ECON1002: Introductory Macroeconomics

Lecture 10: Economic Growth

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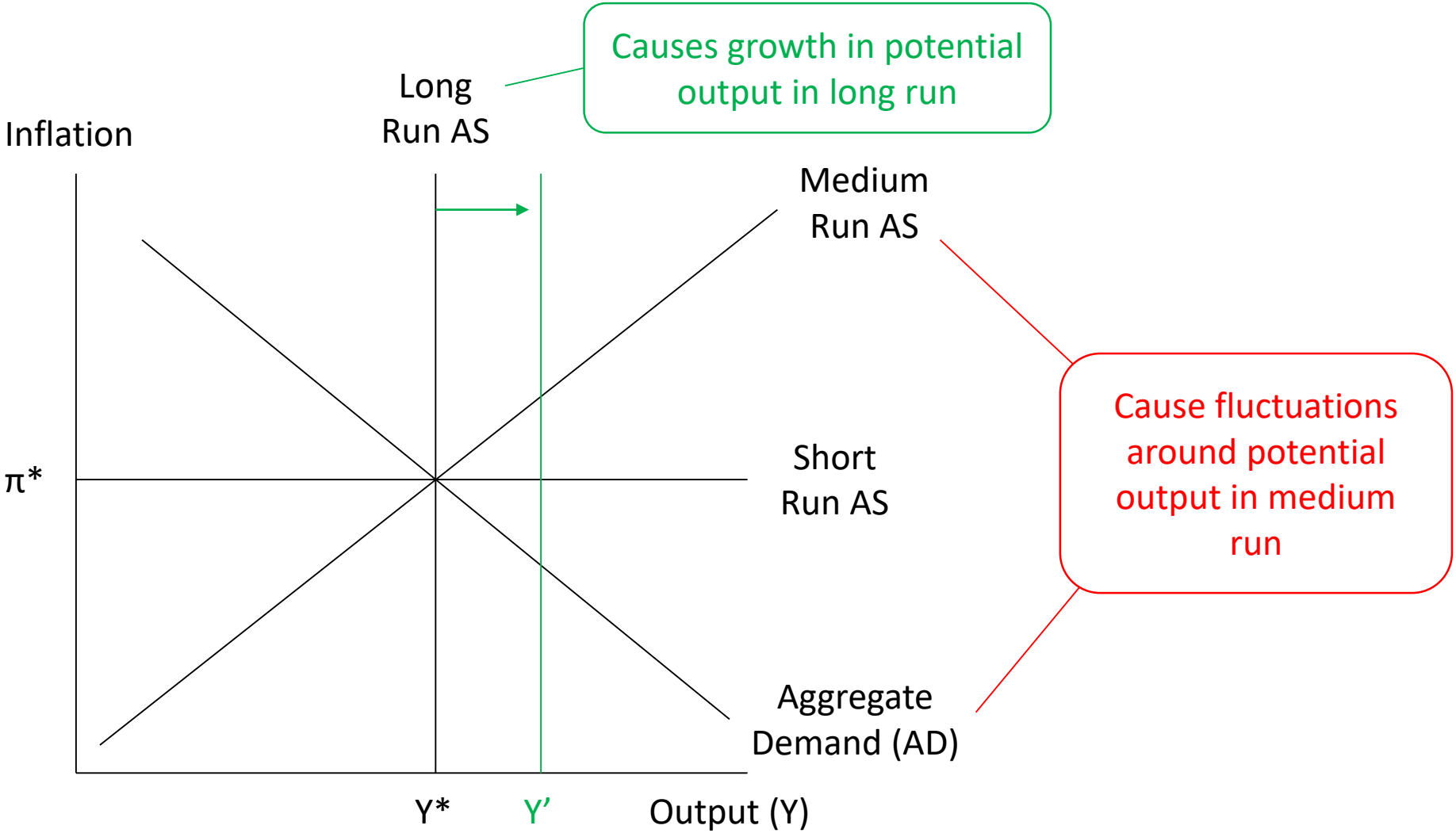
Putting it in context

So far we have discussed short-medium run business cycles. The next two lectures focus on long run economic growth.



We are now interested in answering a different set of questions, so will need a new set of models

Time Horizon	Key Questions
Short – Medium Term	• What causes business cycles? • What causes unemployment? • What causes inflation? • How can fiscal and monetary policy smooth out business cycles and reduce unemployment?
Long Term	• What causes an economy to grow? • Why are some countries rich and other countries poor? • Why are some people in a country rich, and other people poor? • What can governments do to promote growth?

Chapter 11

The economy in the long run: an introduction to economic growth

Learning Objectives

11.1 What are the main facts about the world's experience of economic growth?

11.2 Which countries have grown?

11.3 Which countries have not grown?

11.4 What is the relationship between economic growth an potential output?

11.5 What is the significance of small differences in economic growth rates for countries' standards of living in the long run?

11.6 What economic factors are the main contributors to economic growth?

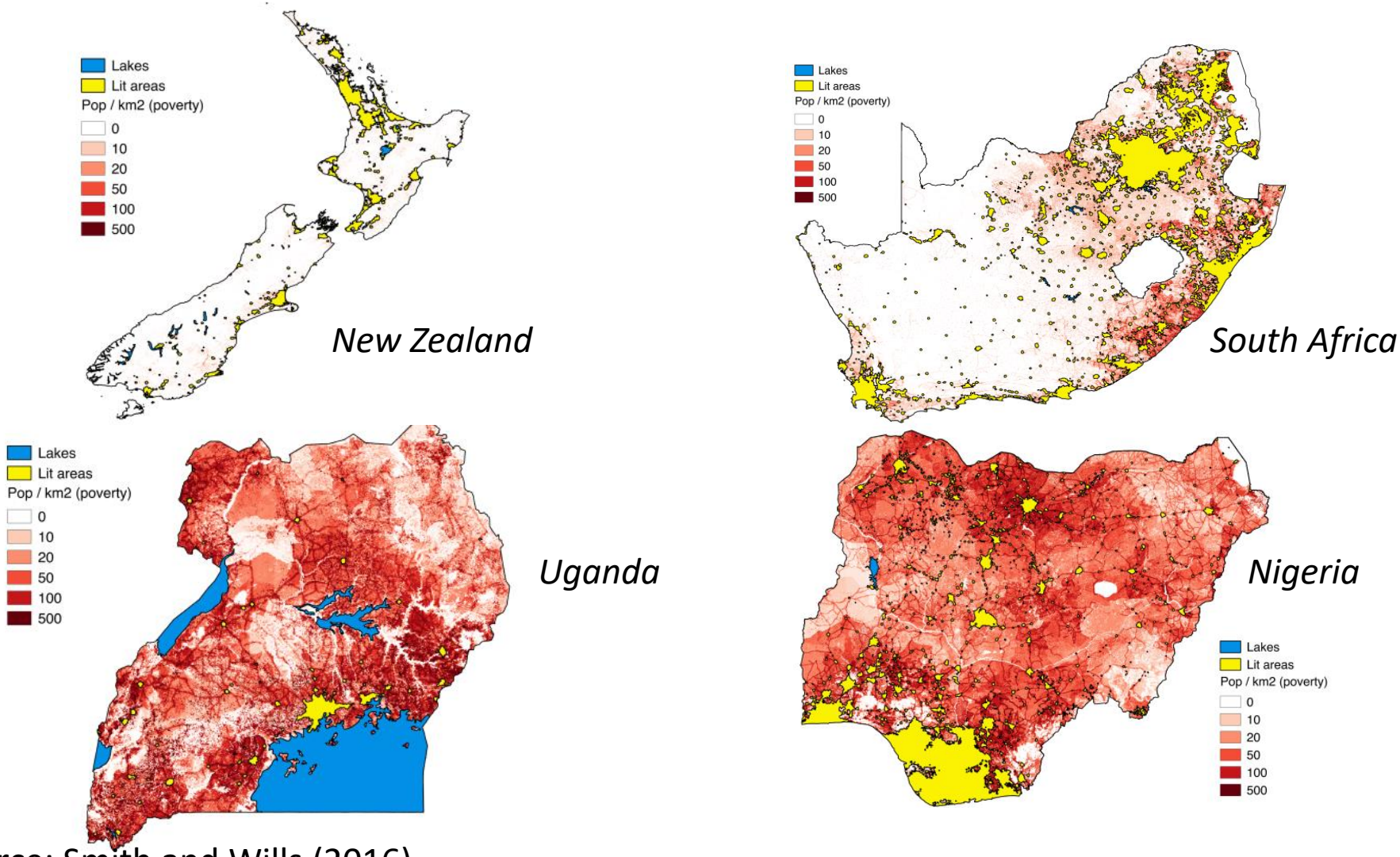
11.7 What are the costs and benefits of economic growth?

11.8 What policies do economists recommend to boost economic growth?

Why were 150 British and colonial troops able to defend Rorke's Drift (South Africa) from 3000-4000 Zulu warriors in 1879?

Why are some countries rich and others poor?

People living in darkness at night



Source: Smith and Wills (2016)

The punchline: Output is driven by labour, land, capital, and technology, which are called "factors of production"

1. Labour

- The number of people

2. Land

- The amount and quality of land, natural resources, waterways, etc

3. Capital

- Capital is stuff that is accumulated by investment

i. Physical

- The physical tools labour uses

ii. Human

- The talent/education/skills of labour

4. Technology

- Technology is the ability to combine other factors in useful ways

i. Inventions

- Combining capital

ii. Institutions

- Combining labour

iii. Management

- Combining labour and capital

Output is driven by labour, land, capital, and technology, which are called “factors of production”

1. Labour

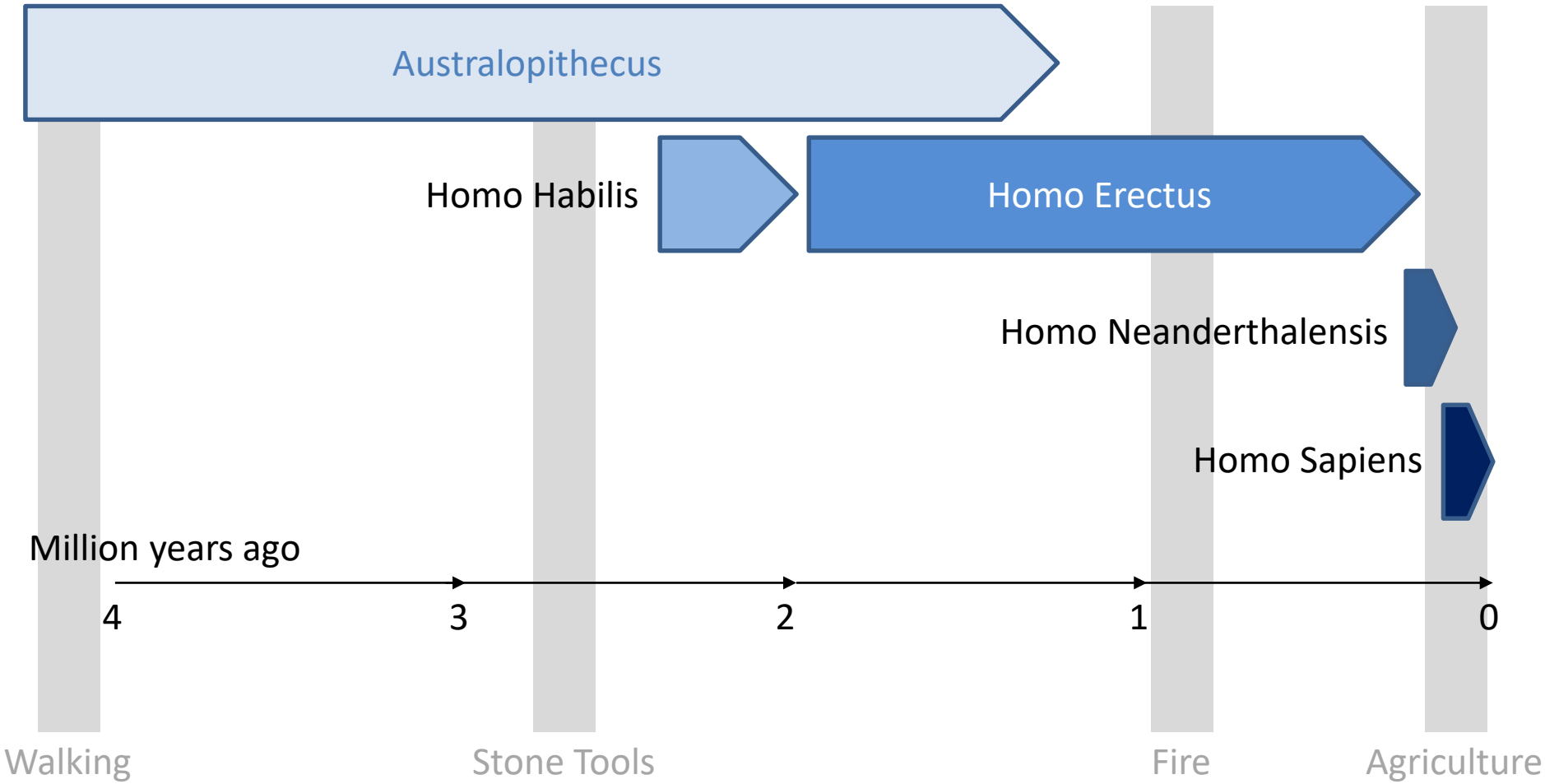
2. Land

3. Capital
   - i. Physical
   - ii. Human

4. Technology
   - i. Inventions
   - ii. Institutions
   - iii. Management

Starting at the beginning. Modern humans (homo sapiens) appeared in Africa about 200,000 years ago, and coexisted/bred with other hominids

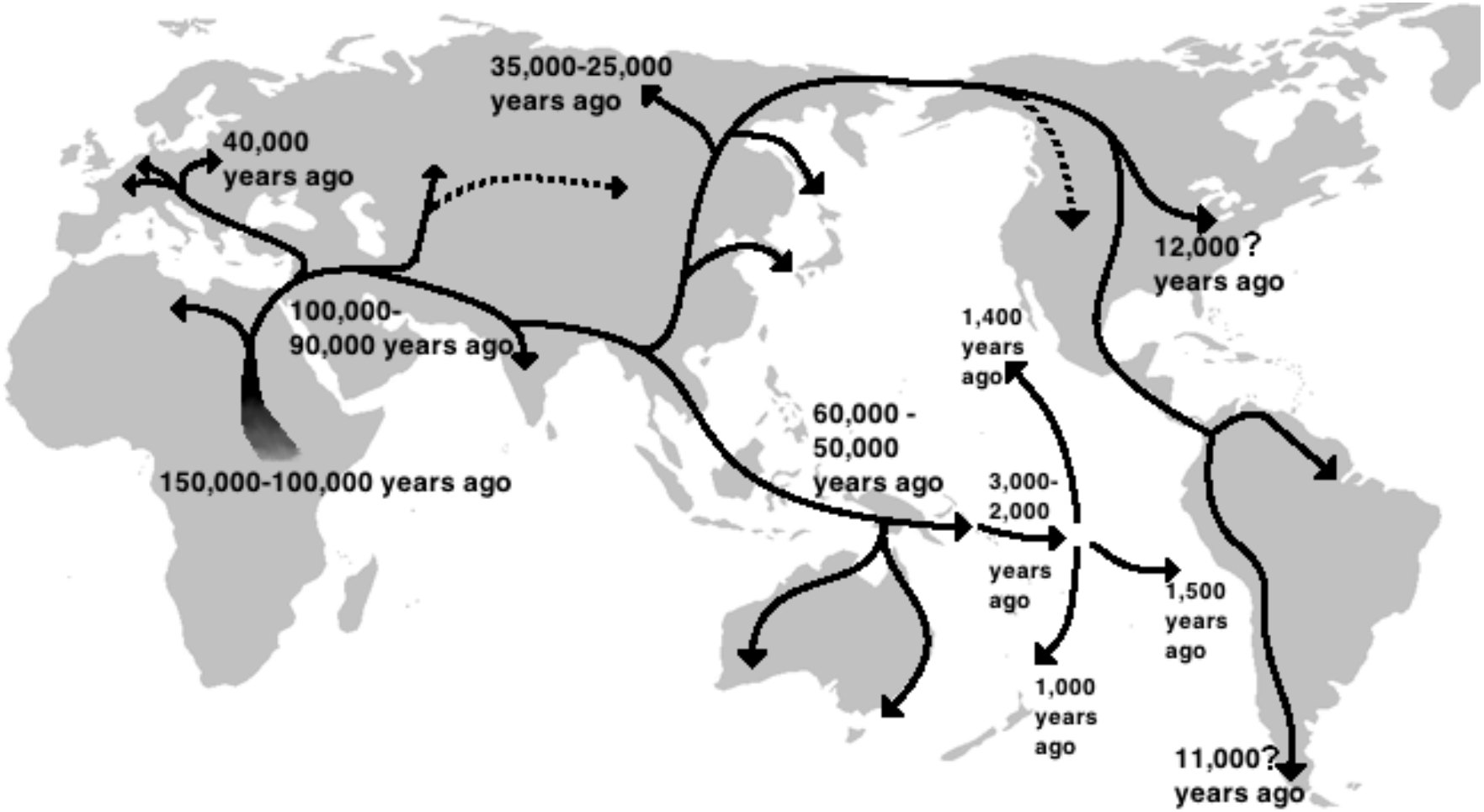
Broad timeline of human evolution



Source: http://humanorigins.si.edu/evidence/human-evolution-timeline-interactive

Humans spread from southern Africa to populate the Earth in waves of migration from 150,000 years ago.

