (for Spain), and our own elaboration. The contribution of labor includes the impact of changes in the composition of the labor force for Spain (1995-2007), the EU-15ex and the US.

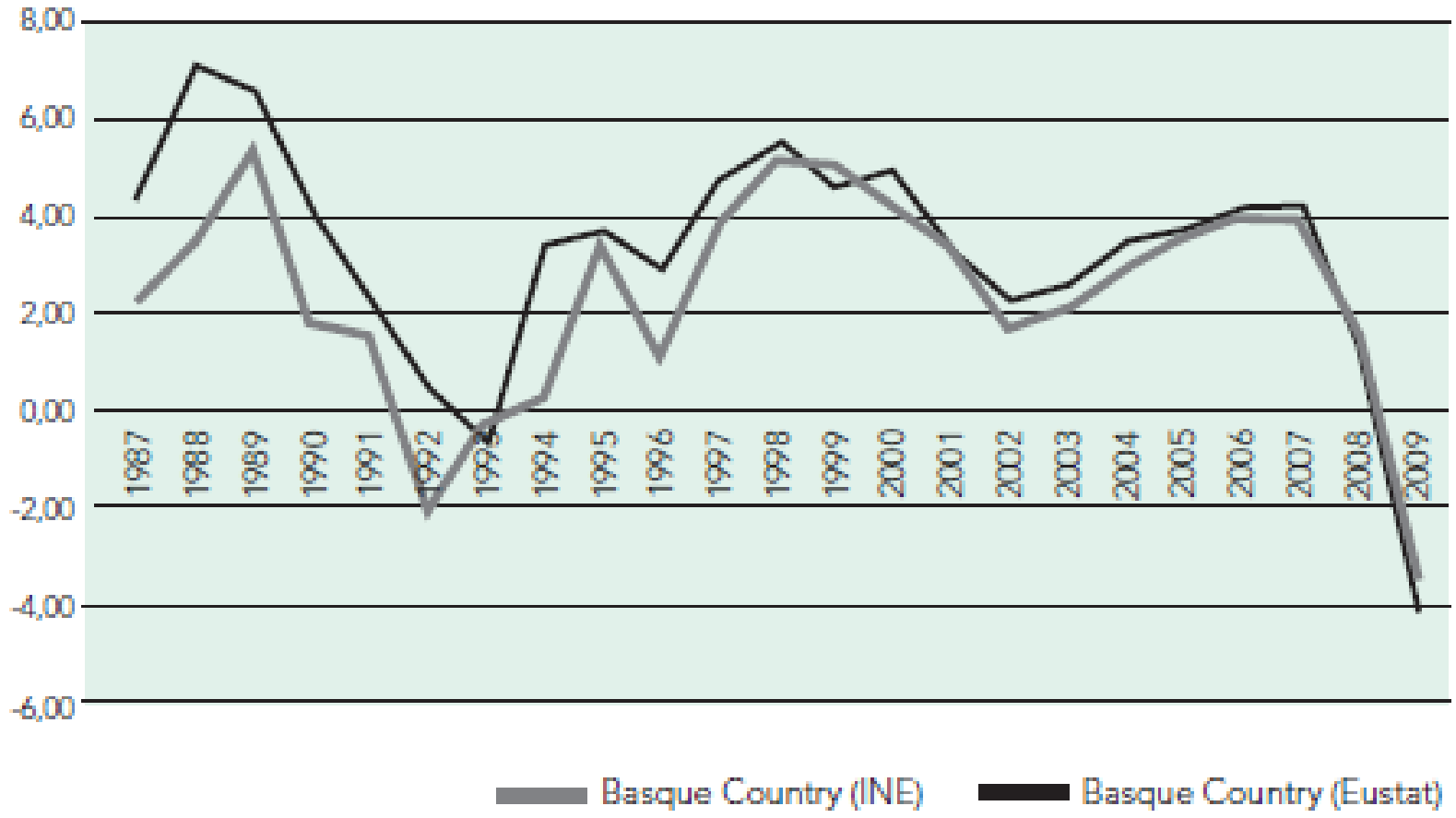
Figure 2. **SOURCES OF GROWTH FOR GROSS VALUE ADDED PER HOUR IN SPAIN, THE EU AND IN THE US**



Sources: EU KLEMS database (for Spain (1980-2007), the EU and the US), INE, FBBVA, FBBVA-IVIE database and EU KLEMS database (for Spain), and our own elaboration. The contribution of labor includes the impact of changes in the composition of the labor force for Spain (1980-2007), the EU-15ex and the US.

Different sources of data for the Basque Country

Figure 3. **REAL GROSS VALUE ADDED GROWTH RATES. 1987-2009**



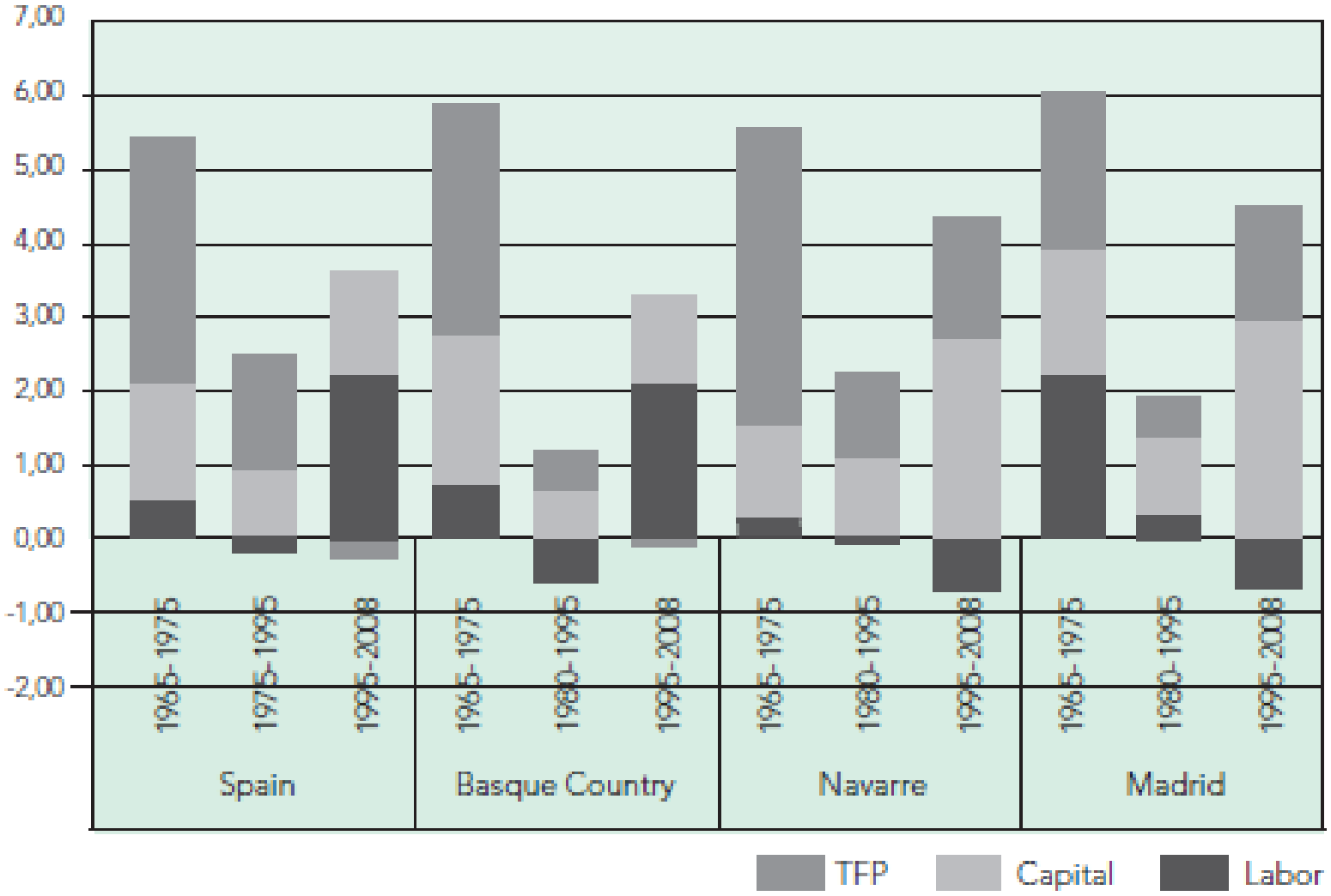
Sources: INE, Eustat, and our own elaboration.

