Technological Change, Population, and Growth

Economics

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UCL

Lecture 2

Context for the lecture

The recent rapid, *sustained increase in income and living standards* is largely due to technological progress. (Unit 1)

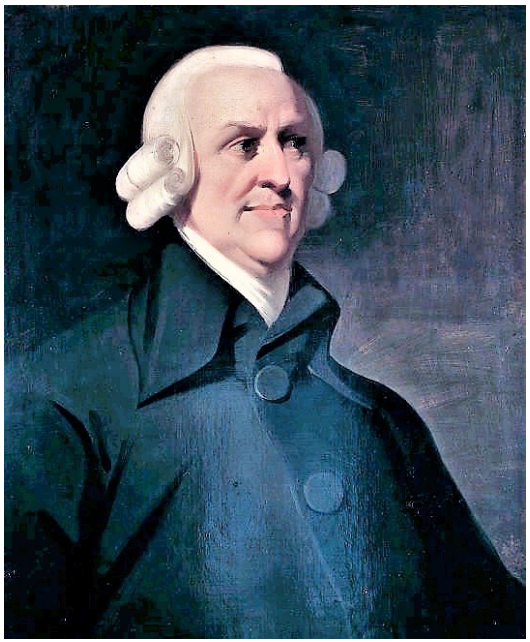
Major changes started very suddenly, almost 200 years ago.

How did the technological revolution start?

Why did it not start *earlier*?

Why did it not start *later*?

Adam Smith & Thomas Malthus



Adam Smith (1723–1790)

Thomas Malthus (1766–1834)

In the Wealth of Nations published in 1776, *Adam Smith* argued that even though each individual may pursue their own self-interest, *coordination* amongst these individuals arises spontaneously when they participate in a *decentralised market*

Malthus hypothesised that sustained increase in living standards is impossible, i.e., living standards can never improve and populations remains forever trapped in the vicious cycle of *poverty* known as the *Malthusian Trap*.

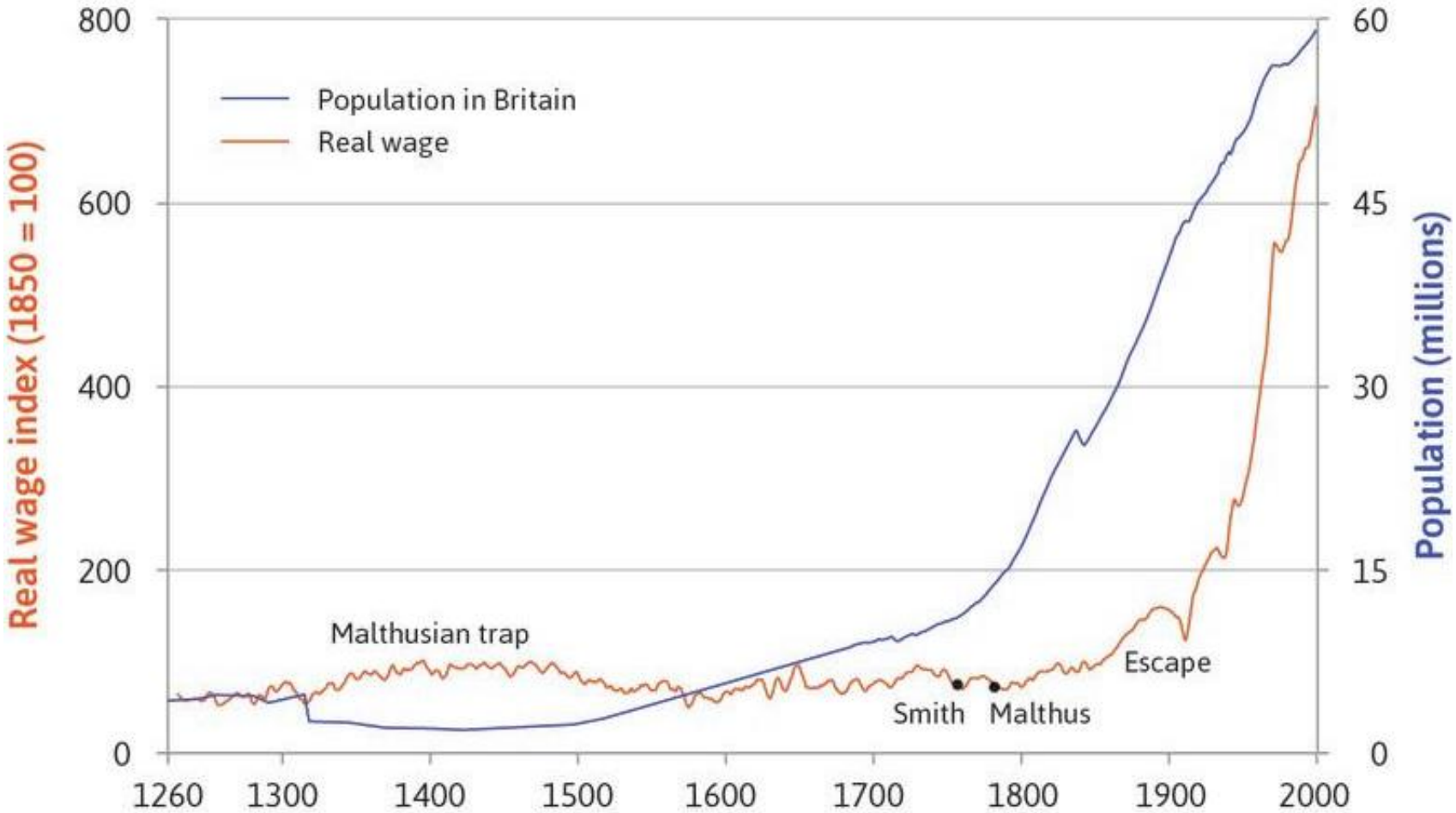
Malthus' first channel

People living at *subsistence level where they barely have enough to eat*

- *a improvement in technology*
- *leads to increase in productivity of labour*
- *leading to greater availability of food*
- *leads to people having more children*
- *increase in population imply there are more mouths to feed with the food society produces*
- *thus population increase leads to decreasing living standards*
- *the population will continue to increase till the population is back to subsistence level*
- *populations are caught in the vicious cycle of poverty*

Adam Smith & Thomas Malthus

Malthus	Adam Smith
While *Malthus* argued that populations are caught in a *vicious cycle of poverty* and individuals *cannot coordinate* their actions to escape the vicious cycle of poverty traps	*Adam Smith* argued that individuals pursuing their self-interest *can coordinate* through market and *improve their living stands*
Low income countries have not seen the living standards of their population change by a significant amount	The living standards have improved dramatically in the high income countries in the last 200 years



Wages of skilled workers (craftsmen) in London and population of Britain (1264–2001). Does something change around 1830s?

Explaining the Industrial Revolution

Timing: Why did the Industrial Revolution start in the 18th Century?

Location: Why did it start in an island off the coast of Europe?

There are many alternative explanations

- 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

  low coal prices, large markets for output
- Relatively high cost of labour and cheap local sources of energy

  Relative prices of inputs

Production

How do you produce things?

