

# Announcements

- If you didn't get an email confirmation that I received your referee report, let me know
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- The final required readings are:
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# Explaining Divergence Since the Industrial Revolution

David Landes in *The Wealth and Poverty of Nations*:

*Paradox: the Industrial Revolution brought the world closer together, made it smaller and more homogeneous. But the same revolution fragmented the globe by estranging winners and losers. It begat multiple worlds.*

# Explaining Divergence Since the Industrial Revolution

- The paradox Landes refers to is another big question, just as important as why England had the Industrial Revolution
- The advances of the Industrial Revolution increased the flow of goods and information between countries
- Why did some countries' economies take off and others stay stagnant even though everyone had access to the new technologies and markets?
- This divergence is one of the most striking features of the modern world



# The Great Divergence

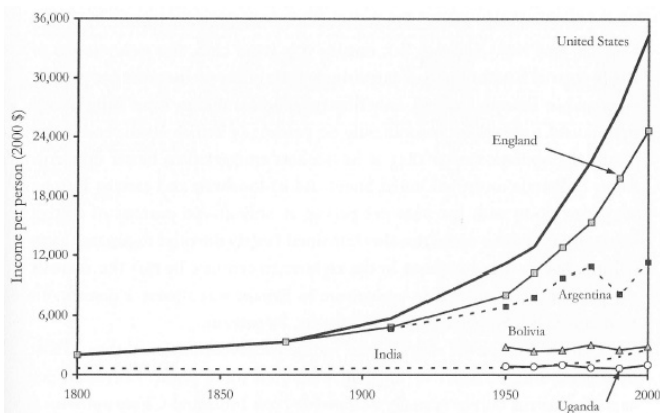


Figure 15.5 Incomes per capita (2000 \$). Data from Prados de la Escosura, 2000 (1910) and Heston et al., 2006 (1950–2000).

# The Great Divergence

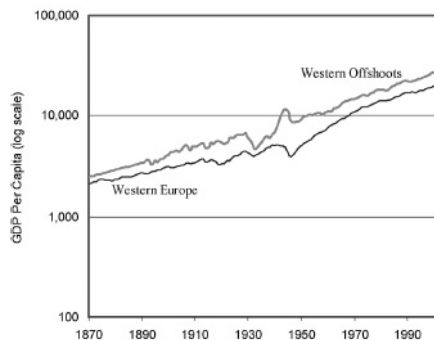


Figure 17. Sustained economic growth: Western Europe and the Western Offshoots, 1870–2001. Source: [Maddison \(2003\)](#).

# The Great Divergence

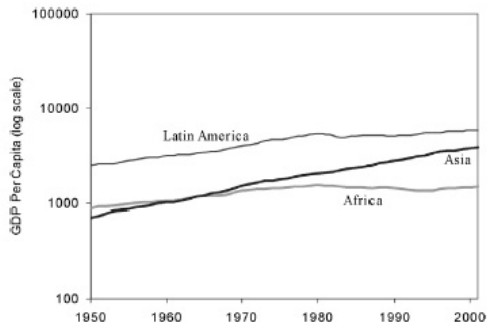


Figure 18. Income per capita in Africa, Asia and Latin America, 1950–2001. Source: [Maddison \(2003\)](#).

# The Diffusion of Technology

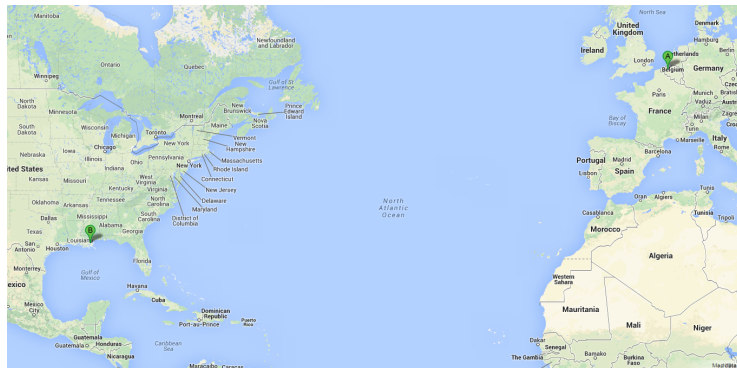
## Time Lags in International Diffusion of Innovations

Country	Cotton Mill (1771)	Watt steam engine (1775)	Steam railway (1825)
Austria	30	42	13
Brazil	75	35	29
France	7	3	7
Germany	13	8	12
India	46	30	28
Mexico	64	43	48
Netherlands	24	10	14
Russia	22	23	11
United States	20	28	5

# Why We Would Expect Globalization

- So other countries were adopting British technology at a rate that would suggest short delay but not a great divergence
- This diffusion of technology would suggest that the whole world could benefit from the same sort of growth as England
- There are a variety of other reasons to think that this sort of globalization into an industrialized world would occur:
  - Technological change: railways, steamships, telegraph, mechanized factories
  - Organizational change: specialized machine-building firms, organization of the factory
  - Political developments: extension of colonial empire

# The Speed of Information



# The Speed of Information



Battle of New Orleans, January 8, 1815

# The Speed of Information



Treaty of Ghent, December 24, 1814



# The Speed of Information

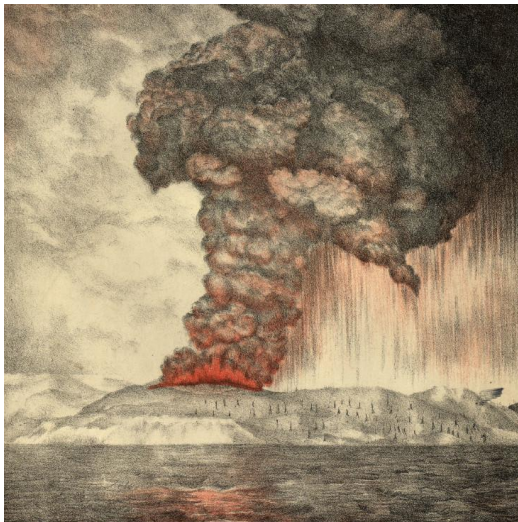
- Flow of information was slightly better at the start of the 19th century than in classical and medieval worlds
- 1844: telegraph is introduced
- 1851: first undersea telegraph cable (between France and England)
- 1866: transatlantic telegraph service
- 1870: India-Britain telegraph service

# The Speed of Information

**Speed of Information Travel**

Event	Year	Distance (miles)	Days	Speed (mph)
Battle of the Nile	1798	2073	62	1.4
Earthquake, Kutch, India	1819	4118	153	1.1
Charge of the Light Brigade	1854	1646	17	4
Treaty of Tien-Sin	1858	5140	82	2.6
Assassination of Lincoln	1865	3674	13	12
Assassination of Alexander II	1881	1309	0.46	119
Nobi Earthquake	1891	5916	1	246

# A Speed of Information Tangent



The 1883 eruption of Krakatoa

# A Speed of Information Tangent

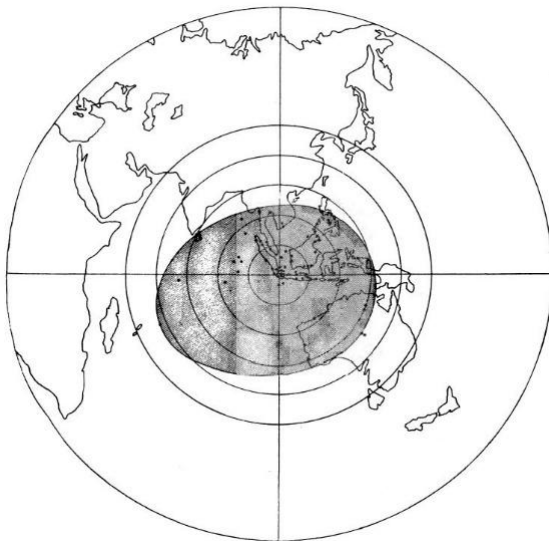
*“So violent are the explosions that the ear-drums  
of over half my ship’s crew have been shattered.  
My last thoughts are with my dear wife. I am  
convinced that the Day of Judgement has come.”  
– Captain of the Norham Castle, 40 miles from  
Krakatoa*

# A Speed of Information Tangent



<https://www.youtube.com/watch?v=BUREX8aFbMs>

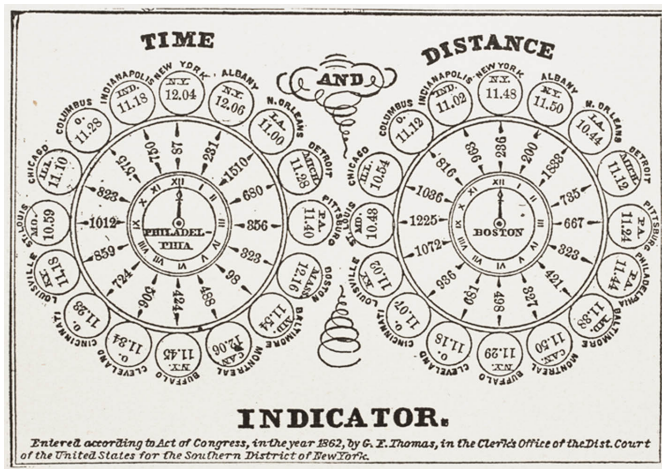
# A Speed of Information Tangent



# A Speed of Information Tangent

- Krakatoa was heard as far away as 3,000 miles (which takes sound about 4 hours at 776 mph)
- Barometers measured spikes in pressure around the globe
- These pressure waves circled the globe three to four times in each direction
- Cities would see the spike from a wave every 34 hours for up to five days

# A Slightly Less Tangential Tangent





# The Cost of Transporting Goods

- Expansion of railroads improved not only communication but also (obviously) goods transportation
- Advances in steam ships greatly improved ocean transport
- Any place with access to a port could get industrial inputs at prices similar to British firms
- British coal was also available through these ports

# Coal Costs

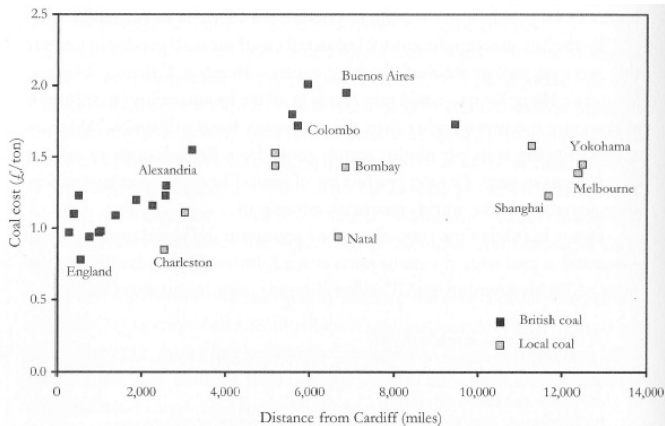
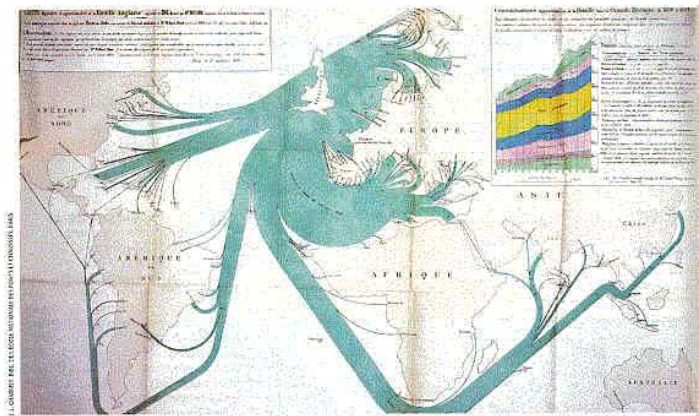


Figure 15.1 Steam coal costs at world ports, 1907. Data from Parliamentary Papers, 1909a.