Major human migrations



Source: https://phys.org/news/2011-11-genographic-humans-migrated-africa-arabia.html

For ~200,000 years all humans were hunter-gatherers. They had the same brains as us, but very low levels of labour and physical capital

Factor of production		Pre-historic levels
1. Labour		• Very low population. Possibly as low as 1,000-10,000 following the Toba eruption in Indonesia ~70,000 years ago (genetic evidence)
2. Land		• Abundant land per person • Relied on natural formations for shelter/food/ water
3. Capital	i. Physical	• Rocks, skins, bones, sticks, etc
	ii. Human	• Knowledge of plants, animals, weather etc
4. Technology	i. Inventions	• E.g. Fire (combining flint and rock)
	ii. Institutions	• E.g. tribe hierarchies
	iii. Management	• E.g. organized hunting of animals

Then, after the last ice-age ~13,000 years ago, humans began to domesticate crops in the "fertile crescent", starting economic growth

Q: Why did agriculture first arise in the fertile crescent?

A: The land was more suitable:

- Very fertile Mesopotamian alluvial plains
- Multiple indigenous high-protein crops
  - Barley
  - Wheat (two types)
  - Legumes
- Multiple domesticable large animals
  - Goats
  - Sheep
  - Cattle
- Dry climate for storage

Source: Diamond (1997)

Output is driven by labour, land, capital, and technology, which are called “factors of production”

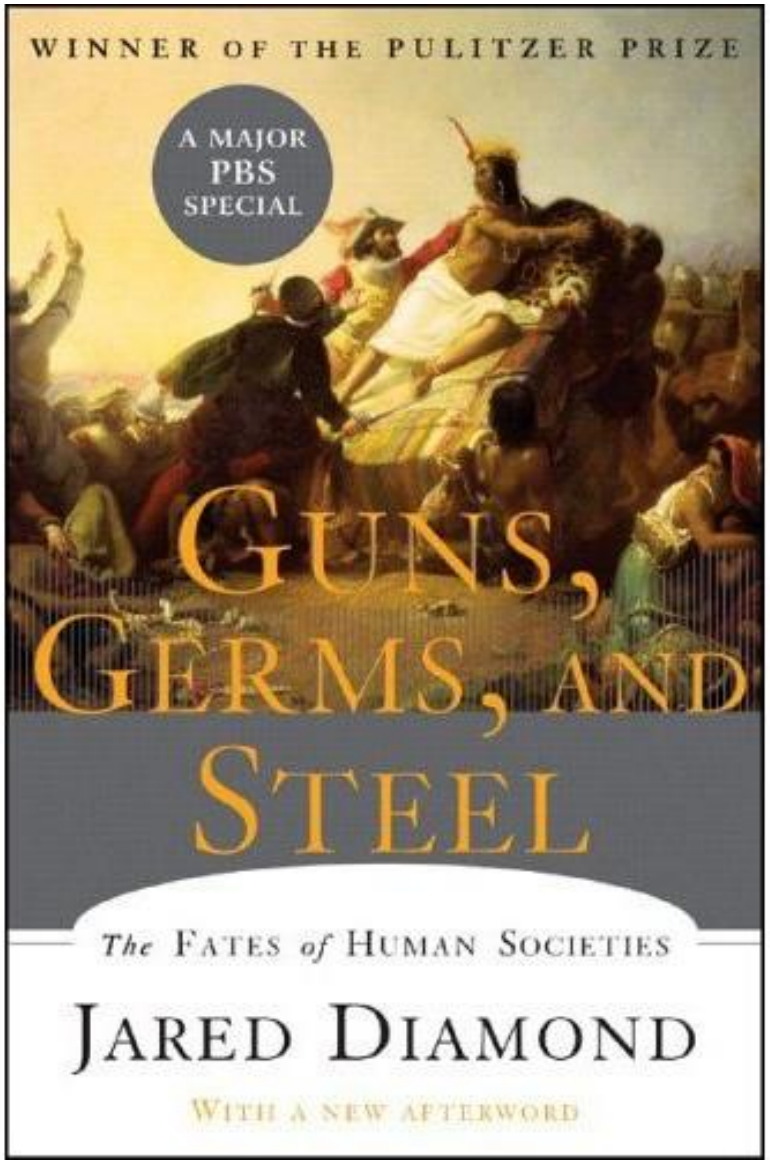
1. Labour

2. Land

3. Capital
   - i. Physical
   - ii. Human

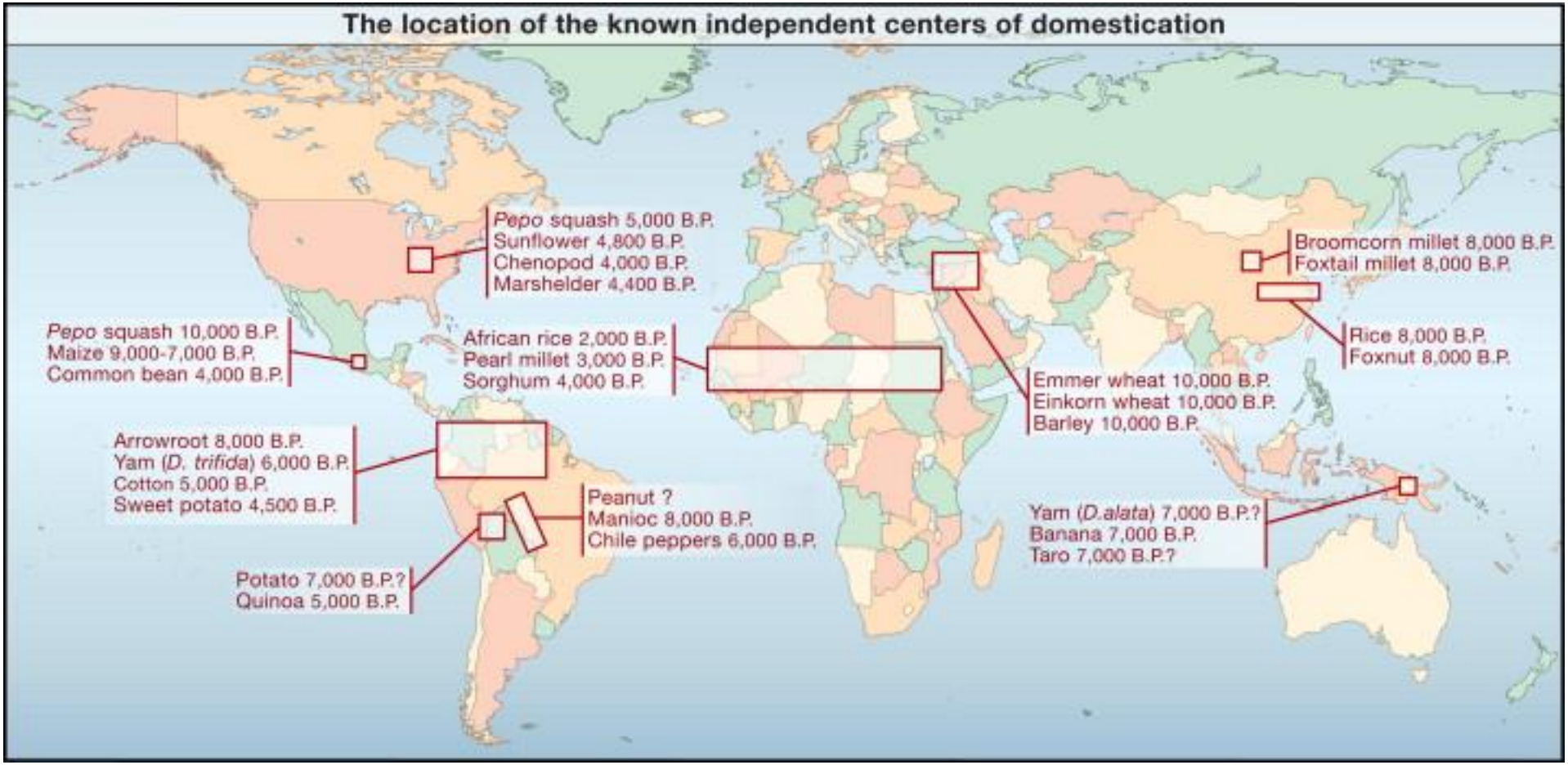
4. Technology
   - i. Inventions
   - ii. Institutions
   - iii. Management

The importance of land in economic growth is clearly described in the "geography hypothesis" of *Guns, Germs and Steel* by Jared Diamond



- Good read – I highly recommend it
- Clear explanation of the role of land and geography in economic growth
- Summaries:
  - https://www.youtube.com/watch?v=VsyXK3Ze63A
  - I didn't tell you to read the concise summary on Wikipedia ;)

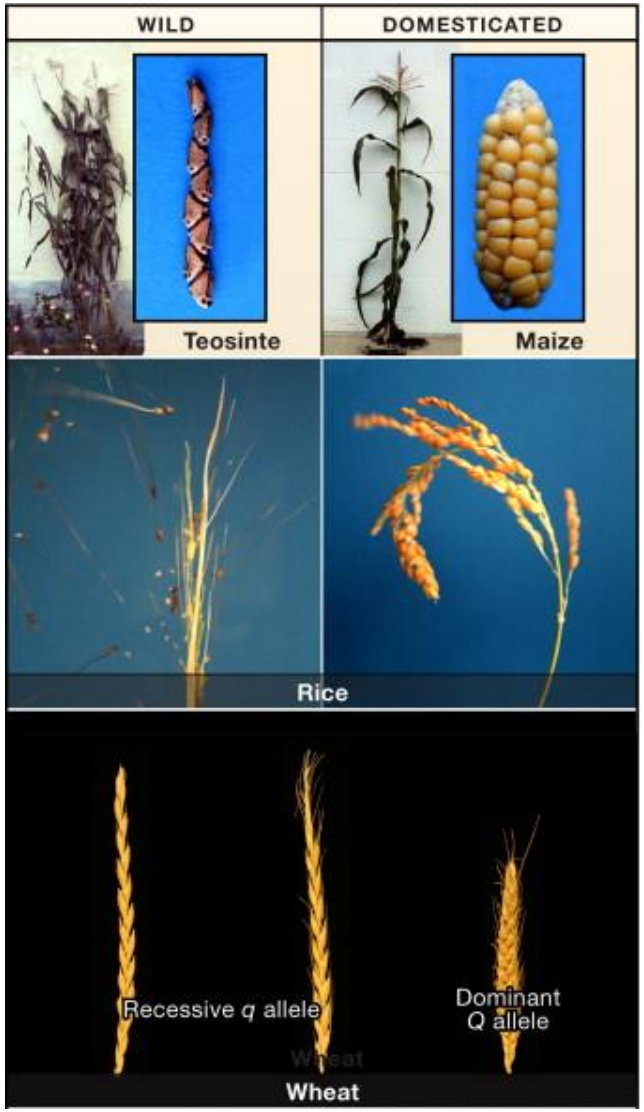
As well as the fertile crescent, agriculture developed independently ~10 times around the world, with different crops

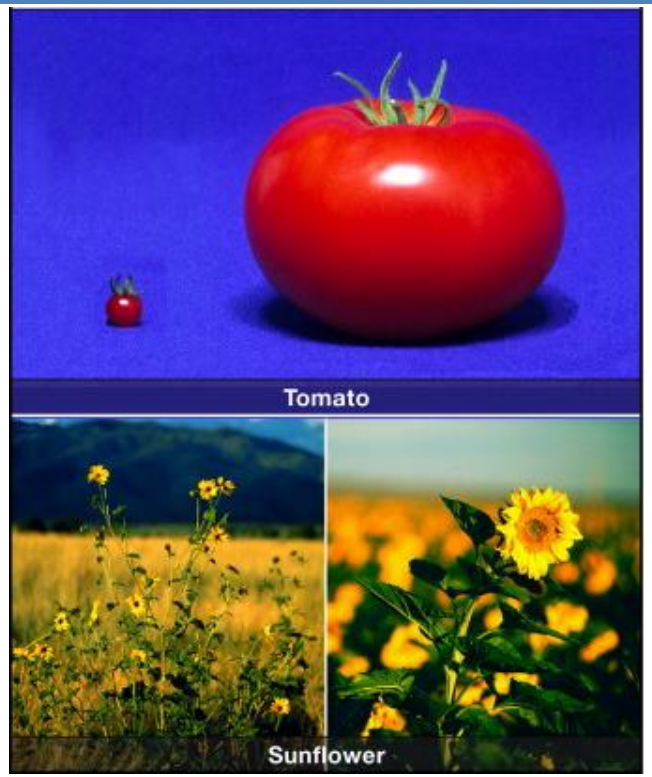


- All places with independent agriculture developed large, complex pre-colonial societies

Source: http://www.cell.com/fulltext/S0092-8674(06)01592-3

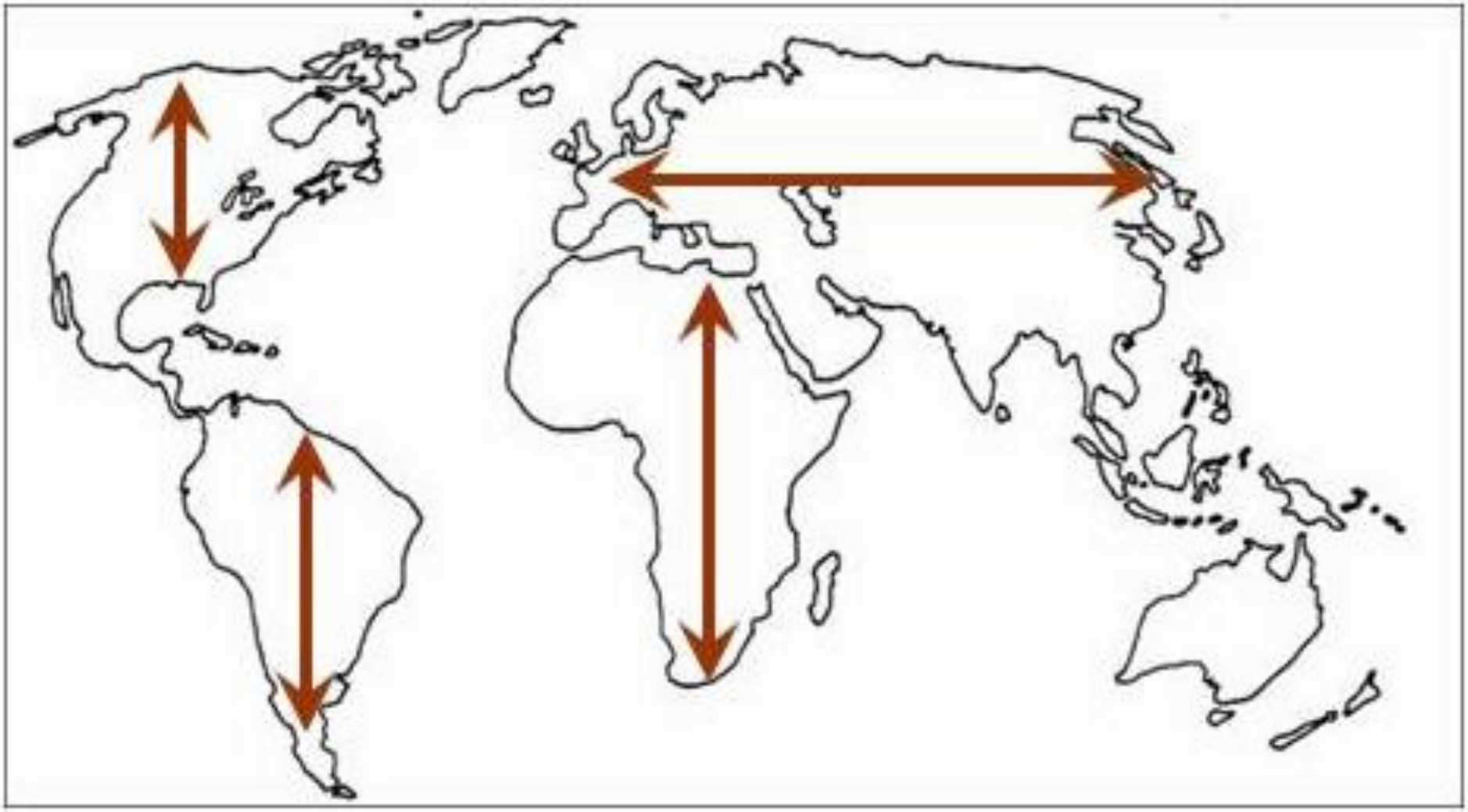
The crops that were initially domesticated were very different to the ones we know today





