

# The role of industrial policies in productive development and sustainable growth

Ricardo Hausmann

Growth Lab - Harvard University, Santa Fe Institute  
OECD Conference on Productivity

Santiago de Chile, September 27, 2023

# Agenda

- Who needs industrial policy?
- A puzzling fact about international convergence patterns
- A theory of technology and of adoption obstacles
- Goal-oriented industrial policy
- The dimensions of industrial policy

# Agenda

- **Who needs industrial policy?**
- A puzzling fact about international convergence patterns
- A theory of technology and of adoption obstacles
- Goal-oriented industrial policy
- The dimensions of industrial policy

# Who needs industrial policy?

- “Little else is requisite to carry a state to the highest degree of opulence from the lowest barbarism but *peace, easy taxes, and a tolerable administration of justice*: all the rest being brought about by the natural course of things.”
  - - Adam Smith, Lecture in 1755

# Traditional definitions of industrial policy

- Investors lack either money or adequate incentives
- Solution: give them credit or subsidies
- They will buy what they need
- Implementation: line item in the budget of the Ministry of Industry + selection mechanism on who to give the money to
- A typical Pigou problem
  - Subsidize positive externalities
  - Tax negative externalities

**Industrial policy is seen as an instrument**

# Typical criticism of industrial policies as instruments

- Government cannot “pick winners”
- Investors that receive support might have come anyway
- It will be captured by inefficient, politically-connected players
- It is best to let the market work

# Policy as instrument vs policy as goal

- Some policies are defined by the goals they pursue
  - Citizen security,
  - Climate policy
  - Instruments are developed to achieve the goal
- Other policies are defined by the instruments they use
  - Tax policy
  - Monetary policy
- Industrial policy has been seen as a set of instruments
  - Incentive: tax expenditures, subsidies, soft loans
- I think of it as defined by the goals that want to be achieved
  - Diversification, technology adoption and adaptation to assure sustained growth and economic convergence

# Agenda

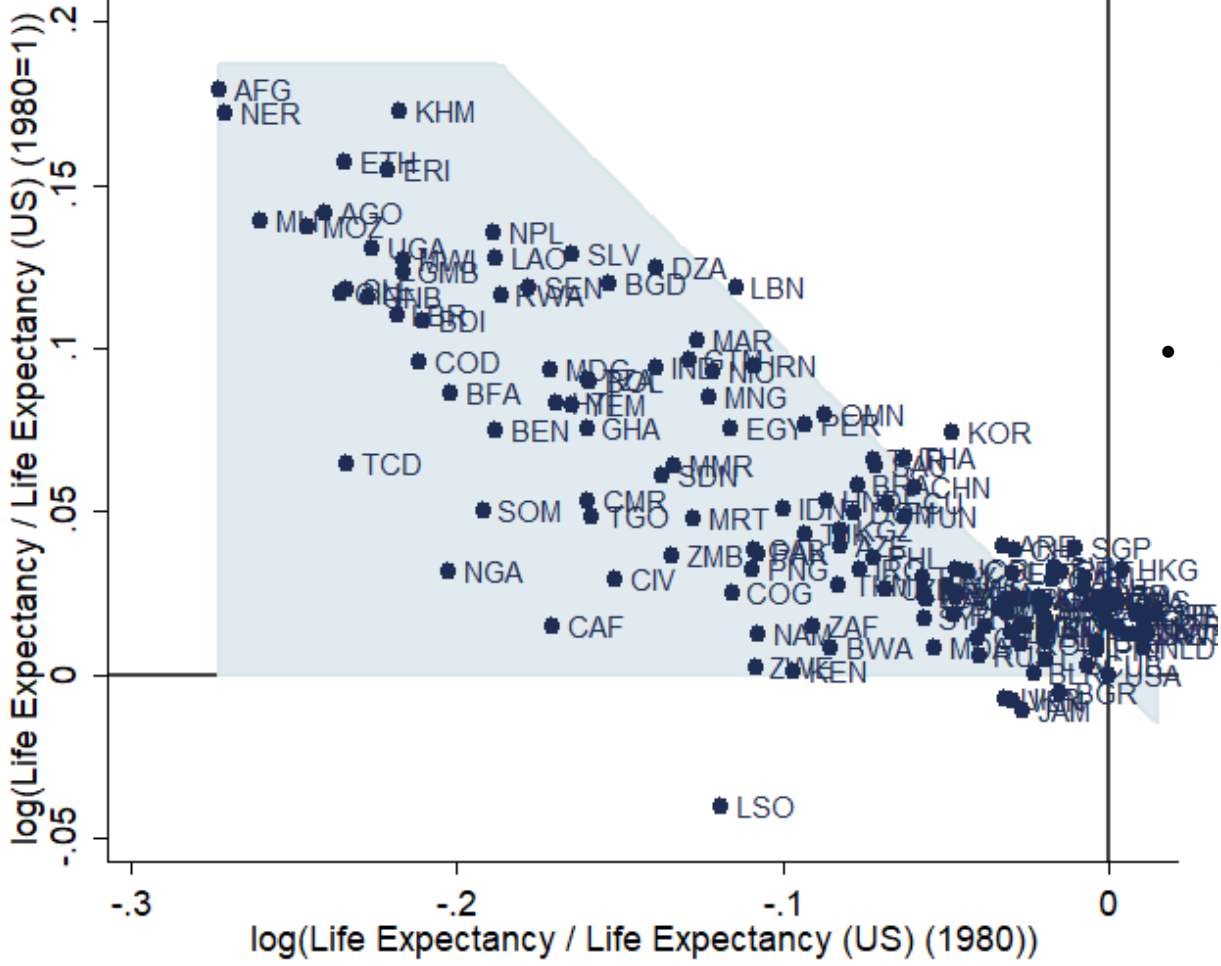
- Who needs industrial policy?
- **A puzzling fact about international convergence patterns**
- A theory of technology and of adoption obstacles
- Goal-oriented industrial policy
- The dimensions of industrial policy



# The view of modern growth

- Improvements in health
  - Declining infant mortality
- The demographic transition
  - Declining fertility rates
  - Declining rates of population growth
- Education
- Female empowerment
- Urbanization
- Investment
- **Technology will naturally flow** to the newly educated, empowered, urbanized households, leading to **economic convergence and sustainable growth**

# Unconditional Convergence in Life Expectancy

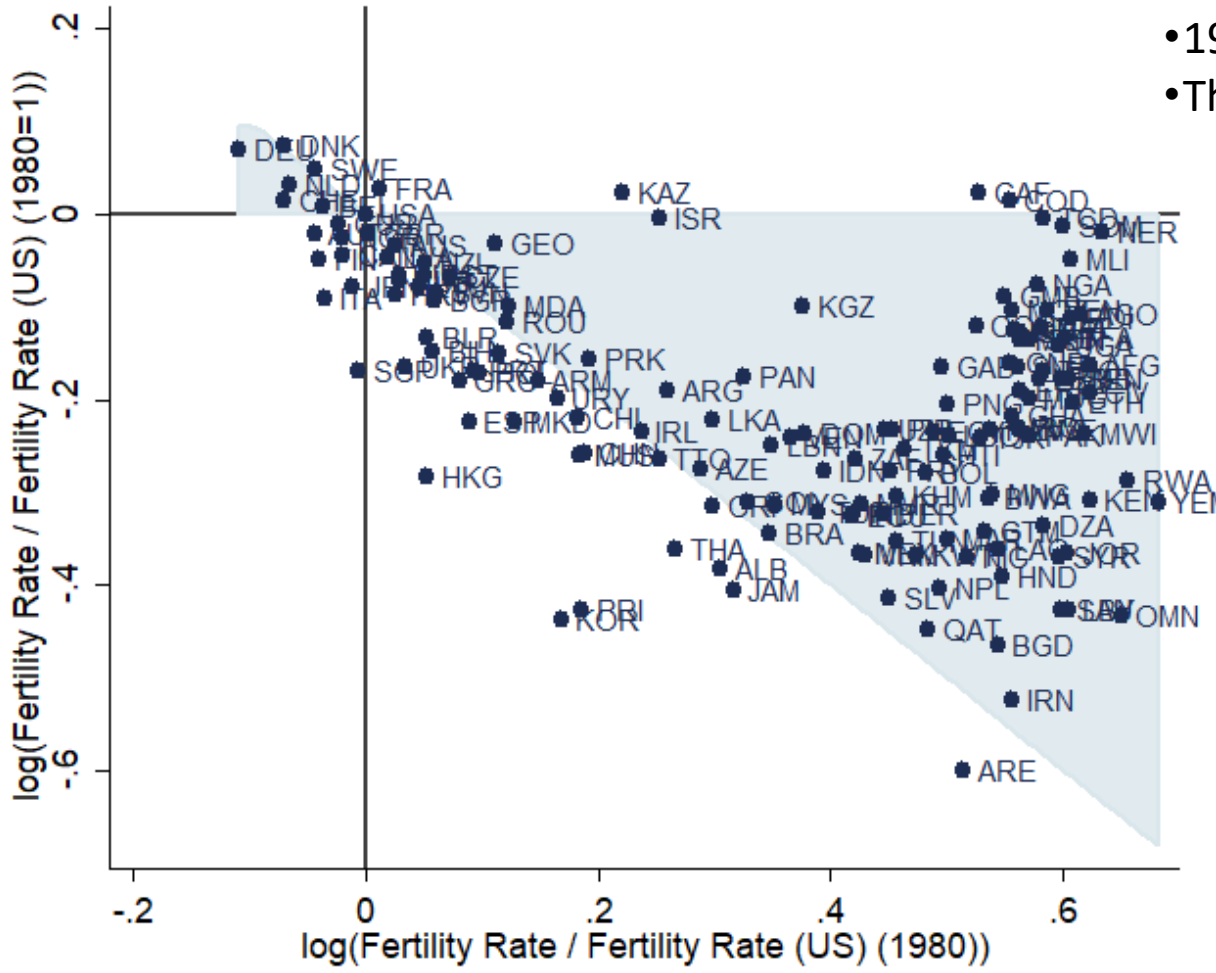


- 1980 below US: 137/150
- Thereof converged: **96%**

- Shaded area:
  - 2<sup>nd</sup> quadrant: country converged to the USA but did not surpass

