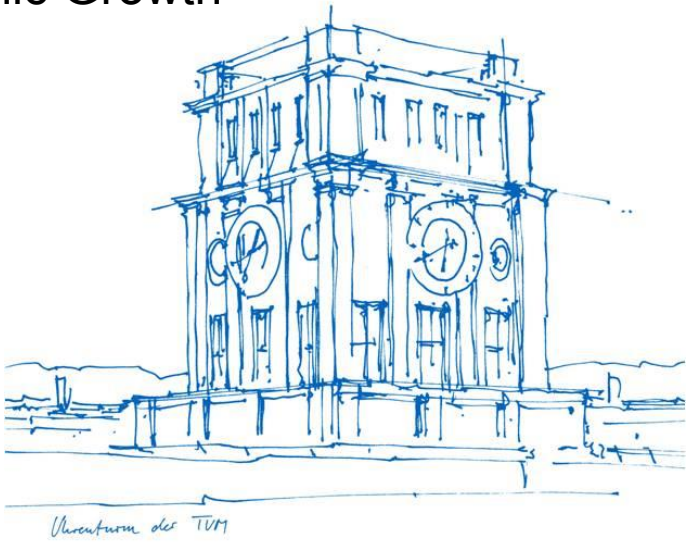
Economics II – Macroeconomics

II. Technological Change and Economic Growth



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Technical University of Munich

Outline

I. Introduction to macroeconomics
II. Technological change and economic growth (chapter 2 in the book)
III. The aggregate economy
IV. Aggregate demand and fiscal policy
V. The labour market
VI. Aggregate demand and unemployment
VII. Credit, banks and money
VIII. Inflation and monetary policy
IX. Technological progress, unemployment and living standards in the long run
X. Economic and financial crises

II. Technological Change and Economic Growth

I. Economic Models
II. Understanding Growth
III. Understanding Stagnation

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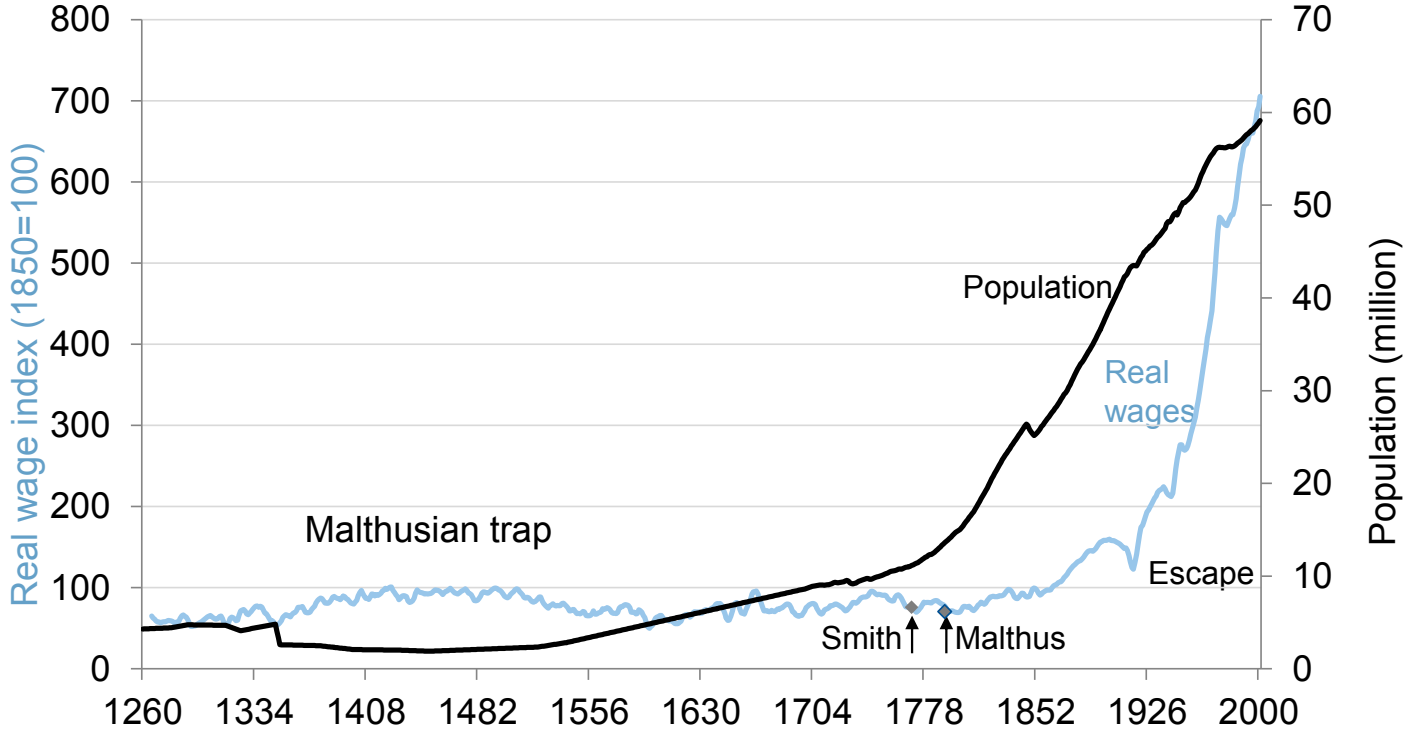
The context for this lecture

The sustained increase in income and living standards due to technological progress

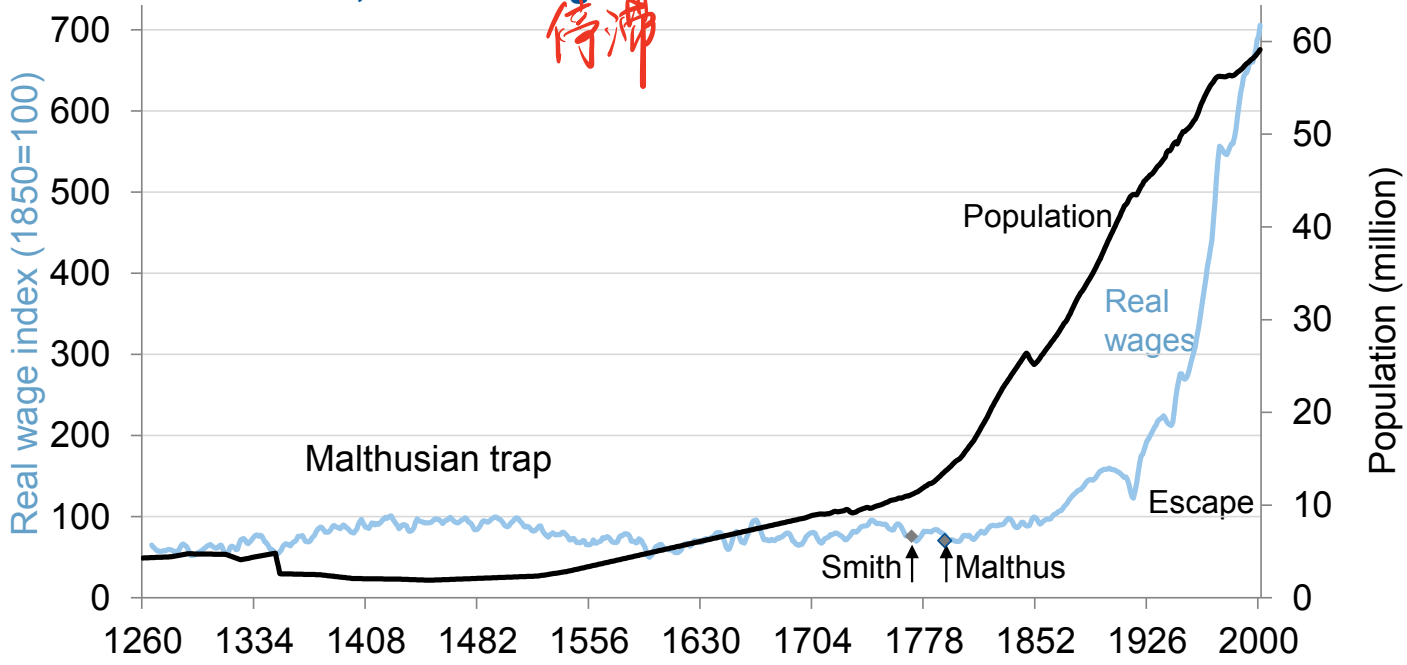
However, these major changes started very suddenly, 200 years ago.