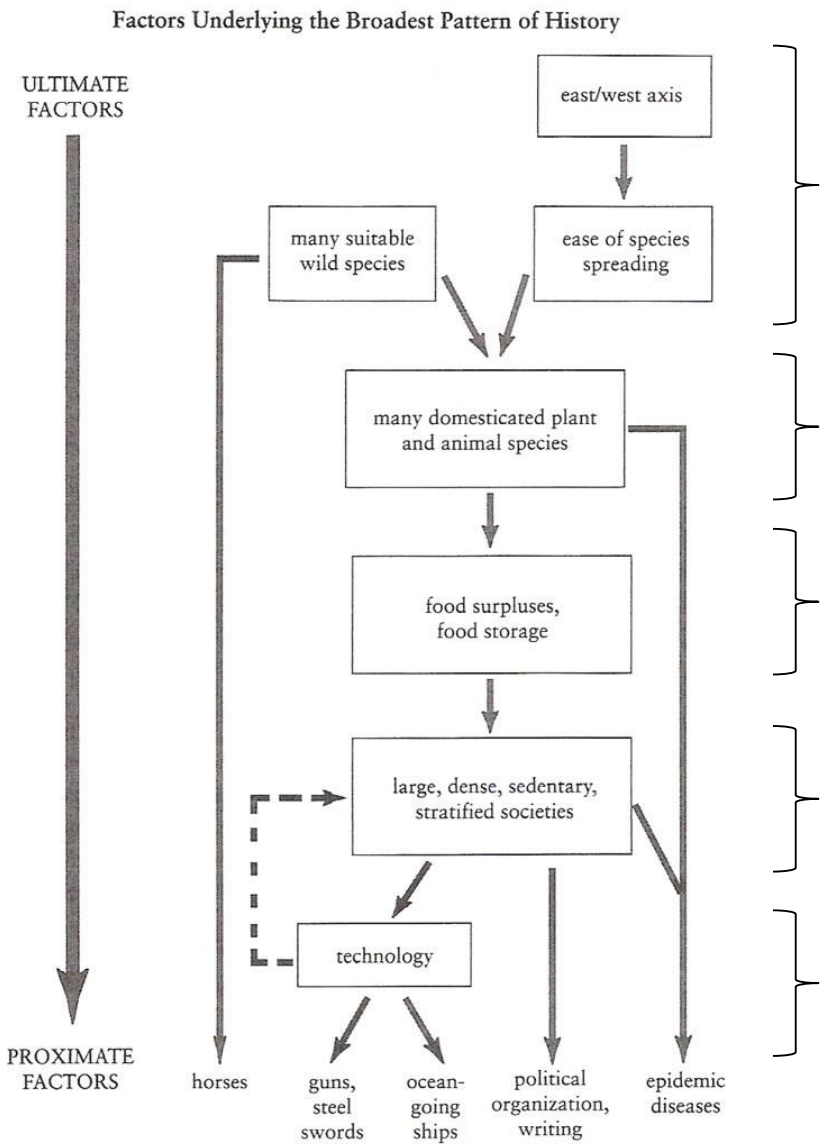
Source: http://www.cell.com/fulltext/S0092-8674(06)01592-3

The book argues Eurasia developed first because agriculture spread more easily (east-west) than in Africa/the Americas (north-south) – hard to test



Source: Diamond (1997). “Guns Germs and Steel”

Diamond argues that many species which spread easily, allowed domestication/agriculture, creating surplus, large societies & technology



Land

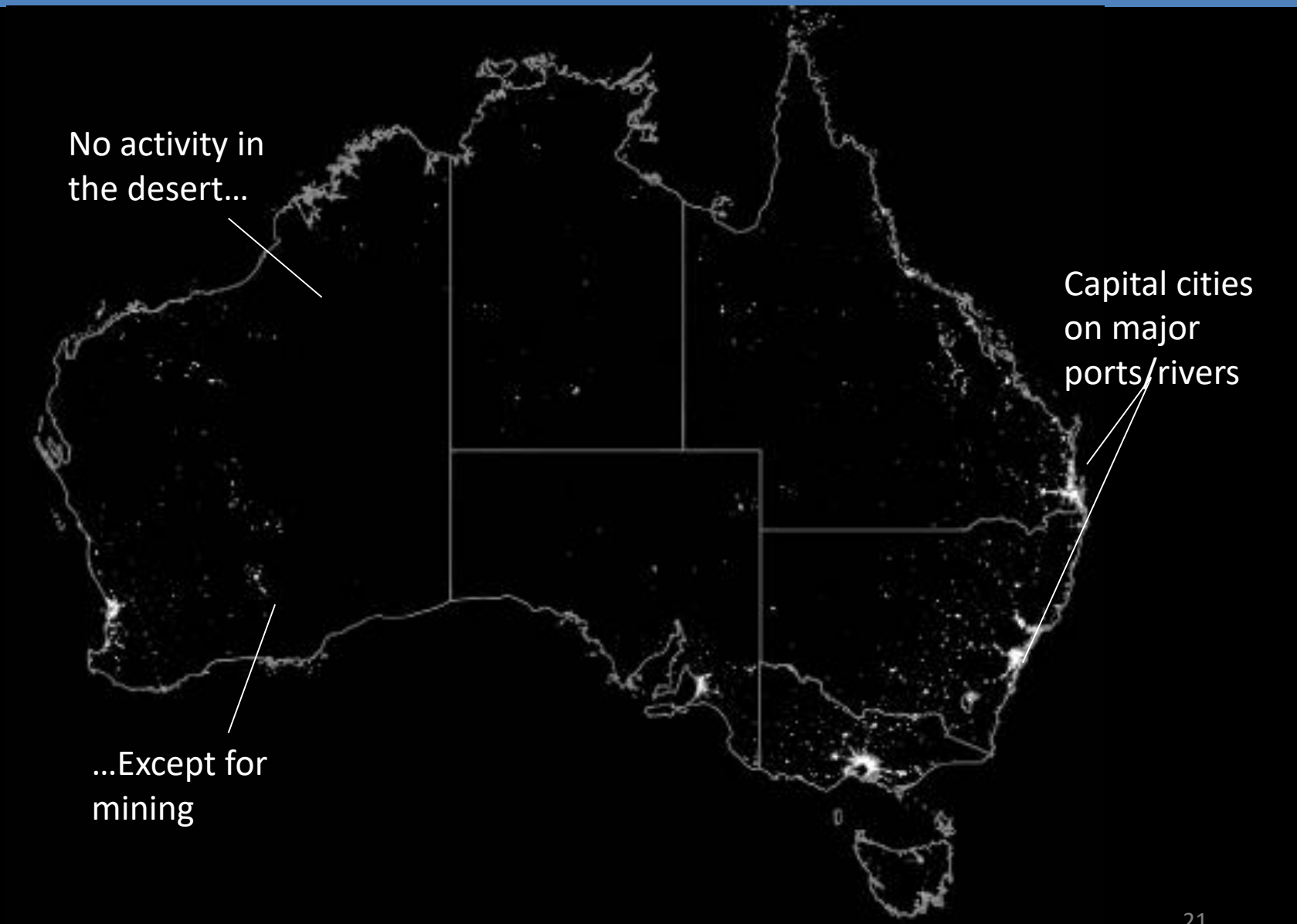
Technology

Capital (investment)

Labour

Technology (inventions, management, institutions) and Capital (human and physical)

The importance of geography is still seen in the location and pace of economic activity today, because "path dependence" is very important



I am currently studying how important geography is for growth, using surfing waves to measure "natural amenities"

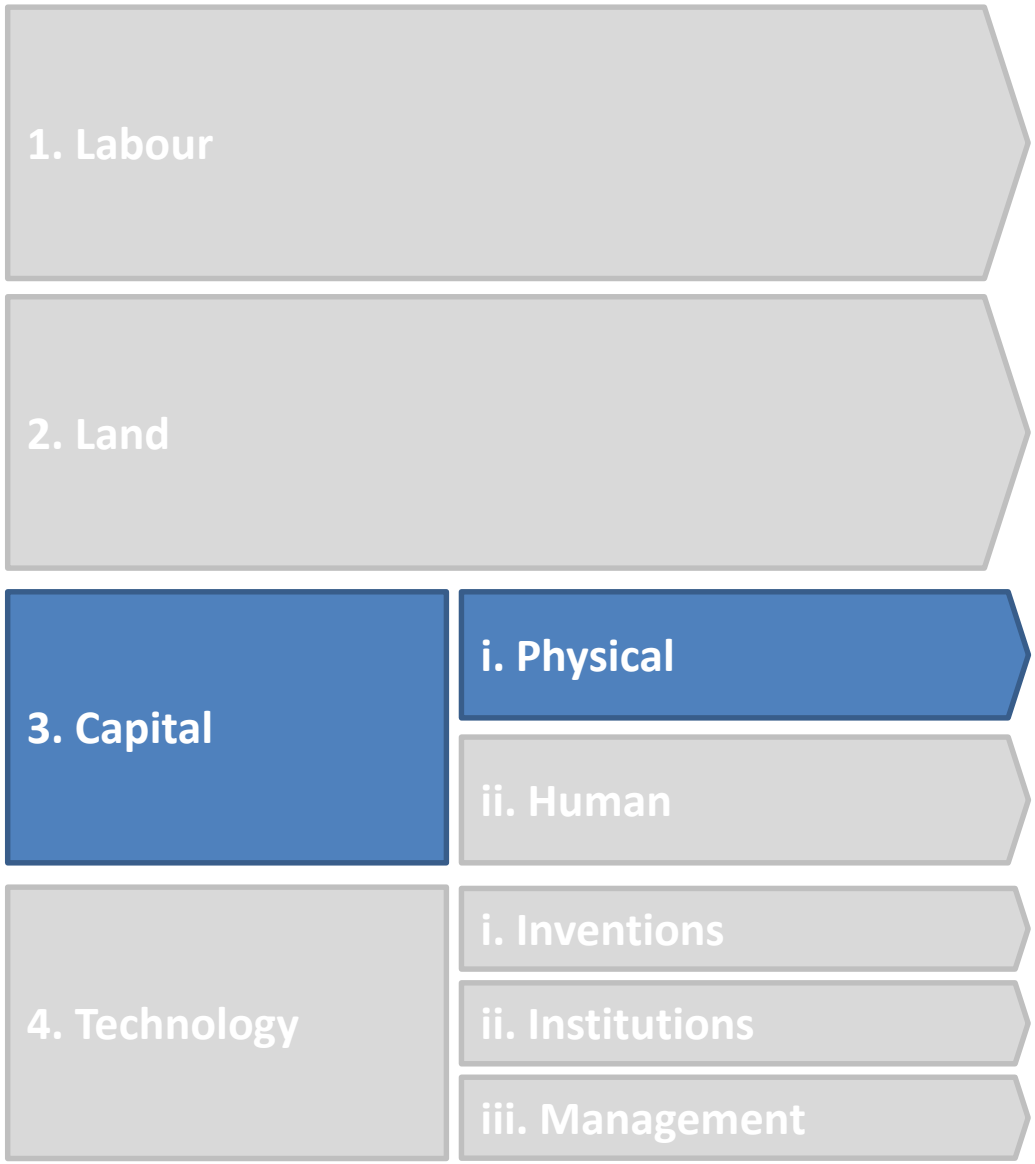
For a summary see 2016 article in [The Economist]

Historically, land also caused some societies to collapse, like the Easter Islanders who destroyed their environment (cut down all their trees)

Source: Diamond (2005), *Collapse*

Land does not need to limit growth though. The stone age didn't end for lack of stones.

Output is driven by labour, land, capital, and technology, which are called “factors of production”



Domesticated crops encouraged humans to settle, and eventually created a surplus of output which could be stored (invested in capital)

Natufian storage pit, Nahal Ein Gev II site, Jordan

Source: http://www.sci-news.com/archaeology/natufian-village-jordan-valley-03644.html

Natufian culture

- 12,500 – 9,500 BCE
- Some of the earliest agriculture in the world
- Earliest evidence of grain storage

Accumulating physical capital allowed complex societies to develop, like Uruk, the first major civilization ~4000 BCE

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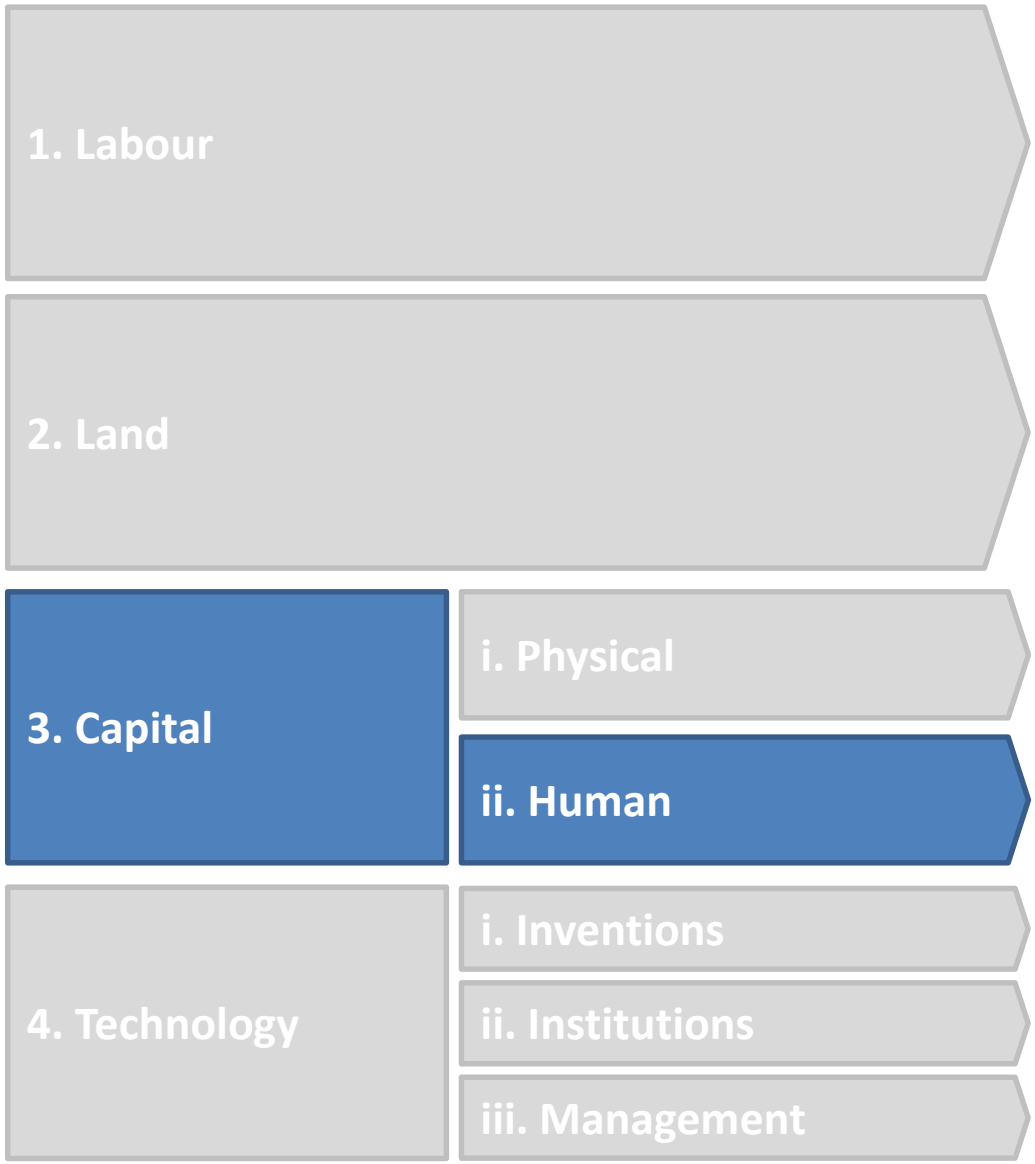


The invention of writing (technology) in Sumer ~3500 BCE allowed humans to easily pass on information and knowledge (human capital)