Source: Own illustration based on WDI

# Unconditional Convergence in Fertility

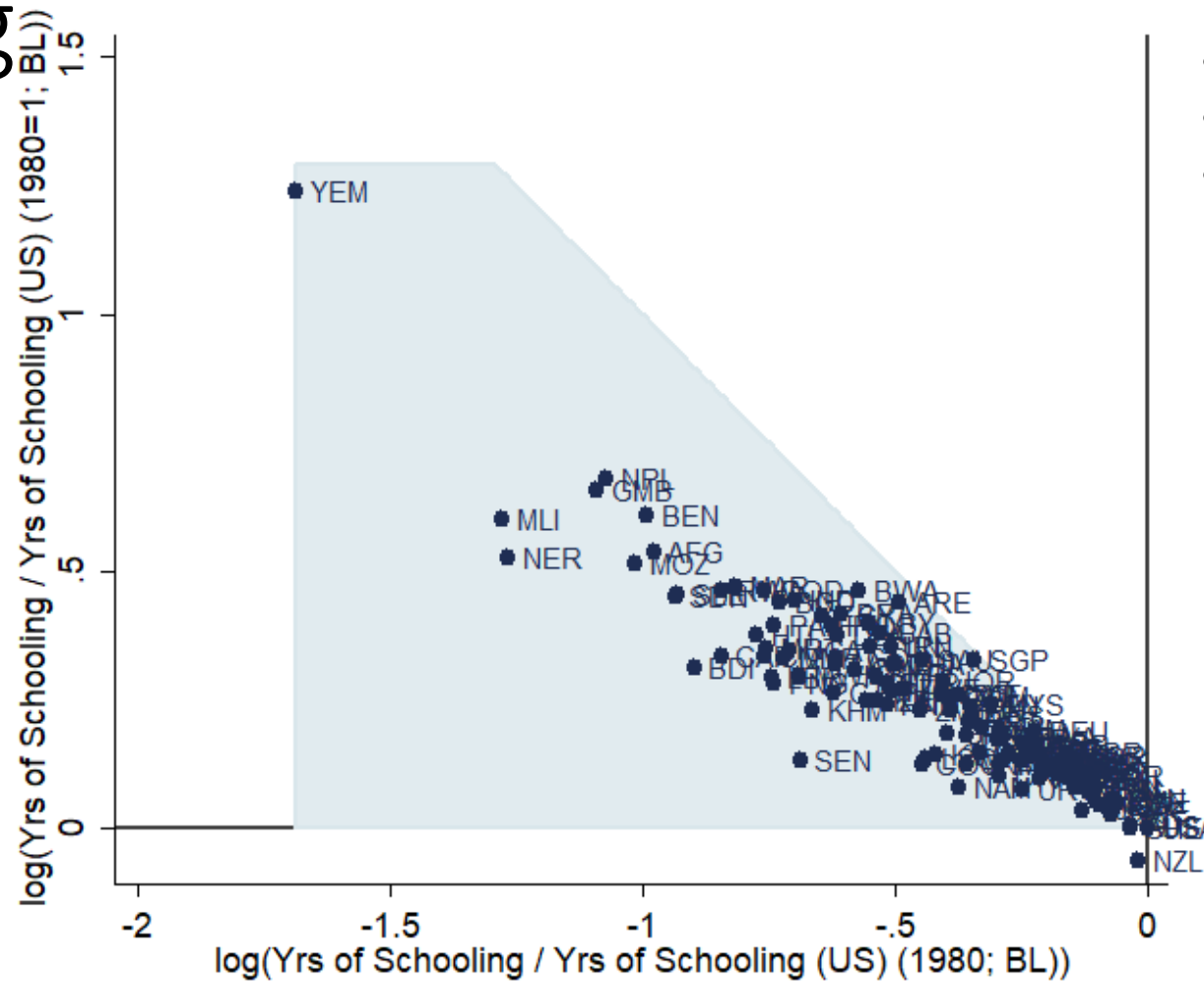


- 1980 below US: 136/150
- Thereof converged: **96%**

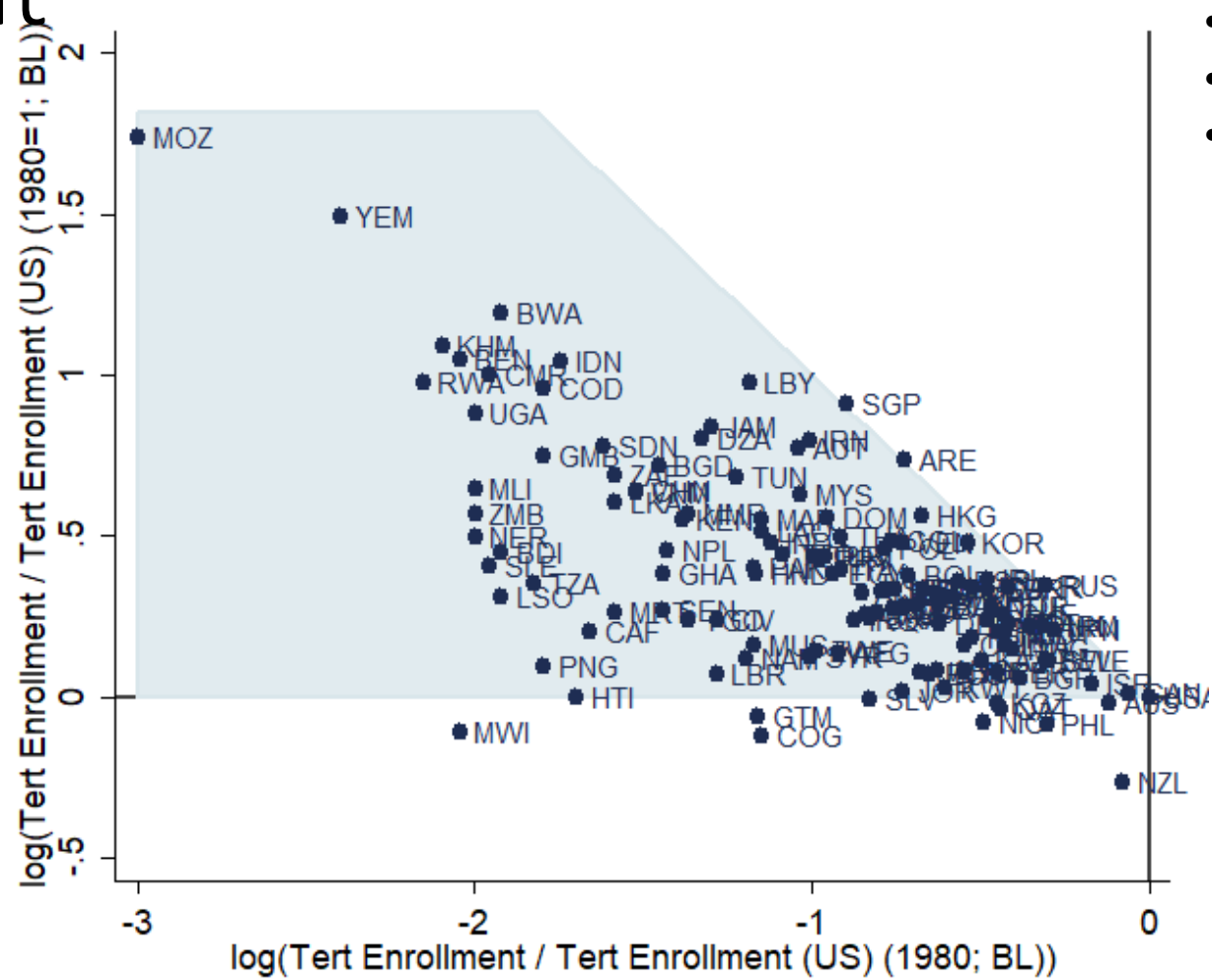
Source: Own illustration based on WDI



# Unconditional Convergence in Years of Schooling

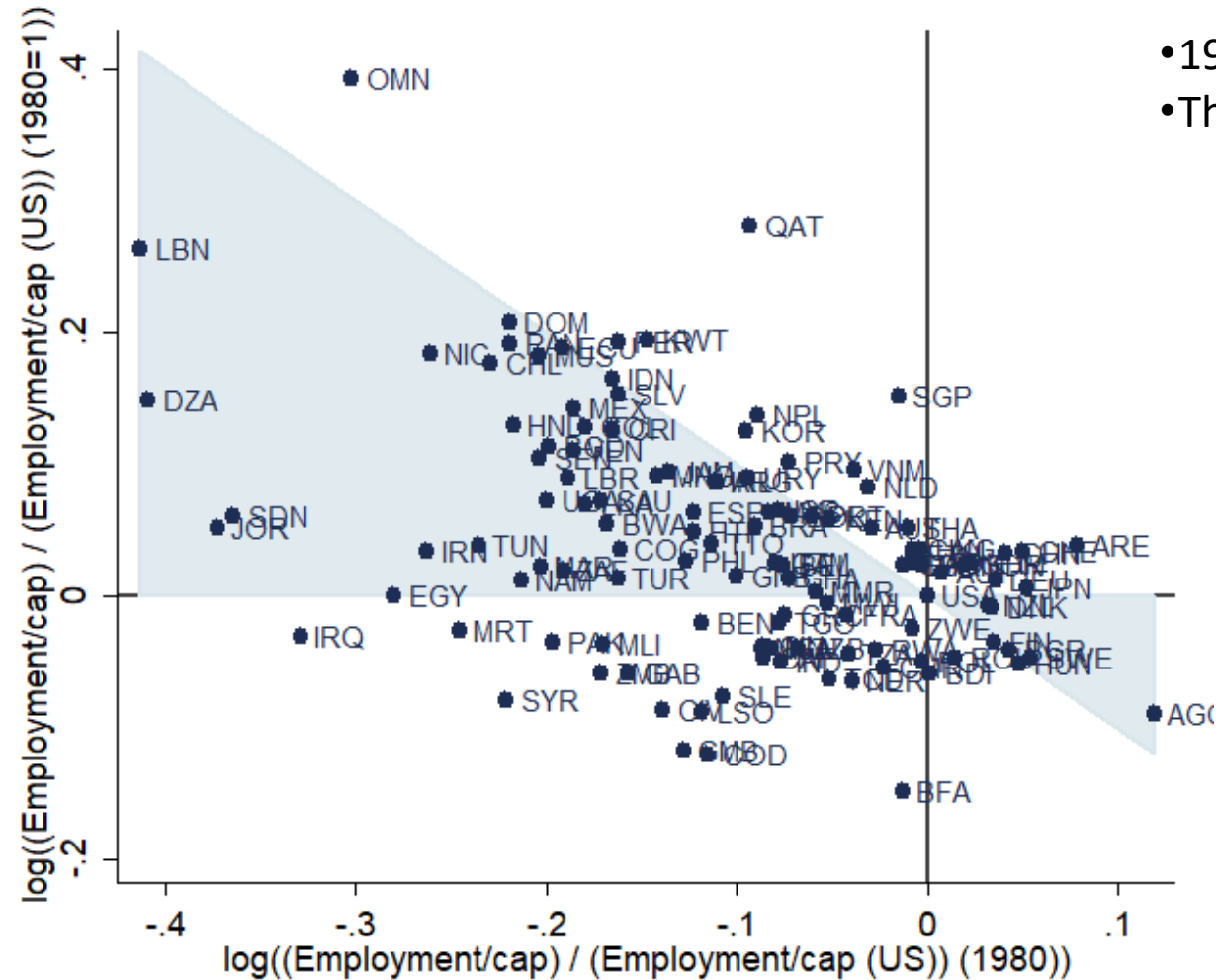


# Unconditional Convergence in Tertiary Enrollment



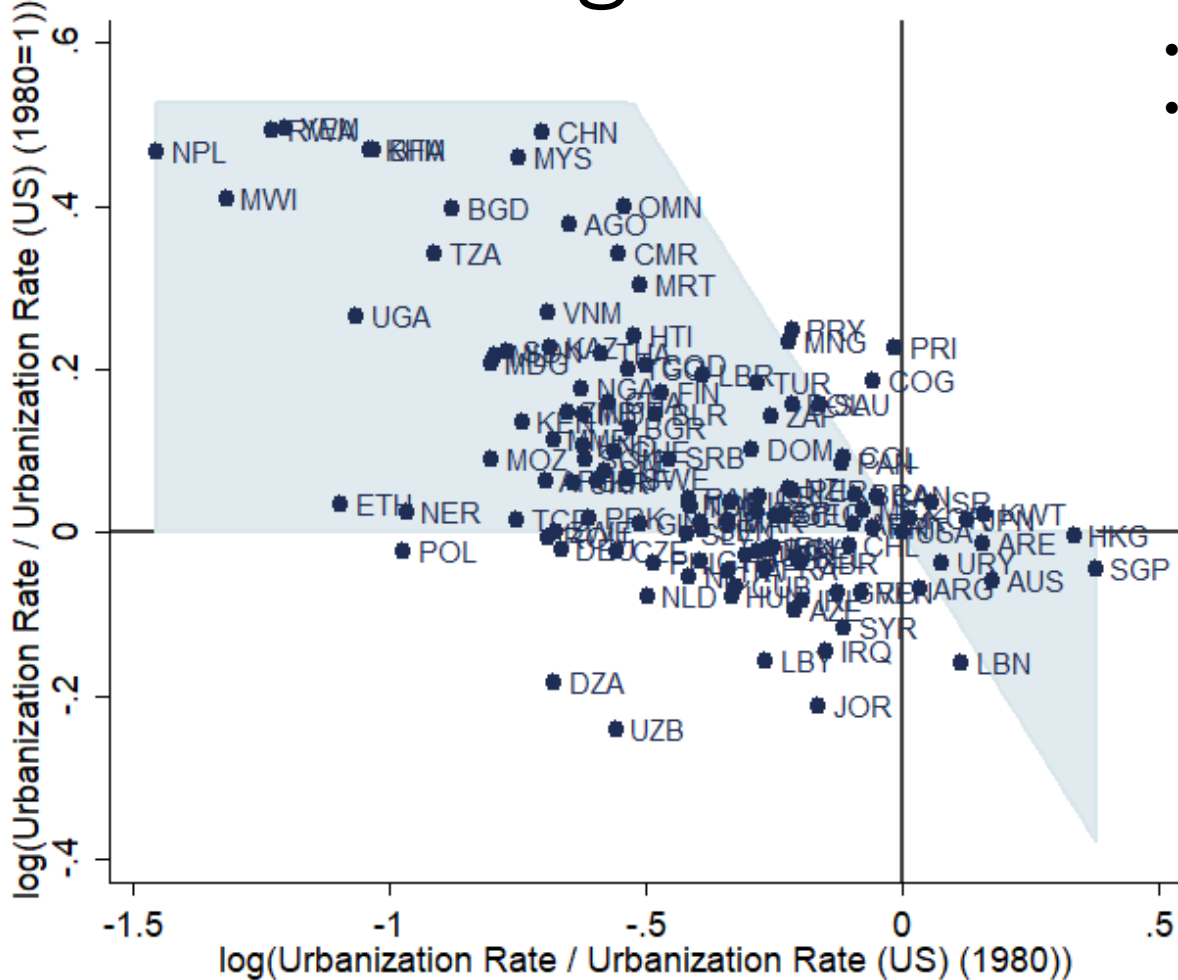
- 1980 below US: 130/130
- Thereof converged: **91%**
- Last year: 2015