# Coal Costs



Charles Joseph Minard, British Coal Exports, 1860

# The Mechanized Factory

- With the lowering of transport costs and improved flow of information, it was becoming easier for other countries to adopt British technology
- Machine-building sector arose, so countries could import capital goods from Britain and the United States
- The mechanized factory employed large numbers of unskilled, untrained short-term workers with minimal supervision
- Countries did not need skilled lifetime workers, the ability to produce capital goods, local innovation, or local natural resources to industrialize

# The Machine-Building Sector



Henry Leland

# The Machine-Building Sector



Cadillac's Brooklands trio, 1908

# The Machine-Building Sector

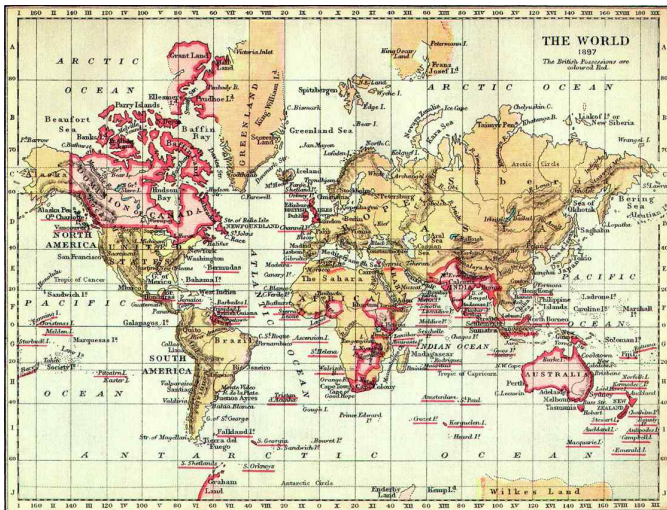


# The Role of Politics

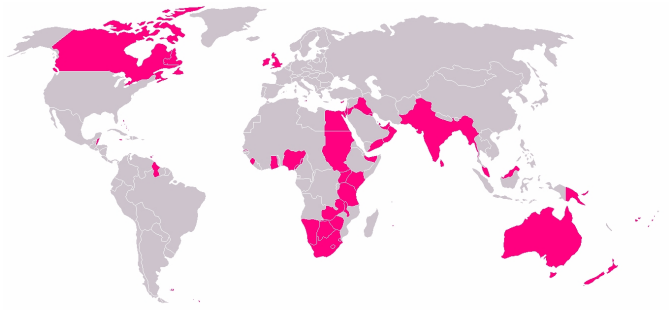
- Globalization may have been aided by the expansion of European colonial territories
- European entrepreneurs could export machinery and techniques to low-wage areas with little risk of expropriation
- Areas within British Empire could trade relatively freely with each other, eliminating concerns of small markets
- Even places not under colonial rule often had trade agreements with European powers
- Britain kept the seas relatively safe for transporting goods



# The British Empire - 1897



# The British Empire - 1921



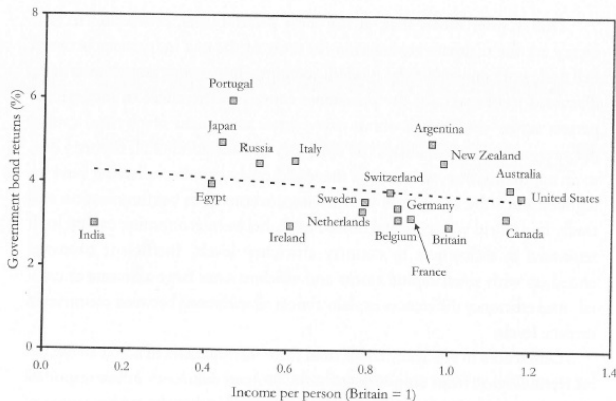
# Why We Would Expect Globalization and Gains for All

- Technology could be adopted fairly easily by other countries, both because of the improved flow of information and the export of capital goods
- Technological change (railways, steamships, telegraph) effectively made the world a smaller place
- The organization of the factory should have given low wage countries an advantage
- Colonial empires facilitated the diffusion of technology and manufactured and also opened up trade
- So why didn't everyone grow rapidly?

# Possible Explanations for Divergence

- We can use our basic framework of land, labor and capital as the main inputs in an economy
- Task is to find differences in the availability or quality of these inputs that may explain divergence
- If major differences don't exist in the availability of these inputs, then the source of divergence may lie in differences in efficiency
- Approach: look for differences in capital per person, land per person and efficiency

# Was it a lack of capital?



**Figure 16.1** Government bond returns, 1900–14. In the absence of national bonds for the United States municipal bonds were used. Egyptian income per person was assumed the same as in the Ottoman Empire. Irish returns were assumed the same as British. Data from table 14.1. Realized returns for India and New Zealand (1870–1913): Edelstein, 1982, 125. Belgium, Britain, Canada, France, Germany, Ireland, Italy, Netherlands, Switzerland, United States: Homer and Sylla, 1996. Argentina, Australia (sterling bonds in London), Egypt, Japan, Portugal, Russia, Sweden: Mauro et al., 2006.

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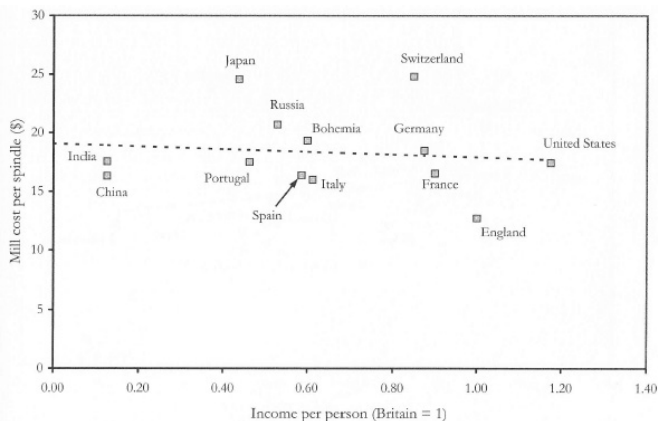


Figure 16.2 Estimated purchase price of capital goods, textile mills, 1910. Data from table 14.1 and Clark, 1987a.

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# Was it a lack of capital?

## **Returns on Capital for British Firms, 1860-1912**

Location of investment	Rate of Return
Britain	5.6
British Empire	6.5
Other foreign countries	5.5

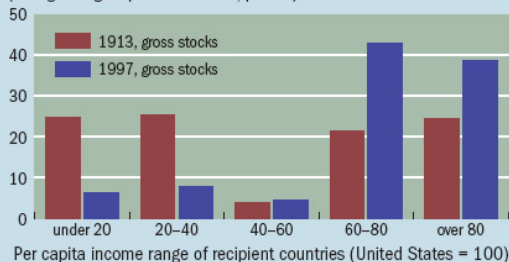
# Was it a lack of capital?

Chart 2

## Who benefits?

Foreign capital used to flow to poor countries, but now flows mostly to rich countries.

(average foreign capital to GDP ratio, percent)

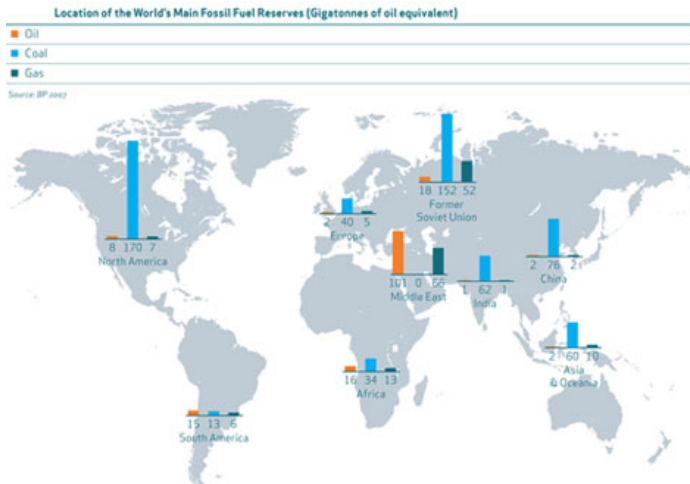


Source: Obstfeld and Taylor, 2004.

# Was it a lack of capital?

- Capital flowed fairly freely around the world
- The returns to capital were comparable across most societies
- There is nothing obvious that prevented people from investing in low income countries
- The cost of capital goods was not prohibitively high in low income countries
- Capital doesn't look like the culprit

# Was it a lack of resources?



# Was it a lack of resources?

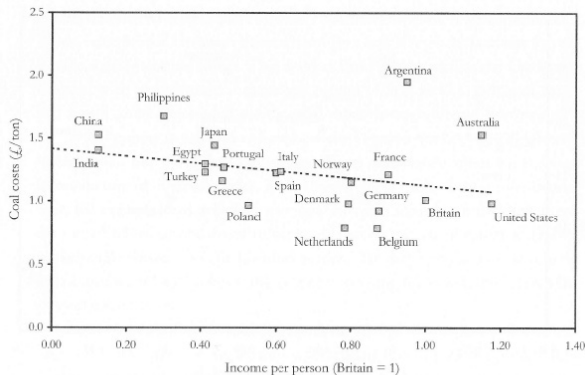


Figure 16.3 Coal costs versus GDP per person, circa 1910. Coal costs from table 16.2 and Clark, 1987a. Incomes from Prados de la Escosura, 2000.

# Was it a lack of resources?

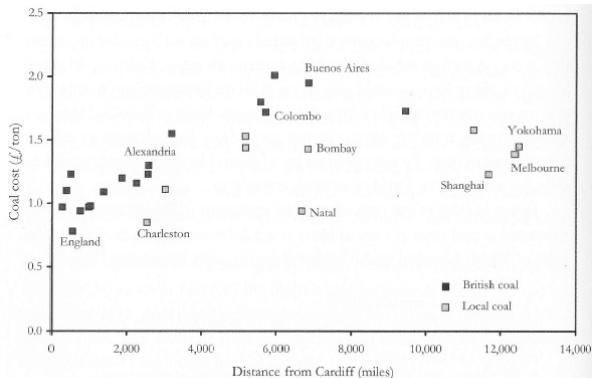


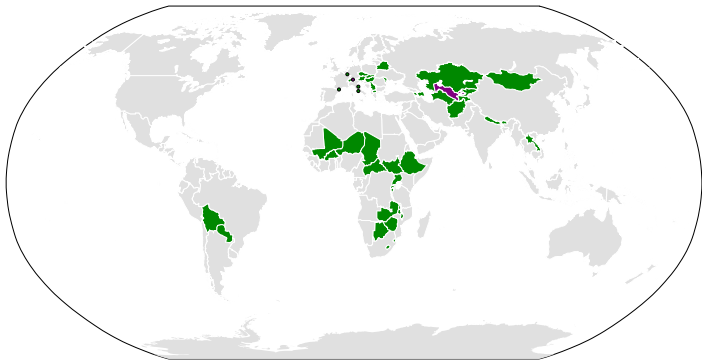
Figure 15.1 Steam coal costs at world ports, 1907. Data from Parliamentary Papers, 1909a.