Obtain range of *inputs*

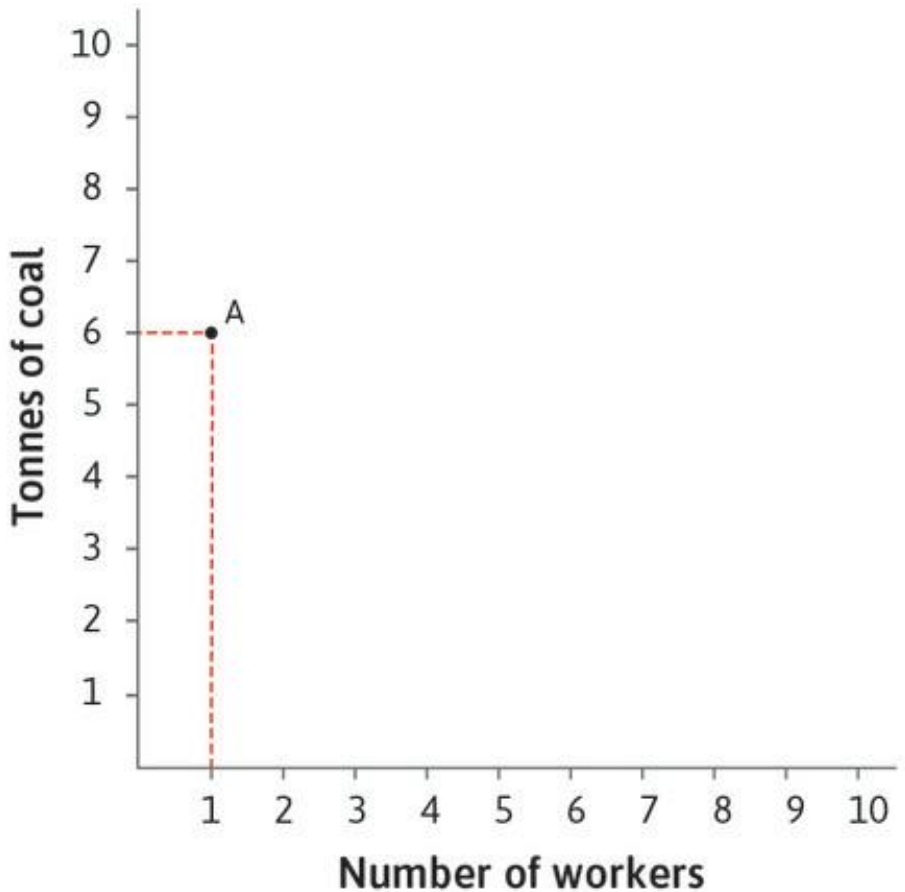
Choose the *technology* — *ideas of how to combine inputs*

Produce the *output*

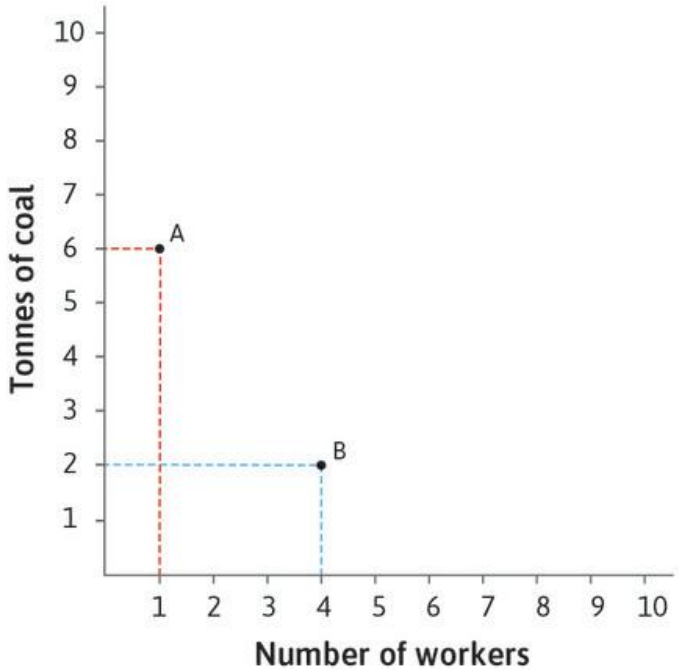
Production of coffee in a coffee shop . . .

1 Barista + 1 espresso machine + $30g$ coffee beans + $300ml$ water + 1 cup = 1 cup of espresso

Making Cloth

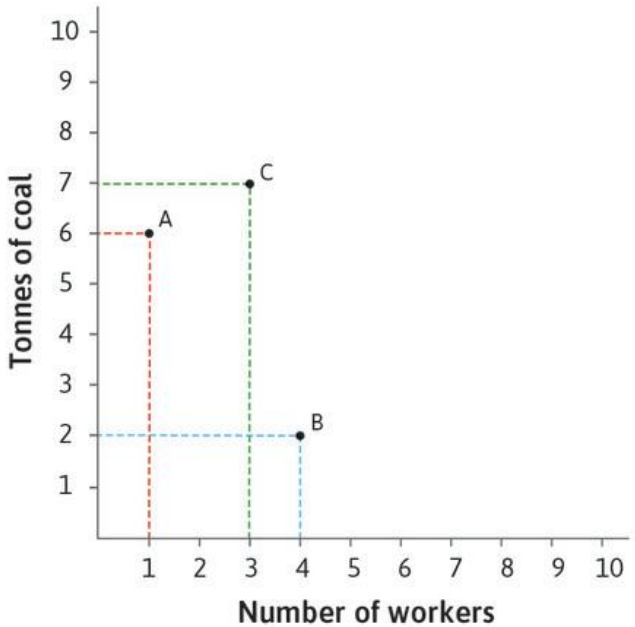


Making Cloth



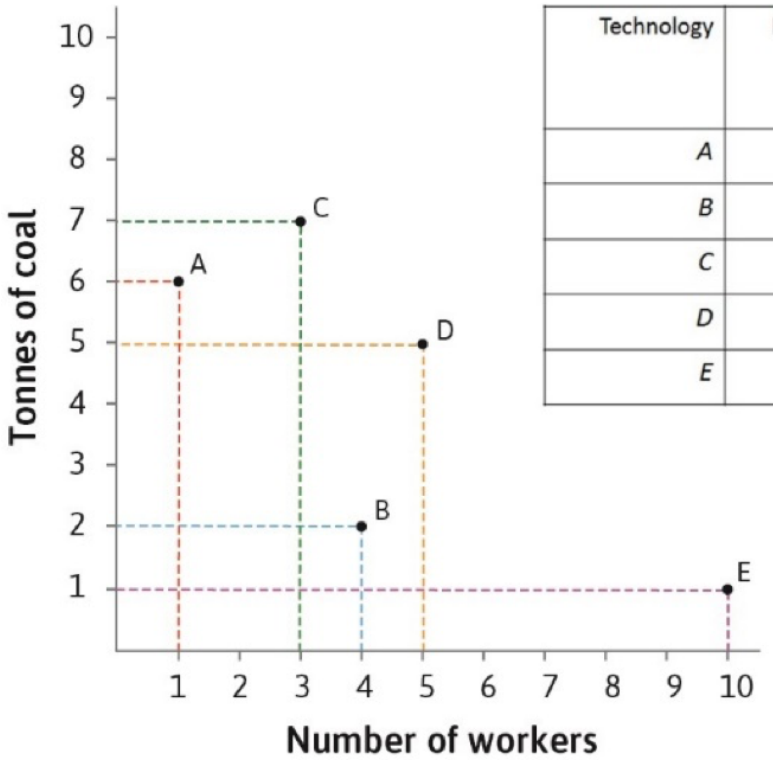
- A is relatively more energy-intensive technology
- B is relatively more labour-intensive technology

Making Cloth



- C uses more energy and labour as compared to A, which makes A an irrelevant choice
- This leaves the choice between technology A and B

Input → *Technology* → Output



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

5 different ways to produce 100 metres of cloth using labour and coals as inputs.