Table 6. **SOURCES OF GROSS VALUE ADDED GROWTH. 1965-2008**

	Spain INE-FBBVA-IVIE	The Basque Country INE-FBBVA-IVIE	The Basque Country Eustat-FBBVA-IVIE	Navarre INE-FBBVA-IVIE	Madrid INE-FBBVA-IVIE
GVA growth. (1)	3.23	2.52	2.93	3.25	3.35
Contribution of labor. (2)	0.64	0.45	0.41	0.76	1.50
Contribution of capital, Total. (3)=(4)+(7)	1.21	1.10	1.09	1.19	1.28
Contribution of capital, Non-ICT. (4)=(5)+(6)	0.90	0.79	0.79	0.88	0.88
Contribution of capital, Public infrastructure. (5)	0.11	0.08	0.08	0.09	0.08
Contribution of capital, Other Non-ICT. (6)	0.79	0.71	0.70	0.79	0.80
Contribution of capital, ICT. (7)=(8)+(9)+(10)	0.31	0.31	0.31	0.31	0.40
Contribution of capital, Hardware. (8)	0.16	0.17	0.17	0.16	0.22
Contribution of capital, Software. (9)	0.07	0.06	0.06	0.06	0.09
Contribution of capital, Communications. (10)	0.09	0.08	0.08	0.09	0.10
Contribution of TFP. (10)=(1)-(2)-(3)	1.38	0.97	1.43	1.30	0.57

Sources: INE, FBBVA, FBBVA-IVIE database, Eustat, EU KLEMS database, and our own elaboration.

Figure 4. **SOURCES OF GROSS VALUE ADDED IN SPAIN, THE BASQUE COUNTRY, NAVARRE AND MADRID**



Sources: INE, FBBVA, FBBVA-IVIE database, Eustat, EU KLEMS database, and our own elaboration.

Table 7. **SOURCES OF GROSS VALUE ADDED GROWTH. 1995-2008**

	Spain	The Basque Country (INE)	The Basque Country (Eustat)	Navarre	Madrid
GVA growth. (1)	3.34 (3.55)	3.25 (3.55)	3.69 (3.95)	3.61 (3.57)	3.87 (3.82)
Contribution of labor. (2)	2.27	2.11	1.83	2.70	2.97
Contribution of capital, Total. (3)=(4)+(7)	1.35	1.19	1.19	1.62	1.55
Contribution of capital, Non-ICT. (4)=(5)+(6)	0.89	0.73	0.74	1.07	1.02
Contribution of capital, Public infrastructure. (5)	0.11	0.07	0.07	0.07	0.11
Contribution of capital, Other Non-ICT. (6)	0.78	0.66	0.67	1.00	0.92
Contribution of capital, ICT. (7)=(8)+(9)+(10)	0.45	0.46	0.46	0.55	0.53
Contribution of capital, Hardware. (8)	0.22	0.23	0.22	0.24	0.25
Contribution of capital, Software. (9)	0.10	0.11	0.11	0.14	0.11
Contribution of capital, Communications. (10)	0.13	0.12	0.12	0.18	0.16
Contribution of TFP. (10)=(1)-(2)-(3)	-0.27 (0.29)	-0.05 (1.20)	0.66 (1.68)	-0.71 (0.29)	-0.65 (0.26)

The figures within parentheses show the results for Spain, the Basque Country, Navarre, and Madrid for the period 2003-2007.

Sources: INE, FBBVA-IVIE database, Eustat, EU KLEMS database, and our own elaboration.

Conclusions

1. Growth rates of output.
   - They were high in the whole period 1965-2008.
2. They were spectacular during 1965-1975.
   Sources of economic growth.
   - Capital and TFP were the main sources of growth during 1965-2008.
   - TFP growth played a residual and declining role in the most recent period 1995-2008.

Conclusions

3. Some caution on the results for the Basque Country.
   - The annual average growth rate of GVA is between 0.25 and 1 % higher if data from Eustat are used, due to differences in GVA deflators (mainly recently) and values in current prices.

Conclusions

4. There was an important improvement in the economic performance during 2003-2007, especially for the Basque Country. A “golden-four-year-growth-period”
5. The recent crisis has broken with the expansion period.

5.2: CURRENT ACCOUNT BEHAVIOR

CURRENT ACCOUNT BEHAVIOR

- Erauskin (2009): “THE CURRENT ACCOUNT AND THE NEW RULE IN A NOT-SO-SMALL OPEN ECONOMY”

INTRODUCTION

- Motivation: huge movements in cross-border holdings of financial assets, and their implication on the behavior of current accounts.
- "The intertemporal approach views the current-account balance as the outcome of forward-looking dynamic saving and investment decisions" (Obstfeld & Rogoff).

$$\mathrm{CA} = S - \mathrm{I}$$

INTRODUCTION

- Which is the impact of a transitory income shock (fluctuations in output, for example) on the current account?
  - Traditional rule: the impact is equal to the amount of savings generated by the shock. However, it does not hold empirically.
  - New rule: the impact is equal to the amount of savings generated by the shock multiplied by the net foreign asset position. It seems to hold empirically. The original idea was proposed by Kraay and Ventura (2000).