# Unconditional Convergence in Employment Ratio



- 1980 below US: 103/120
- Thereof converged: **68%**

# Unconditional Convergence in Urbanization

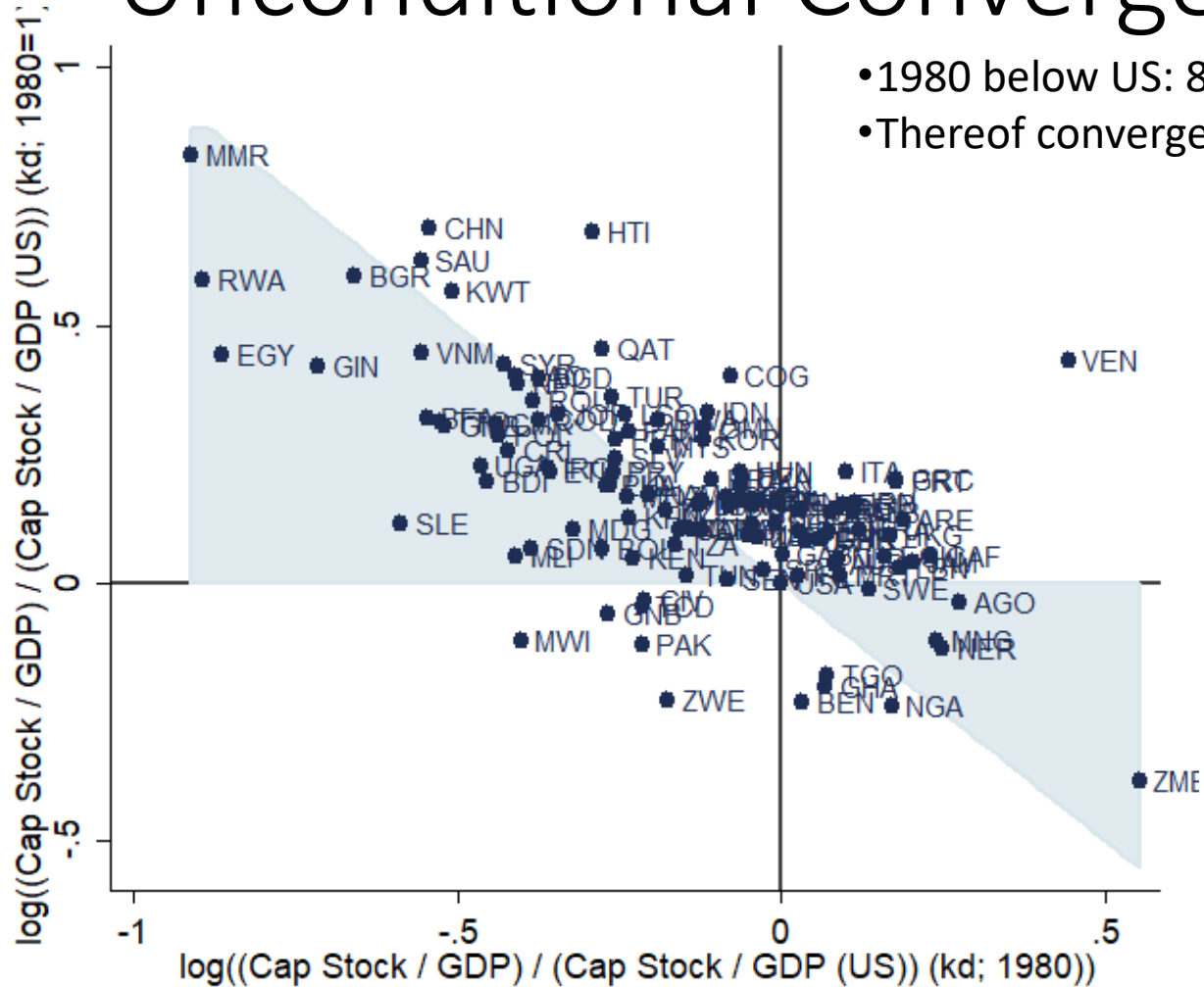


- 1980 below US: 110/121
- Thereof converged: **72%**

Source: Own illustration based on WDI



# Unconditional Convergence in K/Y



- Horizontal axis: baseperiod

$$\left[ \log_{10} \left( \frac{\frac{K_c}{GDP_c}}{\frac{K_{US}}{GDP_{US}}} \right) \right]_{1980}$$

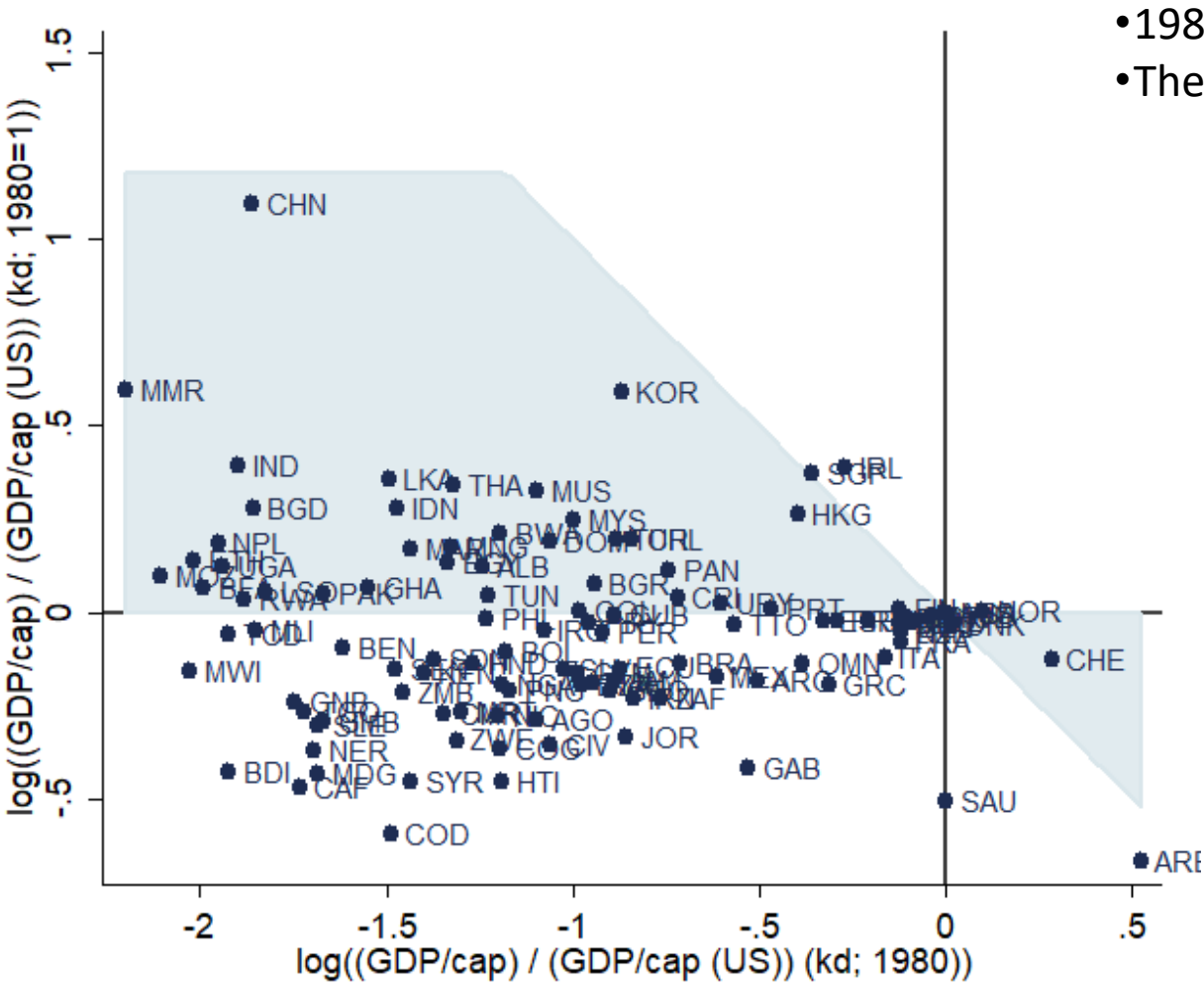
- Vertical axis:

$$\left[ \log_{10} \left( \frac{\frac{K_c}{GDP_c}}{\frac{K_{US}}{GDP_{US}}} \right) \right]_{2020} / \left[ \log_{10} \left( \frac{\frac{K_c}{GDP_c}}{\frac{K_{US}}{GDP_{US}}} \right) \right]_{1980}$$

- All data: 5-year centered MA
- Shaded area:
  - 4<sup>th</sup> quadrant: country converged to the USA but did not surpass
  - 2<sup>nd</sup> quadrant: vice versa

And yet...

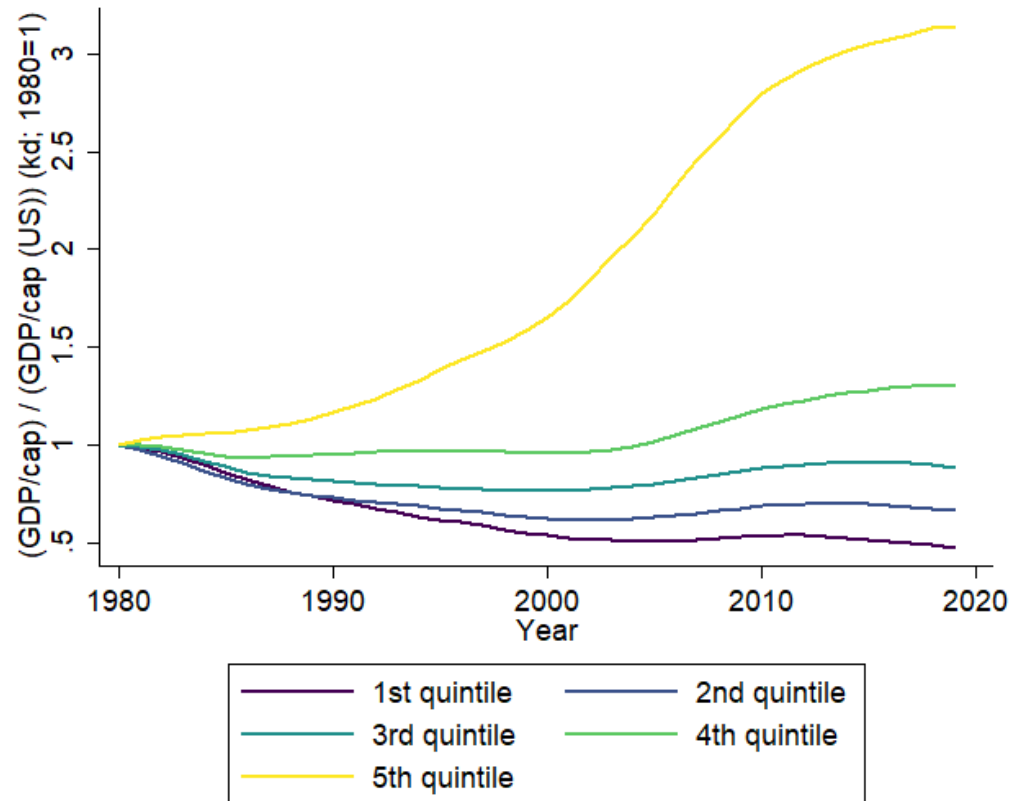
# No Convergence in GDP/cap



- 1980 below US: 104/109
- Thereof converged: **37%**

Source: Own illustration based on WDI

# Very few countries narrowed income gaps

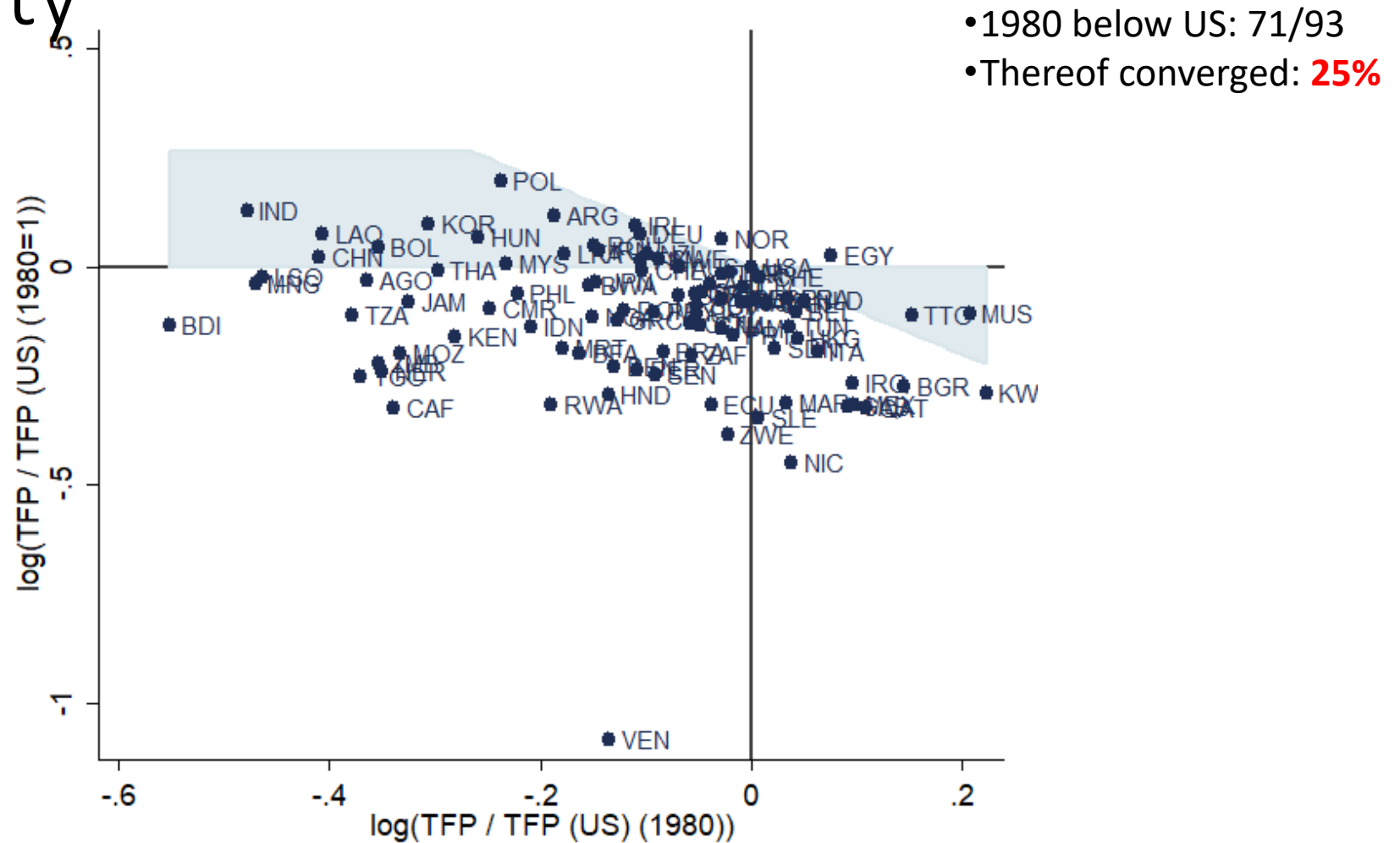


- The median country did not narrow the income gap
- Despite all the narrowing on education, health, female empowerment and urbanization

- Countries in the bottom 75% of incomes in 1980 only, grouped by their subsequent growth

...hence, significant divergence in  
Total Factor Productivity

# No Convergence (or even divergence) in productivity



# So maybe technology adoption is not so easy

- It cannot be just a case of bad institutions
- Because institutions have been good enough to
  - Extend life, educate, empower women, urbanize, invest
- What is weird about technology?