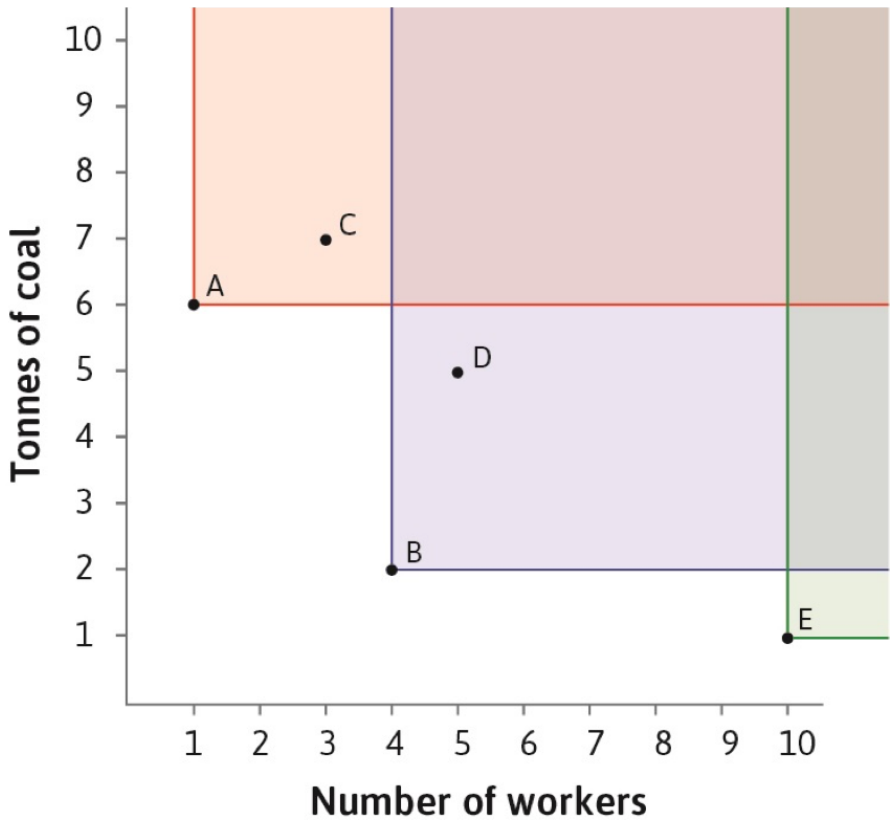
Technology E is relatively labour-intensive;

Technology A is relatively energy-intensive.

Firm's choice: Dominated Technologies

Choose between technologies A, B & E

Technologies C & D are irrelevant because they are dominated by technologies A & B respectively



Cost of Producing Cloth

Cost of producing 100 meters of cloth

$$c = \underbrace{(w \times L)}_{\text{cost of labour}} + \underbrace{(p \times R)}_{\text{cost of coal}}$$

where

- w wage workers earn
- L number of workers employed
- p price of a tonne of coal
- R quantity of coal used

Cost of Producing Cloth

Cost of producing 100 meters of cloth

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

Rearrange to obtain an iso-cost line

$$pR = c - wL$$

$$R = \frac{c}{p} - \left(\frac{w}{p}\right) L$$

If c, the cost of producing 100 metres of cloth is kept constant,

then R coal used decreases as L number of workers employed increases

Iso-cost line

Iso-cost line a line that represent all combination of inputs that cost the same amount

Input prices Wage £10

Coal £20

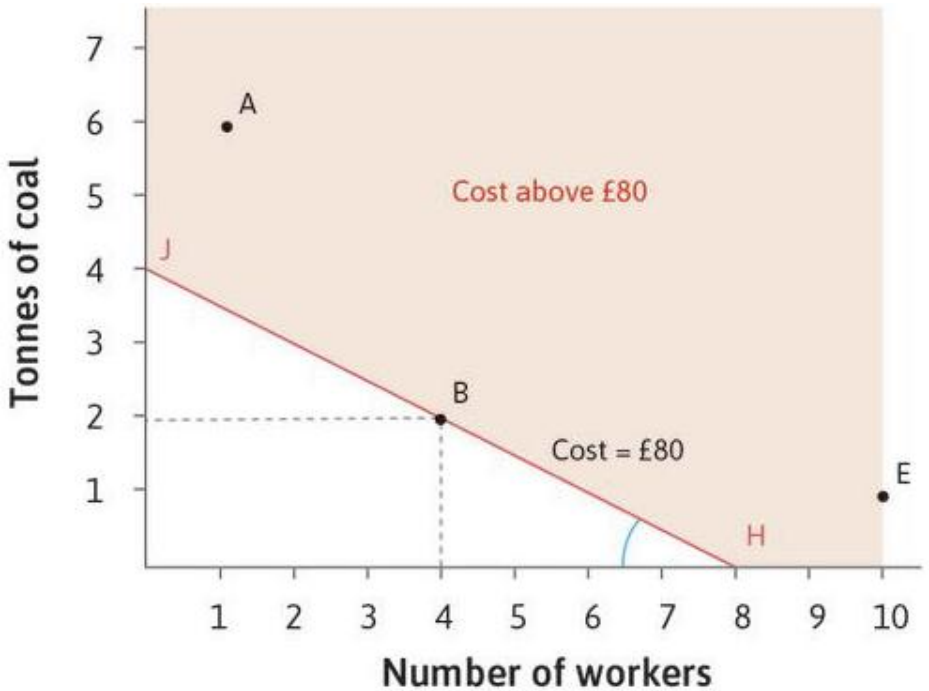
Technology B $4 \times £10 + 2 \times £20 = £80$

Technology J $0 \times £10 + 4 \times £20 = £80$

Technology H $8 \times £10 + 0 \times £20 = £80$

Technology	No. of workers	Coal required	Total Cost (£)
B	4	2	80
J	0	4	80
H	8	0	80

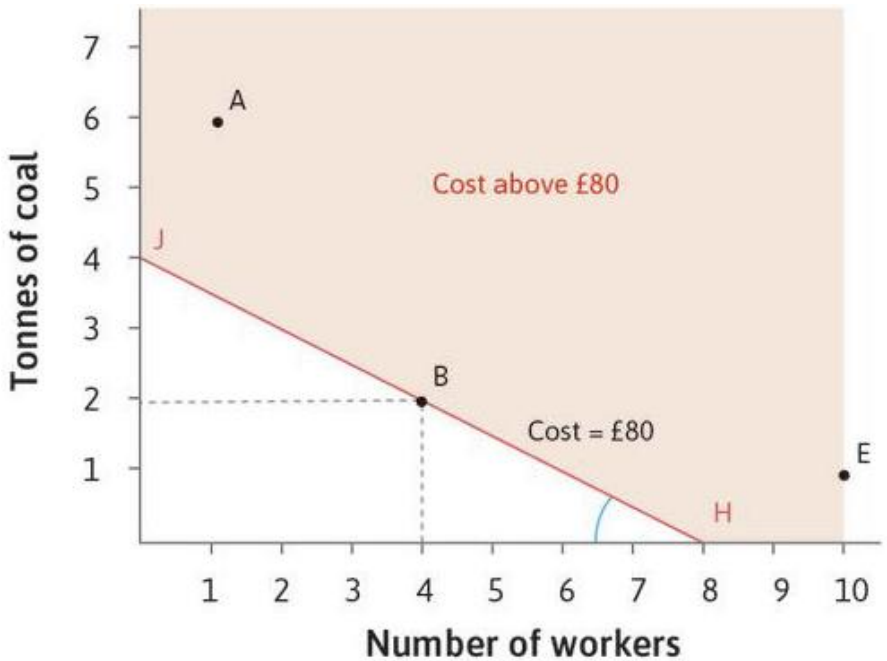
Iso-cost line a line that represent all combination of inputs that cost the same amount *(Line J-B-H in figure below)*



Technology	No. of workers	Coal required	Total Cost (£)
B	4	2	80
J	0	4	80
H	8	0	80
A	1	6	130
E	10	1	120

A & E are on the *higher iso-cost line* than B

Slope of *iso-cost line* is given by $\frac{w}{p} = \frac{10}{20} = 0.5$

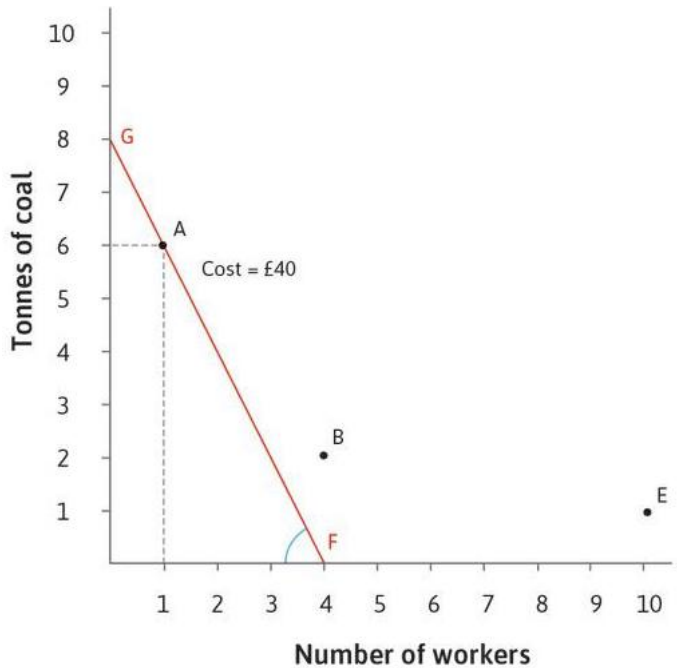


Technology	No. of workers	Coal required	Total Cost
B	4	2	80
J	0	4	80
H	8	0	80
A	1	6	130
E	10	1	120