- How did the technological revolution start?
- Why did it not start earlier?
- Why did it start in Britain?



Real wages over seven centuries: Wages of craftsmen (skilled workers) in London (1264-2001), and the population of Britain.
www.core-econ.org

Use economic models to explain the rapid growth in real wages and population in the last two centuries, and the stagnation in the centuries before that



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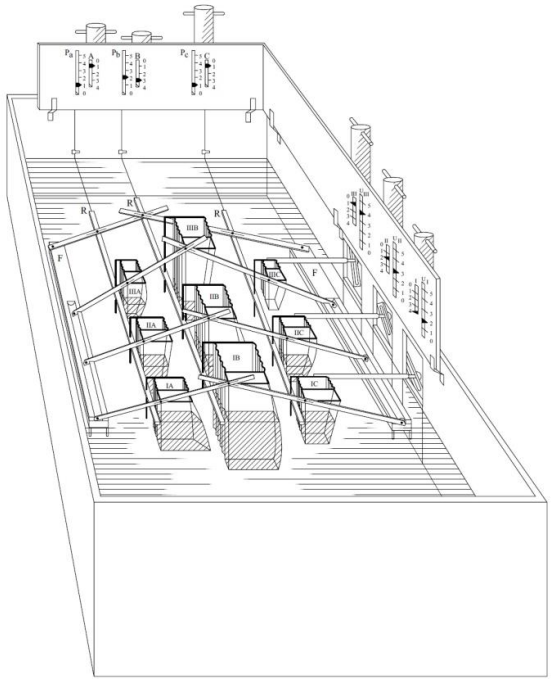
II. Technological Change and Economic Growth

I. **Economic Models**
II. Understanding Growth
III. Understanding Stagnation

Economic models

Irving Fisher built a hydraulic model of the economy as part of his doctoral dissertation back in 1891. It represents three consumers and three goods that they consume.

It consisted of a series of cisterns, rods, floats, bellows, and tubes. Flows of, for example, consumption are represented by liquid moving through tubes and pipes. If you want to know more about hydraulic models of the economy read the following blog post: http://conversableeconomist.blogspot.com/2012/11/hydraulic-models-of-economy-phillips.html



Brainard, W. C. and Scarf, H. E. (2005), How to Compute Equilibrium Prices in 1891. American Journal of Economics and Sociology, 64: 57-83. doi:10.1111/j.1536-7150.2005.00349.x

Why do we need models?

What happens in an economy depends on the actions and interactions of millions of people?

We use models to see the big picture.

To create an effective model we need to distinguish between

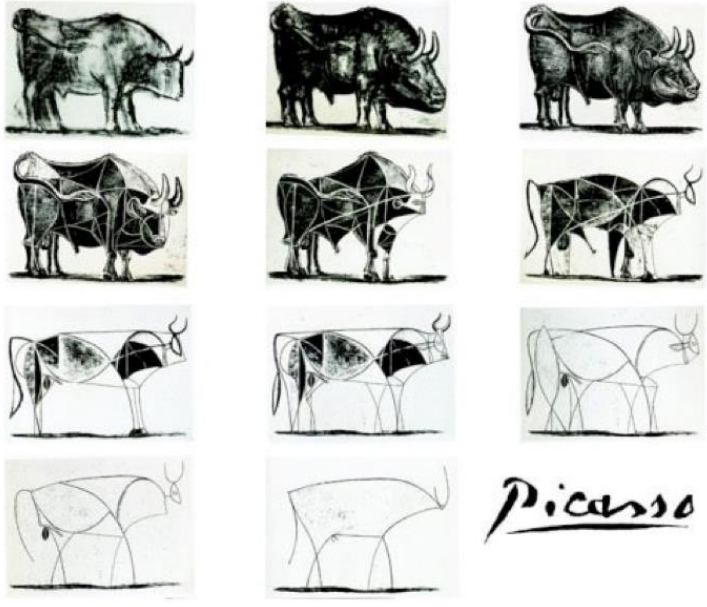
- the **essential features** of the economy that are **relevant to the question** we want to answer, which should be included in the model
- **unimportant details** that can be ignored

Models necessarily omit many details. This is their feature, not a bug!

What is a good model?

- It is clear: it helps us better understand something important
- It predicts accurately: its predictions are consistent with evidence
- It improves communication: it helps us to understand what we agree (and disagree) about
- It is useful: We can use it to find ways to improve how the economy works

What is a good model?



Pablo Picasso, "The Bull", lithographs, 1945

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Building a model

1. Capture the elements of the economy that we think matter for our question
2. Describe how agents act, and how they interact with each other and the elements of the model
3. Determine the outcomes of these actions (an equilibrium)
4. Study what happens when conditions change

Equilibrium of a model = situation that is self-perpetuating. Something of interest does not change unless an external force is introduced that alters the model's description of the situation.

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Key concepts

- **Ceteris paribus**: *all other things being equal;* less is more 等价交换
- **Incentives**: = economic rewards/punishments which influence the benefits/costs of actions
- **Relative prices**
- **Economic rent**: the benefit received from a choice, taking into account the next best alternative (**reservation option**)

  → something you'd like to get, not something you need to pay:

  economic rent = benefit from option taken - benefit from next best option

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Explaining the Industrial Revolution

Why did the **Industrial Revolution** happen first in the 18th Century?
On an island off the coast of Europe?

There are many alternative explanations

- relatively high cost of labour & cheap local sources of energy
- Europe's scientific revolution and Enlightenment
- political and cultural characteristics of nations as a whole
- cultural attributes such as hard work and savings
- abundance of coal and access to colonies

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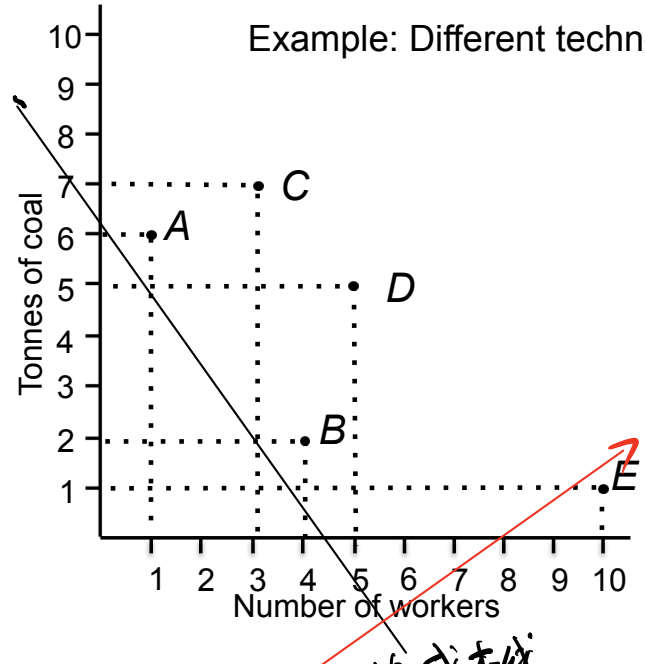
Modelling technology