INTRODUCTION

- However, it is assumed that the country is a small open economy.
- Contribution of the paper:
  - Extending the new rule to a not-so-small open economy: which is the impact of transitory income shocks on the current account in a not-so-small open economy (i.e. in a two-country world)?
  - Empirically test the main predictions: how does the theory fit with the empirical data?

THEORY

- Endogenous growth: domestic and foreign capital is subject to diminishing returns to capital. Aggregate capital stock has an external effect on labor productivity, but the firm faces decreasing returns to capital.
  - "We motivate diminishing returns to domestic capital bluntly as the result of congestion effects or negative externalities. Since the representative consumer is infinitesimal, he/she understands that his/her actions have no influence on the aggregate stock of capital." (Kraay and Ventura, 2000).

THEORY

- Two countries.
- Stochastic shocks. This feature permits incorporating risk to the analysis. Mean-variance approach.
- Continuous time.

THEORY

- One homogeneous good.
- Three assets:
  - Risky domestic capital,
  - Risky foreign capital, and
  - Bonds: risk free endogenous interest rate.

THEORY

- Domestic and foreign wealth:

$$W = K_d + K_d^* + B$$
$$W^* = K_f + K_f^* - B$$

  - Domestic wealth:
    - Domestic capital in the hands of the domestic economy.
    - Foreign capital in the hands of the domestic economy.
    - Net position of risk-free loans.
  - Foreign wealth:
    - Domestic capital in the hands of the foreign economy.
    - Foreign capital in the hands of the foreign economy.

THEORY

- Net foreign asset position:

$$P = K_d^* - K_f + B$$

- The current account is equal the variation in its net foreign asset position:

$$CA = dP = dK_d^* - dK_f + dB$$

THEORY

$$CA = S - I = dW - dK = dW - dW\frac{\partial K_d}{\partial W} - dW^*\frac{\partial K_f}{\partial W^*}$$

- The current account balance is equal to the variation in domestic wealth (that is, savings) minus the variation in domestic capital (domestic net investment).

THEORY

$$CA = S - I = dW - dK = dW - dW\frac{\partial K_d}{\partial W} - dW^*\frac{\partial K_f}{\partial W^*}$$

- When a transitory income shock occurs:
  - Part of the shock is consumed.
  - Part of the shock is saved:
    - Traditional view: countries invest the marginal unit of wealth in foreign assets, when risk associated with investment is low compared to the diminishing returns effect.
    - New view: countries invest the marginal unit of wealth as the average one, when risk associated with investment is high compared to the diminishing returns effect.

THEORY: The three results

$$CA = dW - dW\frac{\partial K_d}{\partial W} - dW^*\frac{\partial K_f}{\partial W^*}$$

1) Traditional view: $\frac{\partial K_d}{\partial W} \to 0$

2) New view: $\frac{\partial K_d}{\partial W} \to \frac{K_d}{W}$

- Small open economy: $dK_f \to 0$

3) Not-so-small open economy: $\frac{\partial K_f}{\partial W^*} \to \frac{K_f}{W^*}$

TRADITIONAL RULE

$$CA = dW$$

- Traditional view: $\frac{\partial K_d}{\partial W} \to 0$
- Small open economy: $dK_f \to 0$
- Result: the impact of transitory income shocks on the current account is equal to the saving generated by the shock.

NEW RULE

$$CA = dW - dW\frac{K_d}{W} = dW\left(\frac{K_d^* + B}{W}\right)$$

- New view: $\frac{dK_d}{dW} \to \frac{K_d}{W}$
- Small open economy: $dK_f \to 0$
- Result: the impact of transitory income shocks on the current account is equal to the saving generated by the shock multiplied by the net foreign asset position of the country.

EXTENDED NEW RULE

$$CA = dW - dW\frac{K_d}{W} - dW^*\frac{K_f}{W^*} = dW\left(\frac{K_d^* + B}{W}\right) - dW^*\frac{K_f}{W^*}$$

- New view: $\frac{dK_d}{dW} \rightarrow \frac{K_d}{W}$ $\frac{\partial K_f}{\partial W^*} \rightarrow \frac{K_f}{W^*}$
- Not-so-small open economy:
- Result: the impact of transitory income shocks on the current account is equal to the saving generated by the shock multiplied by the net foreign asset position of the country ***plus a new term***.

DATA SOURCES

- Complex issue
- Sample: 19 OECD countries (1970-2004).
- The data are based on:
  - International Monetary Funds´s International Financial Statistics
  - World Bank´s World Development Indicators, and
  - Lane and Milesi-Ferretti (2007).

EMPIRICAL EVIDENCE

TABLE 1
The traditional rule

	Pooled regression	Between regression	Within regression
Gross national saving/GDP	0.3421 (0.0368)	0.3559 (0.1231)	0.3405 (0.1061)
R^2	0.1796	0.3297	0.0929
No. of observations	608	19	608

Standard errors are in parenthesis.
Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

TABLE 2
The traditional rule (with control variables)

	Pooled regression	Between regression	Within regression
Gross national saving/GDP	0.3481	0.2711	0.4507
	(0.0325)	(0.1045)	(0.0809)
Time trend	0.0001		0.0008
	(0.0002)		(0.0015)
Population	5.64E-11	5.45E-11	-7.79E-10
	(2.02E-11)	(6.67E-11)	(4.60E-10)
Population growth	-0.0254	-0.0385	-0.0119
	(0.0029)	(0.0096)	(0.0046)
GDP per capita	1.83E-06	2.17E-06	9.29E-07
	(4.71E-07)	(1.25E-06)	(4.64E-06)
GDP per capita growth	-0.0025	-0.0006	-0.0025
	(0.0007)	(0.0100)	(0.0008)
R^2	0.3951	0.7518	0.2279
No. of observations	563	19	563

Standard errors are in parenthesis.
Sources: IFS (IMF), WDI (WB), Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

TABLE 3
The new rule

	Pooled regression	Between regression	Within regression
Gross national saving/GDP			
x Net foreign assets over wealth	0.7470	0.8454	0.6315
	(0.0518)	(0.1562)	(0.1827)
R^2	0.3900	0.6327	0.2201
No. of observations	608	19	608

Standard errors are in parenthesis.
Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