Ancient Kish tablet, Sumer, ~3500 BC

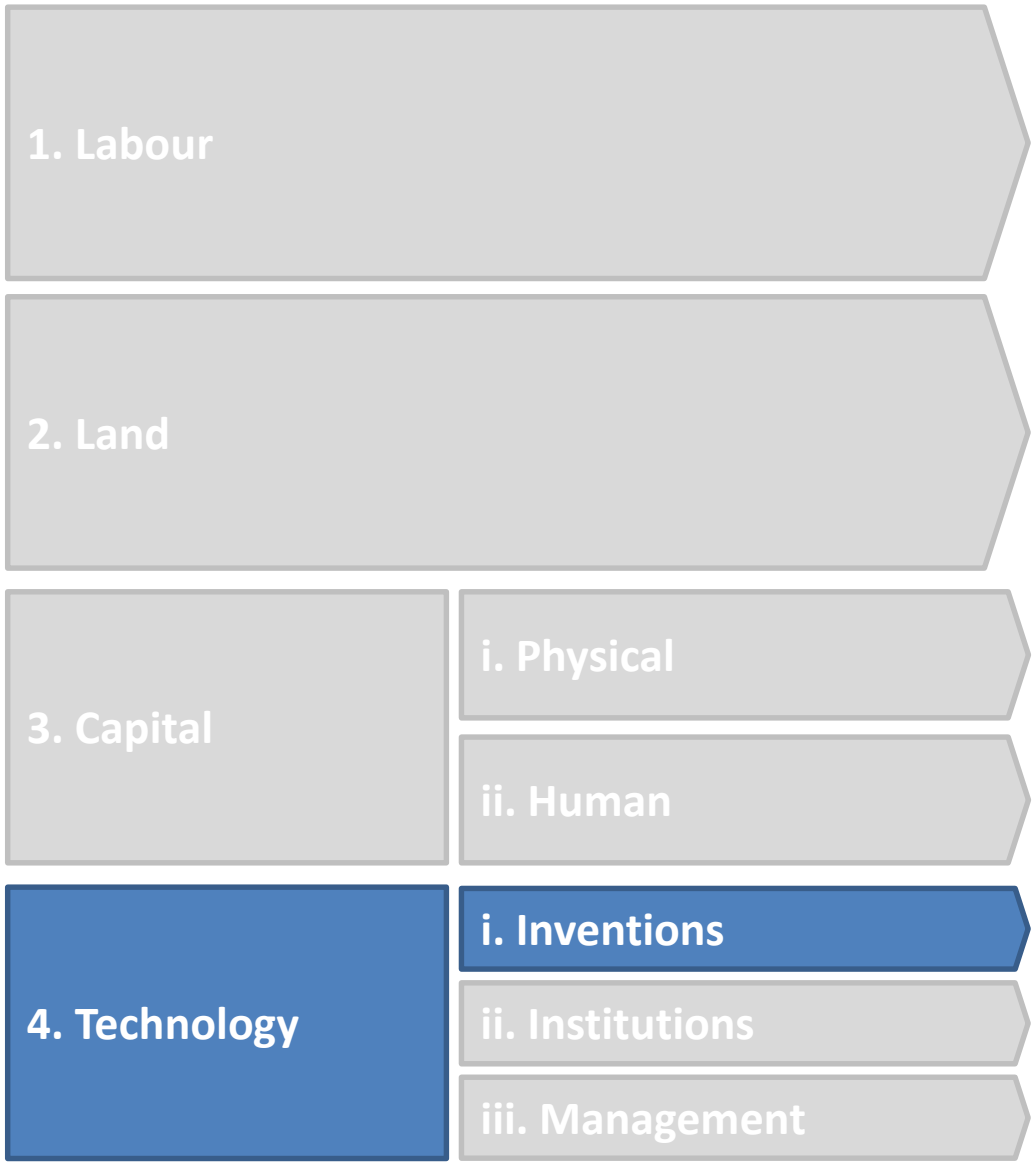
Source: Ashmolean Museum, Oxford

Domesticated animals also inoculated humans from diseases, which killed millions when Europeans started exploring Africa and the Americas

Human Disease	Animal with most closely related pathogen
Measles	Cattle (rinderpest)
Tuberculosis	Cattle
Smallpox	Cattle (cowpox)/ other livestock
Flu	Pigs and ducks
Pertussis	Pigs and dogs
Falciparum malaria	Birds (chickens and ducks)

Source: Diamond (1997), *Guns, Germs and Steel*

Output is driven by labour, land, capital, and technology, which are called “factors of production”



The invention of new technologies has been crucial in human (and pre-human) history

Important early technological inventions

Earliest stone tools
3.3 million BCE
Australopithecus
(pre-human)
Lake Turkana, Kenya

Fire
1.8 million BCE
Homo Habilis
(pre-human)
Southern Africa

Earliest spears
400,000 BCE
(pre-human)
Schöningen, Germany

Earliest wheel
3,500 BCE
Pottery then transport
Mesopotamia

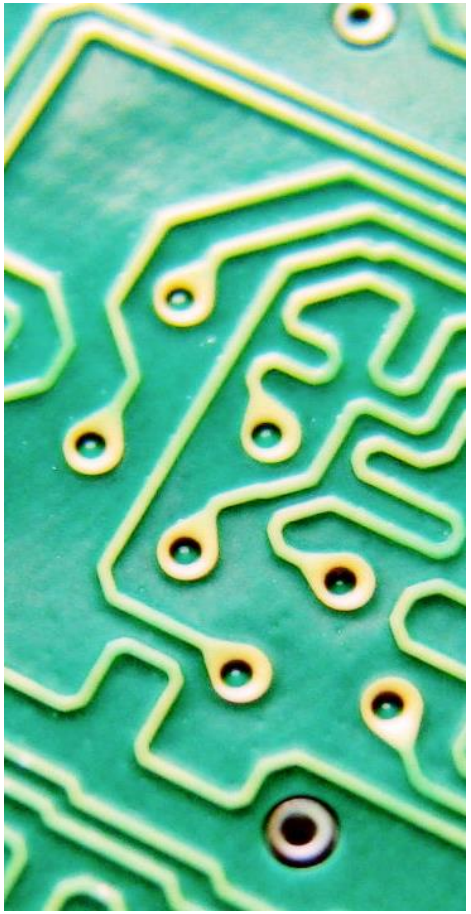
Source: BBC; Archaeology; Smithsonian

A technological innovation is all about putting factors of production together in cleverer ways, eg glass, or silicon chips

+

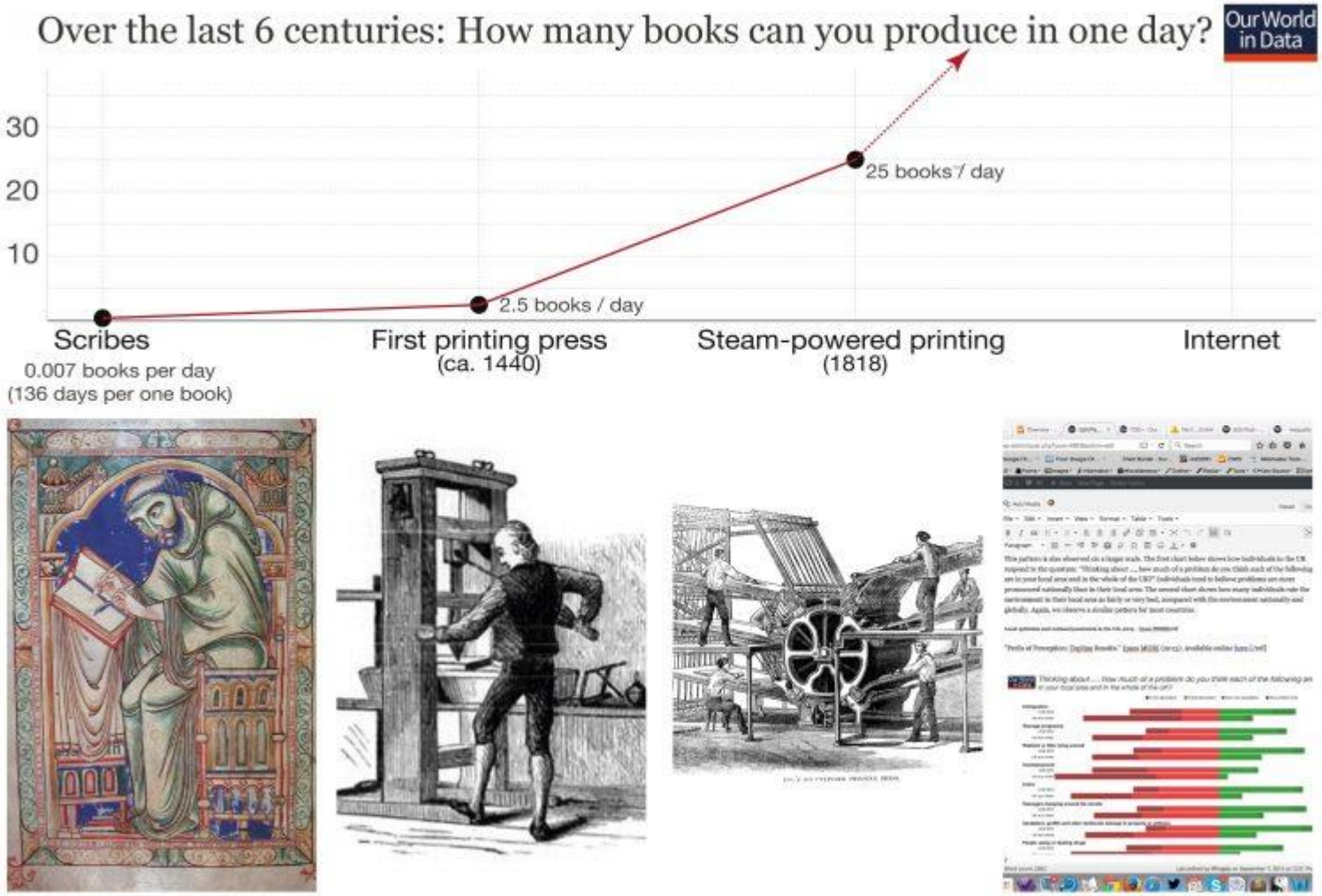
Technology combines sand and fire…

… to create glass…



…and later, silicon chips

New technological innovations are still a major driver of economic growth today



Data sources: Own calculations based on Clark 2008, Eisenstein 1980, and Bolza 1967.

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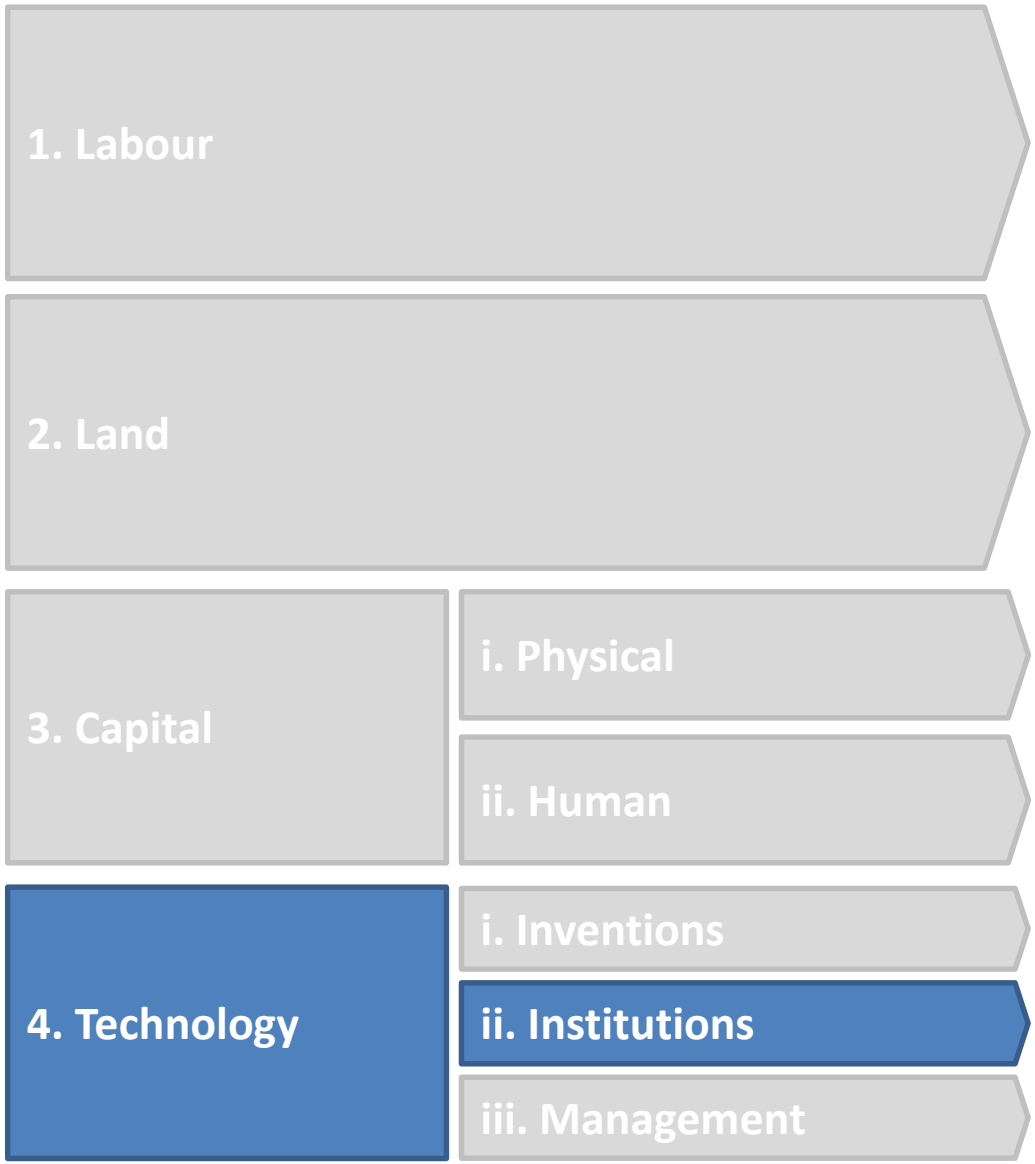
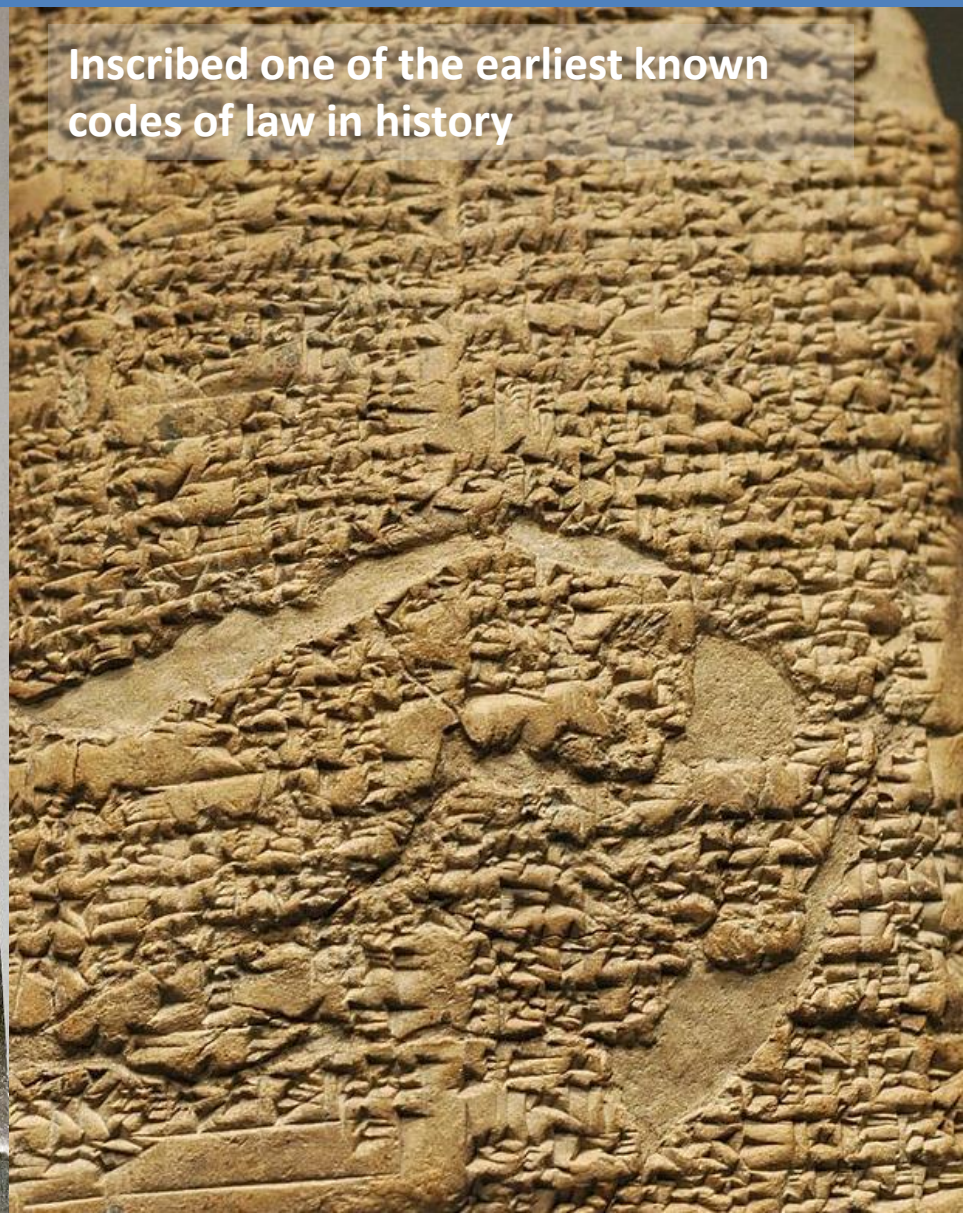