Firms choose between **technologies** (specific combinations of inputs) to produce outputs

Example: Different technologies for producing 100 metres of cloth



Technology	Number of workers	Coal required (tonnes)
A	1	6
B	4	2
C	3	7
D	5	5
E	10	1

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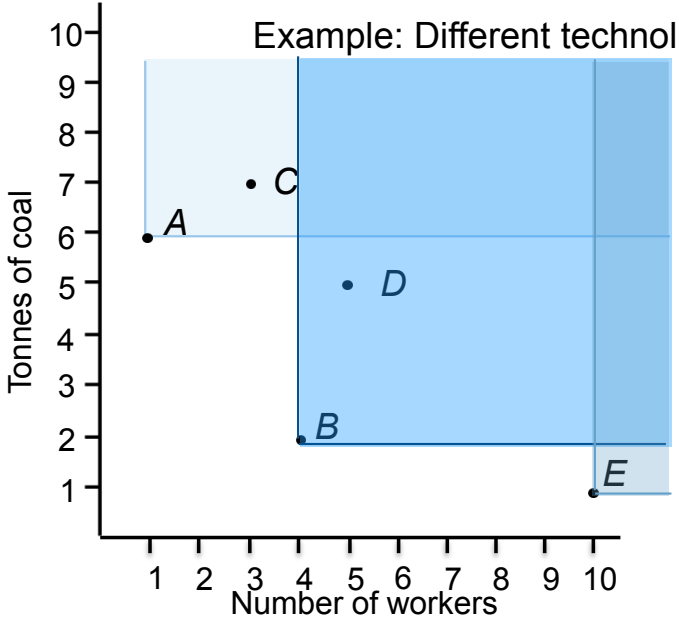
Modelling technology

First step: Ruling out inferior technologies



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~~*C*~~	~~3~~	~~7~~
~~*D*~~	~~5~~	~~5~~
E	10	1

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Firm's choice: minimising cost

Firms aim to maximise their profits, which means producing cloth at **the least possible cost**.

$$profit = revenue - costs$$

This is why the firms' choice of technology depends on economic information about relative prices of inputs.

$$cost = (wage \times workers) + (price\ of\ tonne\ of\ coal \times number\ of\ tonnes)$$
$$= (w \times L) + (p \times R)$$

$$c = wL + pR$$

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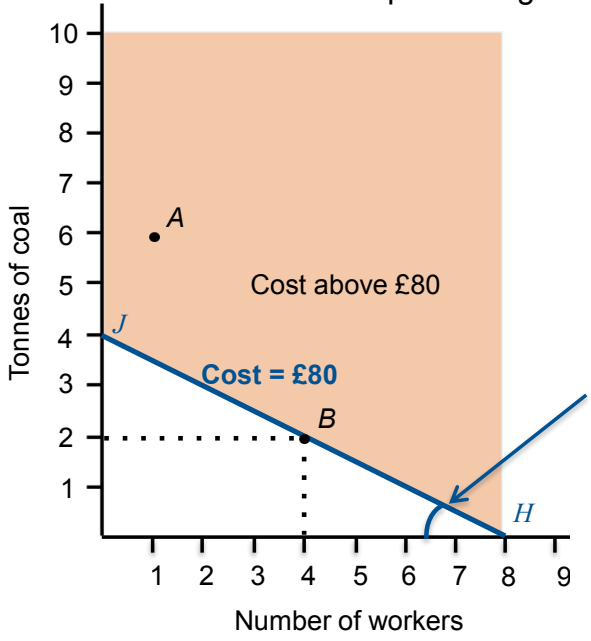
Isocost lines

Isocost lines: combinations of inputs that give the same total cost (slope = relative price of inputs)



Technology	Number of workers	Coal required (tonnes)	Total cost (£)
Wage £10, cost of coal £20 per tonne			
B	4	2	80
A	1	6	130
E	10	1	120

slope of isocost = relative price of inputs

$$-\frac{w}{p} = -\frac{10}{20} = -\frac{1}{2}$$

This is the relative price of labor.

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Isocost lines

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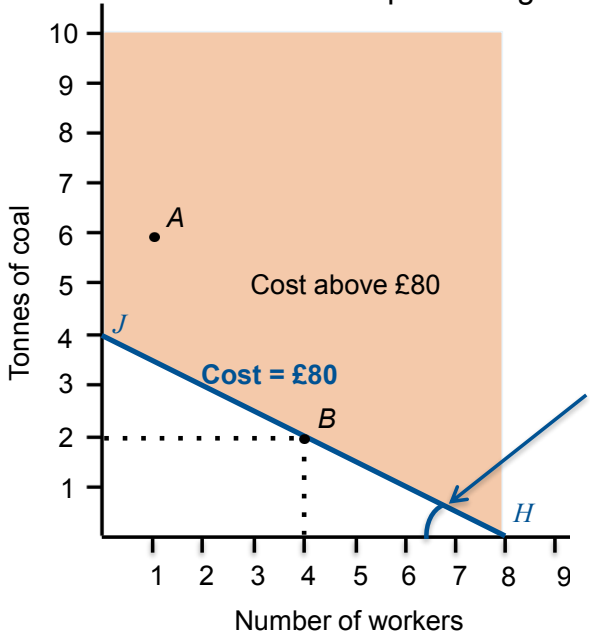

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slope of isocost = relative price of inputs

$$-\frac{w}{p} = -\frac{10}{20} = -\frac{1}{2}$$

$$c = w \times L + p \times R$$

$$\Leftrightarrow c - w \times L = p \times R$$

$$\Rightarrow R = \frac{c}{p} - \frac{w}{p} \times L$$

same as: $y = a + b \times x$

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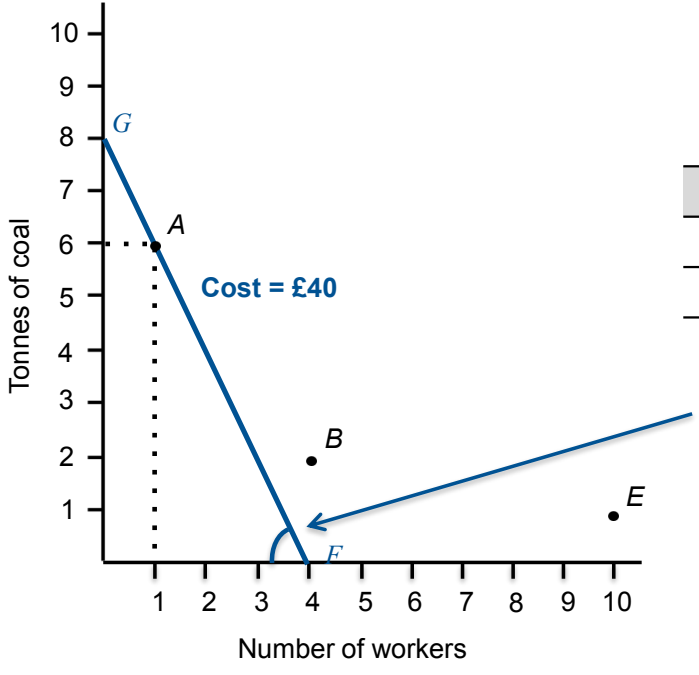
Isocost lines: example with high relative cost of labour.