TABLE 4
The new rule (with control variables)

	Pooled regression	Between regression	Within regression
Gross national saving/GDP			
x Net foreign assets over wealth	0.6340	0.5999	0.7009
	(0.0495)	(0.1330)	(0.1400)
Time trend	-0.0011		0.0005
	(0.0002)		(0.0014)
Population	-5.03E-11	-5.05E-11	-6.05E-10
	(2.24E-11)	(4.82E-11)	(3.96E-10)
Population growth	-0.0152	-0.0198	-0.0086
	(0.0021)	(0.0086)	(0.0048)
GDP per capita	2.54E-06	2.79E-06	-1.38E-06
	(4.87E-07)	(8.73E-06)	(3.99E-06)
GDP per capita growth	-0.0007	0.0087	-0.0008
	(0.0006)	(0.0076)	(0.0006)
R^2	0.4793	0.8532	0.2674
No. of observations	563	19	563

Standard errors are in parenthesis.
Sources: IFS (IMF), WDI (WB), Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

TABLE 8
The extended new rule

	Pooled regression	Between-group regression	Within-group regression
Estimate of a_1	1.0450	1.1121	1.0156
	(0.0612)	(0.1699)	(0.2907)
Estimate of a_2	-0.8657	-1.3476	-0.7397
	(0.0957)	(0.5202)	(0.4050)
R^2	0.4734	0.7412	0.2841
No of observations	608	19	608

Standard errors are in parenthesis.

Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

TABLE 9
The extended new rule (with control variables)

	Pooled regression	Between regression	Within regression
Estimate of a_1	0.9856	1.0718	1.2300
	(0.0726)	(0.2192)	(0.2152)
Estimate of a_2	-1.1324	-1.6177	-1.3135
	(0.1595)	(0.6456)	(0.4231)
Time trend	4.15E-05		0.0027
	(0.0002)		(0.0009)
Population	-1.03E-10	-1.32E-10	-4.05E-10
	(2.07E-11)	(5.21E-11)	(2.70E-10)
Population growth	-0.0072	-0.0056	-0.0031
	(0.0021)	(0.0092)	(0.0039)
GDP per capita	2.08E-06	3.03E-06	-4.48E-06
	(4.36E-07)	(7.42E-07)	(2.67E-06)
GDP per capita growth	-0.0003	-0.0073	-1.36E-06
	(0.0005)	(0.0090)	(0.0005)
R^2	0.5498	0.9036	0.3627
No. of observations	563	19	563

Standard errors are in parenthesis.
Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

CONCLUSIONS

- Increasing financial integration has important implications for the current account.
- The traditional rule has failed to account for the empirical evidence on current accounts.
- KV provided an insightful departure from the traditional rule: the new rule. Moreover, the empirical evidence seemed to validate the new rule. However, it is based on a small open economy assumption.

CONCLUSIONS

- The paper has suggested an extension to the new rule rule abandoning the small open economy assumption. It is broadly supported by the empirical evidence, which seems to reject the new rule.

CURRENT ACCOUNT BEHAVIOR

- Erauskin (2015): “SAVINGS, THE SIZE OF THE NET FOREIGN ASSET POSITION AND THE DYNAMICS OF CURRENT ACCOUNTS”.

MOTIVATION

- Big current account imbalances in recent years.
- Huge variations in gross and net international investment positions.
  - Consequences for current accounts are straightforward.

INTRODUCTION

"The intertemporal approach views the current-account balance as the outcome of forward-looking dynamic saving and investment decisions".