# Was it a lack of resources?

- The reductions in transportation costs made endowments of natural resources less important
- Coal was a big part of industrialization but coal was being shipped all over the world
- The only countries that would be constrained by resources were those that didn't have ports or railroads linking them to other countries
- Resources don't seem to explain divergence

# Was it a lack of resources?



# Was it differences in efficiency?

- It doesn't look like capital and resources were the sources of divergence
- This leaves us with efficiency
- Efficiency differences can lead to big differences in income per person
- Consider the flow of capital: initial differences in efficiency will lead to differences in capital investment which will reinforce differences in income per person

# Efficiency and Capital Investment

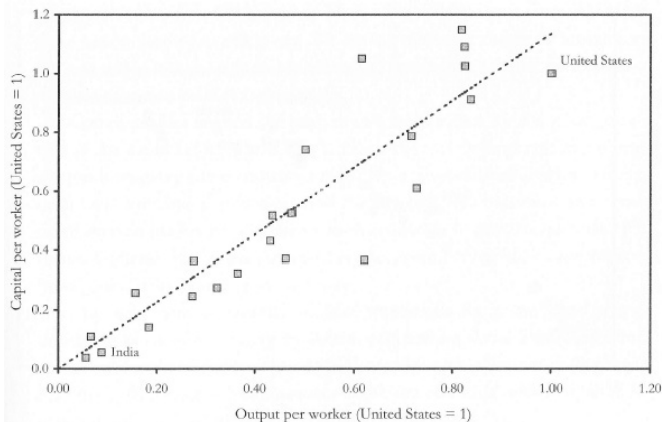


Figure 16.4 Capital per worker versus output per worker, 1990. Data from Penn World Tables, 5.6.

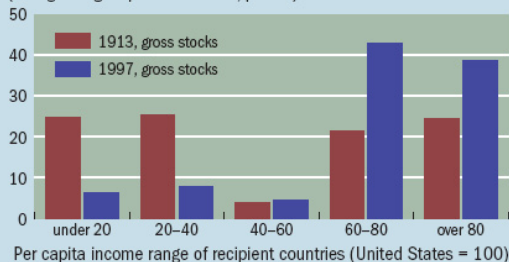
# Efficiency and Capital Investment

Chart 2

## Who benefits?

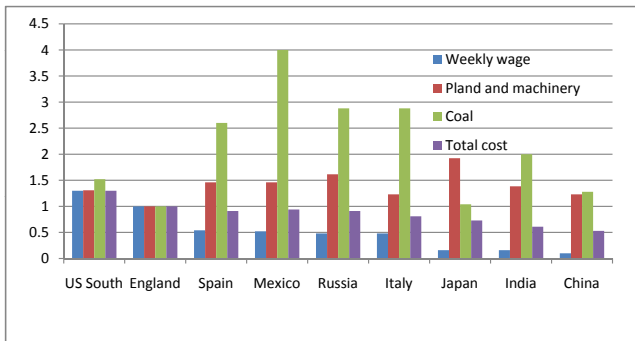
Foreign capital used to flow to poor countries, but now flows mostly to rich countries.

(average foreign capital to GDP ratio, percent)

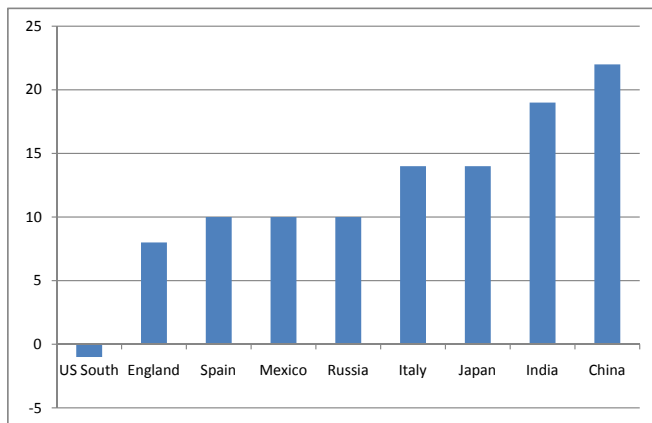


Source: Obstfeld and Taylor, 2004.

# The Costs of Producing Cotton



# Implied Profit Rates in the Cotton Industry



# How big were differences in efficiency?

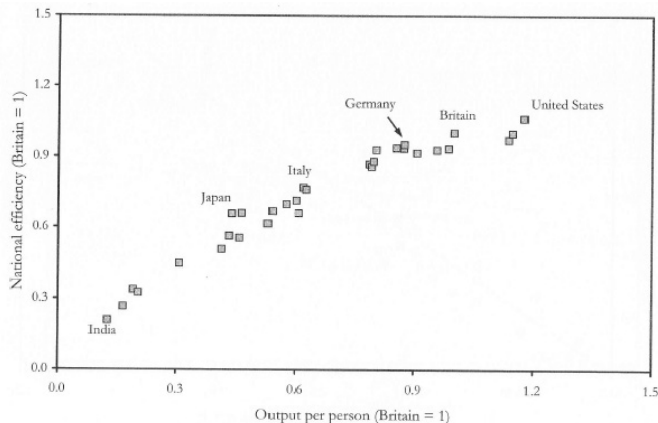


Figure 16.5 Efficiency versus output per worker, 1913.



# Where was inefficiency coming from?

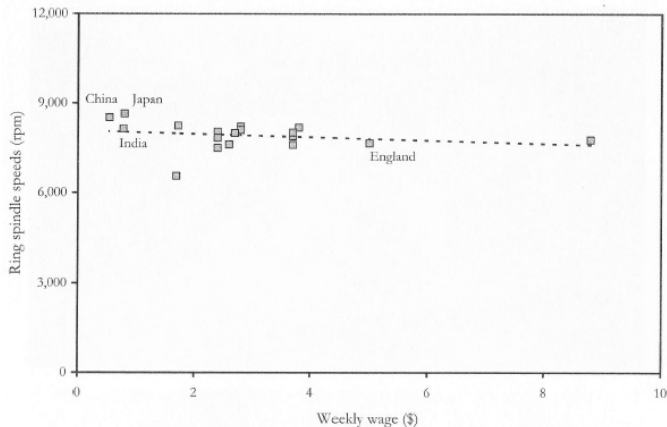


Figure 16.9 Machine outputs and operative wages, 1910.

# Where was inefficiency coming from?

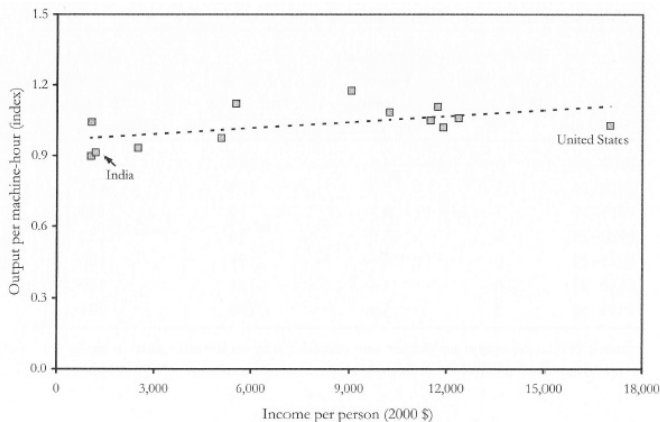


Figure 16.13 Output per cotton textile machine-hour, 1967. Data from Pack, 1987, 140–45.

# Where was inefficiency coming from?

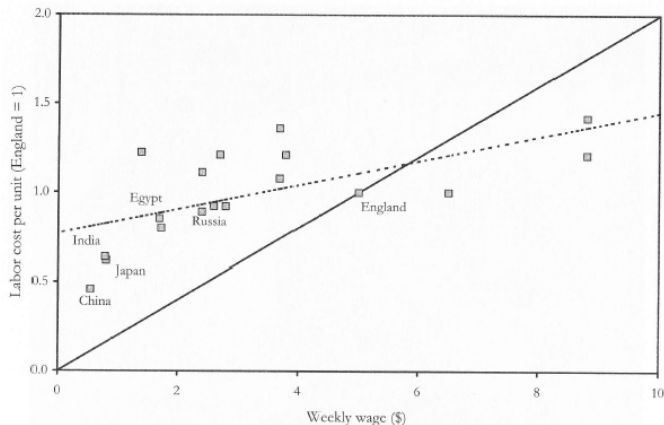


Figure 16.8 Labor costs per unit compared to wage rates, 1910. Data from Clark, 1987a, 152.

# Where was inefficiency coming from?

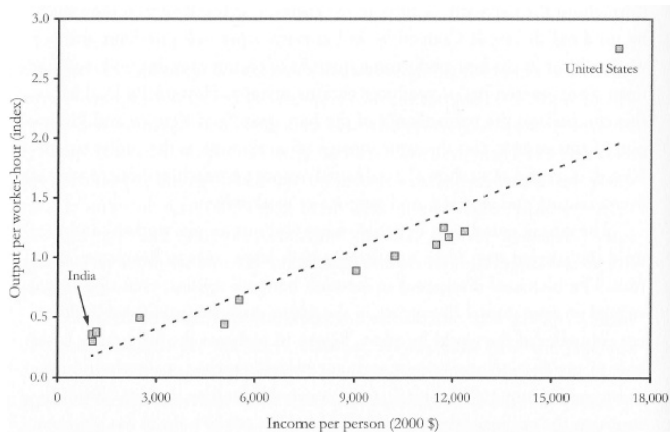


Figure 16.14 Output per cotton textile worker-hour, 1967. Data from Pack, 1987, 140–45.

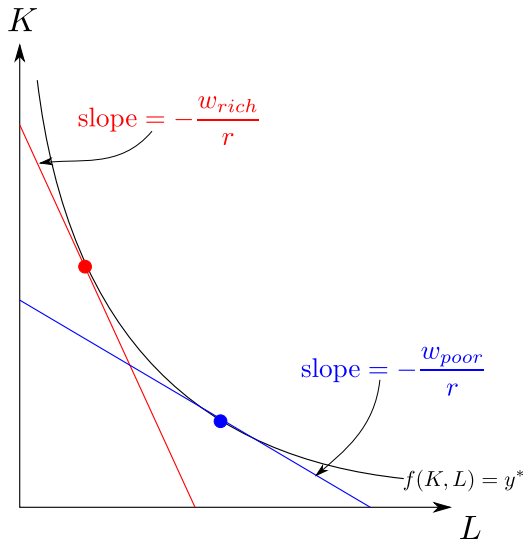
# Where was inefficiency coming from?

- India employed far more labor than Britain for the same production processes
- However, the extra labor didn't seem to improve output
- Output per machine-hour was similar across the countries but more workers were used to staff the machines in India
- This suggests that labor inefficiencies were at the root of the differences between England and India
- The new questions:
  - Why is labor more efficient in some countries than others?
  - Why does this lead to divergence?