Technology	Number of workers	Coal required (tonnes)	Total cost (£)
Wage £10, ***cost of coal £5 per tonne***			
B	4	2	50
A	**1**	**6**	**40**
E	10	1	105

slope of isocost = relative price of inputs

$$-\frac{w}{p} = -\frac{10}{5} = -2$$

This is now the relative price of labor.

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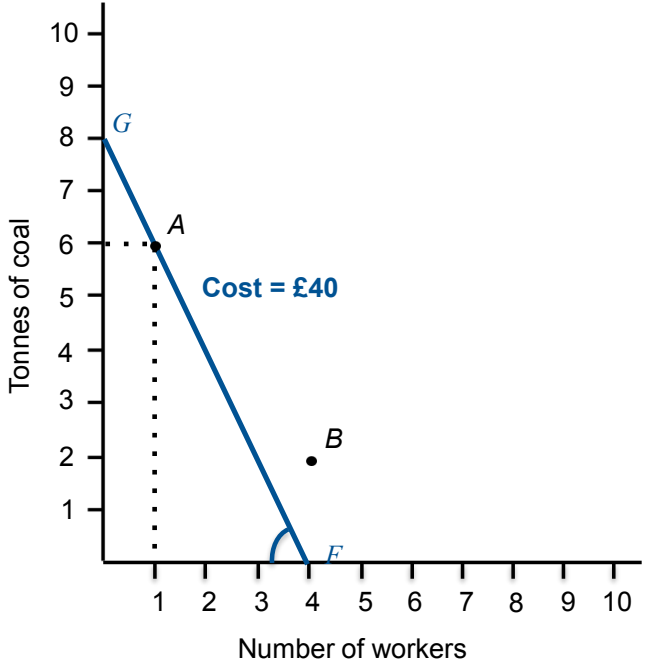
Isocost lines: example with high relative cost of labour.



Technology	Number of workers	Coal required (tonnes)	Total cost (£)
Wage £10, ***cost of coal £5 per tonne***			
B	4	2	50
A	**1**	**6**	**40**
E	10	1	105

- **Economic rent** of using A rather than B = 10
- Incentive for firms to adopt best technology
- Innovation rents aka **Schumpeterian rents**

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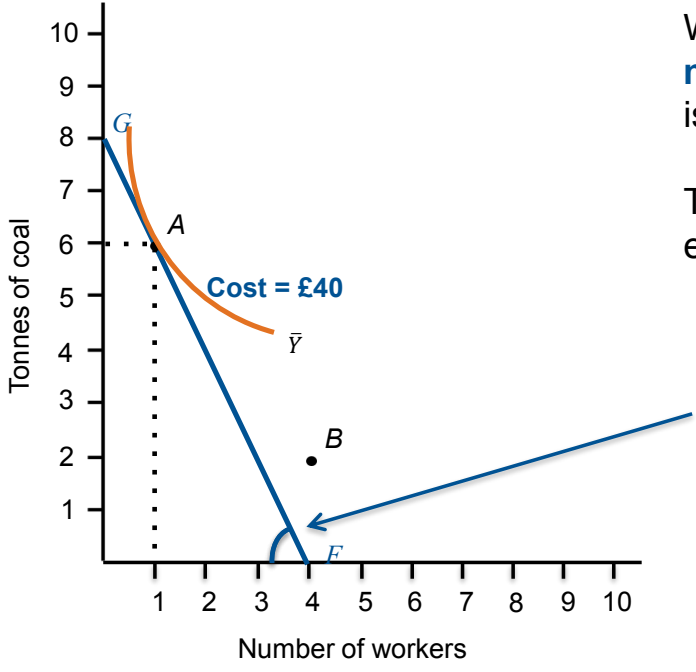
Isocost lines: example with high relative cost of labour.



When relative input usages are optimal, the **marginal rate of technical substitution (MRTS)** is equal to the relative unit costs of the inputs

The slope of the **isoquant** at the chosen point equals the slope of the isocost curve

slope of isocost = relative price of inputs

$$-\frac{w}{p} = -\frac{10}{5} = -2$$

This is now the relative price of labor.

The benefits of innovation

Because relative prices of inputs changed, a firm that will switch to the new cost-minimising technology will have an advantage over its competitors.

Change in profit = fall in costs associated with adopting the new technology (c_1).

This is the **innovation rent**:

$$\text{IR} = \pi_{c_1} - \pi_{c_0}$$

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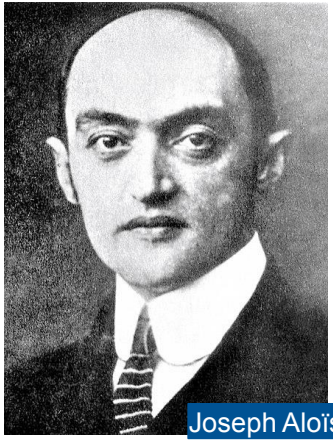
Creative destruction



Joseph Aloïs Schumpeter(1883 – 1950)

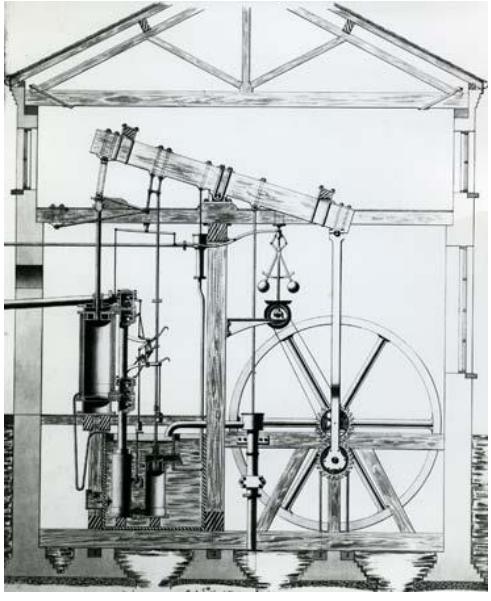
Innovation is the market introduction of a technical or organisational novelty, not just its invention.

The first adopters will enjoy **Schumpeterian (innovation) rents**.

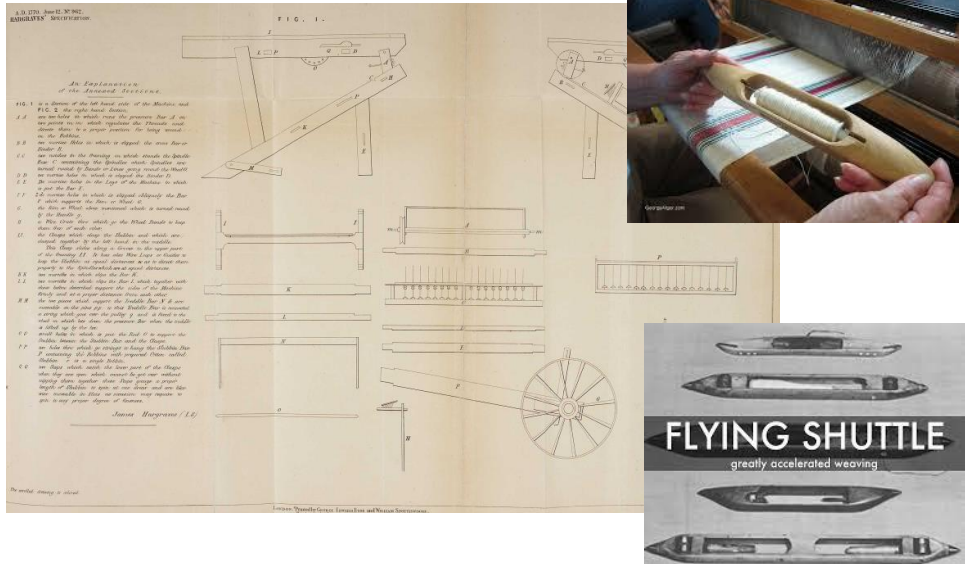
Creative destruction: the process by which old technologies and the firms that do not adapt are swept away by the new because they cannot compete in the market.