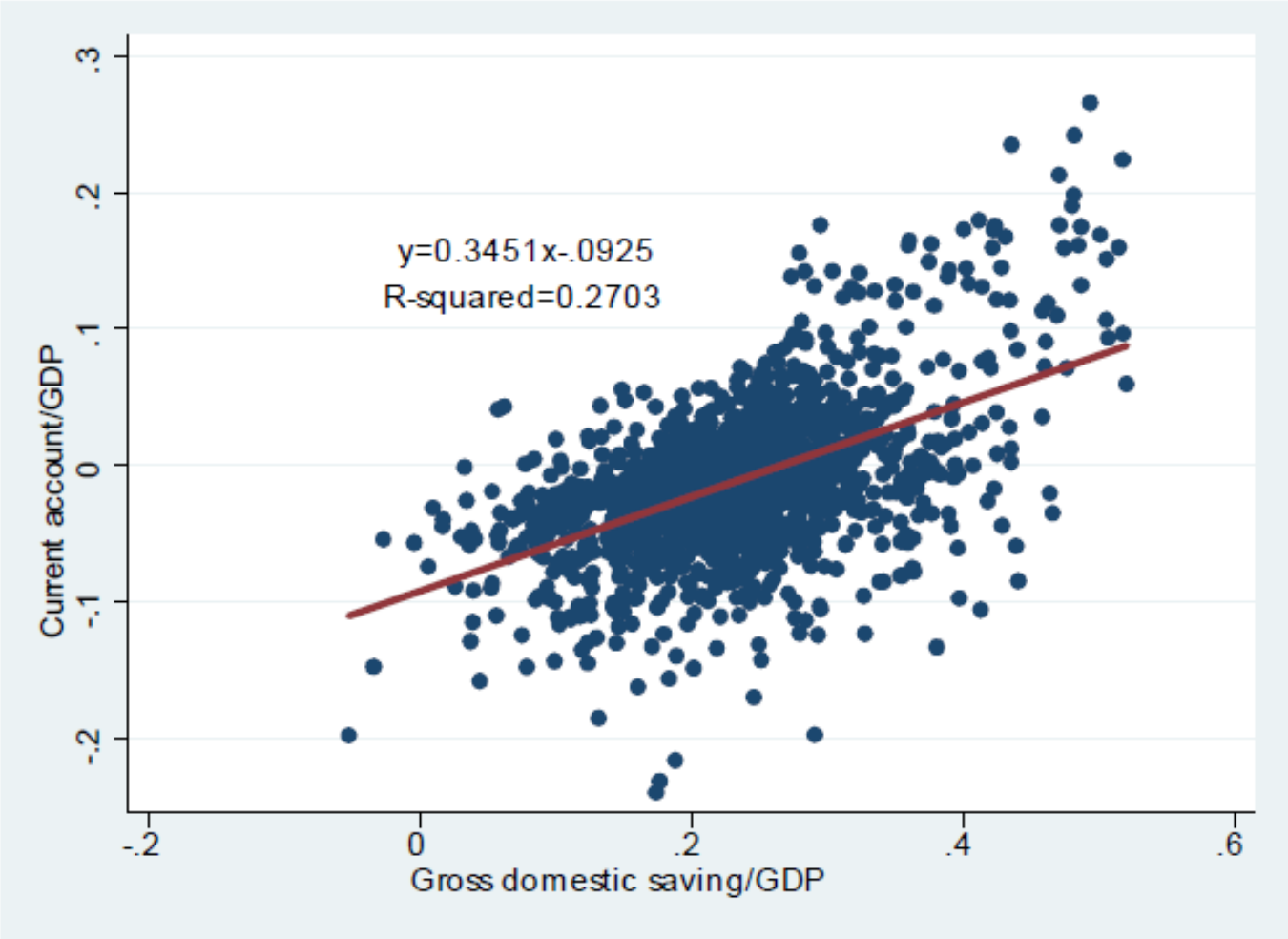
$$\mathrm{CA} = S - \mathrm{I}$$

INTRODUCTION

- Which is the impact of a transitory income shock (fluctuations in output, for example) on the current account? There are two main views:
  - Traditional rule (standard benchmark model):
    - This view is appropriate when domestic capital is subject to diminishing returns and risk associated to investment is low.
    - The marginal unit of wealth (savings) is invested in foreign bonds.
  - Then the impact on the current account is equal to the amount of savings generated by the shock.
    - However, the traditional rule does not hold empirically. Feldstein-Horioka puzzle.

$$CA_{ct} = a_0 + a_1 S_{ct} + u_{ct}$$

Figure 1: The traditional rule

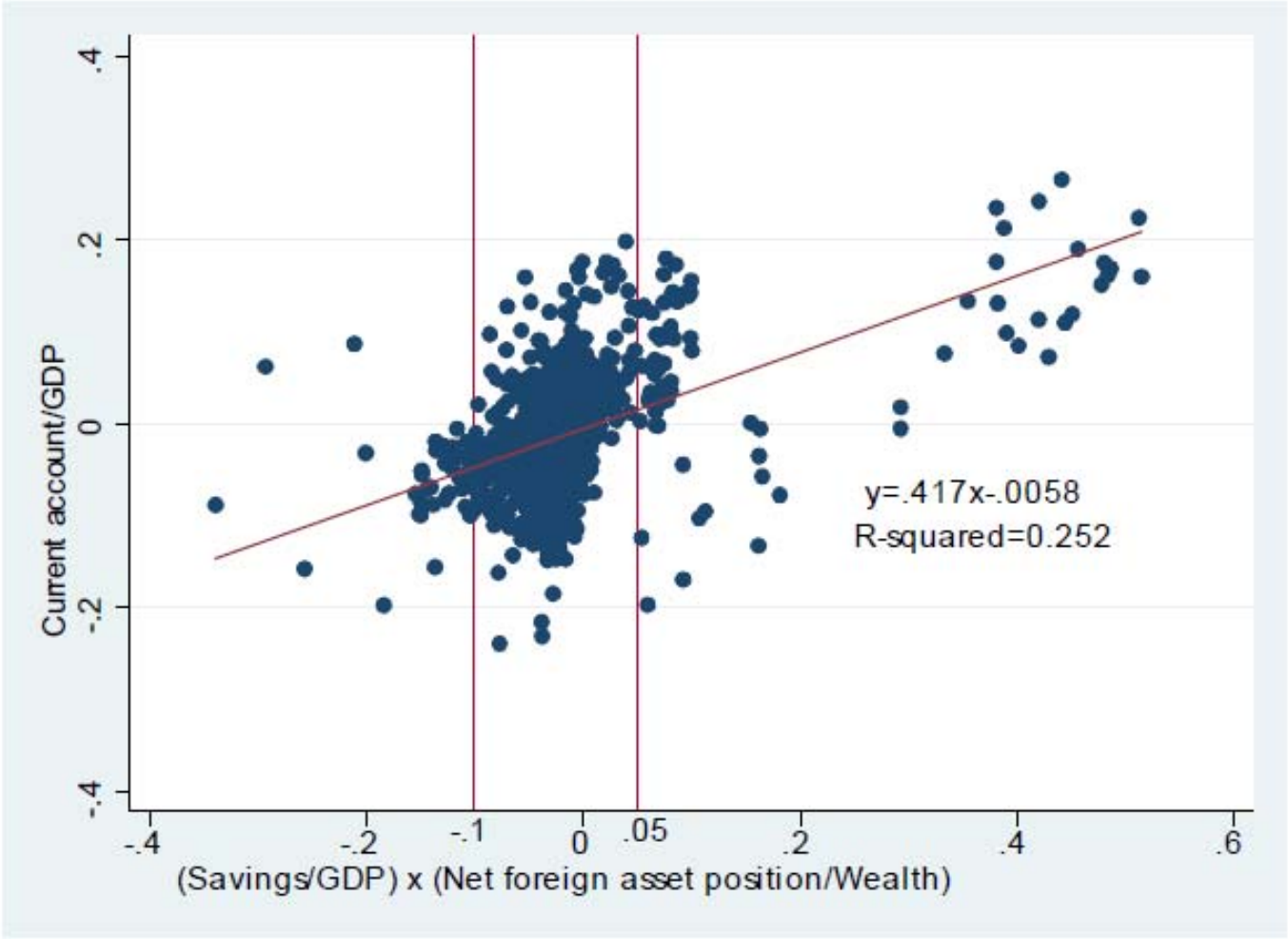


INTRODUCTION

- Two main views (cont.):
  - New rule:
    - The original idea was proposed by Kraay and Ventura (2000).
    - This view is appropriate when risk associated to investment is high compared to the diminishing returns effect.
    - The marginal unit of wealth (savings) is invested as the average unit of wealth.
    - Please note: $W = K_d + P\,;\ P = Net\ foreign\ asset\ position$
      $1 = \frac{\partial K_d}{\partial W} + \frac{\partial P}{\partial W}; \frac{\partial K_d}{\partial W} = \frac{K_d}{W}; \frac{\partial P}{\partial W} = \frac{P}{W}$
  - Then the impact is equal to the amount of savings generated by the shock multiplied by the net foreign asset position.

$$CA_{ct} = a_0 + a_1 \left(\frac{P_{ct}}{W_{ct}} \right) S_{ct} + u_{ct}$$

Figure 2: The new rule



INTRODUCTION

- This paper offers three main contributions:
  - We adapt the new rule to distinguish between gross and net foreign asset positions, because both matter.
  - We combine both the new view and the traditional rule.
  - The empirical evidence suggests that the support for the traditional rule or the new view depends crucially on the size of the net foreign asset position.
    - Intermediate case: the new view dominates.
    - "Big" creditor (+15% domestic wealth) case: the traditional rule dominates.
    - "Big" debtor case (-15% wealth) case: the traditional rule dominates, but the impact is much weaker than for creditors.