Institutions are the technology we use to combine labour in productive ways, like laws

The Babylonian King Hammurabi (1810-1750 BCE)



Inscribed one of the earliest known codes of law in history

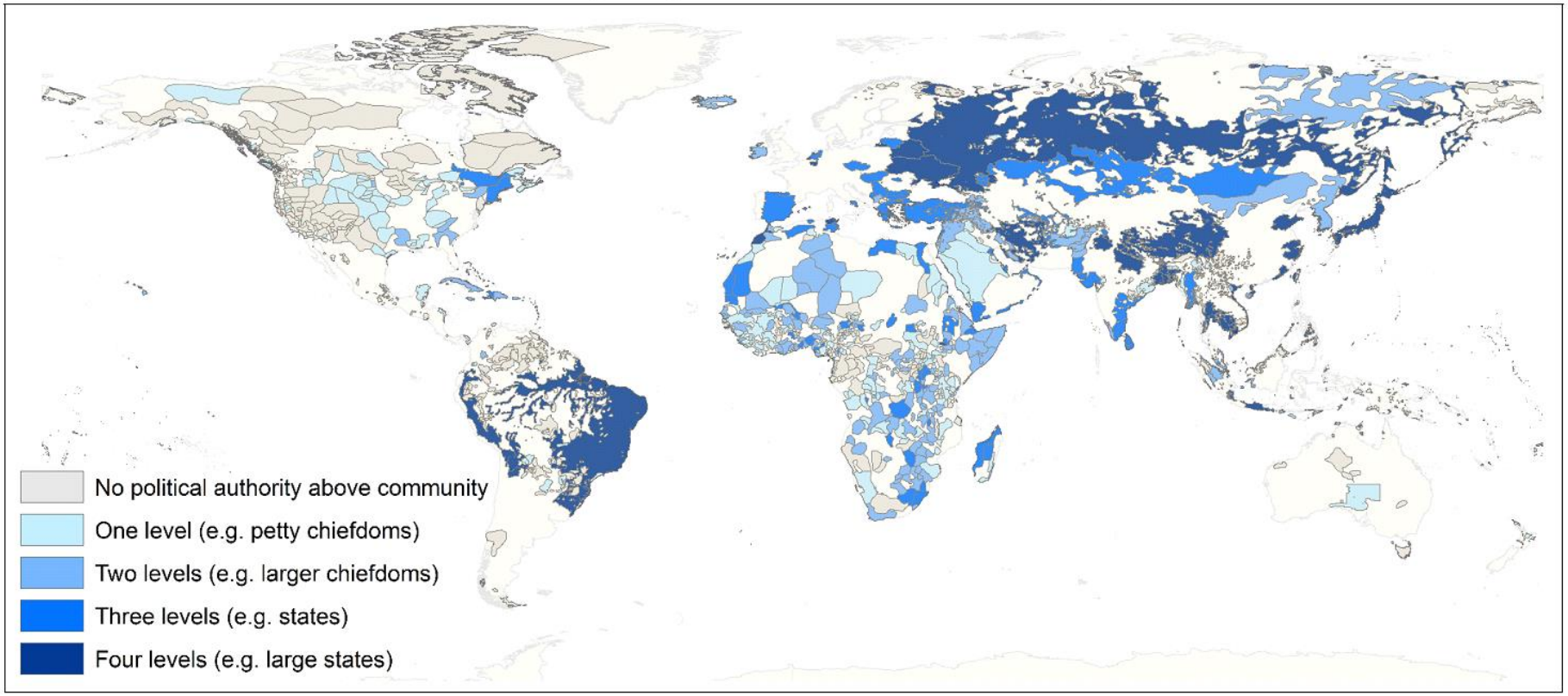
Religion has also been a very effective institution for uniting disparate groups

- Monotheism emerged in the Levant, with Judaism first appearing around 1900 BCE
- Israel/Palestine was a thin strip of fertile, mountainous land from Mesopotamia to Nile delta
- King David used religion to unite the “twelve tribes of Israel”
- Jerusalem, a natural hill fort, became the capital and holy city

Source: http://www.abc.net.au/religion/stories/s796551.htm

Pre-colonial institutions may have their origins in the ability to store, and therefore tax, early agricultural surplus…

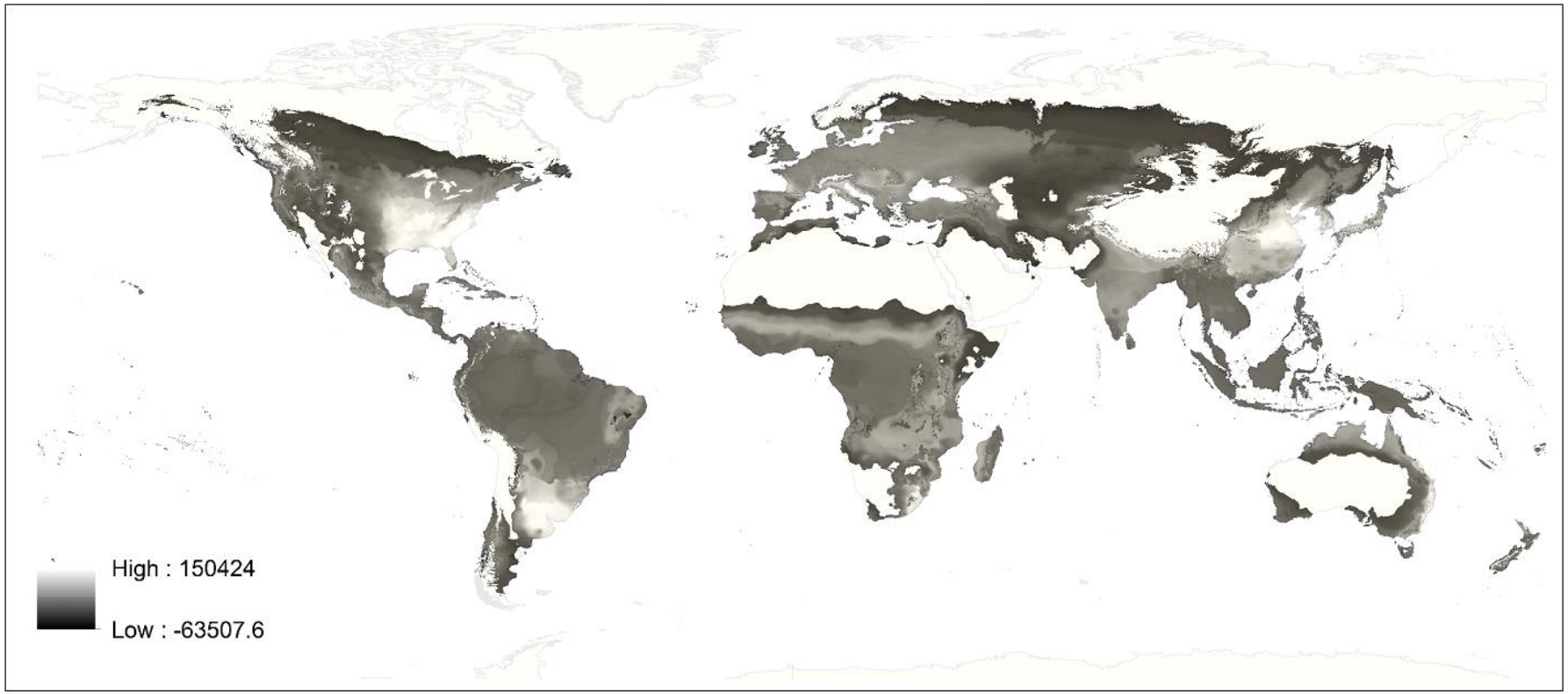
Jurisdictional hierarchy beyond the local community in pre-colonial societies



Source: Mayshar et al. (2015) "Cereals, Appropriability and Hierarchy", CEPR DP 10742

…which is a hypothesis tested using natural variation in the ability to store indigenous food crops around the world (a “natural experiment”)

Difference in potential yields (calories per hectare) of cereals vs roots/tubers



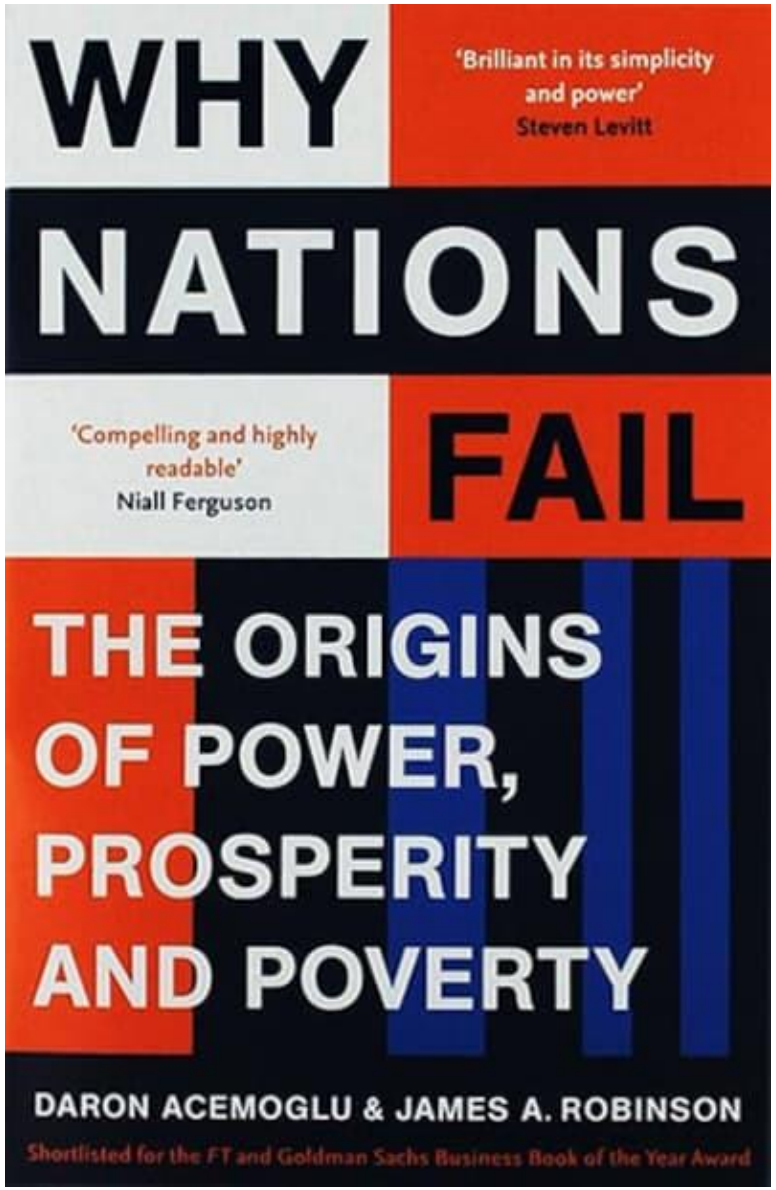
Cereals were easier to store, and thus tax, giving an incentive for social hierarchy and institutions to form

Source: Mayshar et al. (2015) "Cereals, Appropriability and Hierarchy", CEPR DP 10742

Since the age of colonialism, institutions may be even more important than geography in explaining economic growth, eg North vs South Korea

Source: http://marroninstitute.nyu.edu/content/blog/rules-change-north-vs.-south-korea

The "institutions hypothesis" is described in *Why Nations Fail* by Acemoglu and Robinson



- Good read – I highly recommend it
- Critiques the importance of geography since the age of colonialism, arguing institutions are more important.
- Summaries:
  - https://www.youtube.com/watch?v=jsZDlBU36n0
  - Book review by Jared Diamond
  - I also didn't tell you to read the summary of this on Wikipedia

Acemoglu and Robinson argue that extractive institutions hurt growth (reduces incentive to innovate) while inclusive institutions promote it

William III of Orange, King of England, Ireland Scotland 1689-1702

- "Glorious Revolution" of 1688: Overthrew James II, supported by religious leaders and parliamentarians
- Suppressed Catholicism
- Bill of Rights of 1689: limited rights of monarch and entrenched the rights of parliament
- Acemoglu and Robinson argue that this more inclusive institution was needed for the industrial revolution to happen

Deng Xiaoping, Communist Party Chairman, China, 1982-1987

- Mao Zedong led cultural revolution from 1966-1976
- Deng Xiaoping then led far-reaching market reforms:
  - Open to foreign investment
  - Inclusive economic policy
- Acemoglu and Robinson argue this was crucial in China's growth since 1990s

Colonialism: Europeans left good institutions where settler mortality was low, and extractive institutions where it was high