https://en.wikipedia.org/wiki/Joseph_Schumpeter#/media/File:Joseph_Schumpeter_ekonomialaria.jpg

Creative destruction through innovation

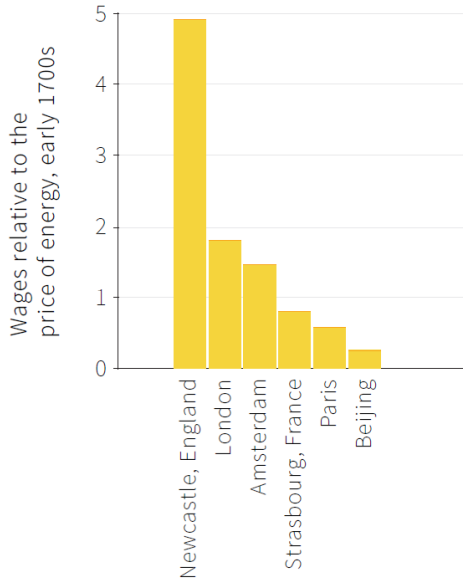


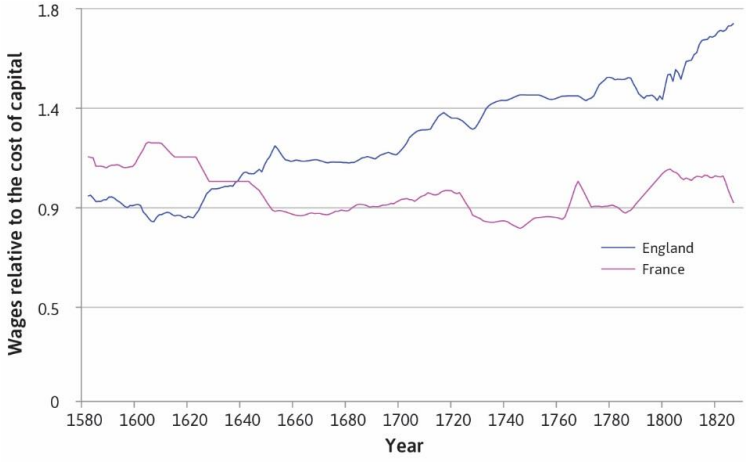
Rotative steam engine, 1781 by James Watt



Spinning Jenny, 1767 by James Hargreaves

Why did industrial revolution start in Britain?





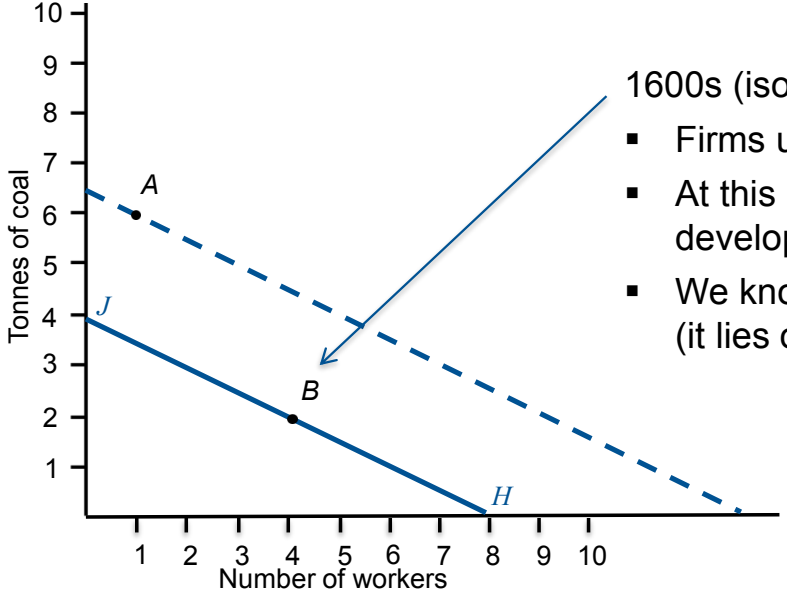
Before the Industrial Revolution technology was *labor-intensive*, capital goods-saving and energy-saving

The new technology was *capital goods-intensive*, energy-intensive and labor-saving!

machine

Understanding growth

Technology was labor-intensive before the Industrial Revolution



1600s (isocost HJ)

- Firms use technology B.
- At this relative price, no incentive to develop technology *A*.
- We know this because A costs more (it lies outside the line *HJ)*.

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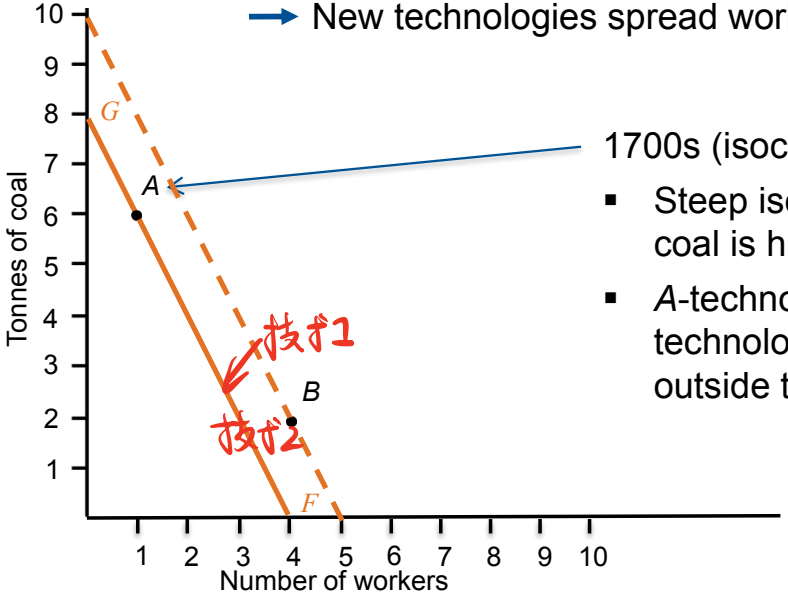
Understanding growth

High relative wages created incentive to innovate more capital-intensive technologies

→ New technologies spread worldwide, causing convergence



1700s (isocost *FG*)

- Steep isocost: relative price of labour to coal is high.
- *A*-technology now lower cost than the *B*-technology. We know this because *B* lies outside the line *FG*.