# Agenda

- Who needs industrial policy?
- A puzzling fact about international convergence patterns
- **A theory of technology and of adoption obstacles**
- Goal-oriented industrial policy
- The dimensions of industrial policy



The neoclassical production function

$$Y = F(A, K, L, H)$$

# The neoclassical world

Product

Black Box

Technology

Capital

Labor

Human Capital

$$Y = F(A, K, L, H)$$

Min. of Science

Min. of Finance

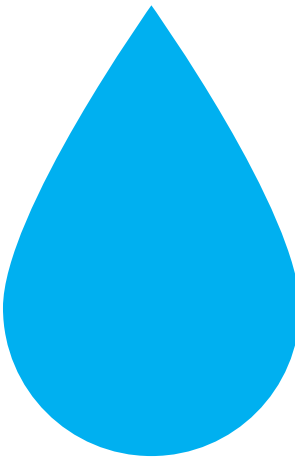
Min. of Labor

Min. of Education

# A Greek version of the world



Earth



Water



Wind



Fire

# ... but maybe the world is different

1 – group IUPAC  
1A – group CAS

period 1	1 <sup>+1</sup> <sub>-1</sub> <b>H</b> hydrogen 1.0079	2 <b>He</b> helium 4.0026
2	3 <sup>+1</sup> <b>Li</b> lithium 6.941	4 <sup>+2</sup> <b>Be</b> beryllium 9.012
3	11 <sup>+1</sup> <b>Na</b> sodium 22.990	12 <sup>+2</sup> <b>Mg</b> magnesium 24.305
4	19 <sup>+1</sup> <b>K</b> potassium 39.098	20 <sup>+2</sup> <b>Ca</b> calcium 40.078
5	37 <sup>+1</sup> <b>Rb</b> rubidium 85.468	38 <sup>+2</sup> <b>Sr</b> strontium 87.62
6	55 <sup>+1</sup> <b>Cs</b> cesium 132.905	56 <sup>+2</sup> <b>Ba</b> barium 137.327
7	87 <sup>+1</sup> <b>Fr</b> francium (223)	88 <sup>+2</sup> <b>Ra</b> radium (226)

atomic number	6	-4 +2 +4	common oxidation states
symbol	<b>C</b>		
name	carbon		
	12.011		atomic mass

- metals
- metalloids
- nonmetals
- unknown

13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
5 <sup>+3</sup> <b>B</b> boron 10.811	6 <sup>+2</sup> <b>C</b> carbon 12.011	7 <sup>+3</sup> <b>N</b> nitrogen 14.007	8 <sup>-2</sup> <b>O</b> oxygen 15.999	9 <sup>-1</sup> <b>F</b> fluorine 18.998	10 <b>Ne</b> neon 20.179
13 <sup>+3</sup> <b>Al</b> aluminum 26.982	14 <sup>+4</sup> <b>Si</b> silicon 28.086	15 <sup>+3</sup> <b>P</b> phosphorus 30.976	16 <sup>-2</sup> <b>S</b> sulfur 32.065	17 <sup>-1</sup> <b>Cl</b> chlorine 35.453	18 <b>Ar</b> argon 39.948
21 <sup>+3</sup> <b>Sc</b> scandium 44.956	22 <sup>+2</sup> <b>Ti</b> titanium 47.867	23 <sup>+2</sup> <b>V</b> vanadium 50.942	24 <sup>+2</sup> <b>Cr</b> chromium 51.996	25 <sup>+2</sup> <b>Mn</b> manganese 54.938	26 <sup>+2</sup> <b>Fe</b> iron 55.845
27 <sup>+2</sup> <b>Co</b> cobalt 58.933	28 <sup>+2</sup> <b>Ni</b> nickel 58.693	29 <sup>+1</sup> <b>Cu</b> copper 63.546	30 <sup>+2</sup> <b>Zn</b> zinc 65.38	31 <sup>+3</sup> <b>Ga</b> gallium 69.723	32 <sup>+4</sup> <b>Ge</b> germanium 72.64
33 <sup>+3</sup> <b>As</b> arsenic 74.922	34 <sup>-2</sup> <b>Se</b> selenium 78.96	35 <sup>-1</sup> <b>Br</b> bromine 79.904	36 <sup>+2</sup> <b>Kr</b> krypton 83.798	37 <sup>+3</sup> <b>Y</b> yttrium 88.906	38 <sup>+4</sup> <b>Zr</b> zirconium 91.224
41 <sup>+4</sup> <b>Nb</b> niobium 92.906	42 <sup>+3</sup> <b>Mo</b> molybdenum 95.96	43 <sup>+4</sup> <b>Tc</b> technetium (98)	44 <sup>+3</sup> <b>Ru</b> ruthenium 101.07	45 <sup>+2</sup> <b>Rh</b> rhodium 102.91	46 <sup>+2</sup> <b>Pd</b> palladium 106.42
47 <sup>+1</sup> <b>Ag</b> silver 107.87	48 <sup>+2</sup> <b>Cd</b> cadmium 112.411	49 <sup>+3</sup> <b>In</b> indium 114.818	50 <sup>+2</sup> <b>Sn</b> tin 118.710	51 <sup>+3</sup> <b>Sb</b> antimony 121.760	52 <sup>-2</sup> <b>Te</b> tellurium 127.60
53 <sup>-1</sup> <b>I</b> iodine 126.904	54 <sup>+2</sup> <b>Xe</b> xenon 131.293	71 <sup>+3</sup> <b>Lu</b> lutetium 174.97	72 <sup>+4</sup> <b>Hf</b> hafnium 178.49	73 <sup>+5</sup> <b>Ta</b> tantalum 180.948	74 <sup>+4</sup> <b>W</b> tungsten 183.84
75 <sup>+4</sup> <b>Re</b> rhenium 186.207	76 <sup>+4</sup> <b>Os</b> osmium 190.23	77 <sup>+3</sup> <b>Ir</b> iridium 192.217	78 <sup>+2</sup> <b>Pt</b> platinum 195.084	79 <sup>+1</sup> <b>Au</b> gold 196.967	80 <sup>+1</sup> <b>Hg</b> mercury 200.59
81 <sup>+1</sup> <b>Tl</b> thallium 204.383	82 <sup>+2</sup> <b>Pb</b> lead 207.2	83 <sup>+3</sup> <b>Bi</b> bismuth 208.980	84 <sup>+2</sup> <b>Po</b> polonium (210)	85 <sup>-1</sup> <b>At</b> astatine (210)	86 <b>Rn</b> radon (220)
103 <sup>+3</sup> <b>Lr</b> lawrencium (262)	104 <sup>+4</sup> <b>Rf</b> rutherfordium (261)	105 <sup>+5</sup> <b>Db</b> dubnium (262)	106 <sup>+6</sup> <b>Sg</b> seaborgium (266)	107 <sup>+7</sup> <b>Bh</b> bohrium (264)	108 <sup>+8</sup> <b>Hs</b> hassium (277)
109 <sup>+9</sup> <b>Mt</b> meitnerium (268)	110 <sup>+10</sup> <b>Ds</b> darmstadtium (271)	111 <sup>+11</sup> <b>Rg</b> roentgenium (272)	112 <sup>+12</sup> <b>Cn</b> copernicium (285)	113 <sup>+13</sup> <b>Nh</b> nihonium (286)	114 <sup>+14</sup> <b>Fl</b> flerovium (289)
115 <sup>+15</sup> <b>Mc</b> moscovium (289)	116 <sup>+16</sup> <b>Lv</b> livermorium (293)	117 <sup>+17</sup> <b>Ts</b> tennessine (294)	118 <sup>+18</sup> <b>Og</b> oganeson (294)		

Lathanides

57 <sup>+3</sup> <b>La</b> lathanium 138.905	58 <sup>+3</sup> <b>Ce</b> cerium 140.116	59 <sup>+3</sup> <b>Pr</b> praseodymium 140.908	60 <sup>+3</sup> <b>Nd</b> neodymium 144.242	61 <sup>+3</sup> <b>Pm</b> promethium (145)	62 <sup>+2</sup> <b>Sm</b> samarium 150.36	63 <sup>+3</sup> <b>Eu</b> europium 151.964	64 <sup>+3</sup> <b>Gd</b> gadolinium 157.25	65 <sup>+3</sup> <b>Tb</b> terbium 158.925	66 <sup>+3</sup> <b>Dy</b> dysprosium 162.500	67 <sup>+3</sup> <b>Ho</b> holmium 164.930	68 <sup>+3</sup> <b>Er</b> erbium 167.259	69 <sup>+3</sup> <b>Tm</b> thulium 168.934	70 <sup>+2</sup> <b>Yb</b> ytterbium 173.054
---	--	--	---	--	---	--	---	---	--	---	--	---	---

Actinides

89 <sup>+3</sup> <b>Ac</b> actinium (227)	90 <sup>+4</sup> <b>Th</b> thorium 232.038	91 <sup>+4</sup> <b>Pa</b> protactinium 231.036	92 <sup>+3</sup> <b>U</b> uranium 238.029	93 <sup>+3</sup> <b>Np</b> neptunium (237)	94 <sup>+3</sup> <b>Pu</b> plutonium (244)	95 <sup>+3</sup> <b>Am</b> americium (243)	96 <sup>+3</sup> <b>Cm</b> curium (247)	97 <sup>+3</sup> <b>Bk</b> berkelium (247)	98 <sup>+3</sup> <b>Cf</b> californium (251)	99 <sup>+3</sup> <b>Es</b> einsteinium (252)	100 <sup>+3</sup> <b>Fm</b> fermium (257)	101 <sup>+3</sup> <b>Md</b> mendelevium (258)	102 <sup>+3</sup> <b>No</b> nobelium (259)
--	---	--	--	---	---	---	--	---	---	---	--	--	---