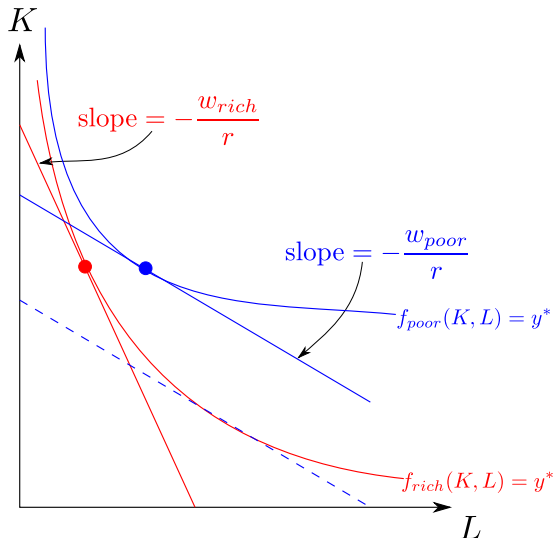
# Two Explanations of Labor Inefficiency

- What we need to explain: India uses similar machines per unit of output but more labor per unit of output
- Two possible explanations:
  - *Poor management plus low wages led to low output per worker:* general inefficiency combined with substituting cheap labor for capital leads to low output per worker
  - *Labor quality is lower in poor countries:* given the same production technology and the same capital, workers are less productive in poor countries than rich countries

# Worker Productivity and the Great Divergence



# Worker Productivity and the Great Divergence





# The Management Explanation

- Capital required per unit of output is driven up by managerial inefficiency
- Capital required per unit of output is driven down by substitution of cheap labor for capital
- Labor required per unit of output is driven up by managerial inefficiency
- Labor required per unit of output is driven up by substitution of cheap labor for capital
- End result is same capital per unit of output across countries but higher labor per unit of output in low-wage countries

# The Worker Quality Explanation

- Much simpler story: worker quality is low meaning each worker produces less all other things being equal
- Was the common view in the 19th century (managerial story is a more modern view)
- Worker quality can differ for a variety of reasons: social norms, wages too low to induce effort, health problems

# Distinguishing Between the Two Explanations

- Both explanations predict the same thing: similar output per machine but big differences in output per worker
- If all we observe are inputs and outputs, we can't distinguish between the two views
- The Indian textile industry provides a wealth of additional information to help distinguish between the two views

# Evidence Against the Bad Management Story

- Britain was exporting managers to Brazil, China, India, Mexico and Russia
- Managers faced major competition which should have forced them to improve efficiency
- Firms in Bombay that reduced worker numbers had profits of 1.7% while firms that did not reduce worker numbers had profits of 2.0%
  - When firms shed workers, they had to increase wages (efficiency wages)
  - Suggests using many workers may not be mismanagement

# Evidence for the Worker Quality Story

- Reports of manufacturers that mill workers were not as productive as English counterparts
- High absentee rates in Indian mills relative to England
- Accounts of undisciplined mills (informal breaks, visits from children and relatives during the work day, etc.)
- Accounts of unattended machines

# Evidence for the Worker Quality Story

*“[The typical worker] washes, bathes, washes his clothes, sokes, shaves, sleeps, has his food, and is surrounded by his relations.” – Quotation from Parliamentary Papers, 1909*

# Evidence for the Worker Quality Story

Absenteeism in Indian Mills, 1955 and 1965

Period	Urban (%)	Rural (%)
Average (1955)	8.0	5.7
Average (1965)	10.6	8.9
First day after wage payment	11.0	6.1
First six days after twice-yearly bonus	12.4	7.7
First day after a holiday	10.5	7.9
Study of 16 South Indian mills, Rudraswamy (1967)		

# Evidence for the Worker Quality Story

## Absenteeism in the United States, 2014

	Full-time wage and salary workers	<u>Absence Rate</u>			<u>Lost worktime rate</u>		
		Total	Illness or injury	Other reasons	Total	Illness or injury	Other reasons
<u>Total</u>							
16 to 19 years	1124	3.3	2.3	1	1.3	0.7	0.5
20 to 24 years	8447	3	2	1	1.3	0.8	0.5
25 to 54 years	75630	2.8	1.8	1	1.4	0.9	0.5
55 years and over	21218	3.5	2.8	0.7	1.9	1.6	0.3
<u>Males</u>							
16 to 19 years	692	2.5	1.7	0.8	0.9	0.5	0.4
20 to 24 years	4788	2.2	1.7	0.5	0.9	0.7	0.2
25 to 54 years	42383	2	1.5	0.5	1	0.8	0.2
55 years and over	11559	3.1	2.5	0.6	1.6	1.4	0.2
<u>Females</u>							
16 to 19 years	432	4.6	3.2	1.5	1.8	1.1	0.8
20 to 24 years	3658	3.9	2.3	1.6	1.9	0.9	1
25 to 54 years	33247	3.7	2.3	1.5	2	1.1	0.9
55 years and over	9658	4.1	3.1	0.9	2.2	1.8	0.4

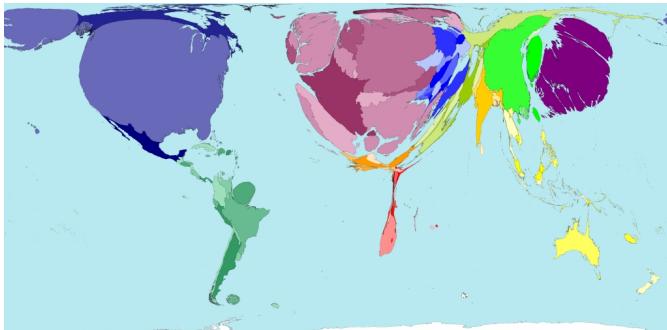
Source: [http://www.bls.gov/cps/cpsaat46.htm#cps\\_eeann\\_abs\\_ft.f.1](http://www.bls.gov/cps/cpsaat46.htm#cps_eeann_abs_ft.f.1)



# Is it really just that some countries are lazy?

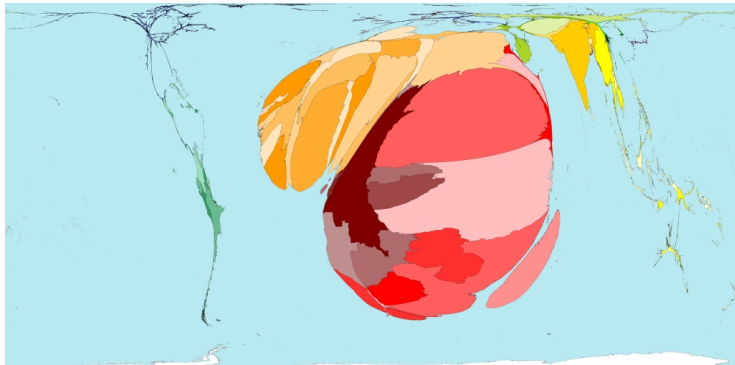
- Social norms may have something to do with labor inefficiency
- Efficiency wages should help with this to some extent
- A much bigger issue may be worker health
- Childhood disease can have long term effects on productivity through hindering physical and cognitive development and as well as human capital investment
- Poor worker health will directly impact productivity (think of how productive you are when you have the flu)

# Public Health Spending Around the World



*Territory size shows the proportion of worldwide spending on public health services spent in that territory. Spending is adjusted for purchasing power parity.*

# Malaria Cases Around the World

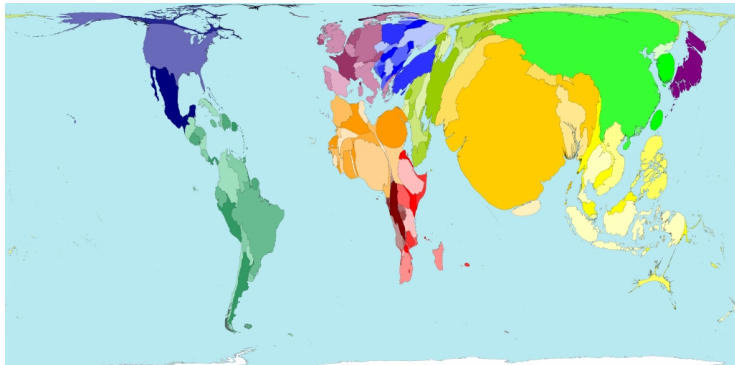


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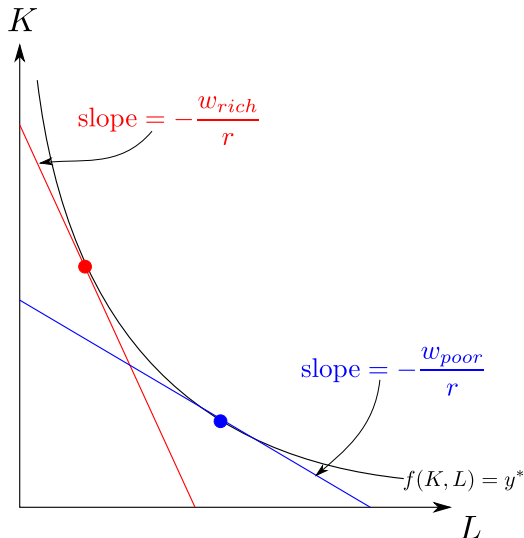
The common symptoms of malaria according to WebMD:

- Fever
- Chills
- Headache
- Sweats
- Fatigue
- Nausea and vomiting
- Muscle or back pain

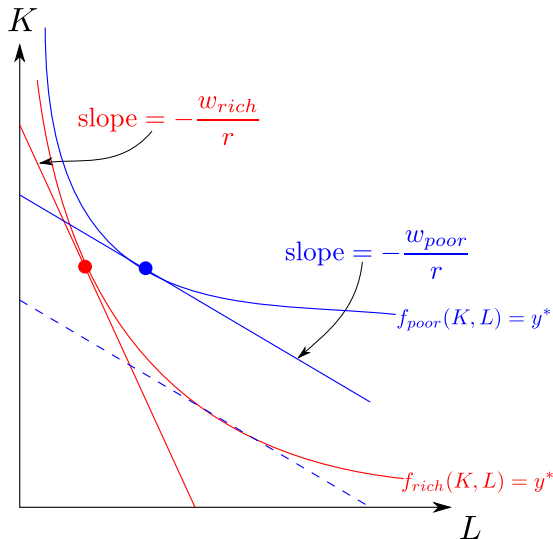
# Years Spent in Poor Health



# Worker Productivity and the Great Divergence



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- Accounts of unattended machines

# Evidence for the Worker Quality Story

*“[The typical worker] washes, bathes, washes his clothes, sokes, shaves, sleeps, has his food, and is surrounded by his relations.” – Quotation from Parliamentary Papers, 1909*

# Evidence for the Worker Quality Story

Absenteeism in Indian Mills, 1955 and 1965

Period	Urban (%)	Rural (%)
Average (1955)	8.0	5.7
Average (1965)	10.6	8.9
First day after wage payment	11.0	6.1
First six days after twice-yearly bonus	12.4	7.7
First day after a holiday	10.5	7.9
Study of 16 South Indian mills, Rudraswamy (1967)		

# Evidence for the Worker Quality Story

## Absenteeism in the United States, 2014

	Full-time wage and salary workers	<u>Absence Rate</u>			<u>Lost worktime rate</u>		
		Total	Illness or injury	Other reasons	Total	Illness or injury	Other reasons
<u>Total</u>							
16 to 19 years	1124	3.3	2.3	1	1.3	0.7	0.5
20 to 24 years	8447	3	2	1	1.3	0.8	0.5
25 to 54 years	75630	2.8	1.8	1	1.4	0.9	0.5
55 years and over	21218	3.5	2.8	0.7	1.9	1.6	0.3
<u>Males</u>							
16 to 19 years	692	2.5	1.7	0.8	0.9	0.5	0.4
20 to 24 years	4788	2.2	1.7	0.5	0.9	0.7	0.2
25 to 54 years	42383	2	1.5	0.5	1	0.8	0.2
55 years and over	11559	3.1	2.5	0.6	1.6	1.4	0.2
<u>Females</u>							
16 to 19 years	432	4.6	3.2	1.5	1.8	1.1	0.8
20 to 24 years	3658	3.9	2.3	1.6	1.9	0.9	1
25 to 54 years	33247	3.7	2.3	1.5	2	1.1	0.9
55 years and over	9658	4.1	3.1	0.9	2.2	1.8	0.4