If price of coal decreases sufficiently, it puts A on a lower iso-cost line than B

Input prices Wage £10

Coal £5



Technology	No. of workers	Coal required	Total Cost (£)
B	4	2	50
A	1	6	40
E	10	1	105

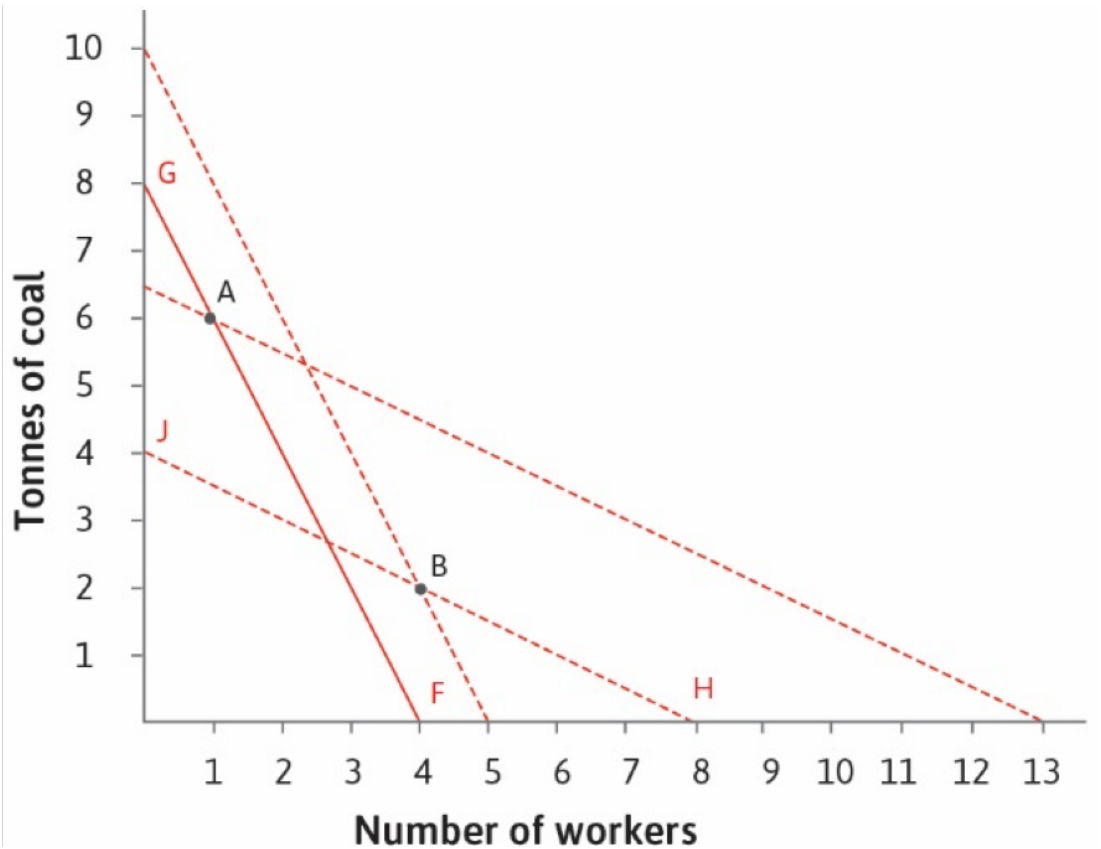
Change in relative prices in Britain

Technology A

Increase in wages relative to price of coal in Britain created an incentive for inventing capital-intensive technologies, which led to the industrial revolution

Technology B

Labour-intensive technology used before the Industrial Revolution



The benefits of innovation

If *relative prices* of inputs change,

a firm that *switches* to the new cost-minimising technology $(B \rightarrow A)$ will have an advantage over its competitors.

$$Profits = Revenue - Costs$$

Profit increase by the same amounts as the decrease in costs due to adopting new technology.

This is called *innovation rent*.

Rent is a very specific term in Economics

Innovation Rent gives incentive to create new technologies.

Creative destruction

The first adopter is called an *entrepreneur*.

An *entrepreneurial firm* is willing to try out new technologies and to start new businesses.

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.

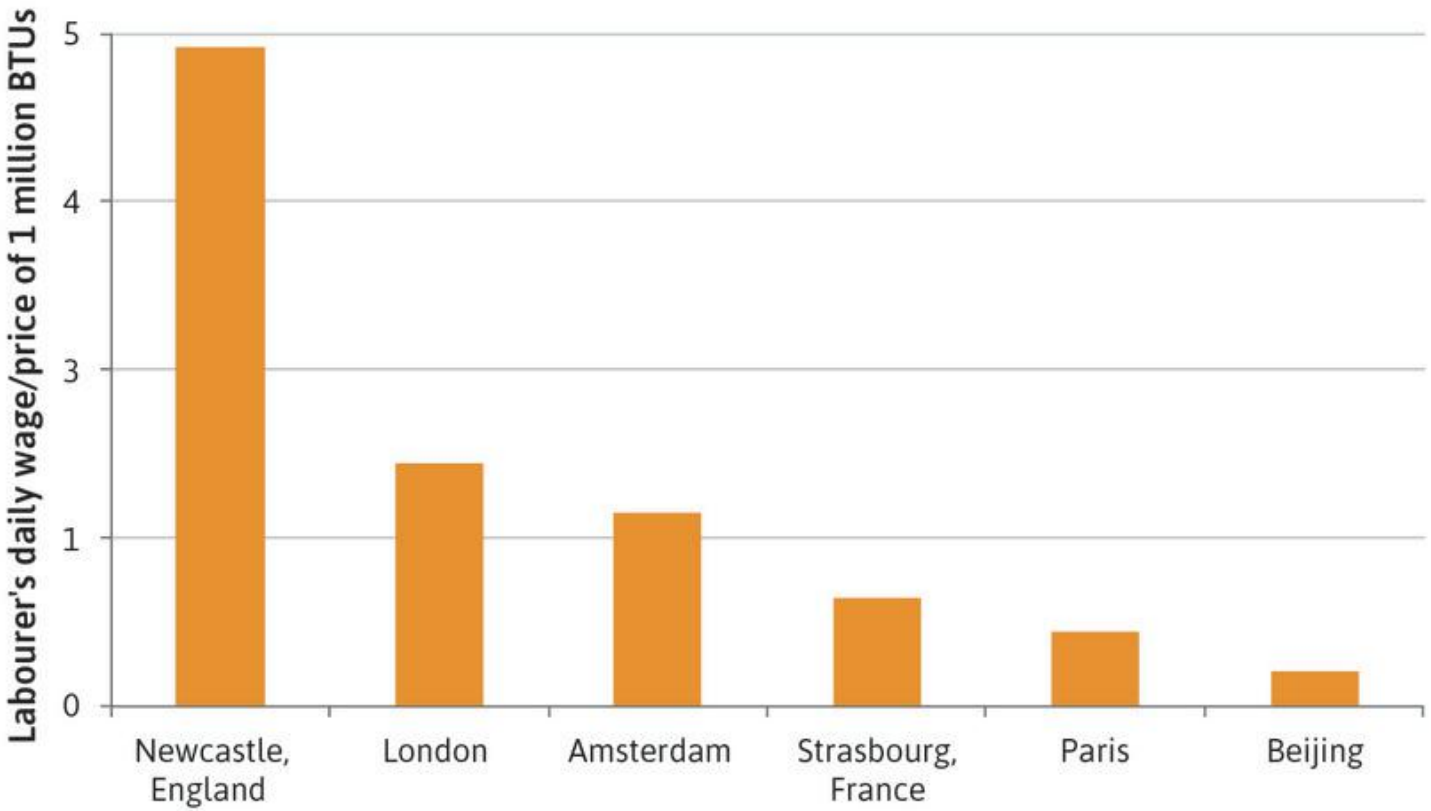
Technological change in Industrial Revolution