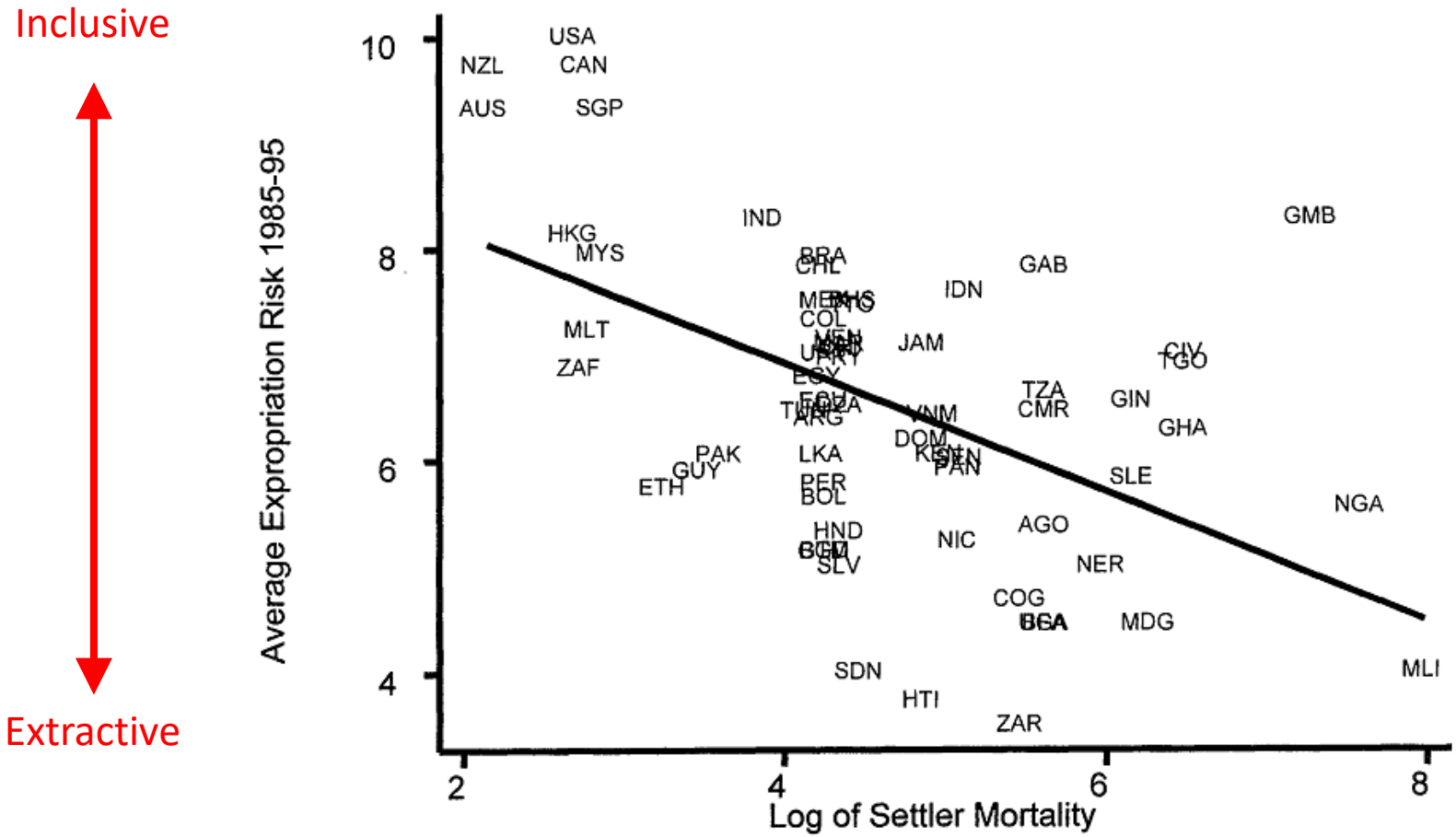


FIGURE 3. FIRST-STAGE RELATIONSHIP BETWEEN SETTLER MORTALITY AND EXPROPRIATION RISK

Source: http://economics.mit.edu/files/4123

Colonialism: Settler mortality can help explain GDP today

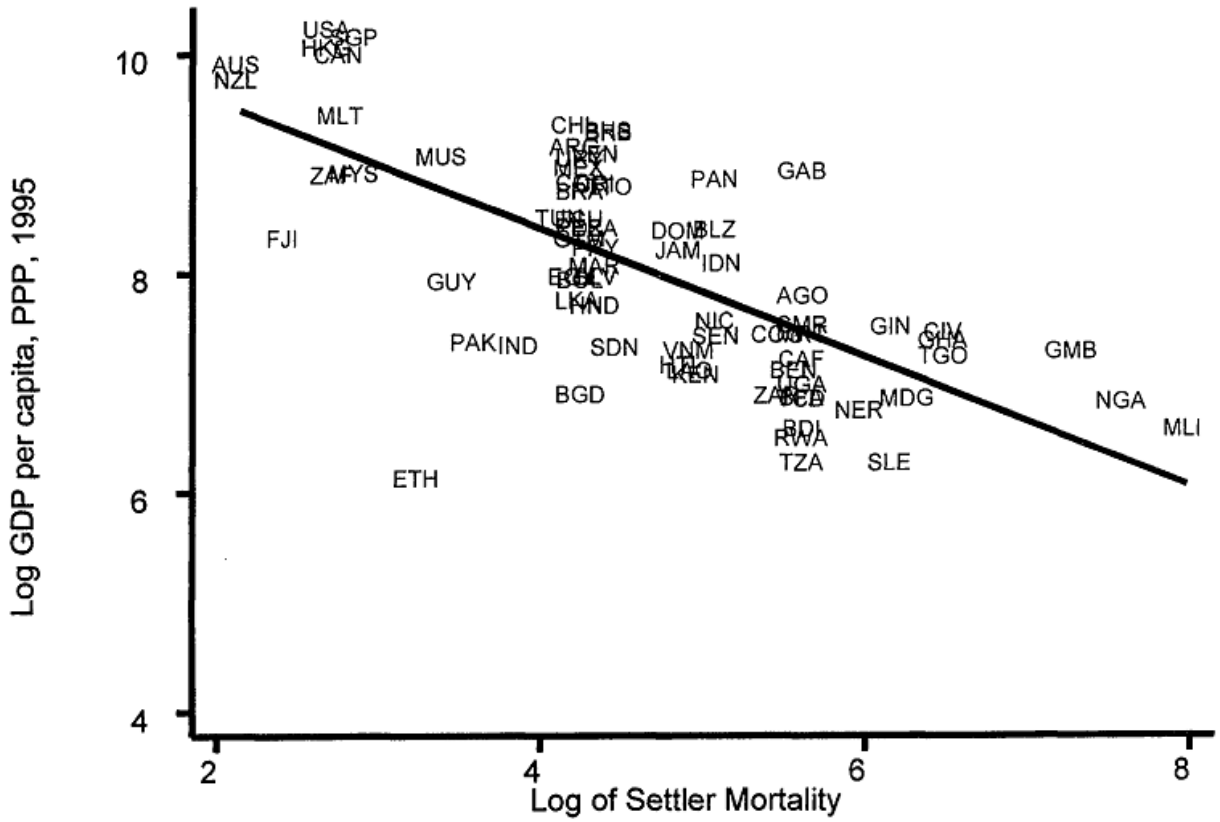


FIGURE 1. REDUCED-FORM RELATIONSHIP BETWEEN INCOME AND SETTLER MORTALITY

Source: http://economics.mit.edu/files/4123

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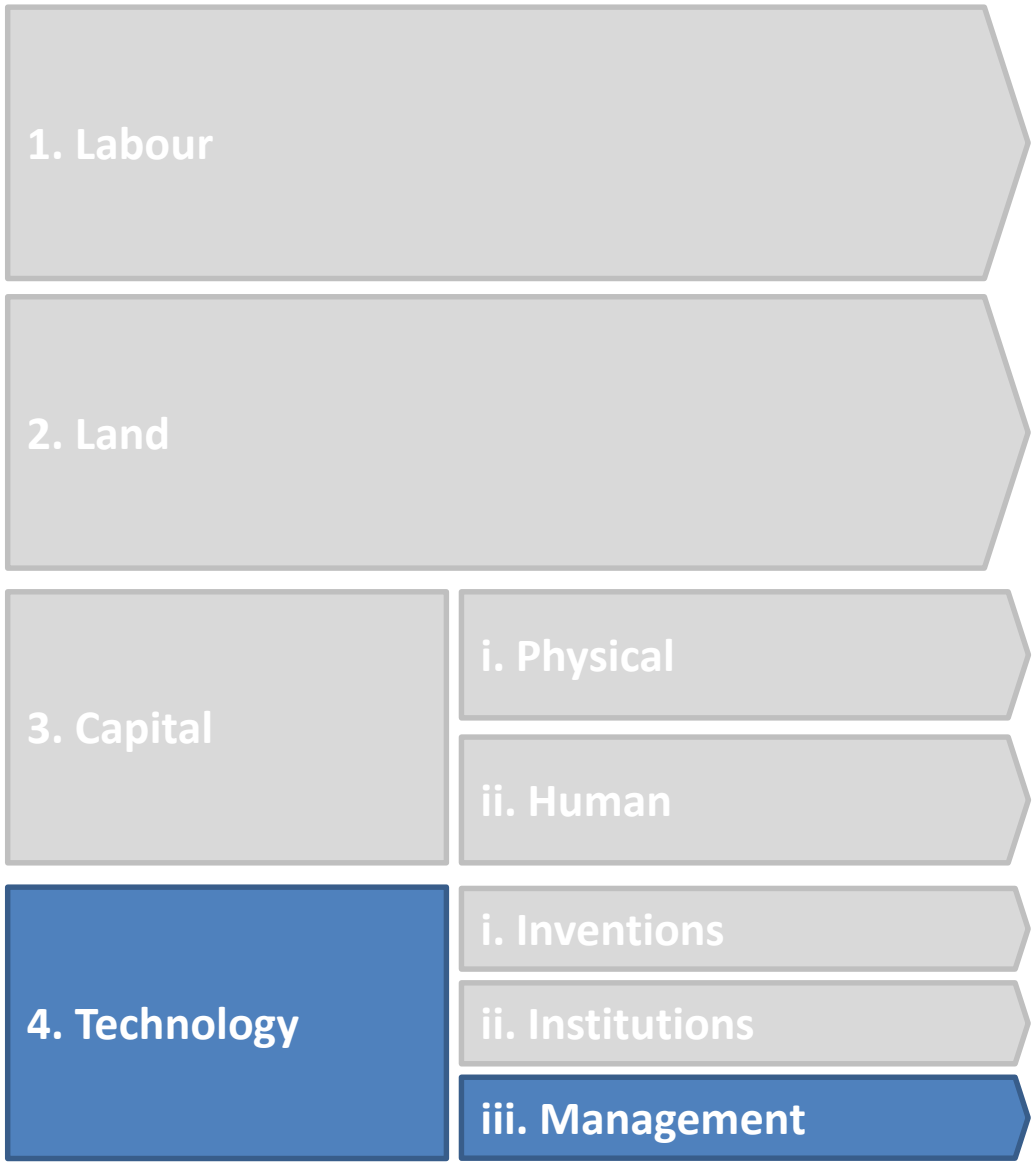


Management is the effectiveness with which capital and labour are combined to produce things, and varies across and within countries

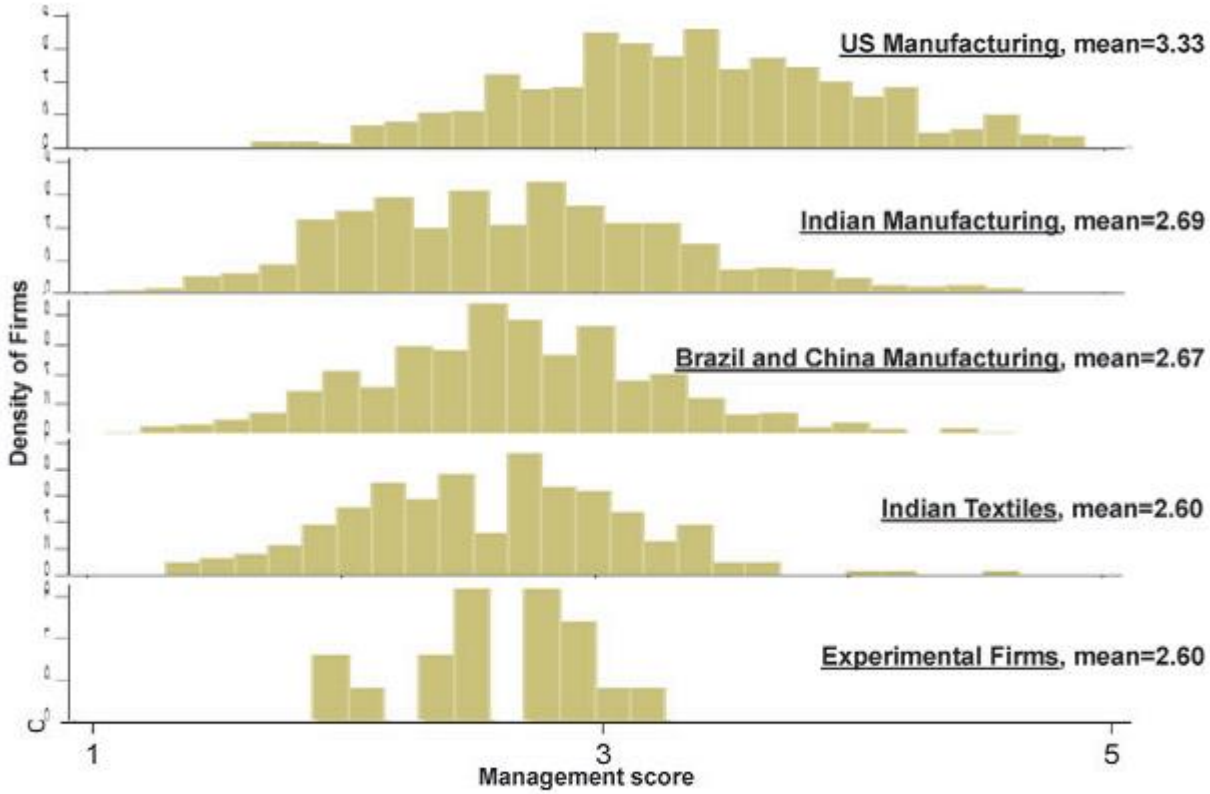


FIGURE I

Management Practice Scores across Countries

Source: Bloom et al. (2013), Does Management Matter? Evidence from India. Quarterly Journal of Economics

For example, some Indian manufacturing firms had very low quality management

Large, scattered inventories of yarn

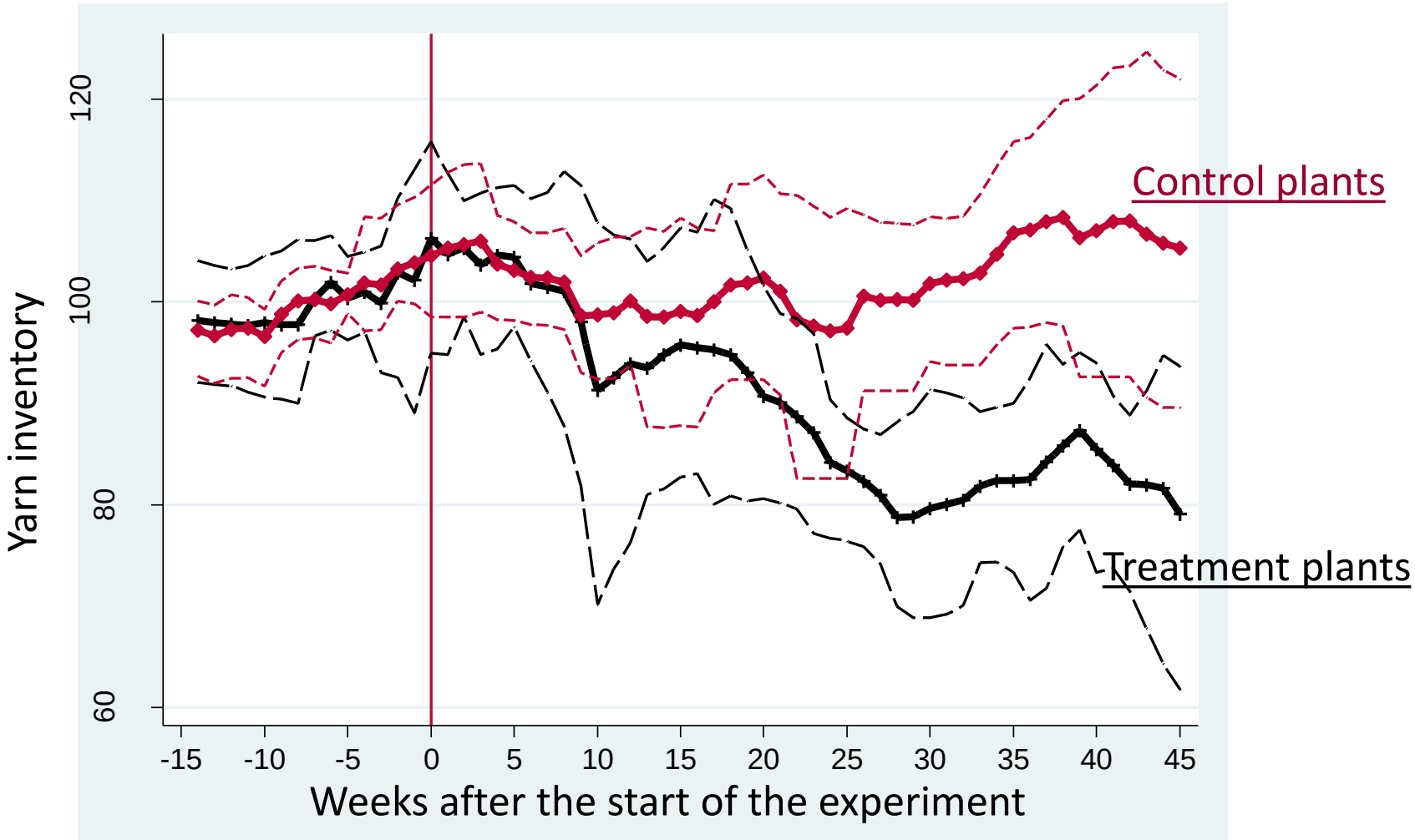
Source: Bloom et al. (2013), Does Management Matter? Evidence from India. Quarterly Journal of Economics

A group of economists visited these firms and helped them improve their management practices, like managing inventory

Yarn is organized, labeled, and entered into the computer with details of the type, age and location.