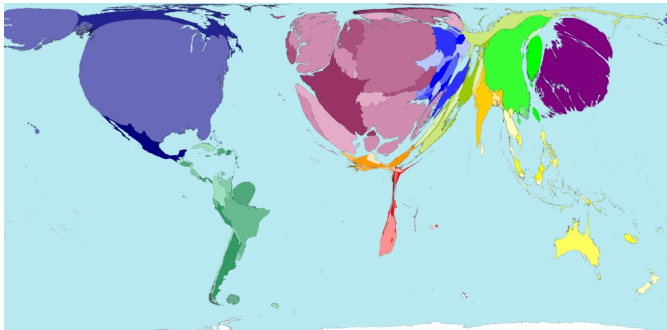
Source: [http://www.bls.gov/cps/cpsaat46.htm#cps\\_eeann\\_abs\\_ft.f.1](http://www.bls.gov/cps/cpsaat46.htm#cps_eeann_abs_ft.f.1)

# Is it really just that some countries are lazy?

- Social norms may have something to do with labor inefficiency
- Efficiency wages should help with this to some extent
- A much bigger issue may be worker health
- Childhood disease can have long term effects on productivity through hindering physical and cognitive development and as well as human capital investment
- Poor worker health will directly impact productivity (think of how productive you are when you have the flu)

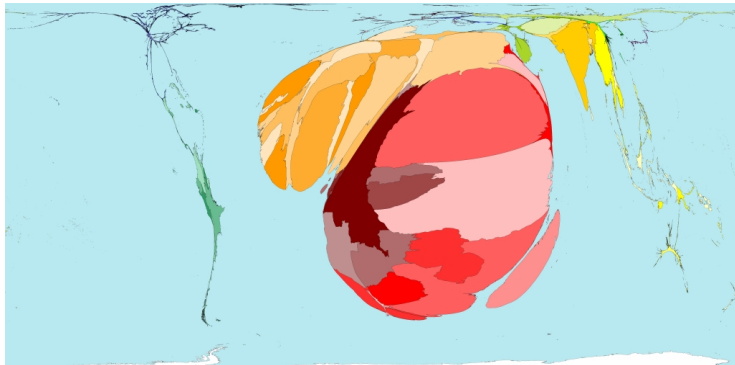


# Public Health Spending Around the World



*Territory size shows the proportion of worldwide spending on public health services spent in that territory. Spending is adjusted for purchasing power parity.*

# Malaria Cases Around the World

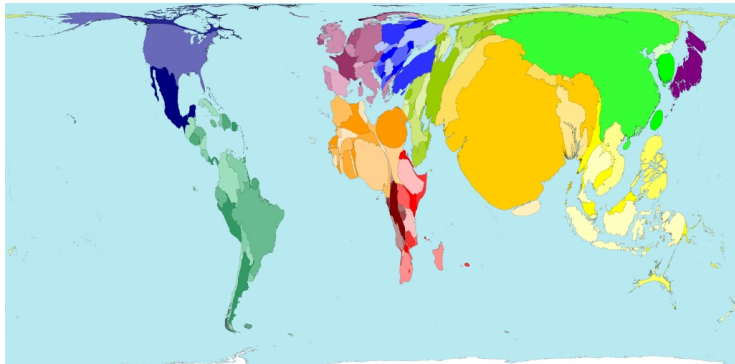


# Malaria Cases Around the World

The common symptoms of malaria according to WebMD:

- Fever
- Chills
- Headache
- Sweats
- Fatigue
- Nausea and vomiting
- Muscle or back pain

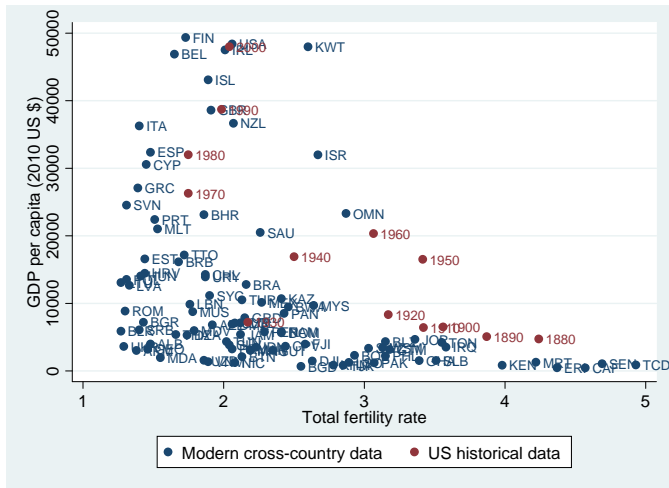
# Years Spent in Poor Health



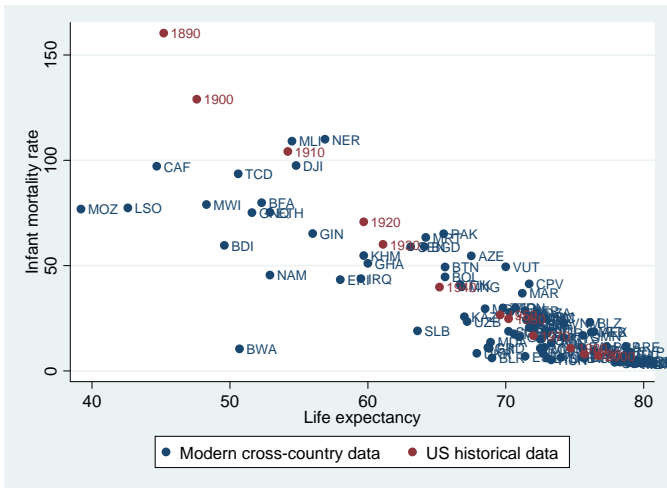
# Some Empirical Tests of Worker Health

- The historical experience of the United States provides some direct evidence of the importance of worker health
- Why look at the US for empirical evidence of a developing country story?
  - Excellent data
  - Good range of health experiences
  - Potential natural experiments
  - Natural laboratory conditions look a lot like those of developing countries

# The US as a Case Study

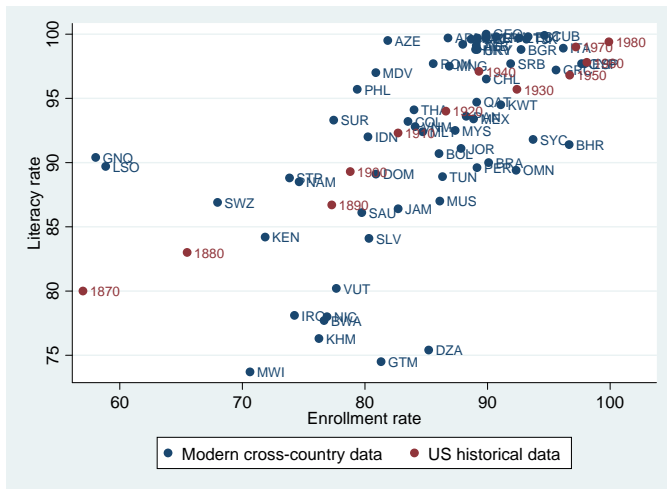


# The US as a Case Study



## Infant mortality rates and life expectancy by country for 2010 and by decade for the US

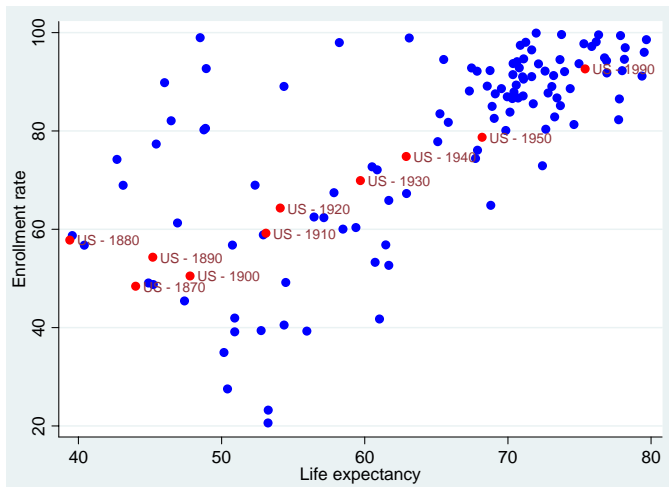
# The US as a Case Study



Literacy rates and enrollment rates by country for 2010 and by decade for the US

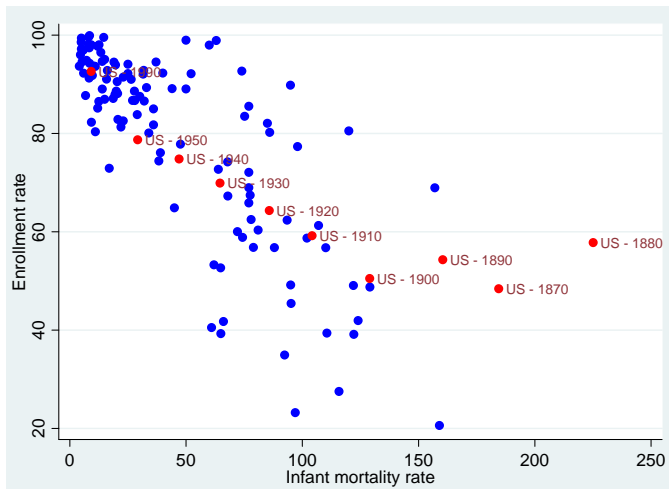


# The US as a Case Study



School enrollment rates and life expectancy by country for the year 2000 (blue points) and by decade for the US (red points)

# The US as a Case Study



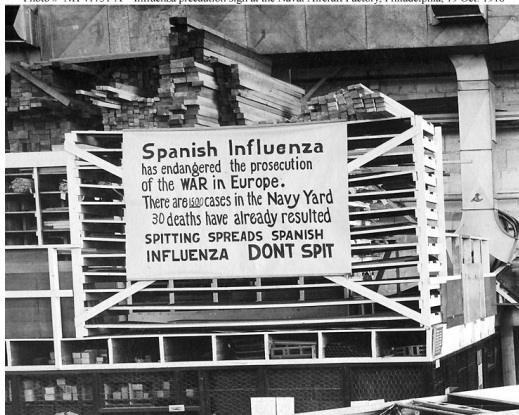
School enrollment rates and infant mortality rates by country for the year 2000 (blue points) and by decade for the US (red points)

# Some Empirical Tests of Worker Health

- The US at the start of the twentieth century can tell us about developing countries today
- The health issues facing the US then are of the same magnitude as the problems facing modern developing nations
- Schooling levels are comparable
- The US still had a large share of its population in rural areas
- We're going to look at two historical events in the US: the influenza pandemic and the eradication of hookworm

# Almond and the Influenza Pandemic

Photo # NH 41731-A Influenza precaution sign at the Naval Aircraft Factory, Philadelphia, 19 Oct. 1918

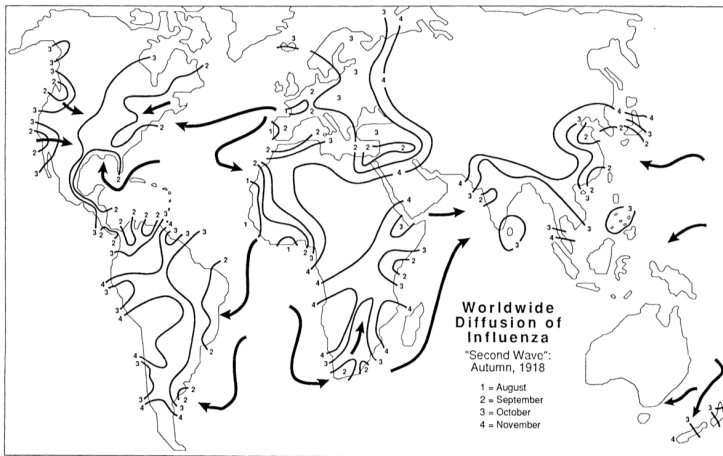


**Spanish Influenza**  
has endangered the prosecution  
of the WAR in Europe.  
There are 1500 cases in the Navy Yard  
30 deaths have already resulted  
**SPITTING SPREADS SPANISH  
INFLUENZA DONT SPIT**