One of the first sectors to undergo technological change was textiles

- Before the Industrial Revolution, making clothes for the household were time-consuming tasks
  - By the late 19th century, a single *spinning mule* operated by a very small number of people could replace more than 1,000 spinsters
  - These machines were powered by *water wheels* and later *coal-powered steam engines* *instead* of using *human labour*

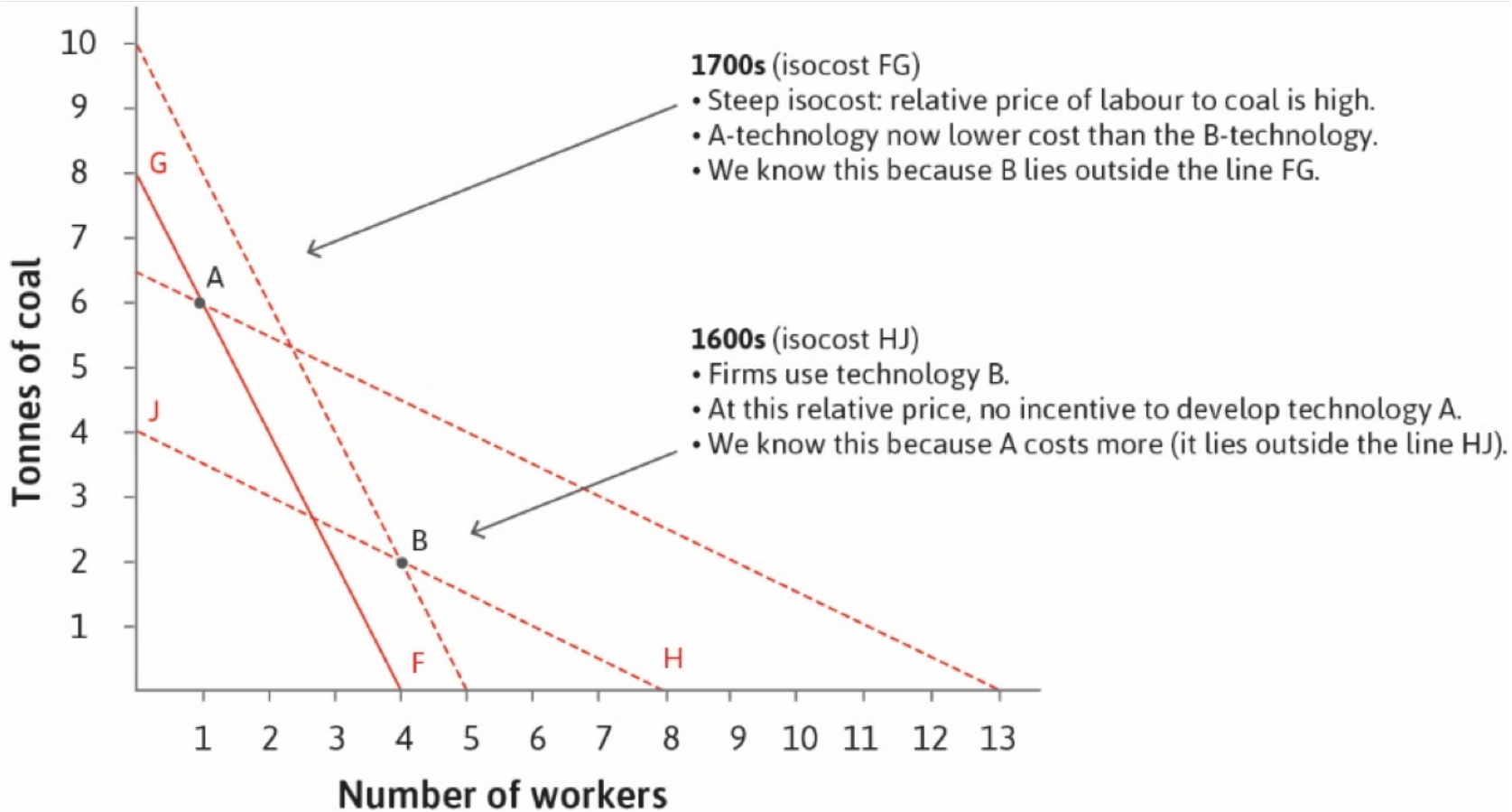
WHY WAS BRITAIN FIRST?

Wages were *higher* in England than in the other countries
Coal was *cheaper* in England than in the other countries



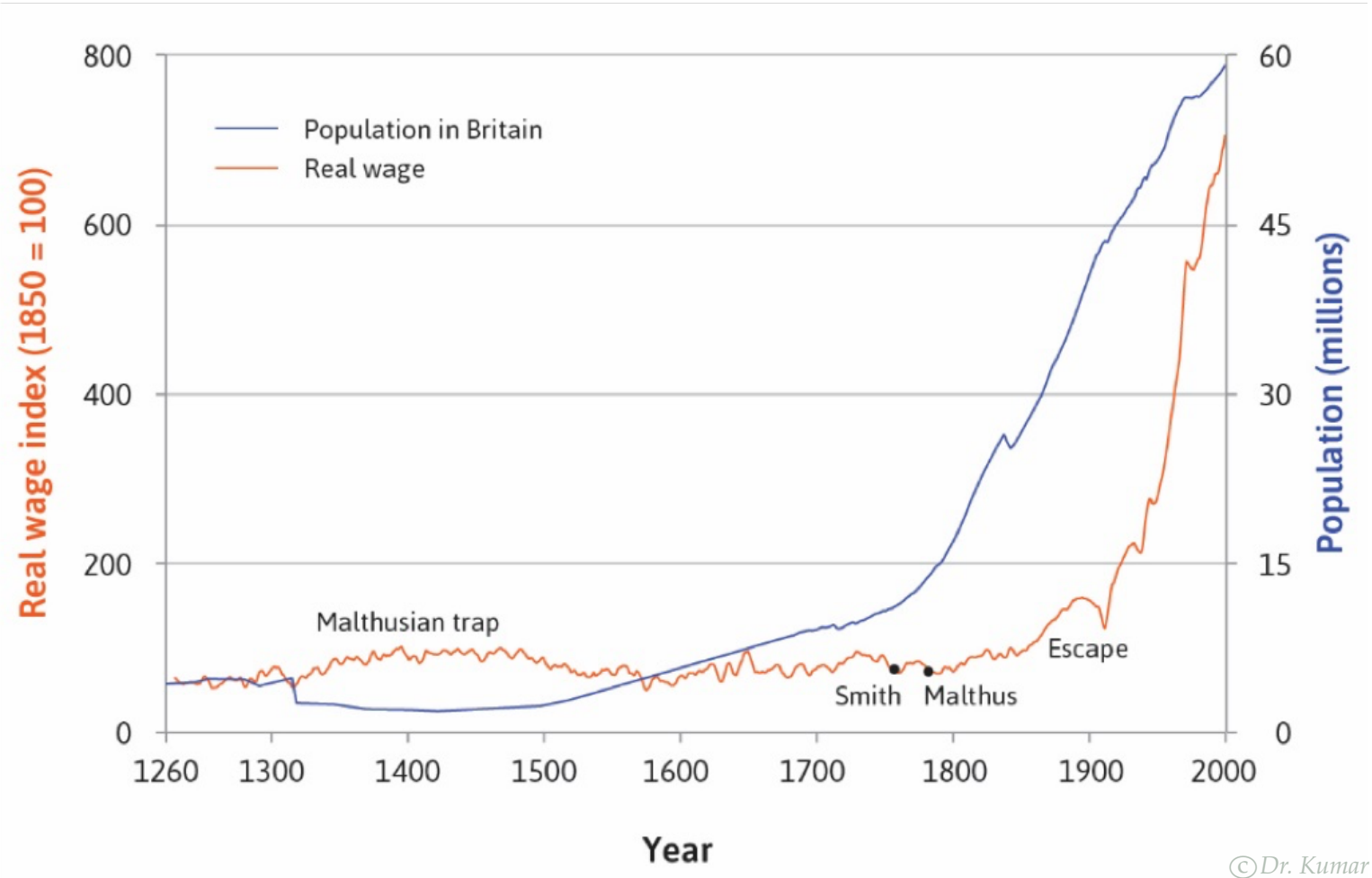
Shift to a lower-cost technology

The combination of capacity to innovate and changing relative prices of inputs led to a switch to energy-intensive technology.