STRUCTURE OF THE PAPER

1. Introduction.
2. Theory.
3. Data sources.
4. Empirical evidence.
5. Conclusions.

THEORY

- Endogenous growth.
  - Capital is subject to diminishing returns. Aggregate capital stock has an external effect on labor productivity, but the firm faces decreasing returns to capital.
- Two countries.
- Two assets:
  - Riskless domestic capital, and
  - Risky foreign capital.
    - Stochastic shocks in the foreign economy. Mean-variance approach.
- Continuous time.

THEORY

- Domestic and foreign wealth:

$$W = K_d + K_d^*$$
$$W^* = K_f + K_f^*$$

- Domestic wealth:
  - Domestic capital in the hands of the domestic economy.
  - Foreign capital in the hands of the domestic economy.
- Foreign wealth:
  - Domestic capital in the hands of the foreign economy.
  - Foreign capital in the hands of the foreign economy.

THEORY

- Preferences (Stone-Geary):

$$Max\ E_0 \int_0^{\infty} \frac{(C-\theta)^{1-\frac{1}{\gamma}} - 1}{1-\frac{1}{\gamma}} e^{-\beta t}\ dt\,;\theta\,,\gamma > 0\,;C > \theta,$$

subject to:

$$dW = [\alpha K_d + \alpha^* K_d^*]dt + K_d^* dy^* - C^* dt$$

THEORY

- Solution for the domestic economy:

$$\frac{K_d}{W} = \frac{\gamma(\alpha - \alpha^*)}{\sigma_{y^*}^2}\left(1 - \frac{\theta/\alpha}{W}\right) + 1$$

$$C = \left\{\gamma\beta - \frac{0.5\gamma(\gamma-1)(\alpha-\alpha^*)^2}{\sigma_{y^*}^2} - \alpha(\gamma-1)\right\}W + \\ + \frac{\theta\gamma}{\alpha}\left(\alpha - \beta + \frac{0.5\gamma(\gamma-1)(\alpha-\alpha^*)^2}{\sigma_{y^*}^2}\right)$$

- Analogous for the foreign economy.

THEORY

- Net foreign asset position:

$$P = K_d^* - K_f$$

- The current account is equal the variation in its net foreign asset position (savings minus investment):

$$CA = dP = dK_d^* - dK_f = \left[1 - \frac{\partial K_d}{\partial W}\right] dW - \frac{\partial K_f}{\partial W^*} dW^*$$

THEORY

- How do countries react?

$$\frac{\partial K_d}{\partial W} = \frac{1}{1 - \gamma\left(\frac{\partial \alpha / \partial K_d}{\sigma_{y^*}^2}\right)\left(W - \frac{\theta}{\alpha}\right)}\left(\frac{K_d}{w - \frac{\theta}{\alpha}}\right)$$

$$-\frac{\partial \alpha / \partial K_d}{\sigma_{y^*}^2}$$ is key.

  - If big, $\frac{\partial K_d}{\partial W} \to 0$
  - If small, $\frac{\partial K_d}{\partial W} = \frac{K_d}{w - \frac{\theta}{\alpha}}$

THEORY

$$CA = dW - dW\frac{\partial K_d}{\partial W} - dW^*\frac{\partial K_f}{\partial W^*}$$

- How do countries react?

$$\frac{\partial K_d}{\partial W} \to \lambda\frac{K_d}{W}$$

$$\frac{\partial K_f}{\partial W^*} \to \mu\frac{K_f}{W^*}$$

$$0 \leq \lambda \leq 1$$

Then:

$$CA = (1-\lambda)dW + \lambda\frac{K_d^*}{W}dW - \mu\frac{K_f}{W^*}dW^*$$

DATA SOURCES

- Complex issue. Domestic wealth.
- Sample: 50 developed and developing countries (1970-2009).
- The data are based on:
  - International Monetary Funds´s International Financial Statistics
  - World Bank´s World Development Indicators, and
  - Lane and Milesi-Ferretti (2007).

EMPIRICAL EVIDENCE

$$CA_{ct} = a_0 + a_1 S_{ct} + u_{ct}$$

Table 1: The traditional rule

	Pooled regression	Between regression	Within regression	Pooled regression	Between regression	Within regression
Estimate of a_1	0.345***	0.312***	0.409***	0.337***	0.330***	0.432***
	(0.0189)	(0.0505)	(0.0857)	(0.0200)	(0.0582)	(0.0753)
Population				1.16e-11***	2.84e-11	-1.45e-10***
				(4.45e-12)	(1.87e-11)	(4.37e-11)
Population growth				-0.000129	0.00383	-0.0123***
				(0.00180)	(0.00440)	(0.00458)
GDP per capita				1.15e-06***	1.30e-06***	1.03e-06
				(1.63e-07)	(4.00e-07)	(2.04e-06)
GDP per capita growth				-0.00190***	-0.00493	-0.00171***
				(0.000374)	(0.00319)	(0.000427)
Time trend				0.000609***		0.000674
				(0.000110)		(0.000418)
R^2	0.270	0.443	0.167	0.361	0.611	0.262
No. of observations	1722	50	1722	1715	50	1715

Robust standard errors are in parenthesis.

*: Significant at 10% level; **: Significant at 5% level; ***: Significant at 1% level.

Sources: International Monetary Fund´s International Financial Statistics (IMFIFS), World Bank´s World Development Indicatos (WBWDI), Lane and Milesi-Ferretti (2007), Nehru and Dareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

$$CA_{ct} = a_0 + a_1\left(\frac{P_{ct}}{W_{ct}}\right)S_{ct} + u_{ct}$$

Table 2: The new rule

	Pooled regression	Between regression	Within regression	Pooled regression	Between regression	Within regression
Estimate of a_1	0.415***	0.368***	0.548***	0.386***	0.291***	0.565***
	(0.0249)	(0.0639)	(0.0301)	(0.0251)	(0.0730)	(0.0299)
Population				2.82e-11***	2.78e-11	-7.19e-11**
				(4.11e-12)	(2.15e-11)	(3.44e-11)
Population growth				-0.00422***	0.000623	-0.0109***
				(0.00163)	(0.00541)	(0.00239)
GDP per capita				7.20e-07***	1.15e-06**	2.79e-07
				(1.83e-07)	(5.04e-07)	(4.61e-07)
GDP per capita growth				-0.000501	0.00162	-0.000512*
				(0.000409)	(0.00314)	(0.000289)
Time trend				0.000778***		0.000960***
				(0.000115)		(0.000167)
R^2	0.246	0.409	0.166	0.323	0.513	0.258
No. of observations	1709	50	1709	1702	50	1702

Robust standard errors are in parenthesis.