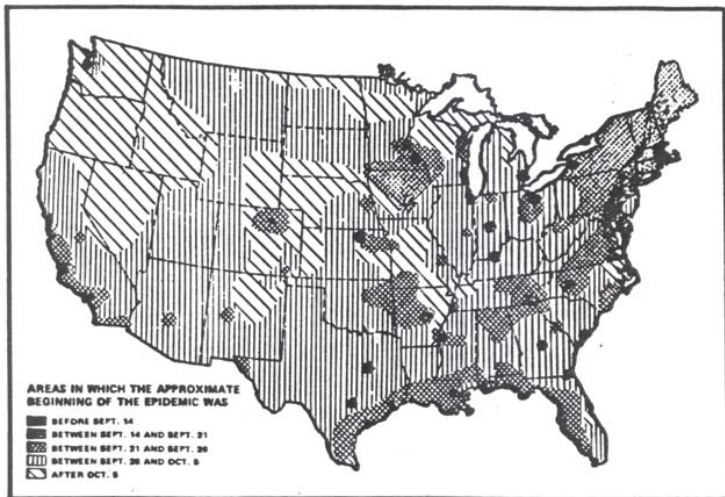
# Almond and the Influenza Pandemic

- The influenza pandemic in 1918 was widespread and deadly
- A unique feature was that it targeted young adults allowing for a sort of natural experiment
- Almond tests the effects of poor in utero health on later life outcomes by identifying individuals in utero during the pandemic
- He can track the effects on educational attainment, occupational outcomes, and physical disability

# Almond and the Influenza Pandemic



# Almond and the Influenza Pandemic

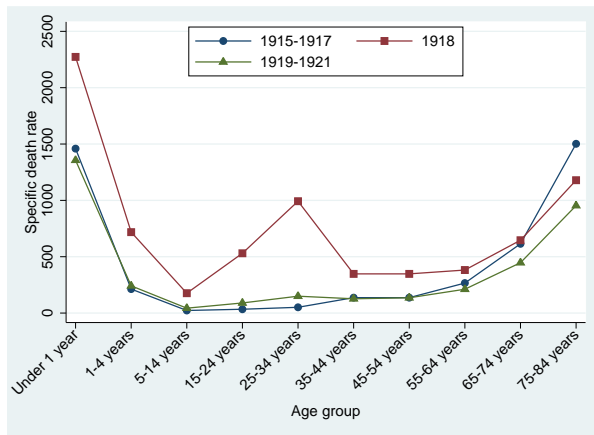


# Almond and the Influenza Pandemic





# Almond and the Influenza Pandemic



# Almond and the Influenza Pandemic

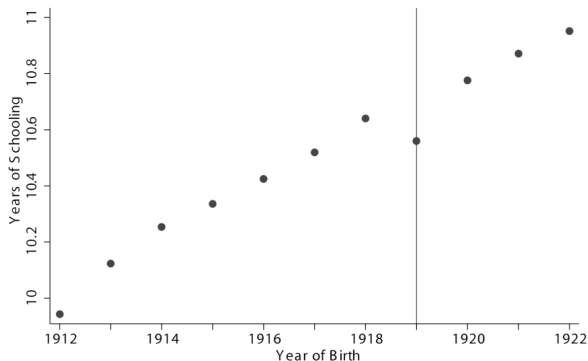


FIG. 3.—1960 average years of schooling: men and women born in the United States

# Almond and the Influenza Pandemic

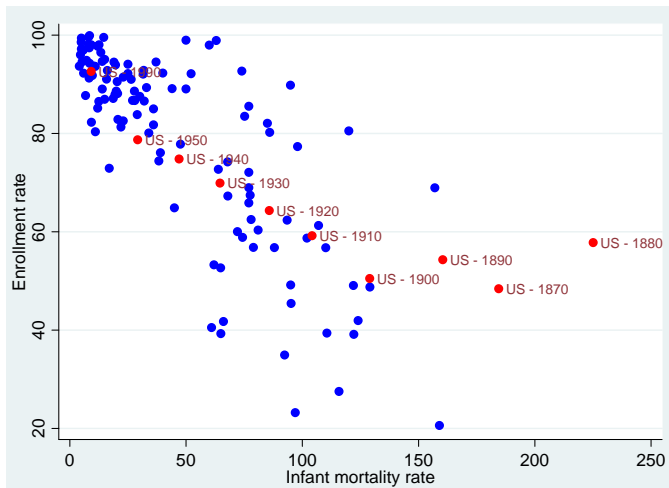


FIG. 7.—1980 male disability rate: physical disability limits work

# Almond and Influenza Pandemic

- The influenza pandemic gives us a chance to isolate the impacts of in utero health on later life outcomes
- The surrounding cohorts all face similar general conditions, allowing us to control for all of the other aspects of an economy correlated with average health outcomes
- What Almond finds is that a health shock in utero has major consequences for long term worker productivity
- It led to lower educational attainment and greater rates of disability, both of which will mean less productive workers
- Remember the general context

# Almond and the Influenza Pandemic



School enrollment rates and infant mortality rates by country for the year 2000 (blue points) and by decade for the US (red points)

# Bleakley and Hookworm in the South

- There is a limitation (which is also an advantage) to Almond's influenza study
- Almond is looking at a cohort that has particularly poor health relative to the rest of the population
- That gives us a good sense of what happens to one worker's productivity when they're sick
- However, it is a different story if the majority of workers are in poor health
- This could lead to broadly different educational institutions and labor markets
- Hookworm in the South will give us a chance to see what happens when you improve the health of all children

# Bleakley and Hookworm in the South

- Bleakley is going to consider more of a permanent shift in health and economic performance
- His focus of study is the eradication of hookworm in the U.S. South
- Hookworm is a parasite that is transmitted through contact with infected fecal matter
- Hookworm is not really deadly, but it does sap your energy
- An eradication campaign began in the South in the 1910s

# Bleakley and Hookworm in the South

**YOU  
MUST READ  
THIS.**

---

THE STATE OF NORTH CAROLINA AND THE COUNTY OF HALIFAX.

Will give everybody in Halifax County for a limited time only, an opportunity to be treated free by a State Specialist for the Hook-Worm Disease or other disease due to intestinal parasites. Examination, treatment, Medicines and all Furnished Absolutely Free. Nearly one-half the people, both old and young have this disease, that is why the State and the County is giving you this chance to be cured. Remember it is for a limited time only as at the end of Four Weeks these Free Medical Dispensaries will be moved to another County.

---

At the Following Points and on the Following Dates you will find the Dispensaries open:

ENFIELD, July the 21st, 28th, August the 4th and 11th, TOWN HALL.  
ROANOKE RAPIDS, July the 22nd, 29th, August the 5th and 12th, GRADED SCHOOL BUILDING.  
WELDON, July the 25th, August the 1st, 8th and 15th, GRADED SCHOOL BUILDING.  
LITTLETON, July the 26th, August the 2nd, 9th and 16th, ACADEMY BUILDING.  
SCOTLAND NECK, July the 27th, August the 3rd, 10th and 17th, OPERA HOUSE.

---

Take advantage of this great opportunity. Come to the Dispensaries on the opening day. Bring your wives and children with you, be examined and see if you have any of these diseases. If you have the medicines they will give will cure every case and bring about a wonderful change in your feelings. All this without any cost to you whatever. Dr. Covington, assisted by a State Laboratory man, will be in charge at each dispensary. Come and have the Doctor show you the Hook-worms and their eggs under the microscope.



# Bleakley and Hookworm in the South



# Bleakley and Hookworm in the South

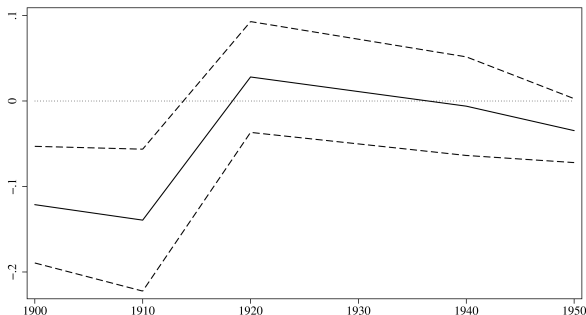


FIGURE II

## Hookworm Eradication and School Attendance, 1900–1950

The y axis plots the year-specific coefficients on the circa-1913 hookworm-infection rate (solid line), plus the RSC-confidence intervals (dashed lines). The x axis is the Census year. The sample consists of all native-born white and black children in the IPUMS between the ages of 8 and 16 in the RSC-surveyed geographic units for 1900, 1910, 1920, 1940, and 1950. For each year, the coefficients are estimated in a regression of a school-attendance dummy on preintervention hookworm infection and demographic controls. Confidence intervals are constructed using standard errors that are clustered on SEA.

# Bleakley and Hookworm in the South

*"...the treatment of these children had transformed the school. Children who were listless and dull are now active and alert; children who could not study a year ago are not only studying now, but are finding joy in learning." – 1915 report from a Tidewater-Virginia community*

# Bleakley and Hookworm in the South

*"As a result of your treatment for hookworm in our school...we have here in our school-rooms today about 120 bright, rosy-faced children, whereas had you not been sent here to treat them we would have had that many pale-faced, stupid children." – 1912 letter from Varnado, LA school board*

# Bleakley and Hookworm in the South

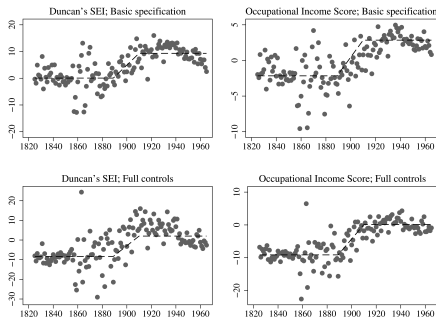


FIGURE III

## Cohort-Specific Relationship Between Income and Pre-Eradication Hookworm

These graphics summarize regressions of income proxies on pre-eradication hookworm-infection rates by state of birth. The y axis for each graphic plots the estimated cohort-specific coefficients on the state-level hookworm measure. The x axis is the cohort's year of birth. Each year-of-birth cohort's point estimate is marked with a dot. The dashed lines measure the number of years of potential childhood exposure to the Rockefeller Sanitary Commission's activities. For the undertaking regressions, the dependent variables are constructed from the indicated income proxies (the Duncan Socioeconomic Indicator and the Occupational Income Score). For each year-of-birth cohort, OLS regression coefficients are estimated on the cross section of incomes by state of birth. In the basic specification, this state-of-birth average income is regressed onto hookworm infection, Lebergott's measure of 1809 wage levels, and regional dummies. The "full controls" specification contains in addition the various controls variables described in the Appendix. The regressions are estimated using weight equal to the square root of the cell size in the underlying microdata.