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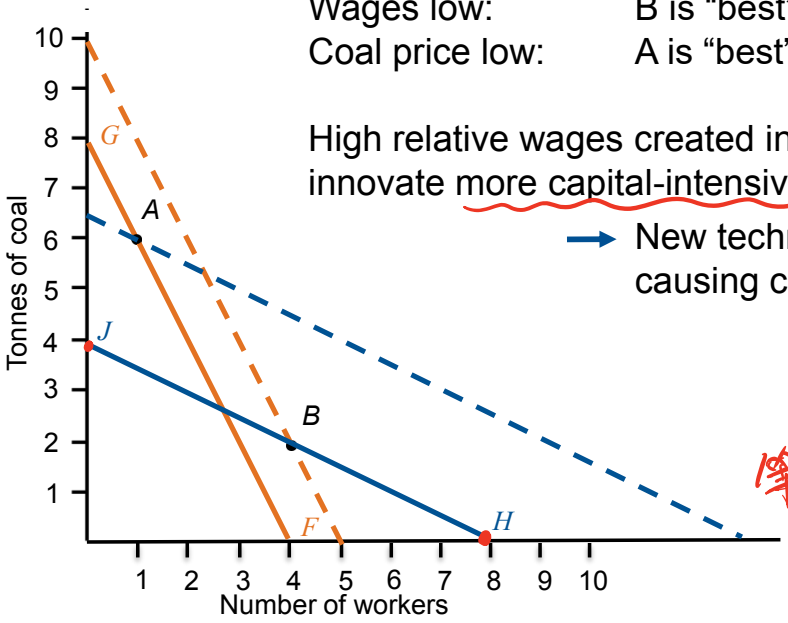
Understanding growth



Wages low: B is “best”
Coal price low: A is “best”

High relative wages created incentive to innovate more capital-intensive technologies

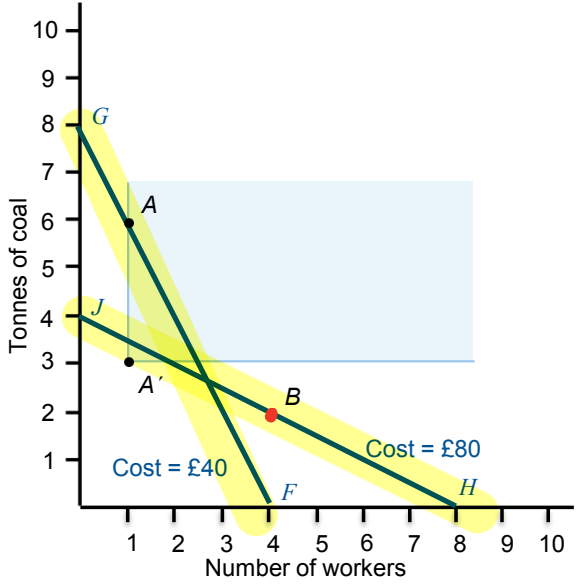
→ New technologies spread worldwide, causing convergence

收敛

等成本线

Technological progress

Technology also became more efficient through process innovation.



Technology	Number of workers	Coal required (tonnes)	Total cost (£)
Wage £10, cost of coal £20 per tonne			
B	4	2	80
A´	1	3	70
Wage £10, cost of coal £5 per tonne			
A	1	6	40
A´	1	3	25

This is part of the explanation of the upward kink in the hockey stick.

Explaining the long flat part of the stick is another story, which requires a different model…

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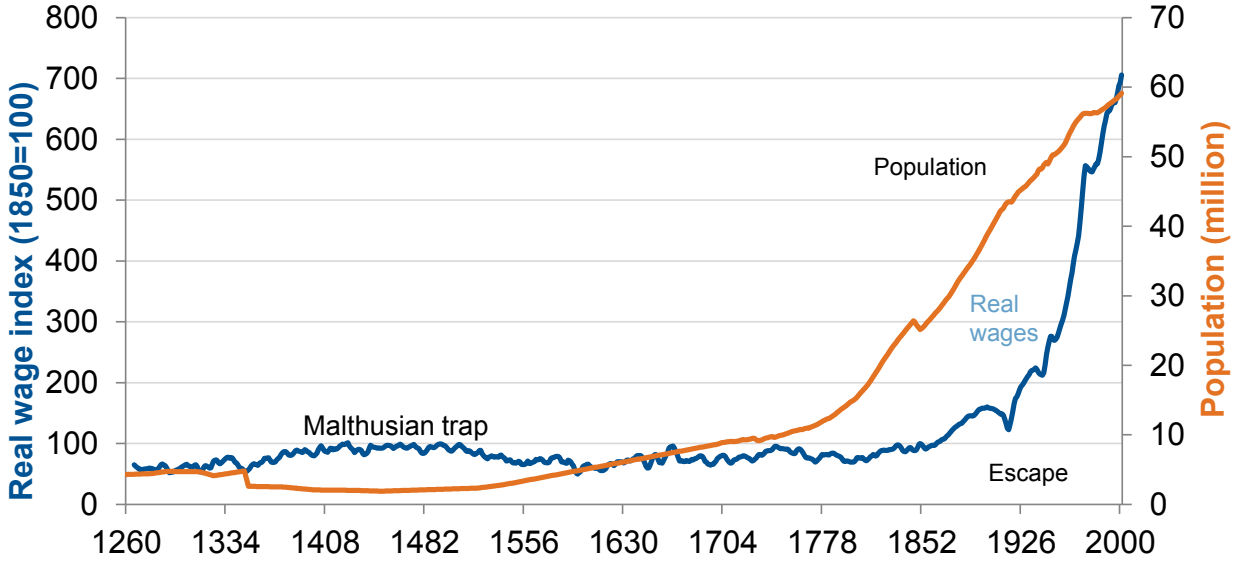
The economy before the Industrial Revolution

- We need a different model to explain the stagnation in population and living standards before 18th century.
- **What was different during this period?**



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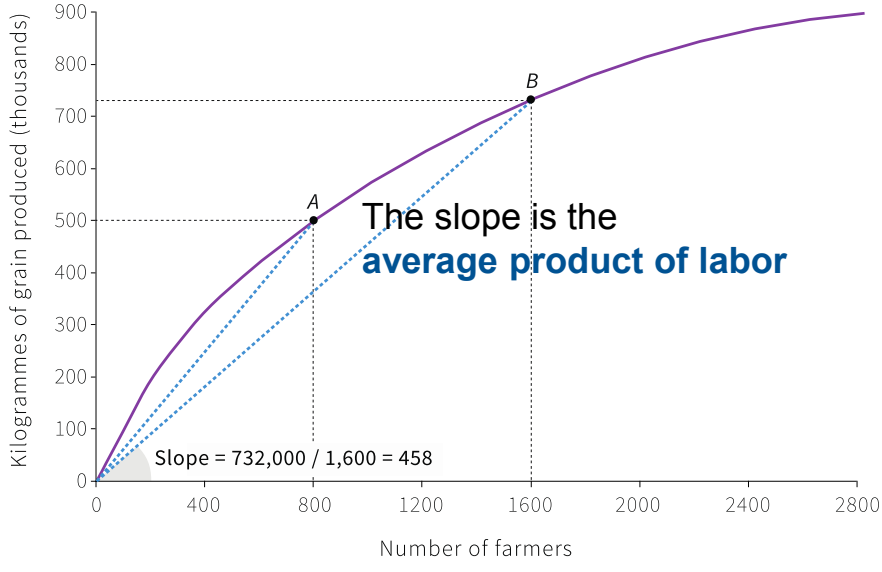
Malthus' model

Production function gives maximum output for a given set of inputs: ***Y= f(X)***

Key ideas:

- Population expands if living standards increase
- Average product of labor is diminishing
- Labor productivity = output/labor

ceteris paribus assumption: amount of land is fixed, all of the same quality



Malthus' model

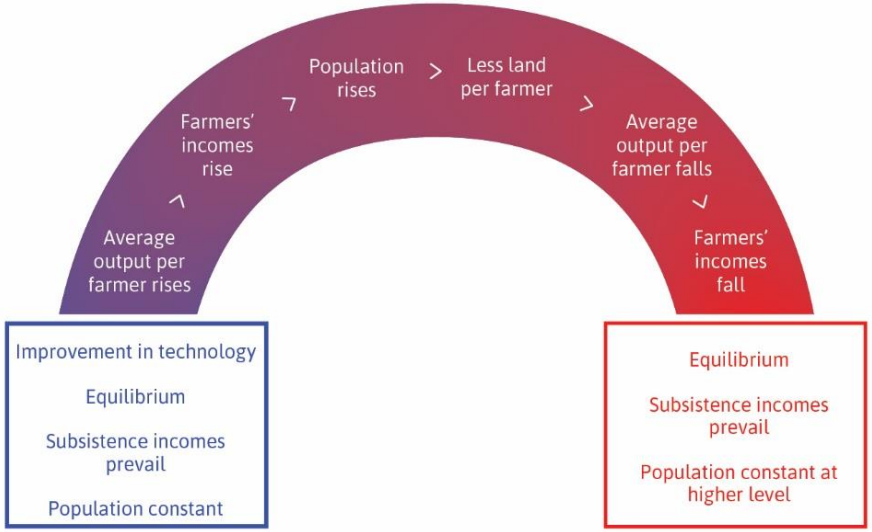
Key ideas:

1. Population expands if living standards increase
2. But the law of diminishing average product of labour implies that as more people work on the land, their income will inevitably fall

In equilibrium, living standards will be forced down to **subsistence level**.