*: Significant at 10% level; **: Significant at 5% level; ***: Significant at 1% level.

Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

Figure 3: The relationship between the net foreign asset position (as a share of domestic wealth) and the term capturing the new rule

EMPIRICAL EVIDENCE

$$CA_{ct} = a_0 + a_1\left(\frac{P_{ct}}{W_{ct}}\right)S_{ct} + u_{ct}$$

Table 3: The new rule for "moderate" net foreign asset positions

	Pooled regression	Between regression	Within regression	Pooled regression	Between regression	Within regression
Estimate of a_1	1.026***	0.747**	1.002***	0.963***	0.724*	0.956***
	(0.121)	(0.293)	(0.107)	(0.132)	(0.386)	(0.102)
Population				0.00143	-0.00283	-0.0739**
				(0.00507)	(0.0270)	(0.0307)
Population growth				0.00111	0.00425	-0.00819***
				(0.00196)	(0.00694)	(0.00309)
GDP per capita				0.352**	0.865	-0.0913
				(0.175)	(0.626)	(0.565)
GDP per capita growth				0.000119	0.00570	-0.000559
				(0.000540)	(0.00370)	(0.000351)
Time trend				0.000982***		0.00101***
				(0.000141)		(0.000211)
R^2	0.127	0.134	0.087	0.198	0.225	0.187
No. of observations	974	44	974	973	44	973

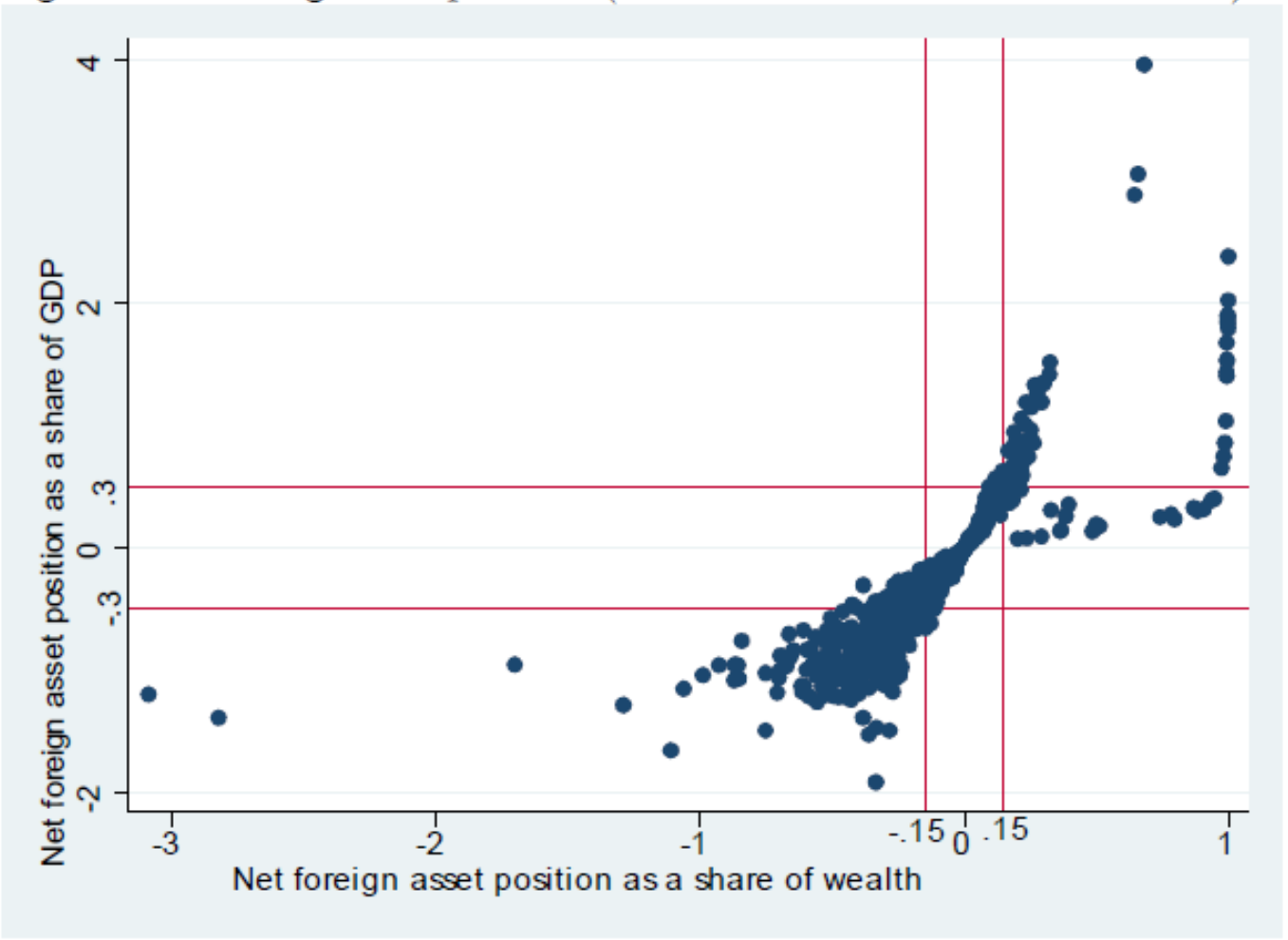
Robust standard errors are in parenthesis.

*: Significant at 10% level; **: Significant at 5% level; ***: Significant at 1% level.

Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

Figure 6: Net foreign asset positions (as a share of wealth vs. share of GDP)



EMPIRICAL EVIDENCE

$$CA_{ct} = a_0 + a_1\left(\frac{P_{ct}}{W_{ct}}\right)S_{ct} + u_{ct}$$

Table 5: The new rule for "moderate" net foreign asset positions (in terms of GDP)

	Pooled regression	Between regression	Within regression	Pooled regression	Between regression	Within regression
Estimate of a_1	1.125***	1.109***	1.128***	1.120***	0.953**	1.156***
	(0.116)	(0.309)	(0.121)	(0.145)	(0.451)	(0.115)
Population				0.00180	0.0103	-0.0815***
				(0.00524)	(0.0256)	(0.0299)
Population growth				0.000103	-0.000816	-0.00714**
				(0.00200)	(0.00633)	(0.00314)
GDP per capita				0.366**	0.619	-0.665
				(0.183)	(0.553)	(0.579)
GDP per capita growth				0.000303	0.00169	-0.000381
				(0.000579)	(0.00342)	(0.000372)
Time trend				0.000878***		0.00119***
				(0.000143)		(0.000216)
R^2	0.142	0.231	0.094	0.211	0.278	0.205
No. of observations	878	45	878	877	45	877

Robust standard errors are in parenthesis.