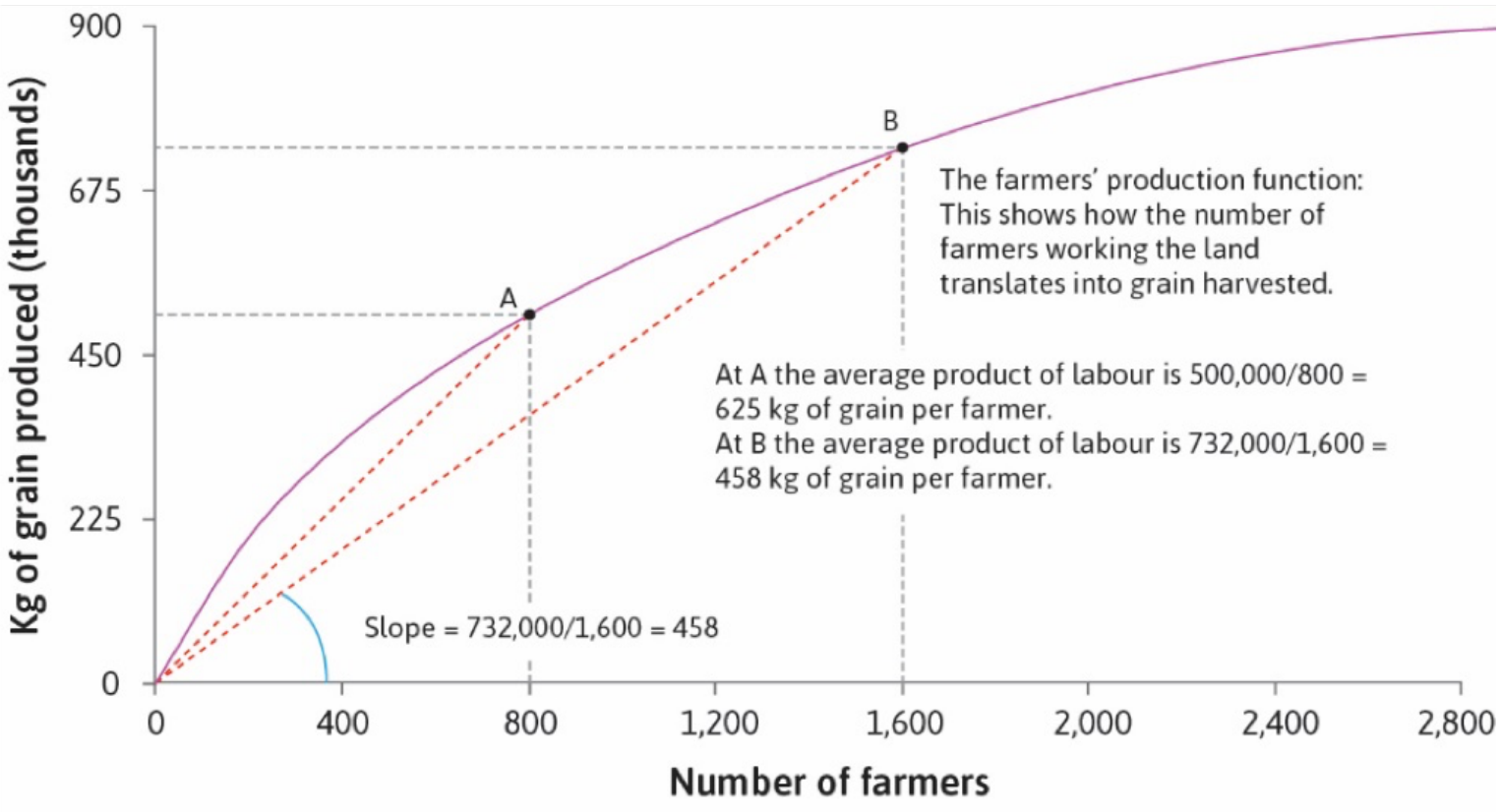
Before the Industrial Revolution

A different model to explain the stagnation in population and living standards before 18th century.



Diminishing average product of labour

Production function gives maximum output for a given set of inputs.



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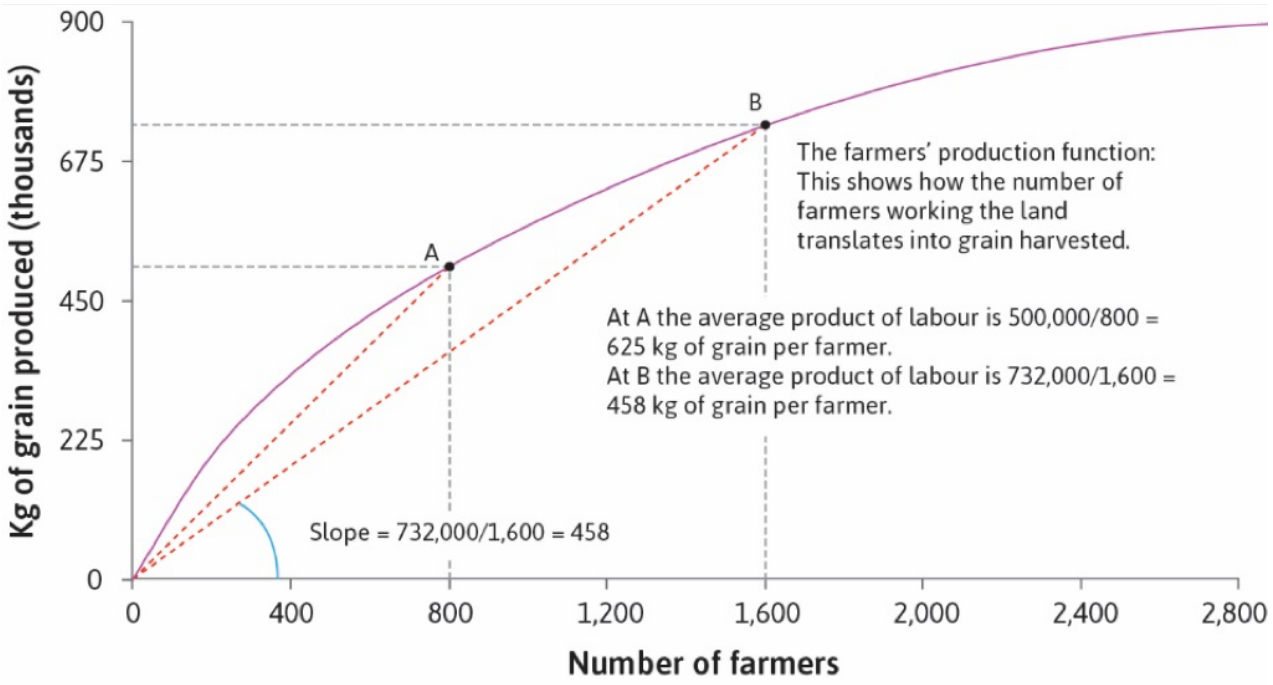


If we keep the available land fixed and increase the numbers of workers used for production, the average output per worker falls