# What is technology?

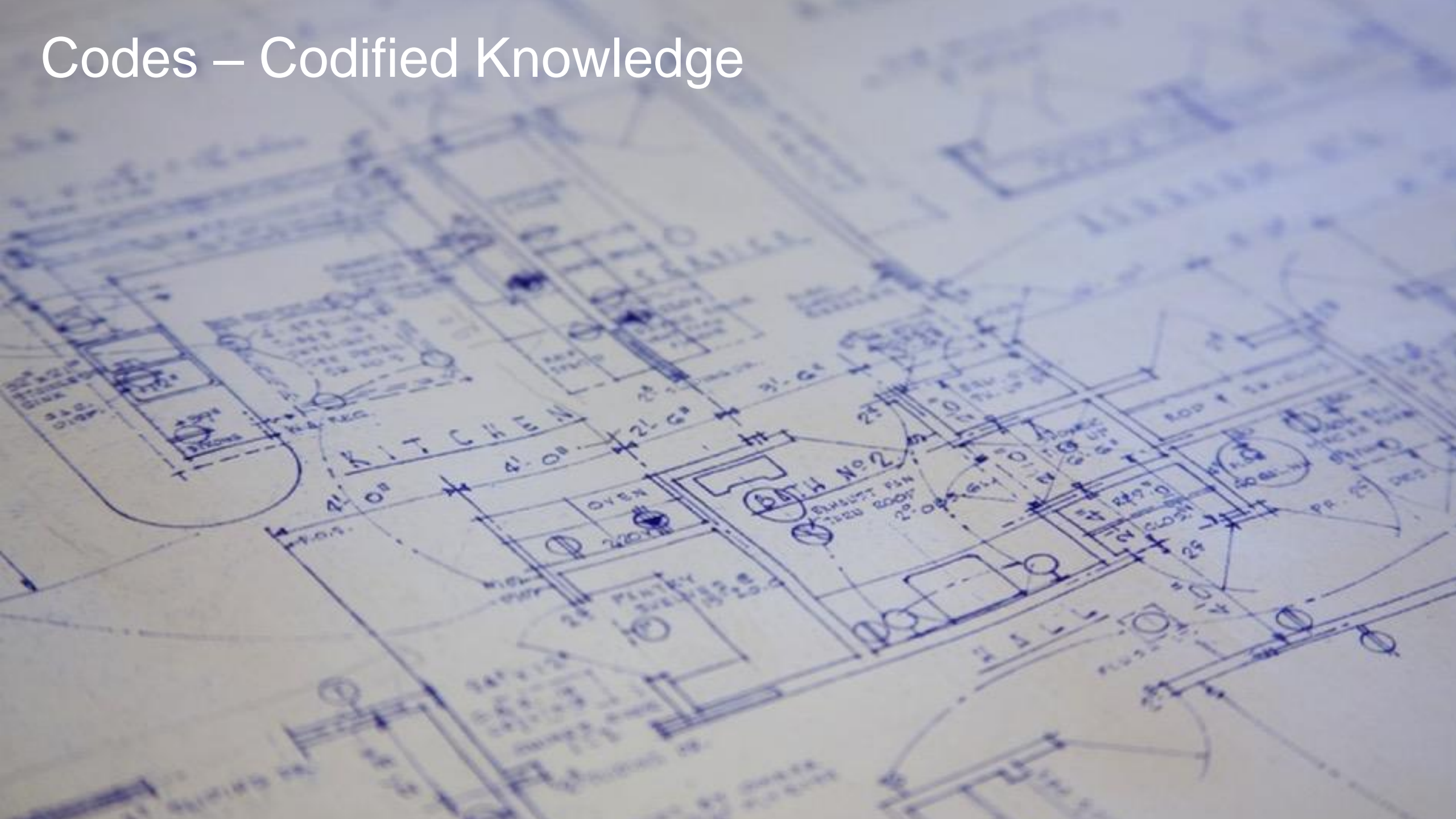




# Tools – Embodied knowledge



# Codes – Codified Knowledge





# Knowhow – Tacit Knowledge









WIKIPEDIA  
The Free Encyclopedia

Main page  
Contents  
Featured content  
Current events  
Random article  
Donate to Wikipedia  
Wikipedia store

Interaction  
Help  
About Wikipedia  
Community portal  
Recent changes  
Contact page

Tools  
What links here  
Related changes  
Upload file  
Special pages  
Permanent link  
Page information  
Wikidata item  
Cite this page


Print/export  
Create a book  
Download as PDF  
Printable version

In other projects  
Wikimedia Commons

Languages   
Afrikaans  
العربية  
Bân-lâm-gú  
Беларуская  
Български  
Català  
Čeština  
Dansk  
Deutsch

Article [Talk](#)

[Read](#) [Edit](#) [View history](#)



# Lift (force)

From Wikipedia, the free encyclopedia

*For other uses, see [Lift \(disambiguation\)](#).*

A fluid flowing past the surface of a body exerts a force on it. **Lift** is the component of this force that is perpendicular to the oncoming flow direction.<sup>[1]</sup> It contrasts with the drag force, which is the component of the surface force parallel to the flow direction. If the fluid is air, the force is called an aerodynamic force. In water, it is called a hydrodynamic force.

## Contents [hide]

- Overview
- Simplified physical explanations of lift on an airfoil
  - Flow deflection and Newton's laws
    - Limitations of deflection/turning
  - Increased flow speed and Bernoulli's principle
    - Conservation of mass
    - Limitations of explanations based on Bernoulli's principle
- Basic attributes of lift
  - Pressure differences
  - Angle of attack
  - Airfoil shape
  - Air speed and density
  - Lift coefficient
  - Pressure integration
- A more comprehensive physical explanation
  - Lift involves action and reaction at the airfoil surface and is felt as a pressure difference
  - The airfoil affects the flow over a wide area around it
  - The pressure differences and the changes in flow speed and direction support each other in a mutual interaction
- The understanding of lift as a physical phenomenon
- Mathematical theories of lift
  - Navier-Stokes (NS) equations
  - Reynolds-Averaged Navier-Stokes (RANS) equations
  - Inviscid-flow equations (Euler or potential)
  - Linearized potential flow
  - Circulation and the Kutta-Joukowski theorem
  - Momentum balance in lifting flows
- Lift of three-dimensional wings
- Viscous effects: Profile drag and stalling



Boeing 747-8F landing













# Collective Knowhow

= the competence to do things that  
can only be done by teams



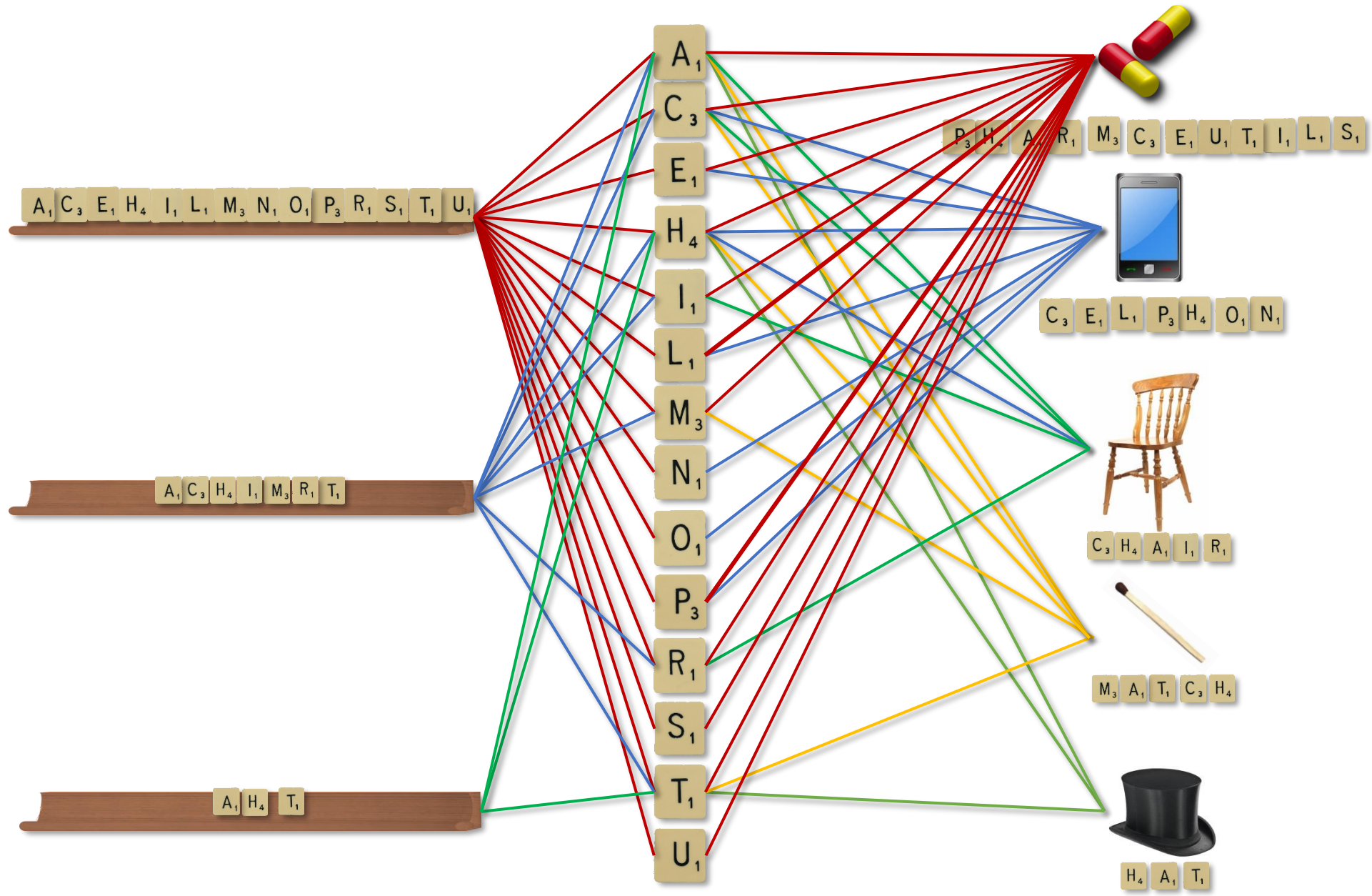




# Places

# Capabilities

# Products



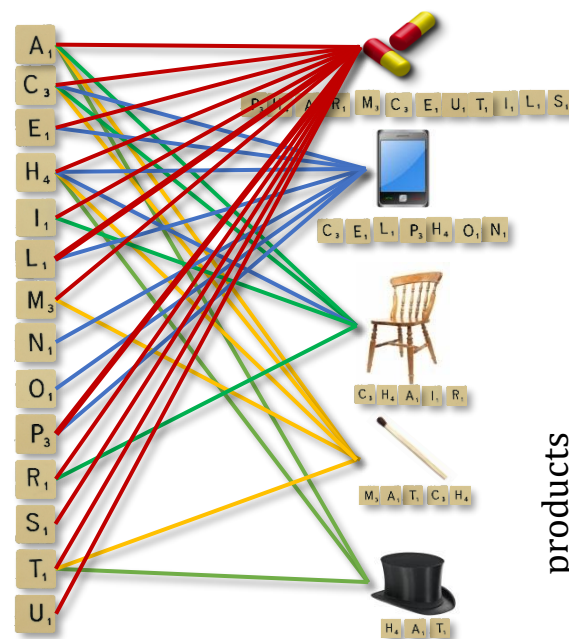
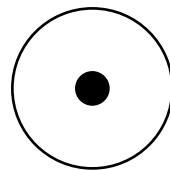
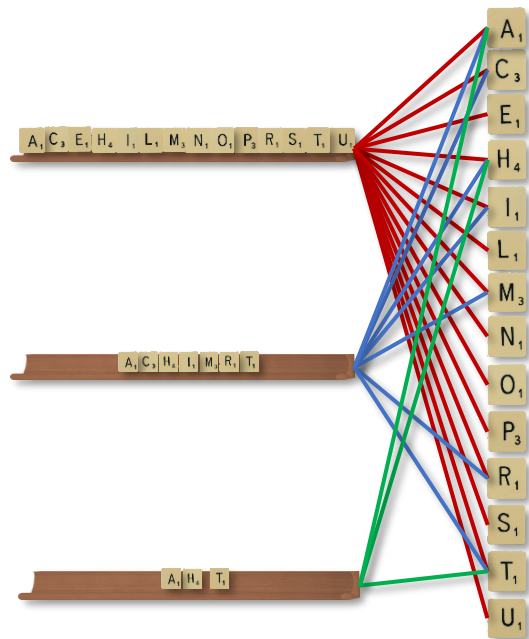


# What are letters?

- Productive capabilities
- Non-tradables: they need to be in the places where production takes place
- Include collective knowhow: different abilities needed by the production process
- Including non-tradable inputs
- And public goods

$C_{ca}$   
countries capabilities

...	...	...
...	...	...
...	...	...