# Bleakley and Hookworm in the South

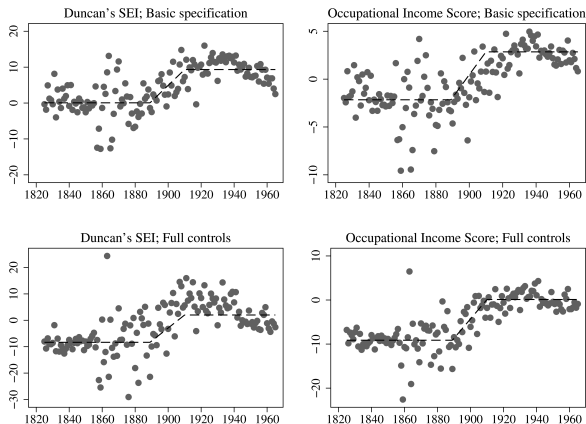
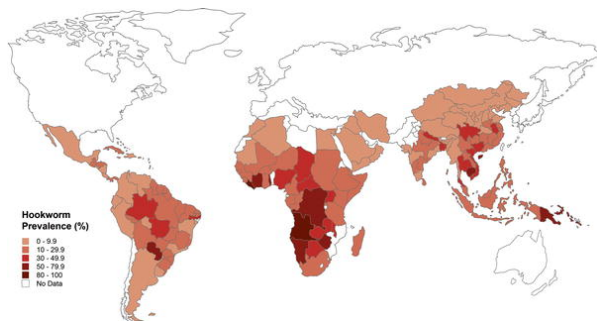


FIGURE III  
Cohort-Specific Relationship Between Income and Pre-Eradication Hookworm

# Bleakley and Hookworm in the South

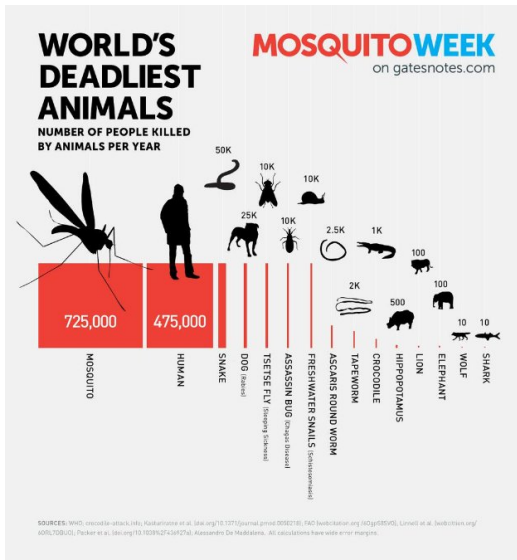


# Health and Human Capital

- We saw from Almond's work on influenza and Bleakley's work on hookworm that health has major impacts on worker productivity and economic development
- The influenza pandemic showed that individuals receiving a negative health shock in utero ended up with lower educational attainments, higher rates of disability and lower incomes
- When hookworm was eradicated in the South, school attendance, educational attainments, occupational status and incomes rose
- These were both American examples, maybe they only apply to America or the 1910s
- Let's quickly look at one more Bleakley paper dealing with eradication of malaria (Bleakley, AEJ: Applied, 2010)



# The (Partial) Eradication of Malaria

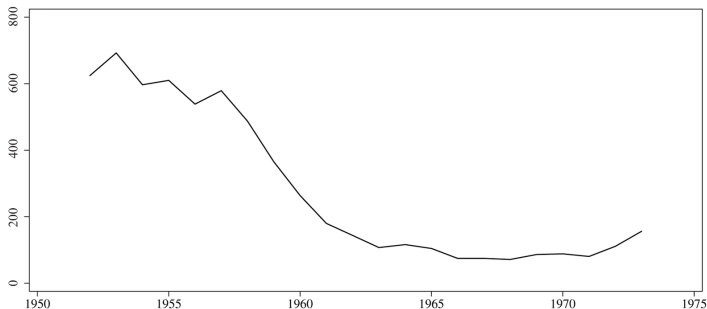


# The (Partial) Eradication of Malaria

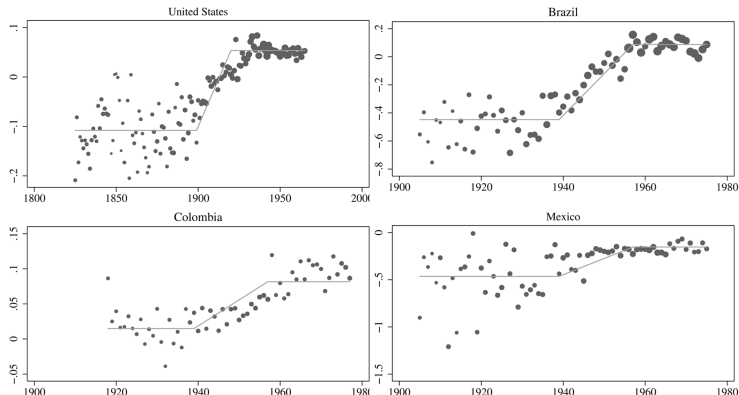


# The (Partial) Eradication of Malaria

Panel A: Large Decline in Malaria Following Onset of Spraying Campaign

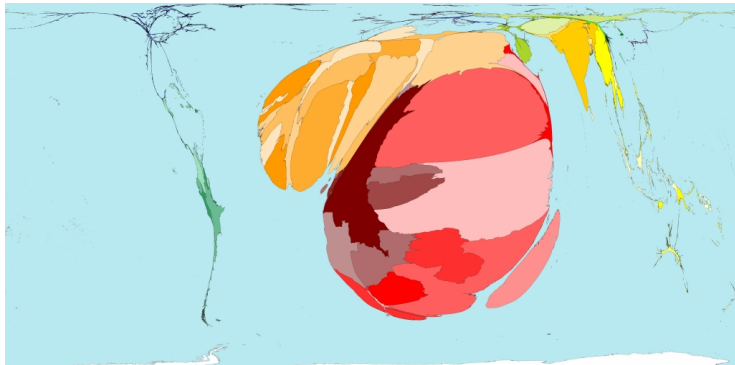


# The (Partial) Eradication of Malaria



**Figure 4.**  
Cohort-Specific Relationships: Income and Pre-Campaign Malaria

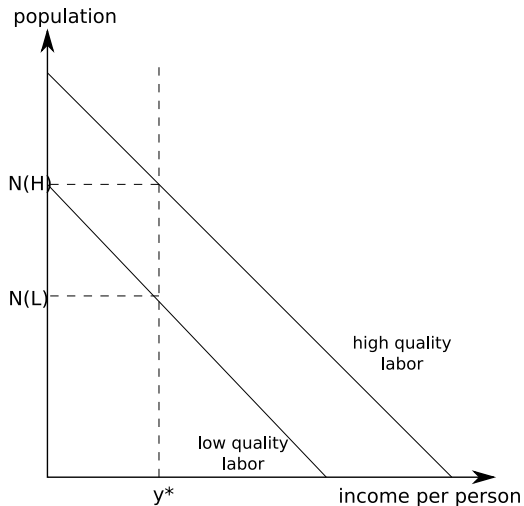
# Malaria Cases Around the World Today



# Why Divergence?

- If labor efficiency is the problem, why did that lead to divergence after the Industrial Revolution?
- Three reasons why differences in labor efficiency leads to more divergence today than in preindustrial world:
  - ① In the Malthusian world, labor efficiency affected population, not income per person
  - ② Modern medicine has allowed for lower income per person levels than in preindustrial times
  - ③ New production techniques may have raised the wage premium for high-quality labor

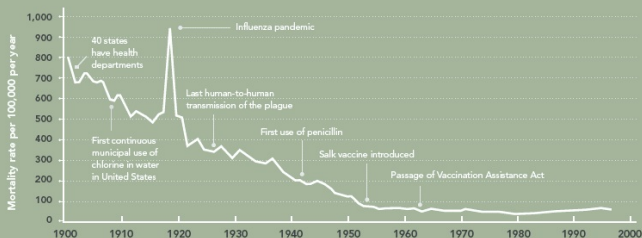
# Labor Efficiency in a Malthusian World



# A Partial Break from the Malthusian World

FIGURE 1.1

Crude infectious disease mortality rate in the United States, 1900–1996



Source: Adapted from Armstrong, Conn et al. (1999).

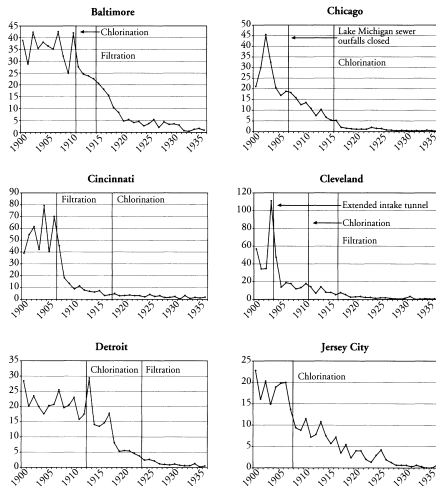


# A Partial Break from the Malthusian World



# A Partial Break from the Malthusian World

Figure 2. Typhoid Fever Trends (Mortality per 100,000) and Sanitary Interventions, 1900–1936



From Cutler and Miller (2005)

# A Partial Break from the Malthusian World

*Last month Mrs. Franklin D. Roosevelt, who loves few things better than a big family feast, gave up Thanksgiving dinner at Hyde Park to rush to Boston where Son Franklin Jr. lay abed with what was described to the press as 'sinus trouble.' The young man did have infected sinuses, and he was in the capable, Republican hands of Dr. George Loring Tobey Jr., a fashionable and crackerjack Boston ear, nose and throat specialist. He also had a graver affliction, septic sore throat, and there was danger that the Streptococcus haemolyticus might get into his blood stream. Once there the germs might destroy the red cells in his blood. In such a situation, a rich and robust Harvard crewman is no safer from death than anybody else.*

# A Partial Break from the Malthusian World

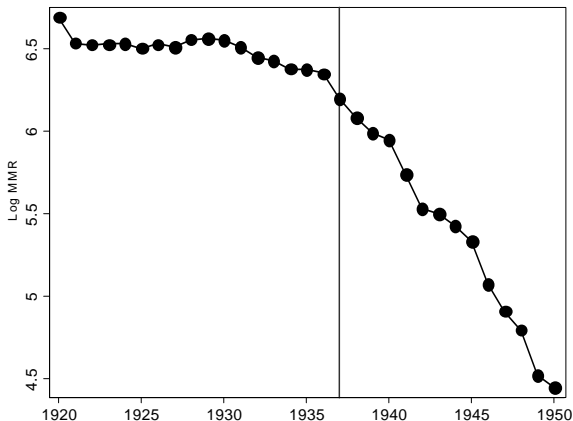
*When Franklin Roosevelt's throat grew swollen and raw and his temperature rose to a portentous degree. Dr. Tobey gave him hypodermic injections of Prontosil, made him swallow tablets of a modification named Prontylin. Under its influence, young Roosevelt rallied at once, thus providing an auspicious introduction for a product about which U. S. doctors and laymen have known little. – Time Magazine, 12/28/1936*

# A Partial Break from the Malthusian World



# A Partial Break from the Malthusian World

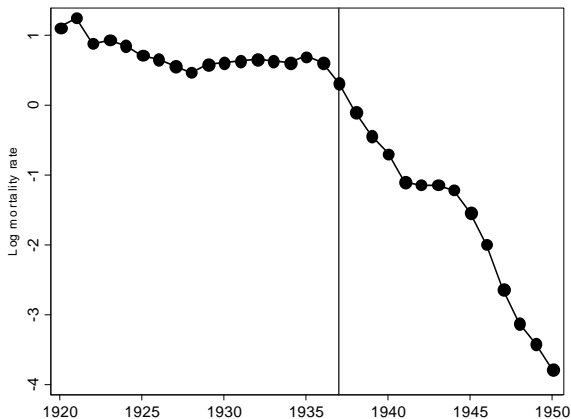
a. Log maternal mortality ratio (deaths per 100,000 live births)



From Jayachandran, Lleras-Muney and Smith (2009)

# A Partial Break from the Malthusian World

c. Log scarlet fever mortality rate per 100,000



From Jayachandran, Lleras-Muney and Smith (2009)