Conclusion: Population and income will stay constant.

Implications: Malthus' Law



Model predicts a "self-correcting" response to new technology. In the long run, an increase in productivity will result in increased population, but not increased wages.

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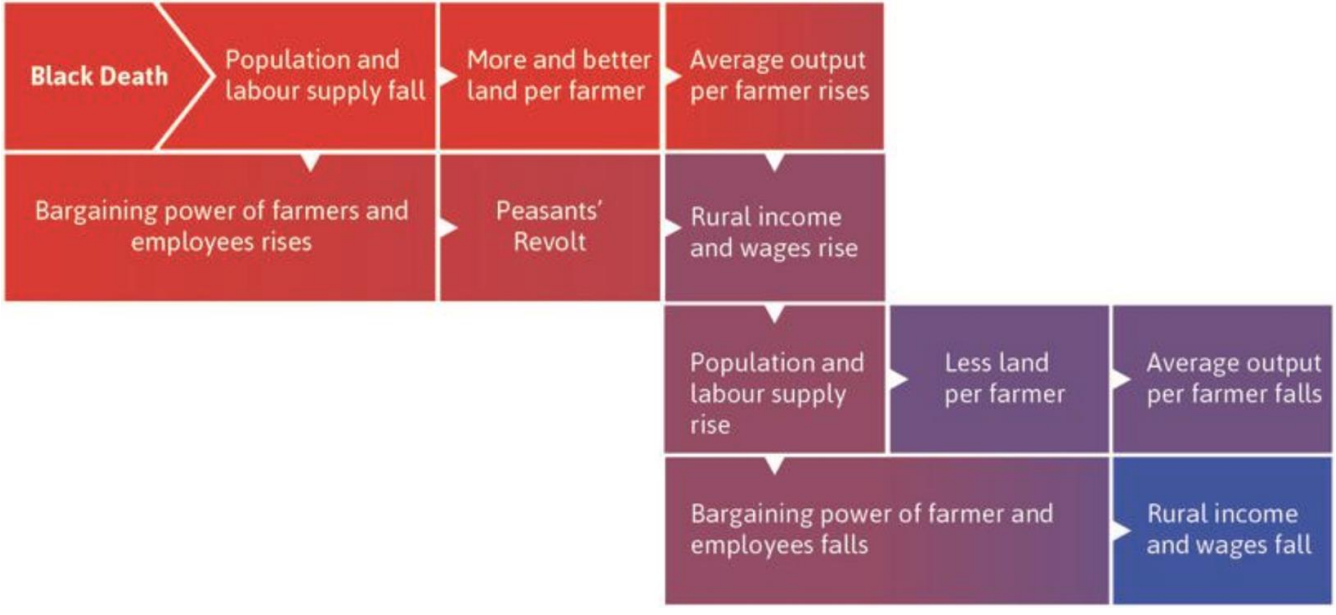
Was Malthus correct?



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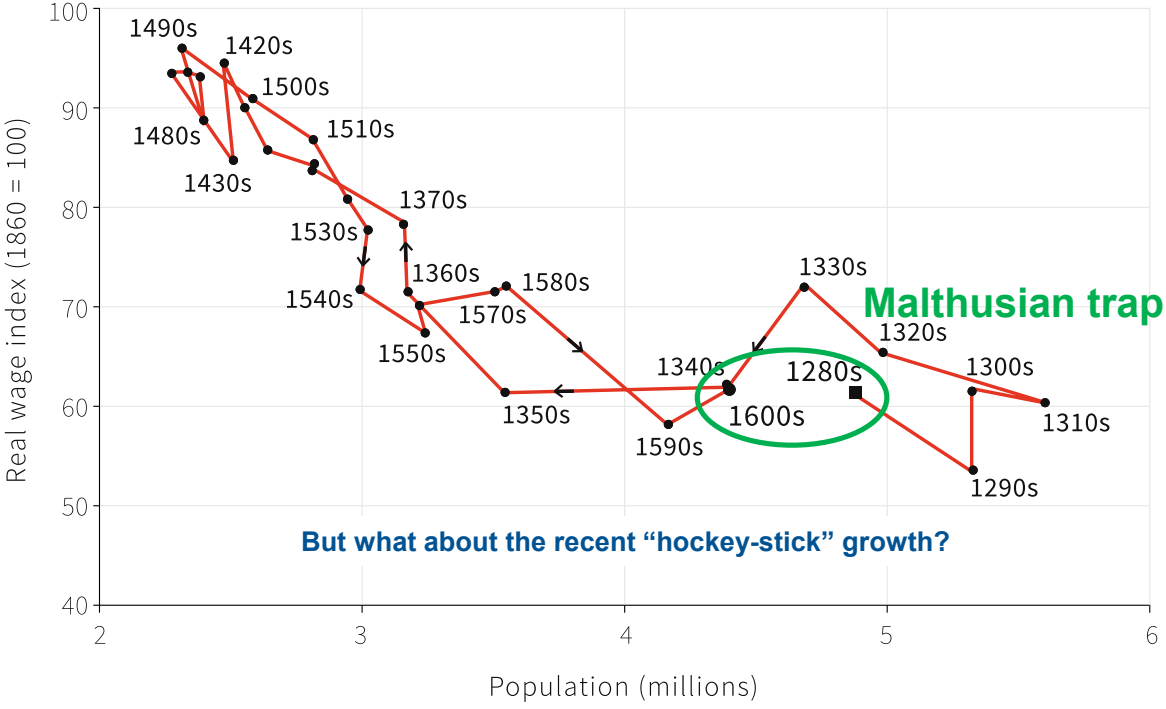