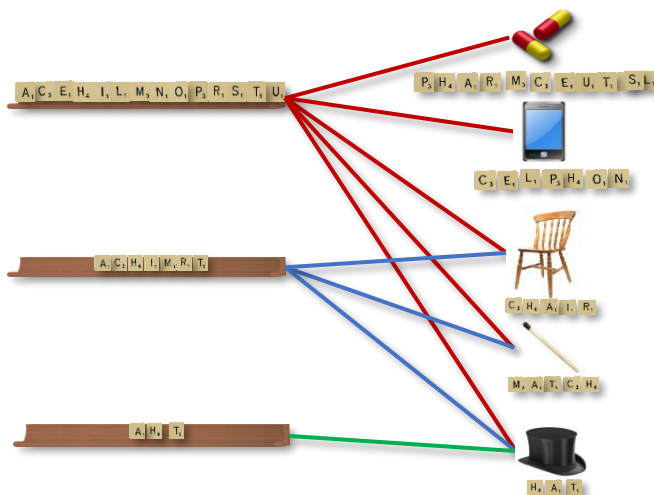


$P_{pa}$   
products capabilities

...	...	...
...	...	...
...	...	...

$M_{cp}$   
countries products

...	...	...
...	...	...
...	...	...

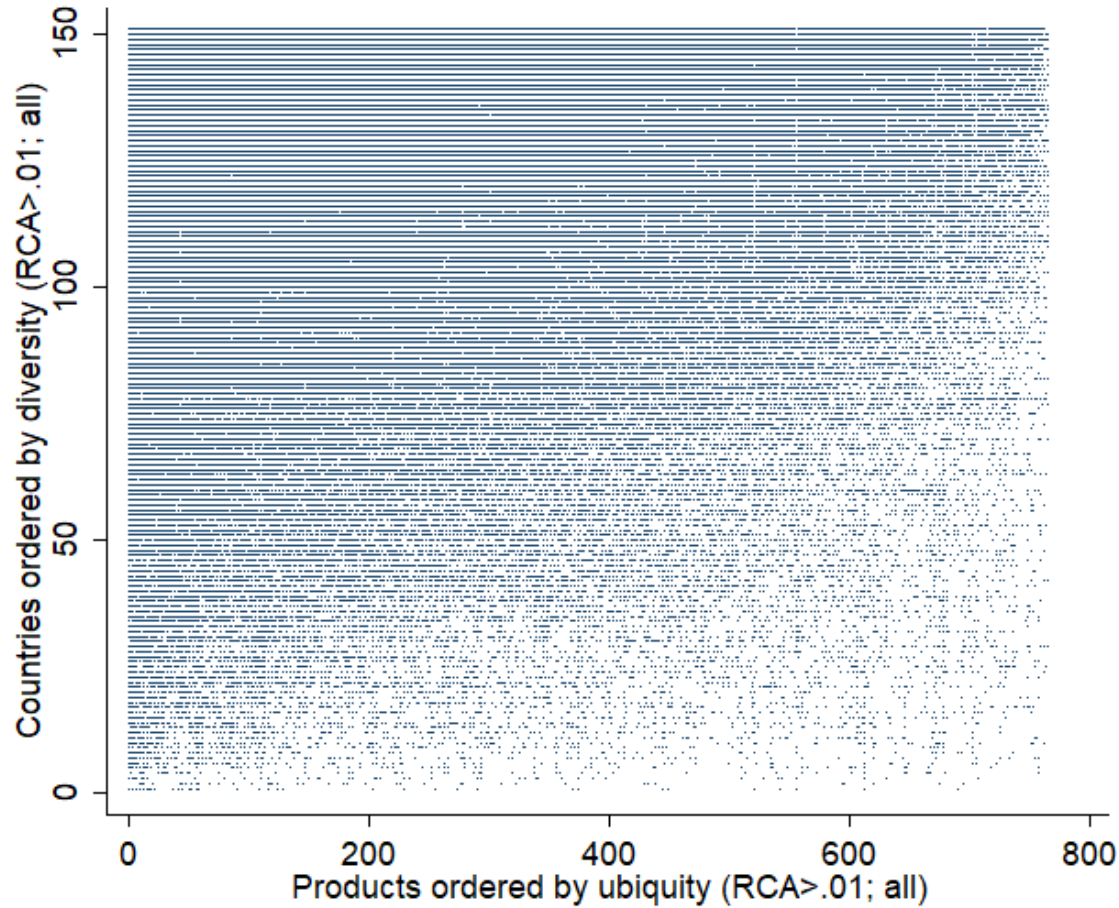


Production:

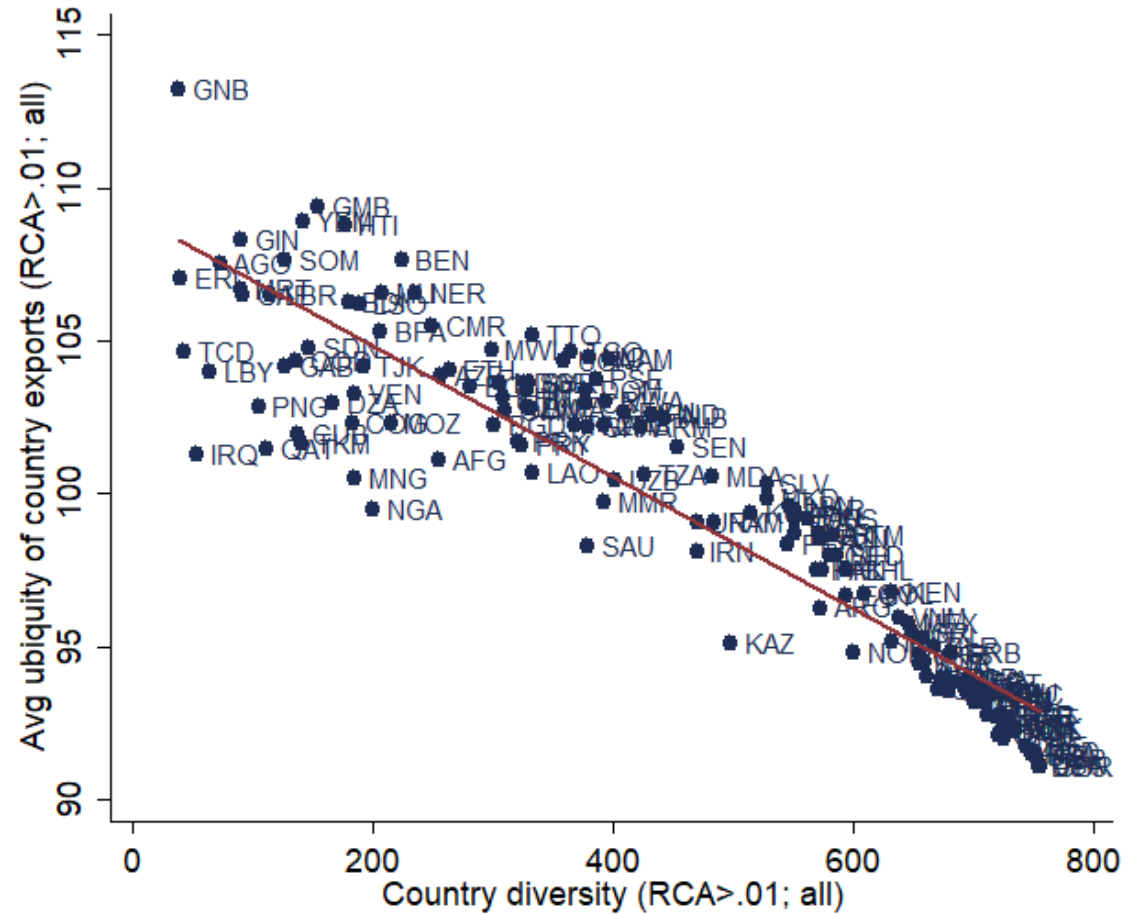
$$[M_{cp}] = 1 \text{ si } \vec{P}_p \text{ is a subset of } \vec{C}_c$$

# 'Nestedness' of Country Exports

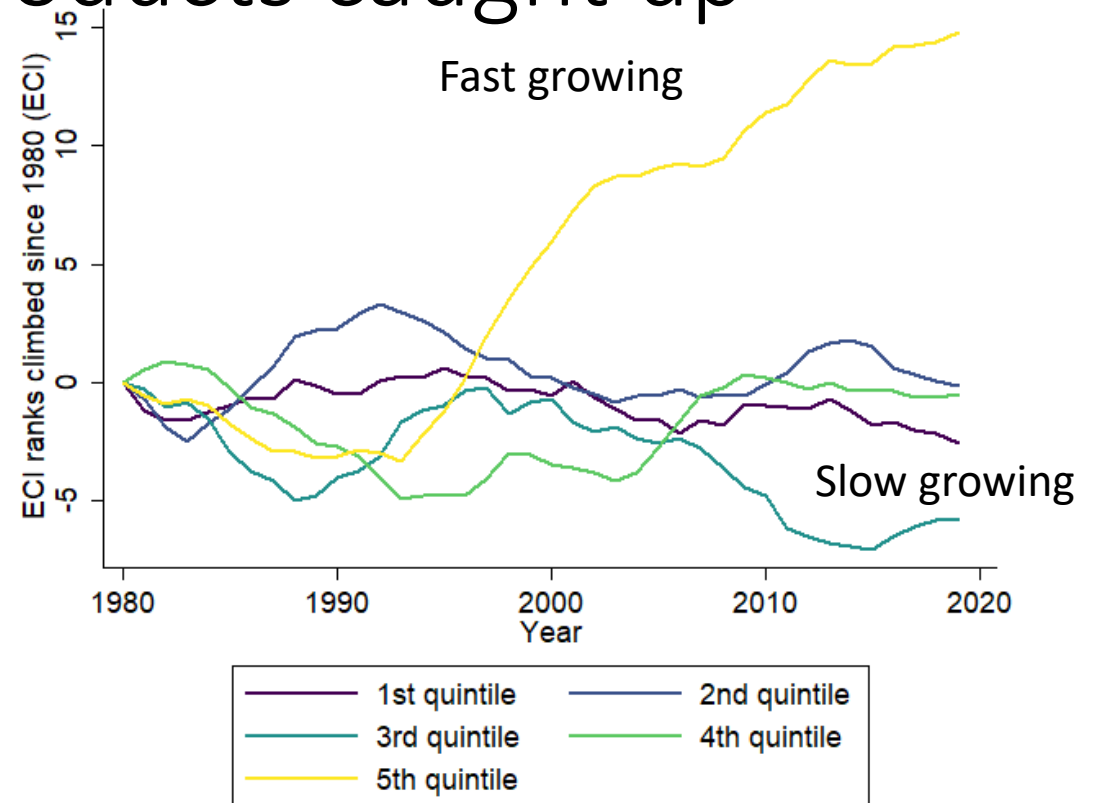
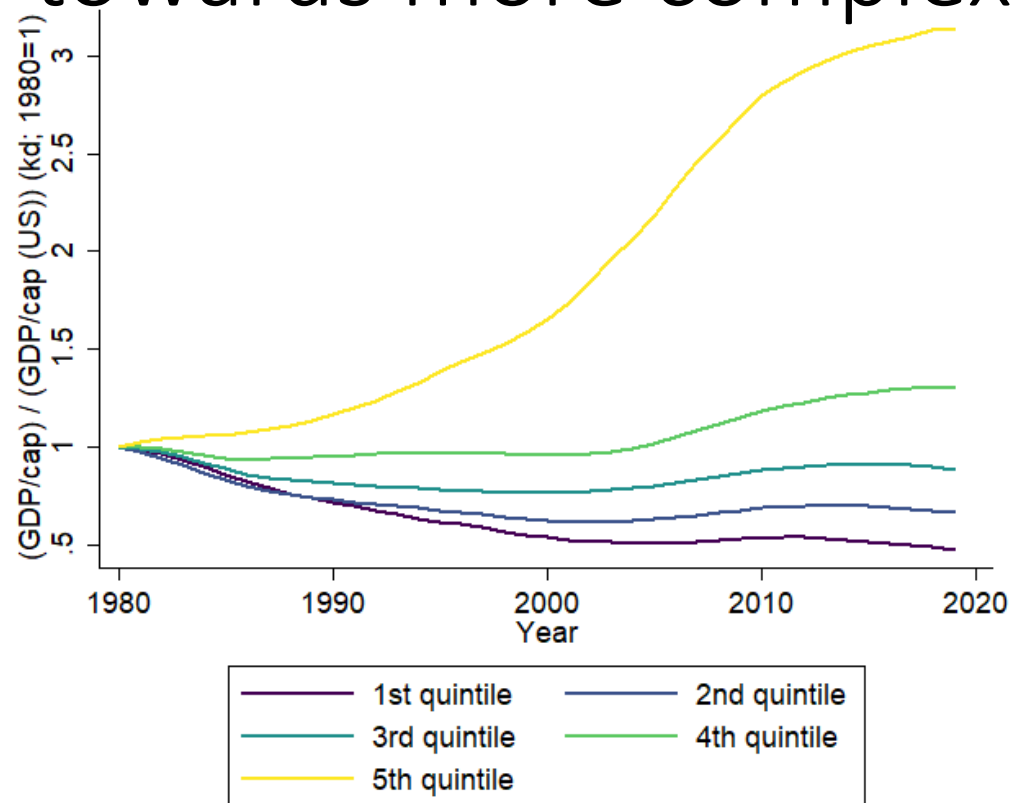
RCA > .01