This is the law of *diminishing average product of labour*

Malthus' second channel

Key Concepts

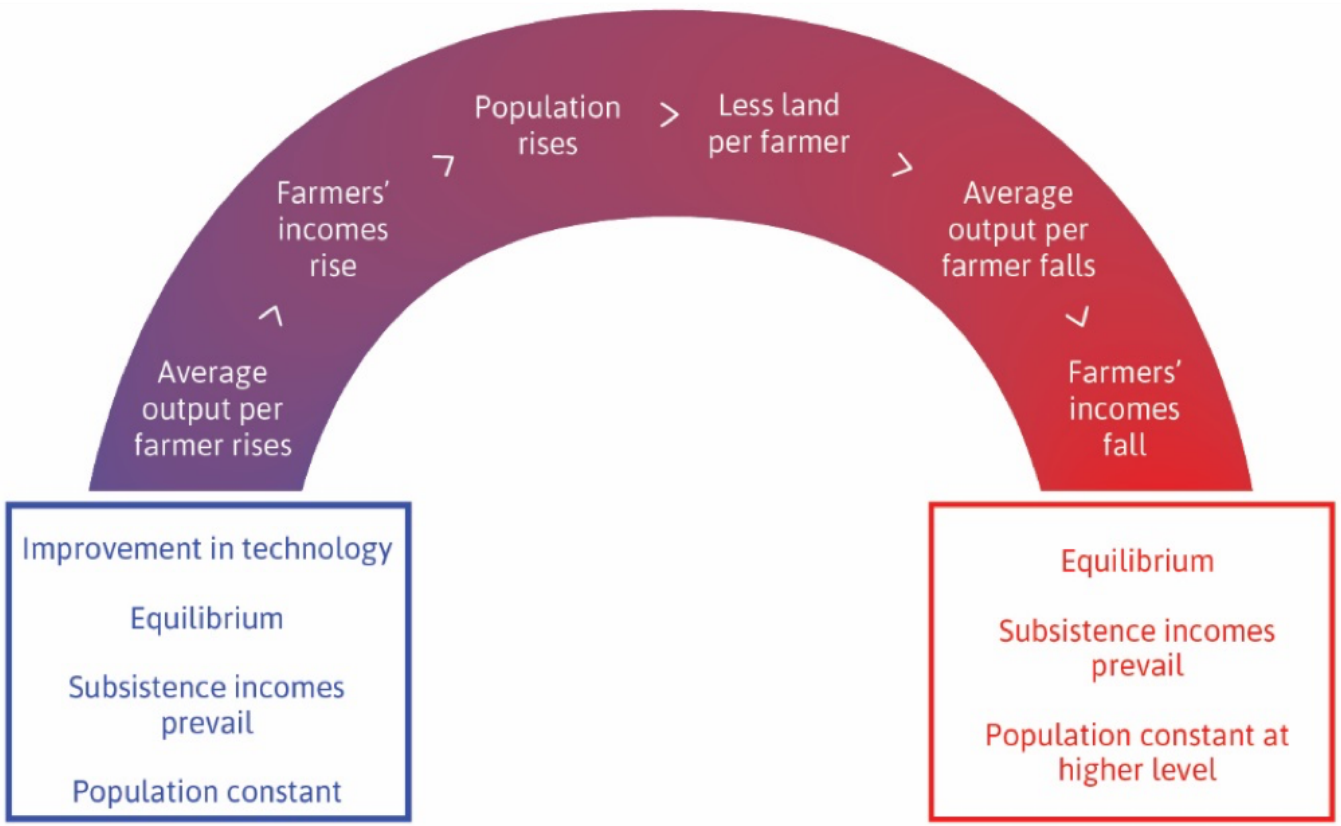
1. Population *expands* if living standards increase
2. But the law of diminishing average product of labour implies that as more workers work on the land, their average output will inevitably *fall*

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

Population and income will stay constant.

The Malthus' Law

Model predicts a self-correcting response to new technology.

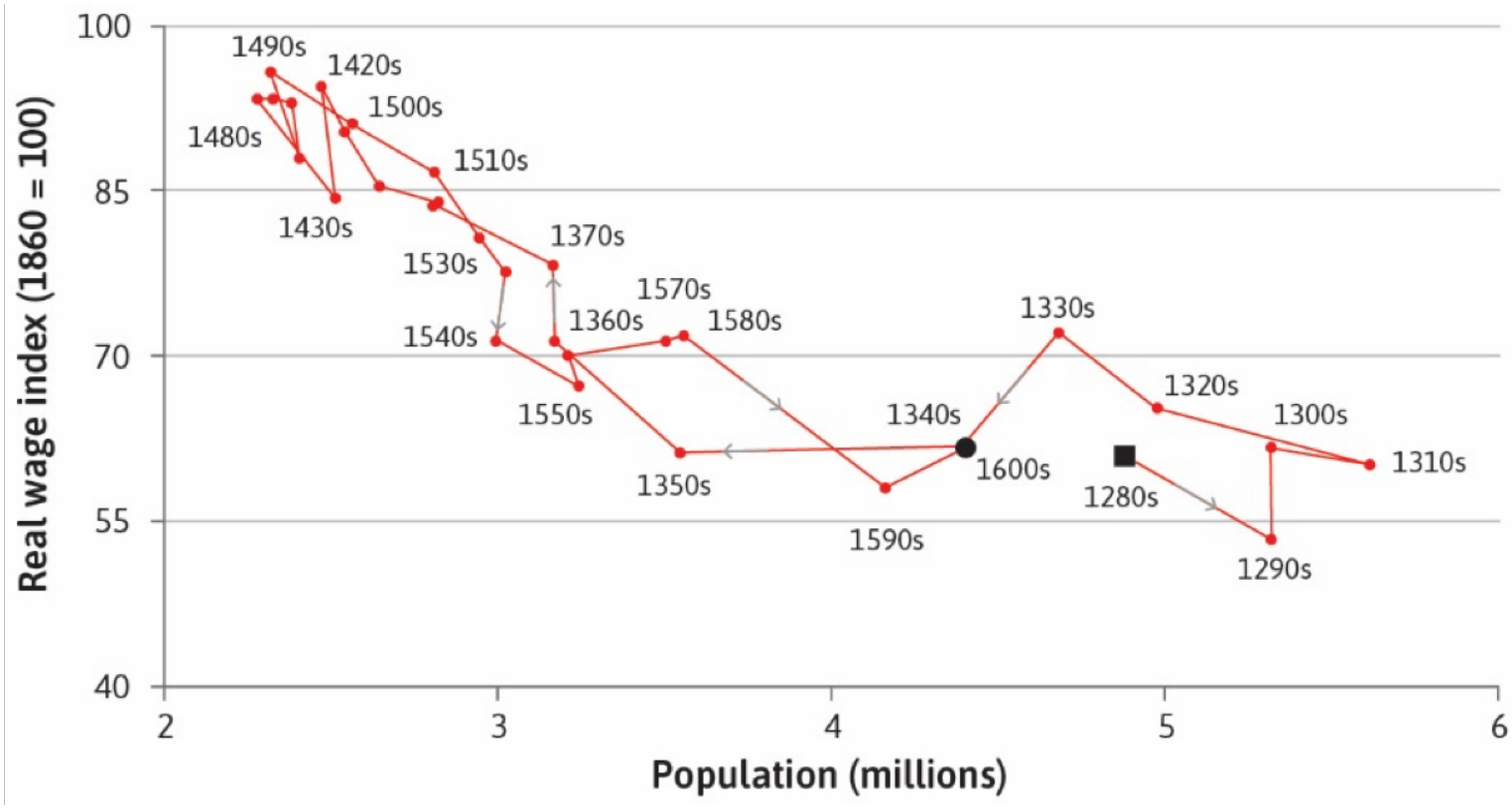


In the long run, an increase in productivity will result in increased population but not increased wages.

Was Malthus correct?

The relationship between real wages and population in England between 1280-1600 show evidence of this "*Malthusian trap*".

But what about the subsequent "*hockey-stick*" growth?