Revising Malthus' Law

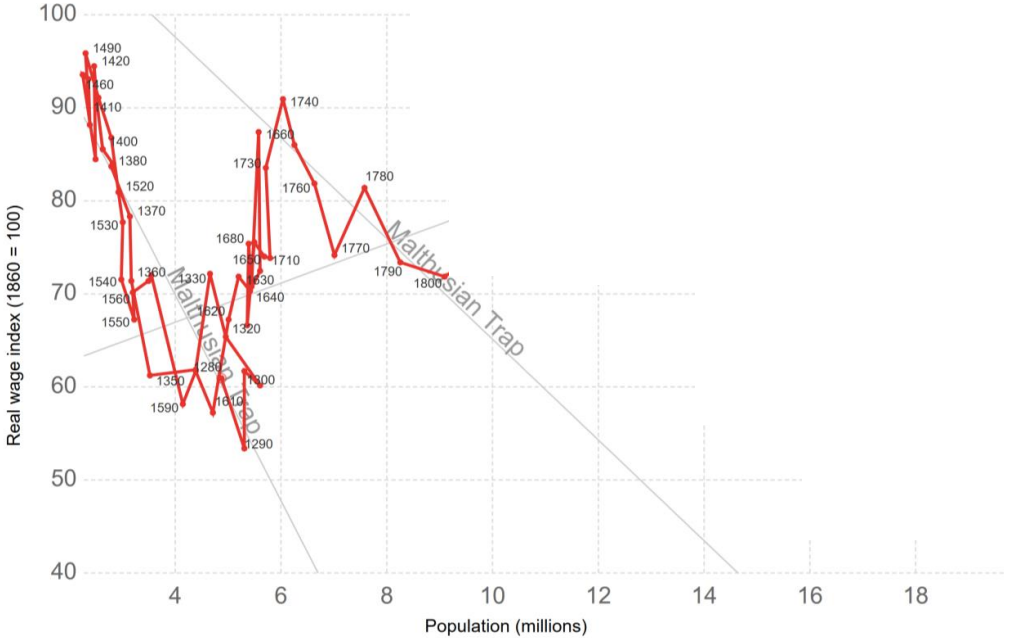
3 conditions cause the **Malthusian trap**:

1. Diminishing average product of labor
2. Rising population in response to increases in wages
3. **Absence of improvements in technology** to offset the diminishing average product of labor

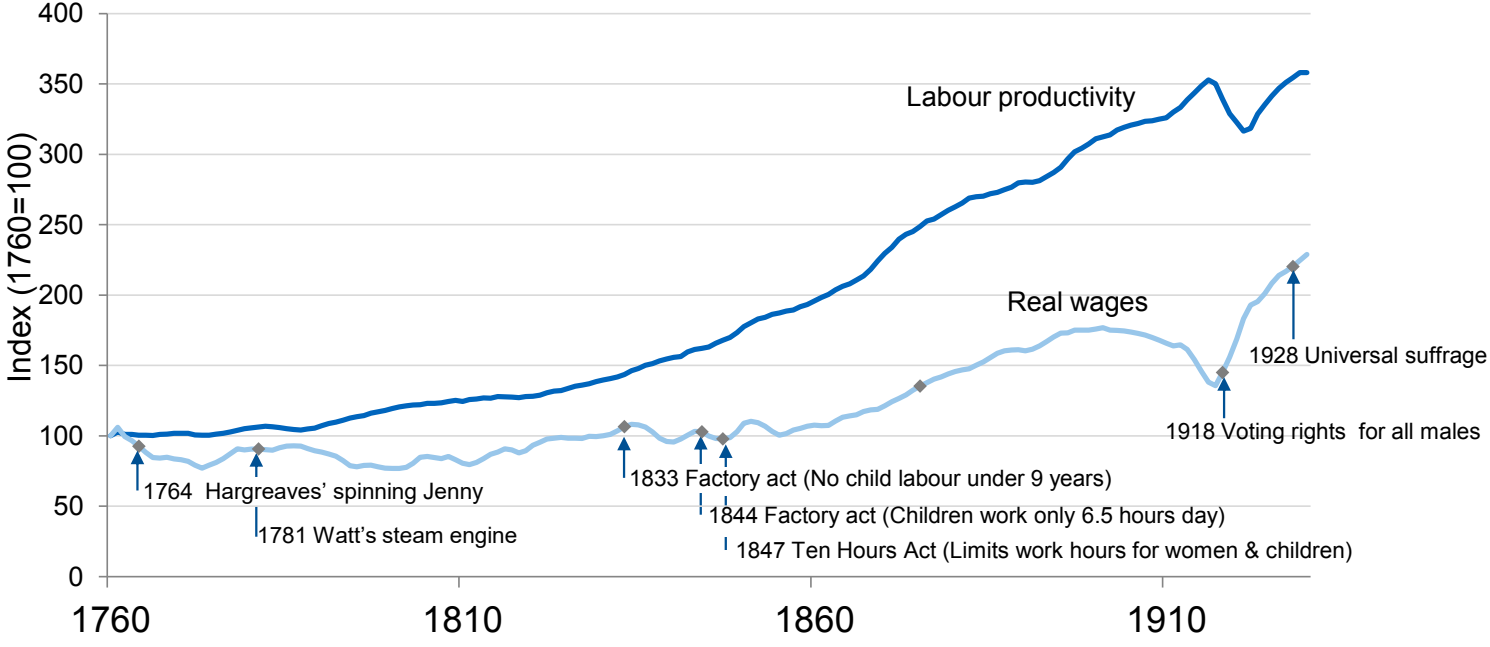
→ The **permanent technological revolution** meant that the third condition no longer holds

→ Models that are useful to explain some contexts may fail in others

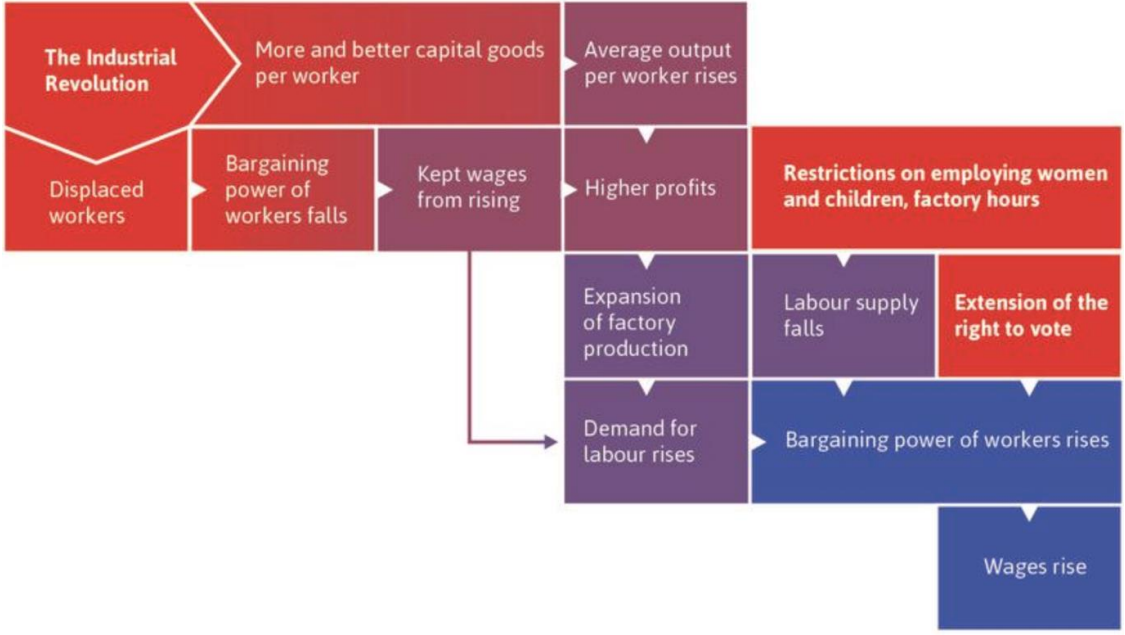
The “great escape” (England)



Effects on productivity and wages



Effects on productivity and wages



Summary

1. Introduction to economic models
   - Less is sometimes more

2. We used models for insights on the technological revolution

- **Model of a firm**: why firms may move to new technologies when input prices change, high wages (relative to capital, including energy) motivated **technological innovation**
- **Malthus' model**: why economic stagnation persisted and why permanent technological change enabled economies to escape it

Economics II – Macroeconomics

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