*: Significant at 10% level; **: Significant at 5% level; ***: Significant at 1% level.

Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

$$CA_{ct} = a_0 + a_1 S_{ct} + a_2 \left(\frac{K^*_{d,ct}}{W_{ct}}\right) S_{ct} + a_3 \left(\frac{K_{f,ct}}{W^*_{ct}}\right) S^*_{ct} + u_{ct}$$

Table 6: The traditional rule and the new view for "moderate" net foreign asset positions

	Pooled regression	Between regression	Within regression	Pooled regression	Between regression	Within regression
Estimate of a_1	0.187***	0.204**	0.206***	0.242***	0.238**	0.293***
	(0.0198)	(0.0826)	(0.0320)	(0.0210)	(0.101)	(0.0335)
Estimate of a_2	0.712***	0.662**	0.662***	0.681***	0.644**	0.607***
	(0.0634)	(0.291)	(0.0683)	(0.0631)	(0.316)	(0.0713)
Estimate of a_3	-0.442***	-0.398	-0.397***	-0.495***	-0.407	-0.442***
	(0.0684)	(0.339)	(0.0713)	(0.0668)	(0.359)	(0.0687)
Population				-0.0111**	0.00215	-0.162***
				(0.00480)	(0.0189)	(0.0284)
Population growth				0.000913	0.00400	-0.0139***
				(0.00135)	(0.00523)	(0.00277)
GDP per capita				0.0985	0.337	-0.593
				(0.134)	(0.489)	(0.538)
GDP per capita growth				-0.00219***	-0.00182	-0.00189***
				(0.000342)	(0.00298)	(0.000318)
Time trend				0.000391***		0.000606***
				(0.000113)		(0.000202)
R^2	0.414	0.554	0.296	0.451	0.579	0.371
No. of observations	974	44	974	973	44	973

Robust standard errors are in parenthesis.
*: Significant at 10% level; **: Significant at 5% level; ***: Significant at 1% level.
Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

$$CA_{ct} = a_0 + a_1 S_{ct} + a_2 \left(\frac{K^*_{d,ct}}{W_{ct}}\right) S_{ct} + a_3 \left(\frac{K_{f,ct}}{W^*_{ct}}\right) S^*_{ct} + u_{ct}$$

Table 8: The traditional rule and the new view for "big" creditor countries

	Pooled regression	Between regression	Within regression	Pooled regression	Between regression	Within regression
Estimate of a_1	1.001***	0.785***	1.344***	0.902***	-0.0607	0.754***
	(0.0802)	(0.141)	(0.111)	(0.0837)	(1.453)	(0.0947)
Estimate of a_2	-0.0623***	-0.0682**	-0.0430***	-0.0104	0.00522	-0.00277
	(0.0110)	(0.0230)	(0.0153)	(0.0103)	(0.135)	(0.0109)
Estimate of a_3	0.186***	0.00375	0.199***	-0.0320	-0.253	-0.144***
	(0.0333)	(0.0661)	(0.0347)	(0.0319)	(0.436)	(0.0372)
Population				0.751***	-1.250	5.004
				(0.248)	(2.671)	(8.895)
Population growth				-0.00837**	0.0298	-0.0156***
				(0.00410)	(0.0363)	(0.00428)
GDP per capita				2.267***	3.114	7.523***
				(0.547)	(3.437)	(1.710)
GDP per capita growth				0.000603	-0.00584	-0.000154
				(0.00100)	(0.0112)	(0.00108)
Time trend				0.00411***		0.00314***
				(0.000439)		(0.000958)
R^2	0.600	0.877	0.671	0.867	0.912	0.875
No. of observations	121	12	121	121	12	121

Robust standard errors are in parenthesis.
*: Significant at 10% level; **: Significant at 5% level; ***: Significant at 1% level.
Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

EMPIRICAL EVIDENCE

$$CA_{ct} = a_0 + a_1 S_{ct} + a_2 \left(\frac{K^*_{d,ct}}{W_{ct}}\right) S_{ct} + a_3 \left(\frac{K_{f,ct}}{W^*_{ct}}\right) S^*_{ct} + u_{ct}$$

Table 10: The traditional rule and the new view for "big" debtor countries

	Pooled regression	Between regression	Within regression	Pooled regression	Between regression	Within regression
Estimate of a_1	0.280***	0.161	0.346***	0.303***	0.209*	0.381***
	(0.0289)	(0.105)	(0.0378)	(0.0296)	(0.119)	(0.0404)
Estimate of a_2	0.124***	0.490**	-0.0272	0.113***	0.442**	0.0357
	(0.0396)	(0.219)	(0.0415)	(0.0384)	(0.212)	(0.0429)
Estimate of a_3	-0.188***	-0.493**	-0.00290	-0.197***	-0.520**	-0.0529
	(0.0493)	(0.229)	(0.0528)	(0.0482)	(0.222)	(0.0519)
Population				0.216***	0.207*	0.0821
				(0.0329)	(0.109)	(0.169)
Population growth				-0.00884***	-0.00383	-0.0162***
				(0.00210)	(0.00663)	(0.00493)
GDP per capita				0.890***	1.389*	-2.163
				(0.232)	(0.686)	(1.605)
GDP per capita growth				-0.00239***	-0.00253	-0.00248***
				(0.000451)	(0.00410)	(0.000424)
Time trend				-0.000136		0.000307
				(0.000181)		(0.000357)
R^2	0.195	0.268	0.141	0.307	0.422	0.234
No. of observations	612	35	612	606	35	606

Robust standard errors are in parenthesis.
*: Significant at 10% level; **: Significant at 5% level; ***: Significant at 1% level.
Sources: IMFIFS, WBWDI, Lane and Milesi-Ferretti (2007), Nehru and Dhareshwar (1993), and own elaboration.

CONCLUSIONS

- The combination of the traditional rule and the new view provides a satisfactory framework to explain the dynamics of current accounts, when the size of the NFA is considered:
  - Moderate size: the new view dominates.
  - "Big" creditor: the traditional rule dominates.
  - "Big" debtor: the traditional rule dominates, but the impact is weaker.
- Future research: Bigger sample, recent crisis, …

6. CONCLUSIONS

CONCLUSIONS

- The literature on economic growth has provided many fruitful insights on many issues.
- However, many others remain unanswered, suggesting avenues for future research.
- When addressing an issue for research, I would recommend an appropriate mix of theoretical (adopting a model suitable for the objectives planned) and empirical contents.

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