Revising Malthus' Law

Three conditions are required to stay in the Malthusian trap:

1. Diminishing average product of labour
2. Rising population in response to increases in wages
3. *No improvements in technology* to *offset* the *diminishing average product of labour*

Permanent technological revolution

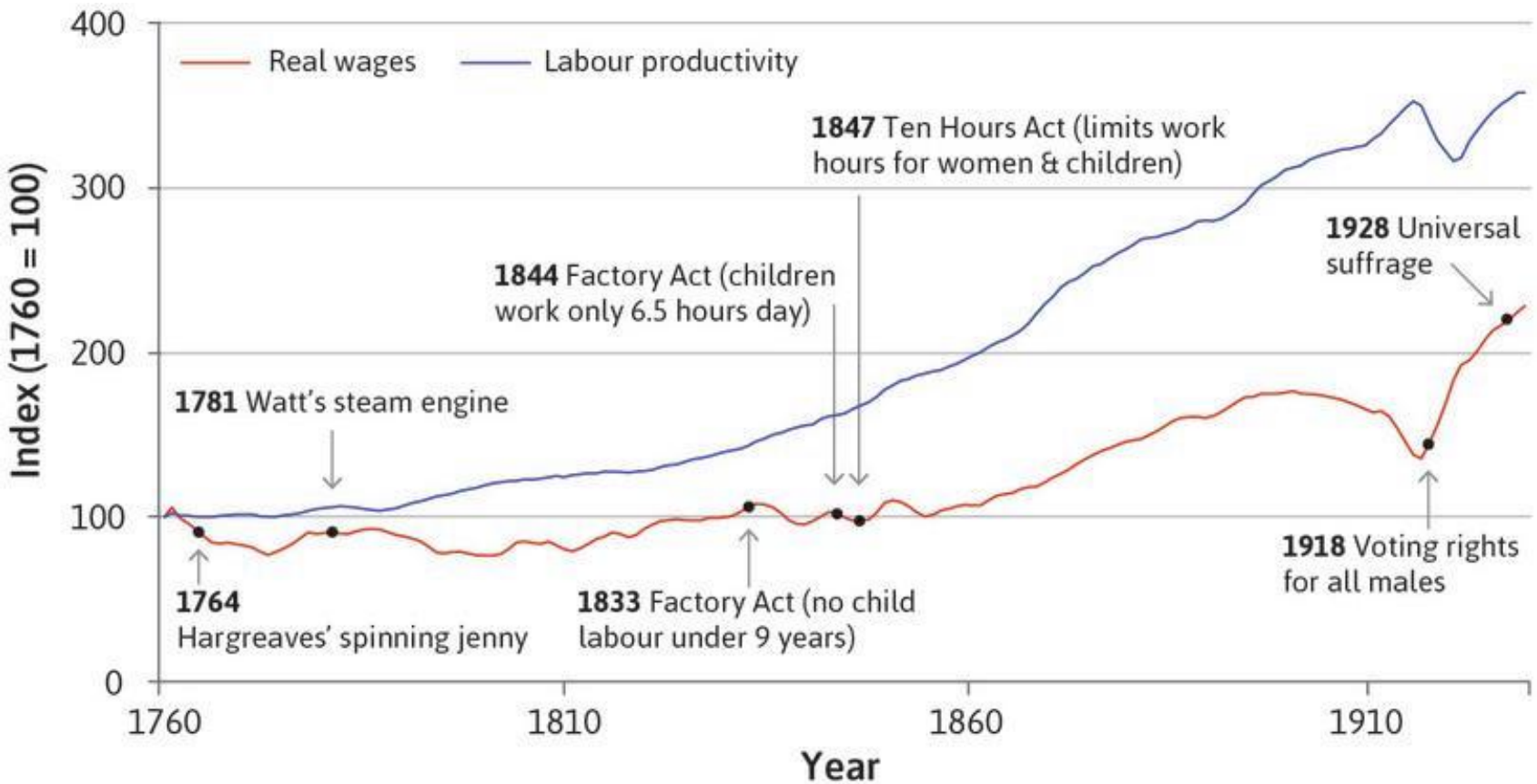
technology progresses at faster rate than population growth

offsets diminishing average product of labour

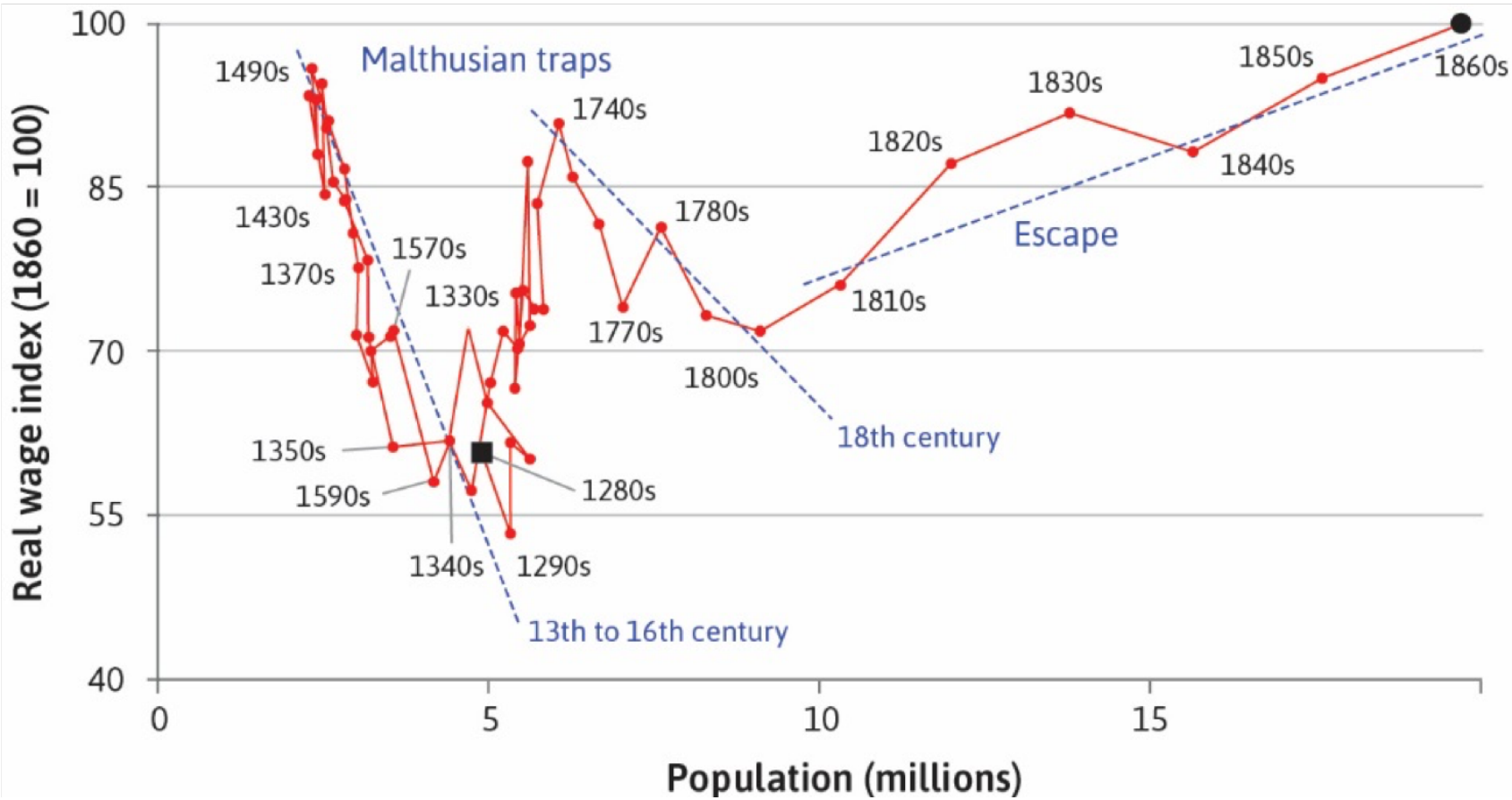
third condition no longer holds and

Explains why Britain was able to escape the Malthusian trap.

Labour Productivity and Real Wage



Escaping the Malthusian trap



Summary

High wages relative to energy prices (coal)

gave the entrepreneurs incentive to innovate,

which lead to the *industrial revolution*

Permanent technological revolution where technology progressed at a rate faster than population growth

it allowed to Britain to escape economic stagnation, i.e., the Malthusian Trap.