Source: Bloom et al. (2013), Does Management Matter? Evidence from India. Quarterly Journal of Economics

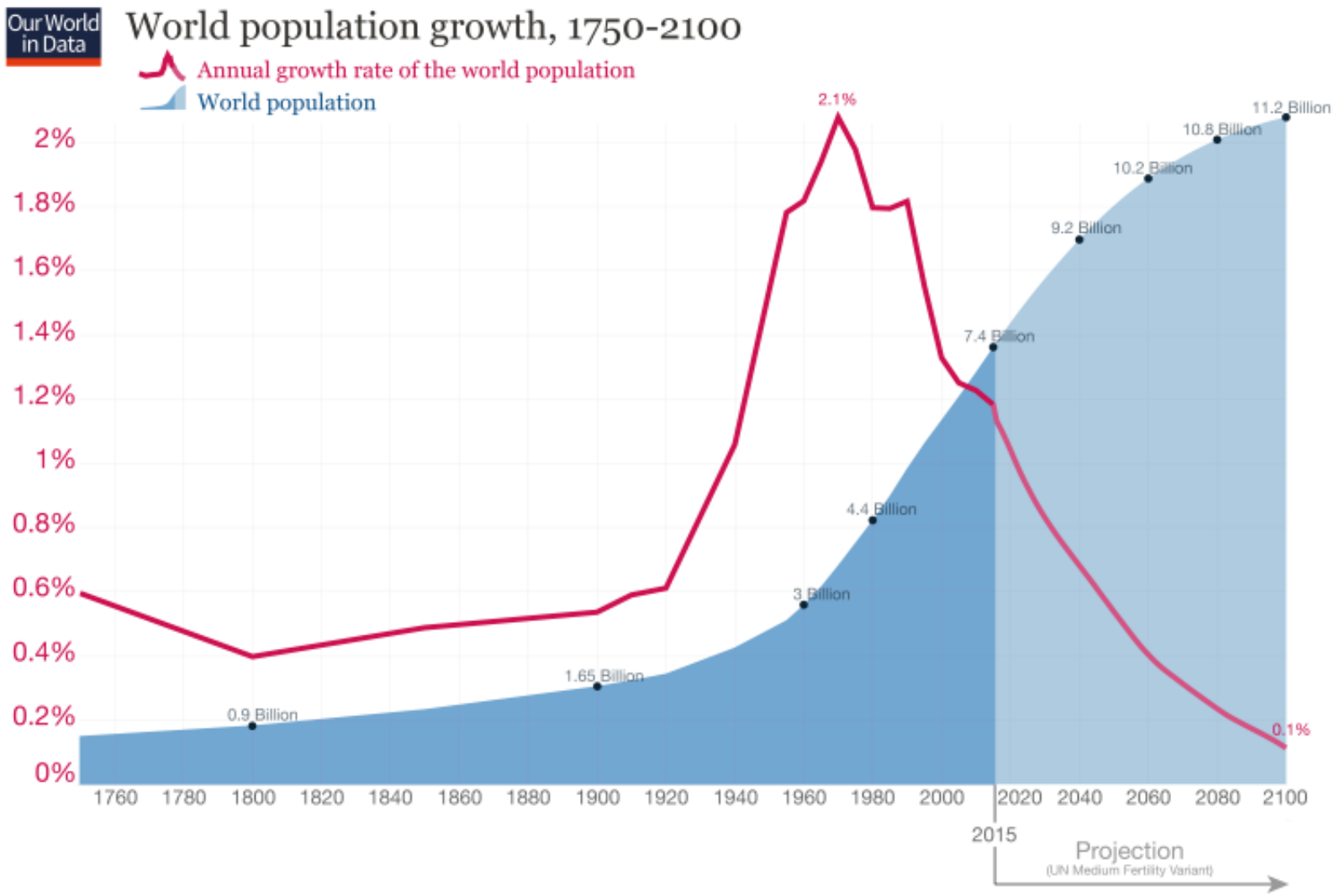
The result was a much more efficient use of inventory, reflecting factors of production being used more "cleverly"



Source: Bloom et al. (2013), Does Management Matter? Evidence from India. Quarterly Journal of Economics

Bringing it all together

The rate of world population growth has slowed dramatically since the 1960s

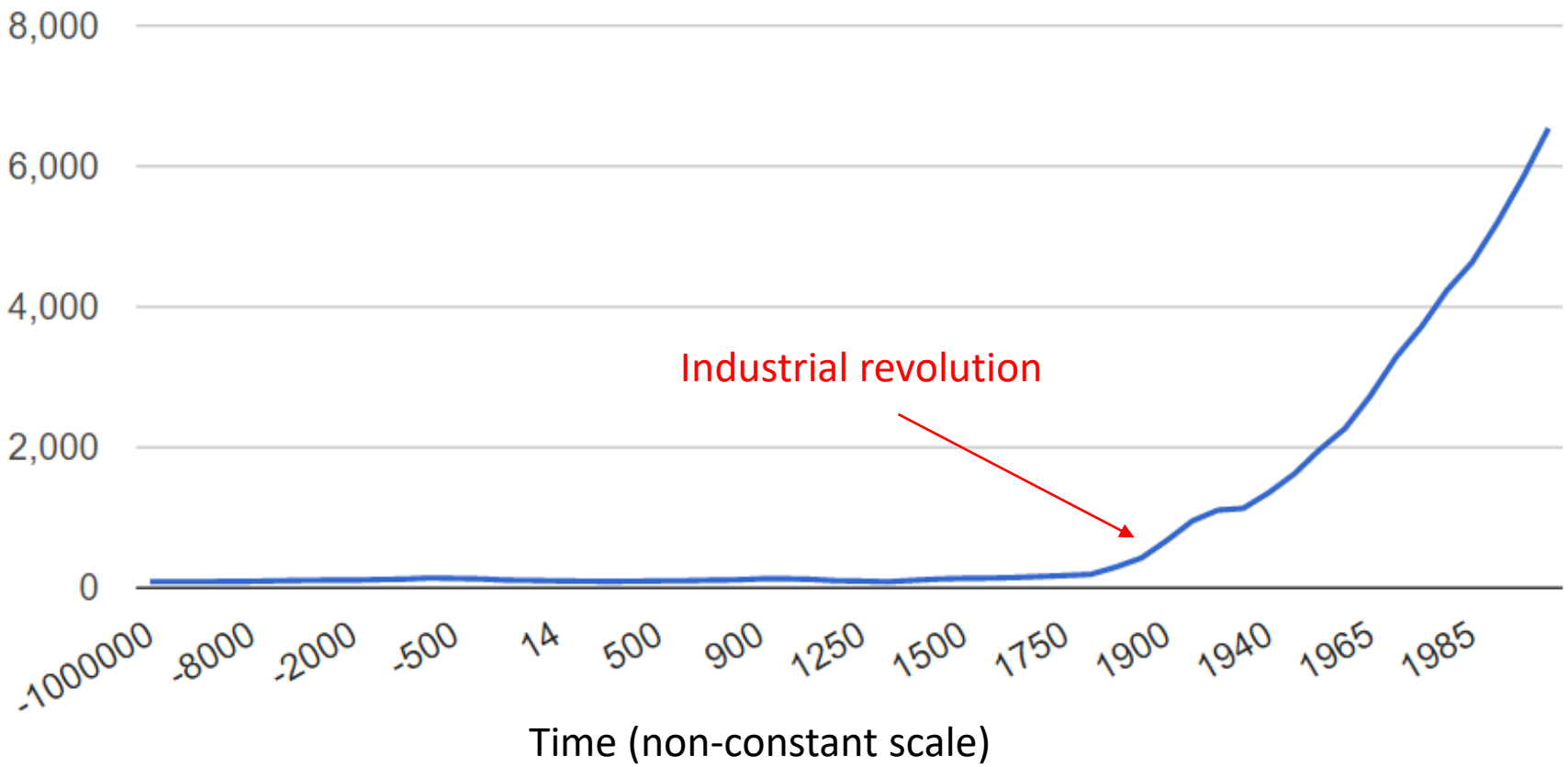


Data sources: Up to 2015 OurWorldInData series based on UN and HYDE. Projections for 2015 to 2100: UN Population Division (2015) – Medium Variant.
The data visualization is taken from OurWorldinData.org. There you find the raw data and more visualizations on this topic.

Licensed under CC-BY-SA by the author Max Roser.

Labour is the most important of the four factors in production, because it involves people. So, we are usually interested in output per person

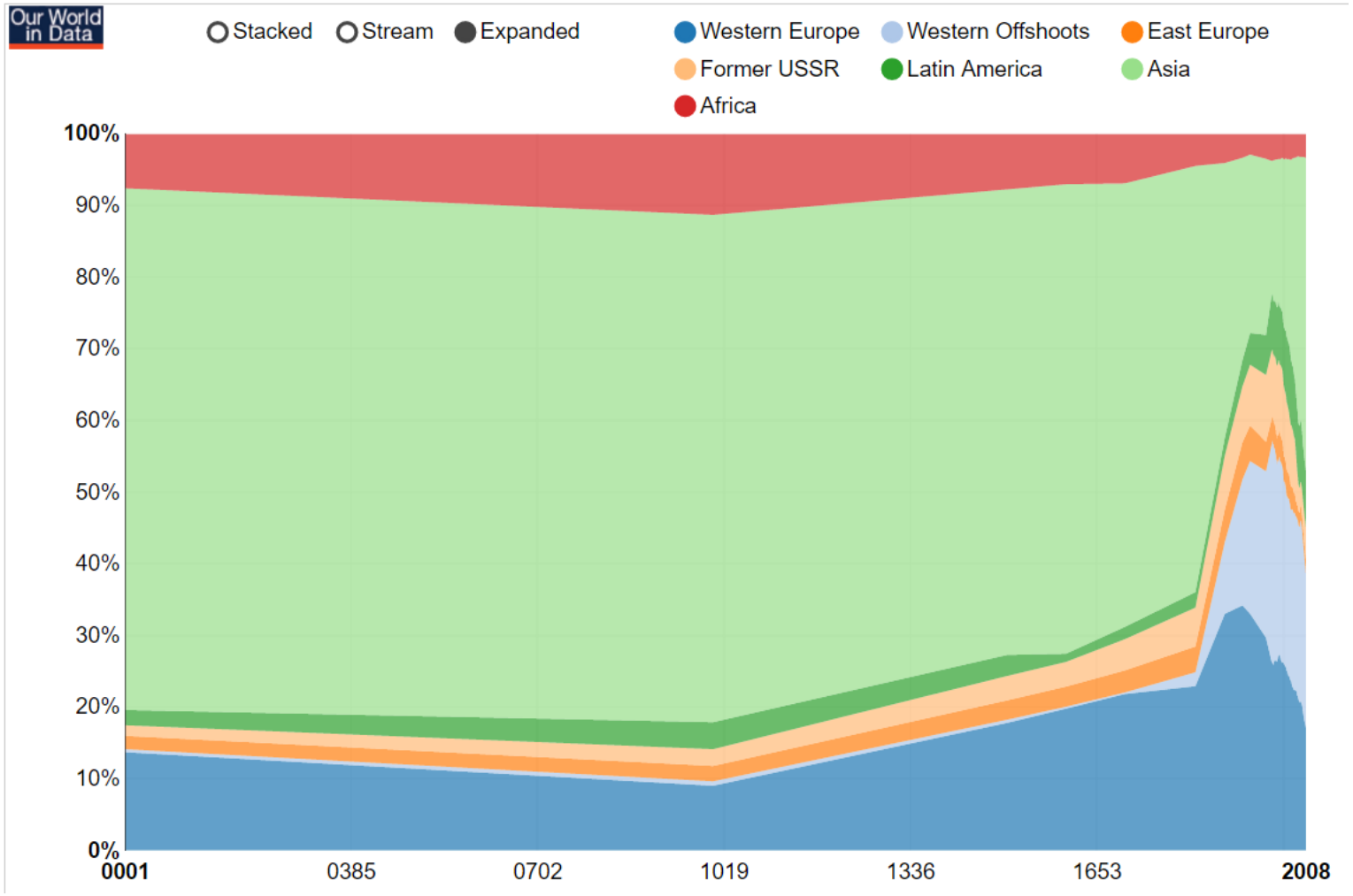
Average world GDP per capita, 1 million BCE – now (1990 dollars)



Source: https://ourworldindata.org/economic-growth

For the majority of human history, most output has been produced in Asia, where most people lived

Share of world GDP by region, %



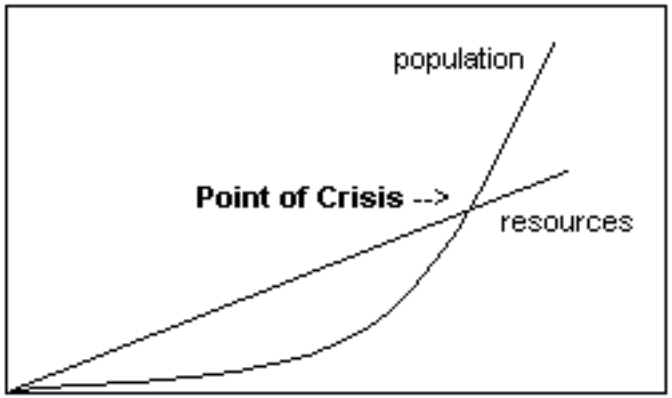
Source: https://ourworldindata.org/

Thomas Malthus (1766-1834) worried that extra productivity just went to a larger population, so we are eventually doomed.

Thomas Malthus

"The power of population is so superior to the power of the Earth to produce subsistence for man, that premature death must in some shape or other visit the human race." —*Thomas Malthus, 1798*

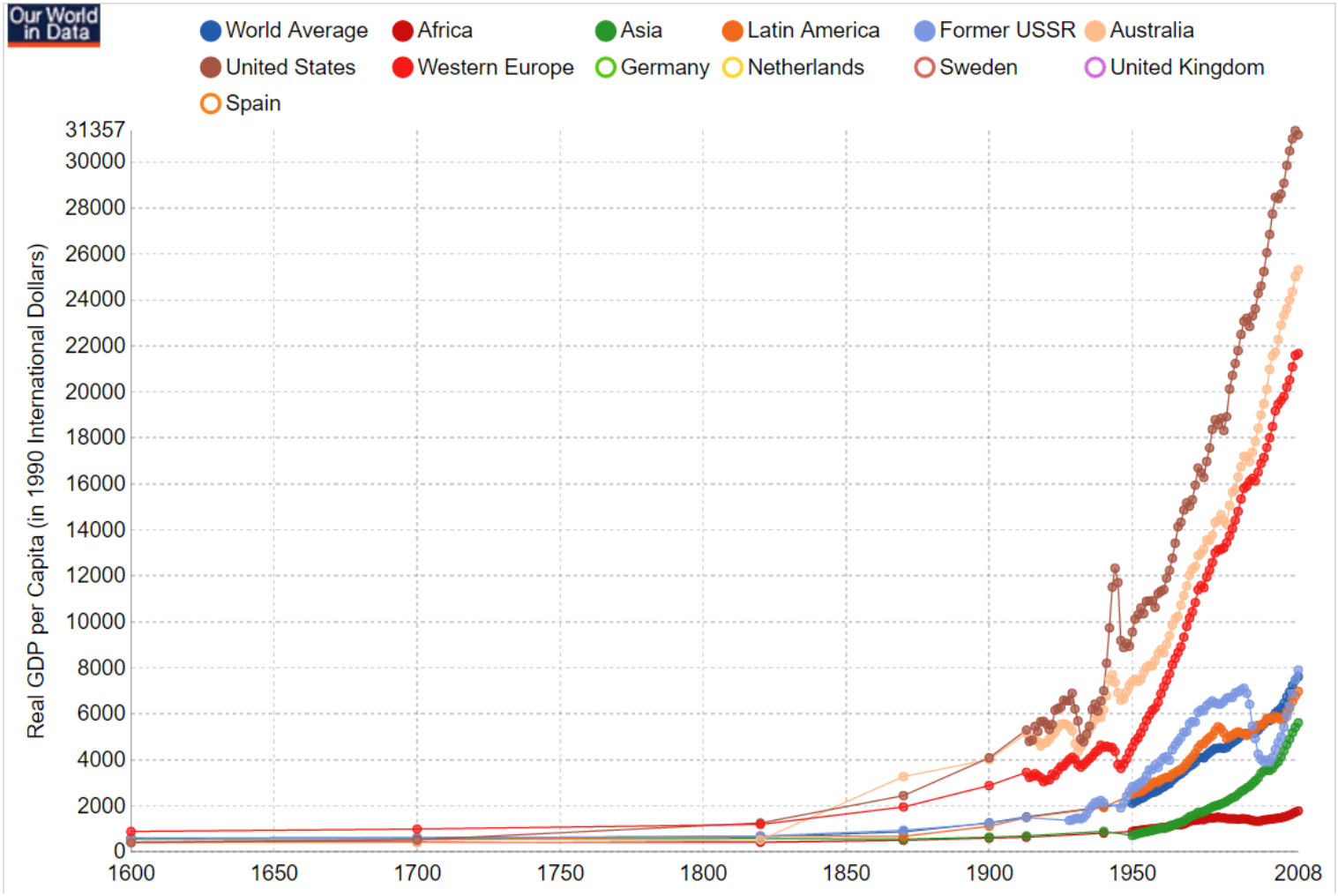
"If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next 100 years."
—*The Club of Rome think tank, 1972*



Malthus' Basic Theory

Malthus may have been right before the industrial revolution, but has certainly not been since

Real GDP per capita, 1990 dollars



Source: https://ourworldindata.org/

Average labour productivity is the reason why

Average labour productivity

Output per worker (avg labour productivity)

$$\frac{y}{POP} = \frac{y}{N} \times \frac{N}{POP}$$

Output per person

Share of workers (labour force participation)

Average labour productivity in Australia has consistently risen throughout history, increasing income per person