RCA > .01



# Only the countries that diversified their exports towards more complex products caught up



- Countries in the bottom 75% of incomes in 1980 only, grouped by their subsequent growth
- Source: Own illustration based on WDI and <https://atlas.cid.harvard.edu/>

# What can go wrong with technology adoption

- **Knowhow is hard to acquire**
  - Because it is a slow process at the individual level
  - ...and because of its collective (team) nature
- **Coordination failures**
- **Knowledge spillovers**
- **Public goods**







Which is the odd one out?



# Which is the odd one out?



B<sub>3</sub> E<sub>1</sub> A<sub>1</sub> R<sub>1</sub>



Z<sub>10</sub> E<sub>1</sub> B<sub>3</sub> R<sub>1</sub> A<sub>1</sub>



L<sub>1</sub> I<sub>1</sub> O<sub>1</sub> N<sub>1</sub>



# Knowledge spillovers: Silicon valley



# Technology needs Public Goods

Driving a car needs roads, traffic signs, road rules



# The Invisible Hand of the Market

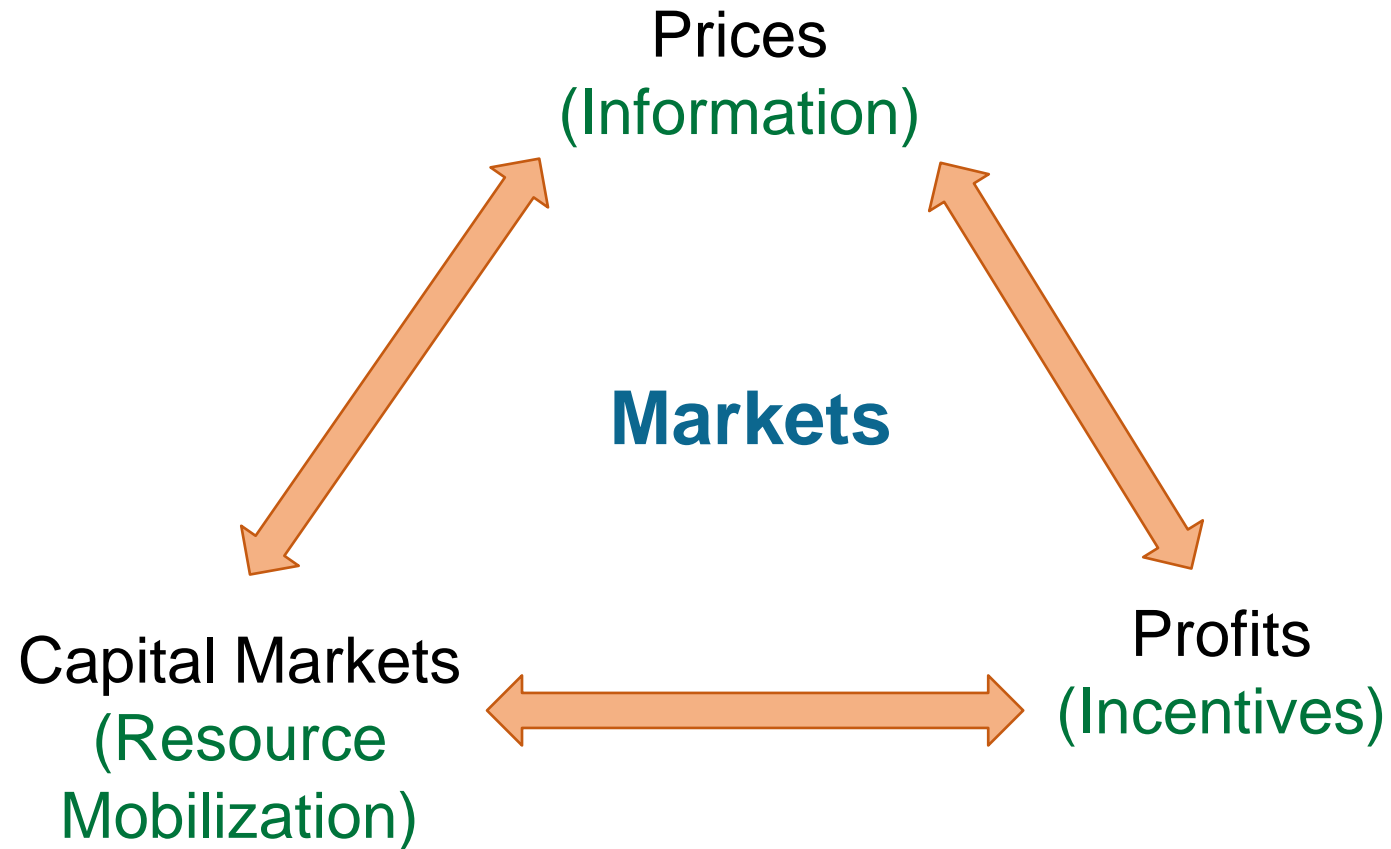




# Markets Self-Organize



# The invisible hand of the market





**But Public Goods Are Different.  
The Government is NOT self-organizing**





# Public Goods Are Different

No prices → No information



# Public Goods Are Different

No profit motive → No incentive





# Public Goods Are Different

No internal capital markets → No decentralized resource mobilization



## How is the provision of public inputs organized?

- No prices
  - No information
- No profit motive
  - No incentive
- No decentralized capital market
  - Resource allocation mechanism
- How does the government set its very large basket of public inputs?
  - Where does it get its ***information?***
  - ***Incentive*** to respond to the information
  - ***Resource mobilization*** to address the issue

# Agenda

- Who needs industrial policy?
- A puzzling fact about international convergence patterns
- A theory of technology and of adoption obstacles
- **Goal-oriented industrial policy**
- The dimensions of industrial policy

# What role for “industrial policy”?

It is about diversification, and technology adoption and adaptation

# The problem that industrial policy needs to solve

- Production requires many relatively specific public goods
- ...and inputs from missing markets
- Giving money to firms does not solve the problem
  - They cannot buy public goods or spend money in missing markets
- You need to sort out what is missing
- ...but you have no clue what it may be
  - $\sim 10^3$  government agencies and  $\sim 10^6$  pages of legislation
- The obstacles may lurk anywhere
- You face an information revelation problem
- You cannot assign ex ante the area of legislation or the government ministry under whom the solution space lies

# These problems are particularly serious at the extensive margin

- Industries that exist can act or complain
- Industries that do not yet exist don't complain
- Governments are bad at supplying the public goods needed by industries that exist
- But they are hopeless at supplying the needs of industries that don't yet exist
- So you need organizations that can explore these spaces

# You may not know what to do

- But you know that you don't know
- So the policy involves processes that reveal information, solve problems and accumulate institutional learning
- This requires reimagining institutions that can act in this role
  - E.g. Smart development banks, investment promotion, cluster organizations, SEZs
- Industrial policy needs a constellation of learning organizations that engage with economic activity, reveal information and learn
  - This is a continuous process in living organizations

# This policy needs to be high-bandwidth

- Industries need very different public goods
- ...and face very different coordination failures and missing markets
- Markets face very different distortions
- So, horizontal policies (treating all the same) will not work
- But how many vertical policies do you need?  $10^0$ ?  $10^1$ ?  $10^2$ ?  $10^3$ ?
  - Prioritize a few vs increase government bandwidth
  - METI in Japan has ~230 deliberation councils
- So, think  $\sim 10^2$
- Most countries need to increase the bandwidth of their policies rather than prioritize fewer sectors



Vertical policies will have to be very different because industries they differ along many dimensions

- Existing industries vs new industries
- Globally mature technologies vs nascent technologies
- Globally mature markets vs new markets
- Need for light vs heavy technological adaptation
- Possibility of starting small vs. need to start at a sufficient scale
- Presence of potential agents of change and their type

# Varieties of agents of change

- Foreign Direct Investment (FDI)
- Mergers & Acquisitions (reverse FDI)
- Conglomerates
- State-owned enterprises
- Development Corporations
- Immigration
- Diasporas and return migration

# In conclusion

- Industrial policy should be seen as defined by its goals, not its instruments
  - Economic convergence
  - Climate change
- It should focus on:
  - Identifying and solving coordination failures and missing public goods
  - Attracting missing capabilities and industries
  - Engaging with agents of change
  - Stimulating the development of R&D capabilities for technological adaptation and adoption