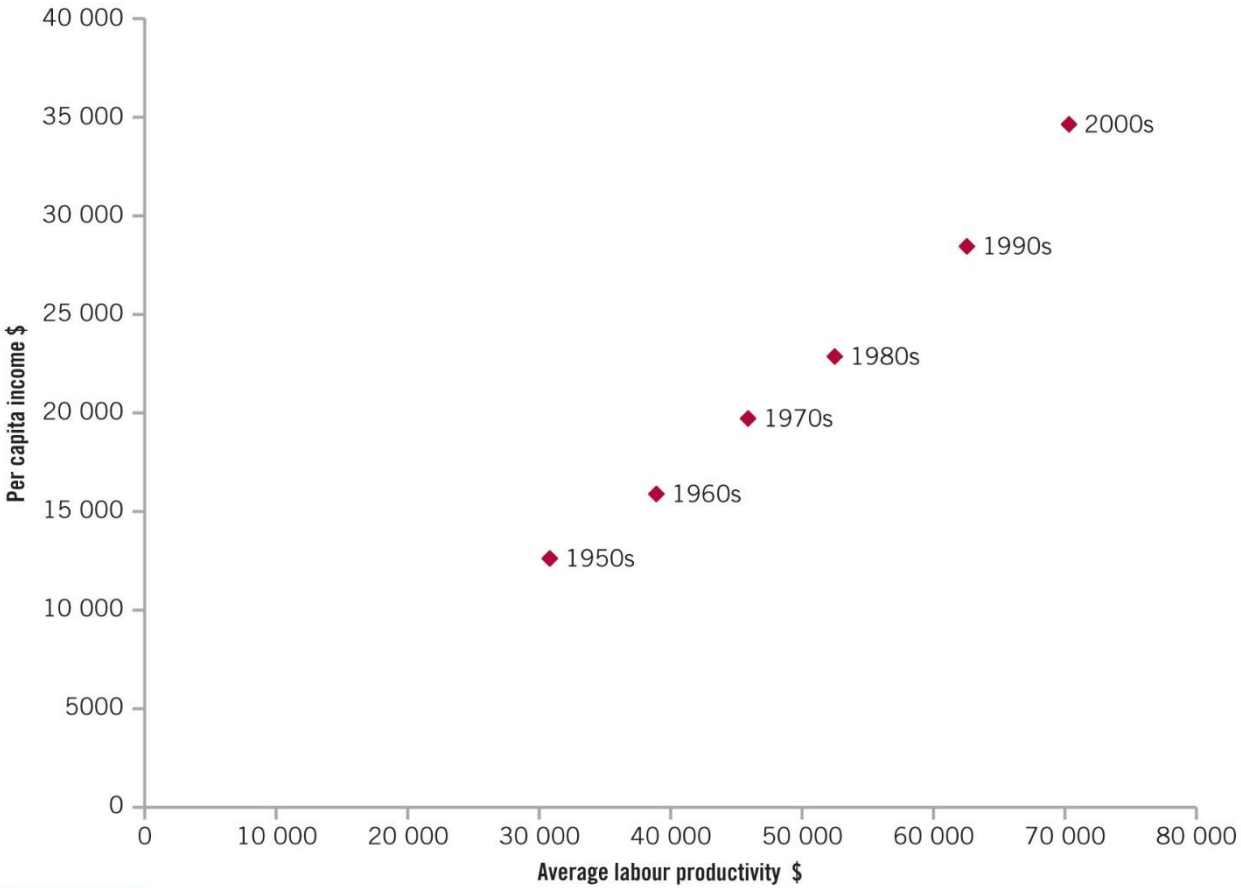


Figure 11.5 **Real GDP per person and average labour productivity** Real GDP per person in Australia grew by 175 per cent over the period from the 1950s. Over the same period, average labour productivity grew by 128 per cent.

Source: Authors' calculations using data from Robert C. Feenstra, Robert Inklaar and Marcel P. Timmer (2013), 'The Next Generation of the Penn World Table' available for download at www.ggdc.net/pwt.

Labour force participation has also risen (as we've seen previously), but not by as much

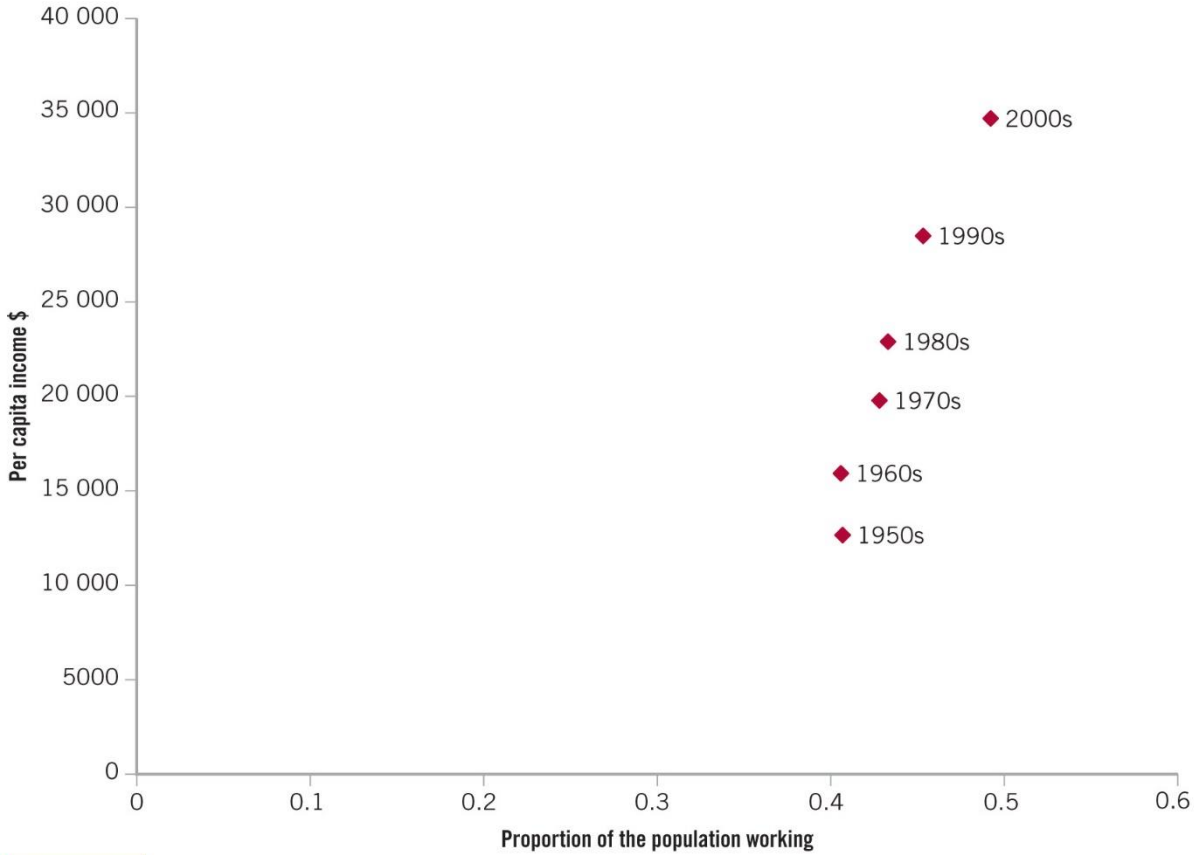


Figure 11.6 **Real GDP per person and the proportion of the population engaged in work** Real GDP per person in Australia grew by 175 per cent over the period from the 1950s. Over the same period, the proportion of the population engaged in work grew by 21 per cent.

Source: Authors' calculations using data from Robert C. Feenstra, Robert Inklaar and Marcel P. Timmer (2013), 'The Next Generation of the Penn World Table' available for download at www.ggdc.net/pwt.

We have seen that labour, land, capital and technology all increase growth. Policies can influence these factors, but must focus on per capita

Factor of production		Policies
1. Labour		• Baby bonuses/one child policies/Immigration • Healthcare, Higher retirement ages • Women's empowerment
2. Land		• Colonialism/war • Trade
3. Capital		• Saving current production, or borrowing (tradeoffs)
	i. Physical	• Interest rates, public infrastructure, etc.
	ii. Human	• Education and training
4. Technology	i. Inventions	• Public R&D – basic science, tax incentives
	ii. Institutions	• Separation of powers, checks and balances
	iii. Management	• Tax incentives, low tariffs (import competition)

Chapter 12

The production function approach to understanding growth

Learning Objectives

12.1 What is a production function?

12.2 What determines a firm's demand for primary factors of production?

12.3 How can a production table be used to illustrate a production function?

12.4 What is the functional form of the Cobb–Douglas production function?

12.5 What is the purpose of growth accounting?

We can model all those factors using a production function

General Form

$$Y_t = f(\underset{\textit{tech.}}{A_t}, \underset{\textit{land}}{T_t}, \underset{\textit{capital}}{K_t}, \underset{\textit{labour}}{L_t})$$

Specific Form (example)

$$Y_t = T_t^{\alpha} K_t^{\beta} \underset{\textit{human capital}}{H_t^{\gamma}} \, (A_t L_t)^{1-\alpha-\beta-\gamma}$$

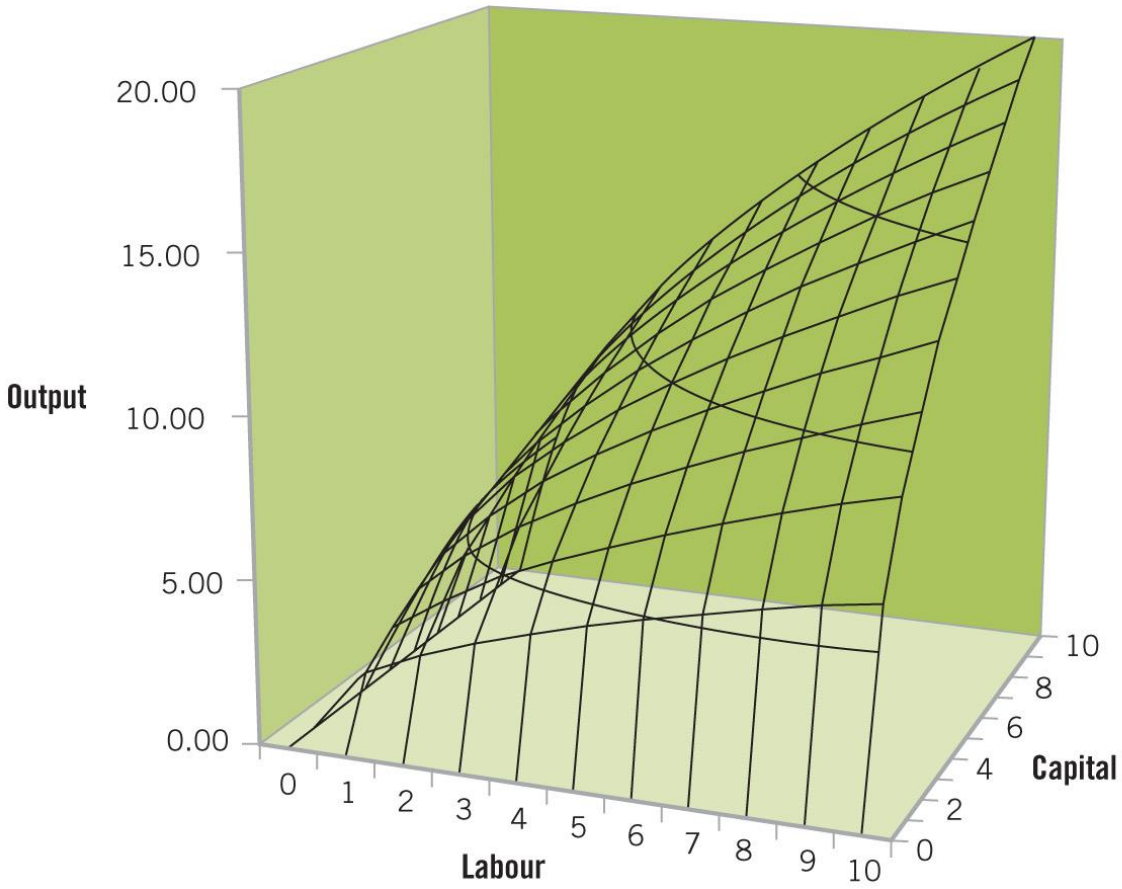
Cobb-Douglas Form

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

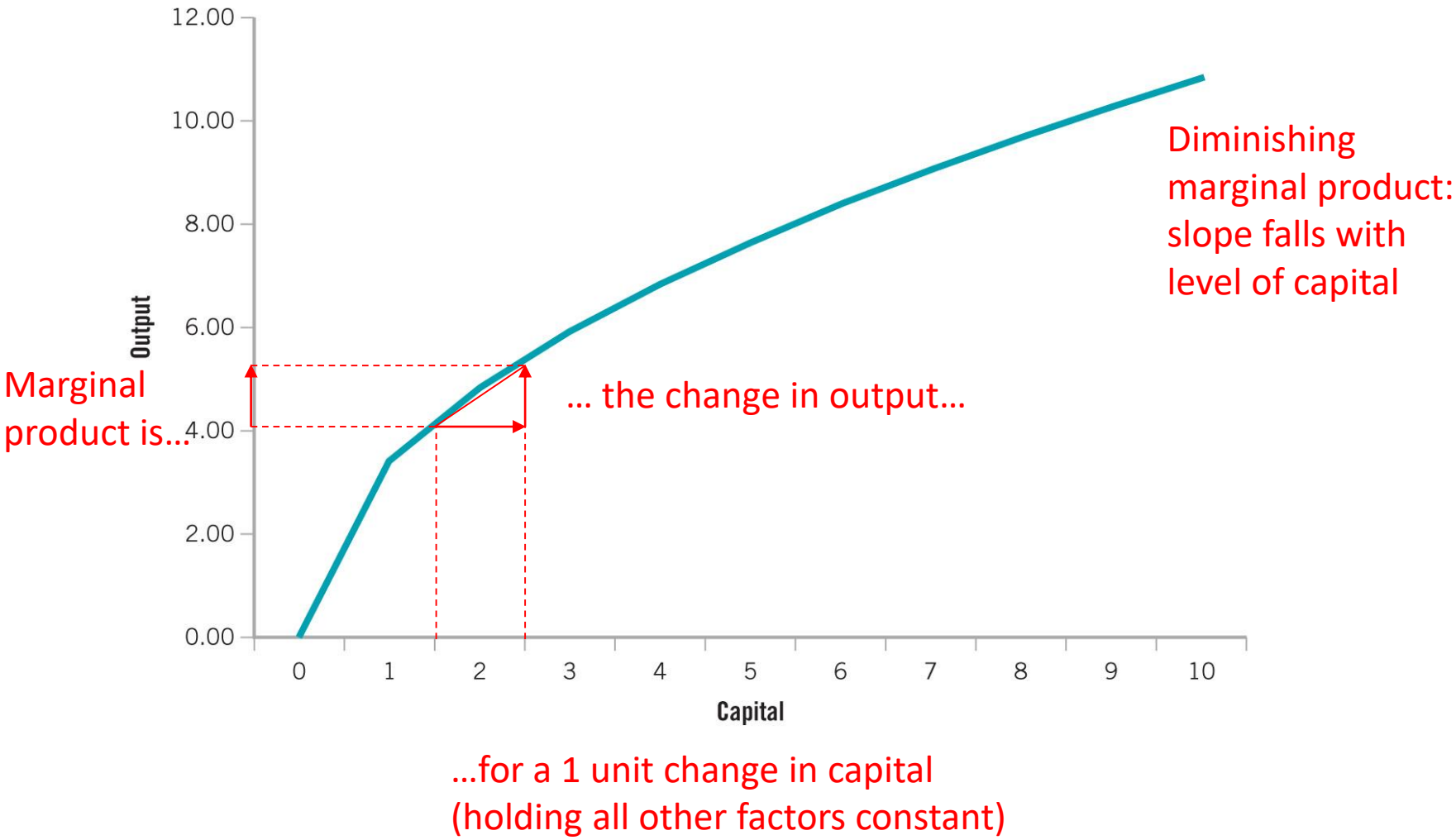
None of the specific forms are <u>true</u>, they just have useful characteristics, like diminishing marginal product

The Cobb-Douglas production function can be plotted on a three-dimensional surface plot. More capital and more labour increase output

The Cobb-Douglas production function on a surface plot



Taking a slice for a given level of labour gives us a two-dimensional production function for capital



The marginal product can be found by partially differentiating the production function with respect to each factor

Cobb-Douglas Form

$$y_t = A_t k_t^{\alpha} l_t^{1-\alpha}$$

Marginal Product of Capital

$$MP_k = \frac{\partial y}{\partial k} = \alpha A_t k_t^{\alpha-1} l^{1-\alpha} = \alpha \frac{y_t}{k_t}$$

Note: we use the partial derivative, ∂, rather than total derivative, d, because we ignore changes in other factors like labour and technology

Marginal Product of Labour

$$MP_l = \frac{\partial y}{\partial l} = (1-\alpha) A_t k_t^{\alpha} l^{1-\alpha-1} = \frac{(1-\alpha) A_t k_t^{\alpha} l^{1-\alpha}}{l_t} = (1-\alpha)\frac{y_t}{l_t}$$

Factors earn their marginal product in a perfectly competitive environment (not always the case), because firms maximize profits

To find what a firm will pay their workers, let's study how the firm makes profits

$$\Pi_t = PY_t - rK_t - wL_t$$

Profit equals price x quantity produced, less rent paid to capital, less wages paid to workers

The firm will add workers until they maximize profits, so adding another worker won't increase profit any more

$$\frac{\partial \Pi_t}{\partial L_t} = P\frac{\partial Y_t}{\partial L_t} - 0 - w$$

Take partial derivative w.r.t labour

$$= 0$$

Set marginal profit to zero

$$MP_L = {}^{w}/_{P}$$

Rearrange

Marginal product of labour = real wage

..or..

Marginal Benefit = Marginal Cost

Same process for capital

To be continued next lecture