# A Partial Break from the Malthusian World

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**HERIDIN HYDROCHL.**  
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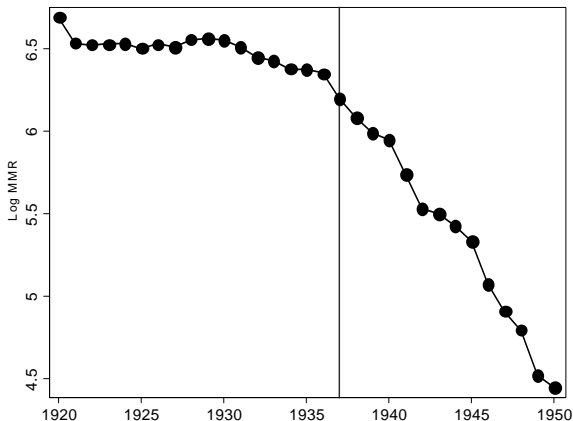
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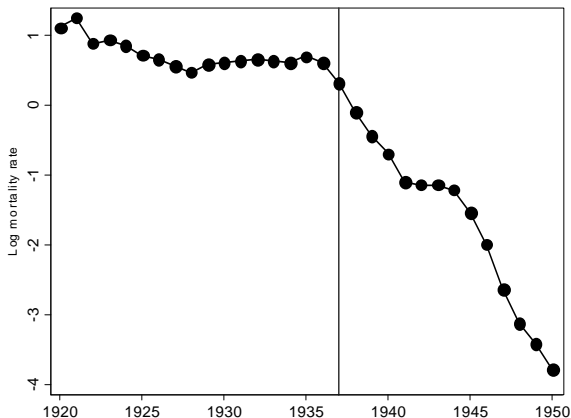
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From Jayachandran, Lleras-Muney and Smith (2009)

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c. Log scarlet fever mortality rate per 100,000



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**SOMATOSE**  
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**SYCOSE**  
*The antipyretic*

**PIRACETIN**  
*The antipyretic*

**TRICHAL**  
*The antipyretic*

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NEW YORK.**

# A Partial Break from the Malthusian World

- Advances in sanitation and medicine have dramatically improved our ability to keep people alive
- This is mostly a good thing for the people and the economy
- Generally, better health has allowed us to live longer, more productive lives: good for our happiness, good for the economy
- Consider the social returns estimated by Cutler and Miller (2005)



# A Partial Break from the Malthusian World

**Table 10. Social Rates of Return**

	Point Estimate	95% CI Low	95% CI High
% Mortality Reduction Due to Clean Water	0.1326	0.0373	0.2280
1915 Mortality Reduction per 100,000 Population	208	58	357
1915 Deaths Averted	1,484	418	2,551
1915 Person-Years Saved	57,922	16,301	99,543
1915 Annual Benefits in Millions of 2003 Dollars	679	191	1,167
1915 Annual Costs in Millions of 2003 Dollars	29		
Social Rate of Return	23:1	7:1	40:1
Cost per Person-Year Saved in 2003 Dollars	500	1,775	291

# A Partial Break from the Malthusian World

- So modern medicine medicine has made us much, much healthier and more productive
- Why is this related to the Great Divergence?
- If you are still in a somewhat Malthusian economy, better health isn't good from an income standpoint
- Health improvements effectively lower the subsistence income floor
- You end up with more people living at a lower income, leading to bigger gaps relative to rich countries
- Compounding this are modern gains in food production

# A Partial Break from the Malthusian World



# A Partial Break from the Malthusian World

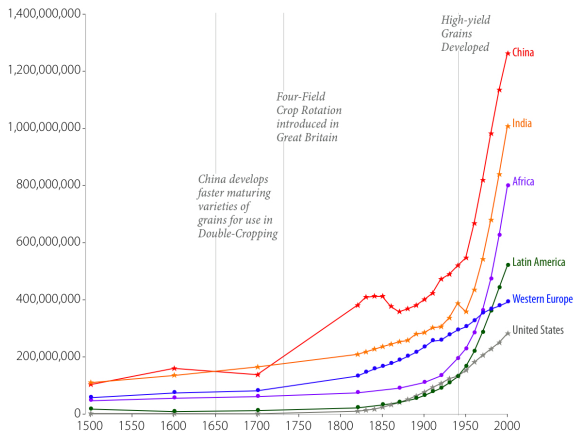


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to view more examples

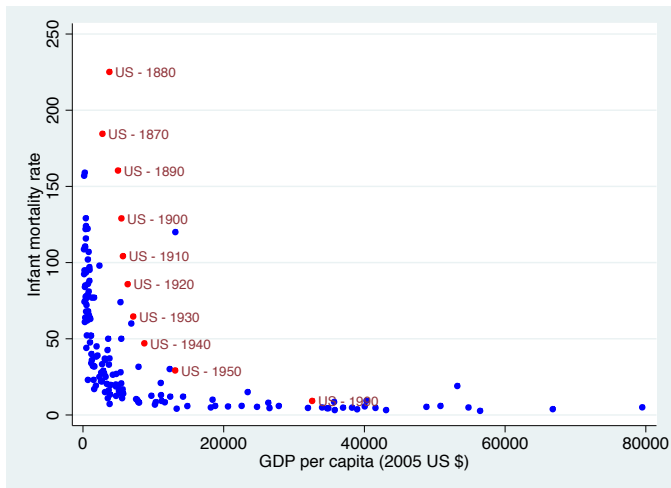
## Population Growth over the Last 500 Years

China, India, Africa, Latin America, Western Europe, and United States

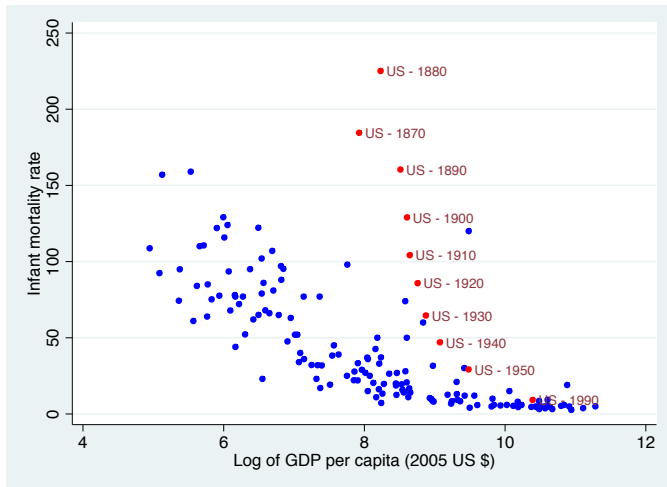


Source: Angus Maddison, University of Groningen

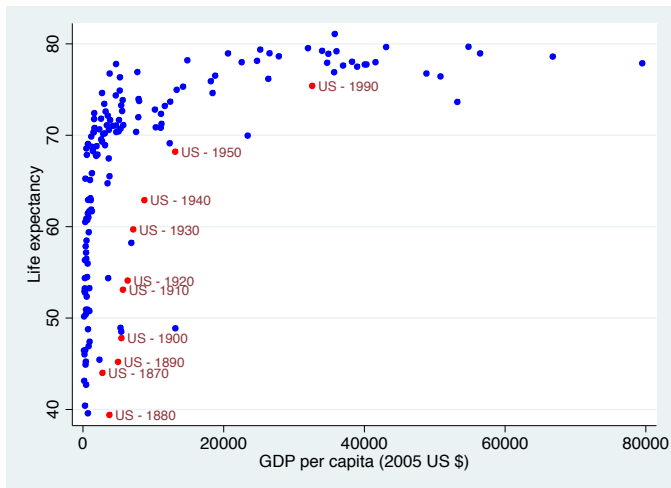
# Modern Medicine



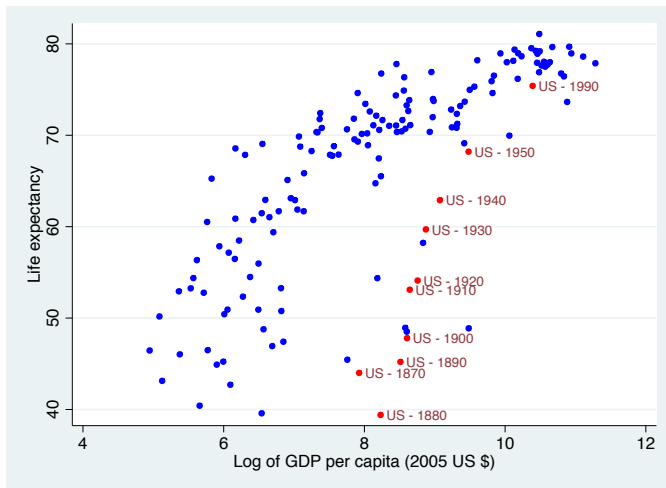
# Modern Medicine



# Modern Medicine



# Modern Medicine





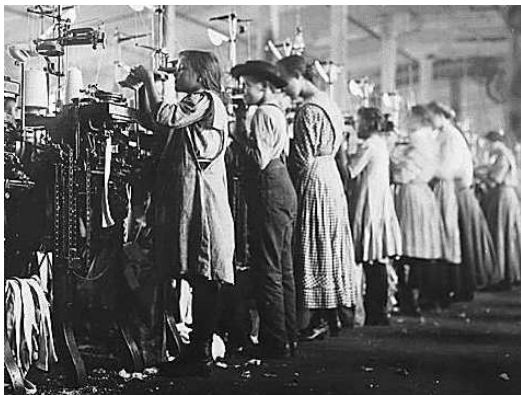
# Technology-Skill Complementarities

- A final component of divergence is skill-biased technological change
- The early industrialization we've talked about replaced skilled workers with machines and unskilled workers
- However, technological change since then hasn't necessarily benefited unskilled workers
- The technological change in the 20th century in particular seems to be more *skill-biased*

# Artisanal Production



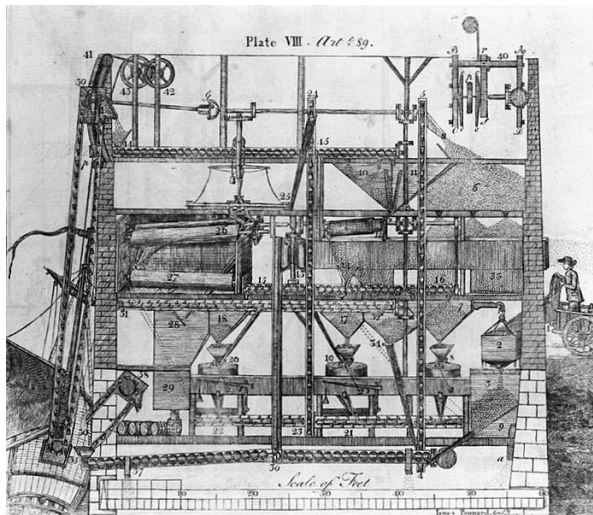
# Factory Production



# Assembly Line Production



# Batch/Continuous Process Production



*These five machines perform every necessary movement of the grain, and meal, from one part of the mill to another, and from one machine to another, through all the various operations, from the time the grain is emptied from the wagoner's bag until completely manufactured into flour without the aid of manual labor, excepting to set the different machines in motion. – Oliver Evans, 1848*

# Technology-Skill Complementarities

TABLE I  
PREDICTIONS OF THE FRAMEWORK

<i>Technological change</i>	$K/Q$	$K/(L_s + L_u)$	$L_s/(L_s + L_u)$
(a) Shift from artisanal or hand trades ( $H$ ) to factory production ( $F$ )	$\uparrow^a$	$?^b$	$\downarrow^c$
(b) Shift from factory ( $F$ ) to assembly-line ( $A$ ) production (Hicks-neutral technical change)	$\downarrow$	$\rightarrow$	$\rightarrow$
(c) Shift from assembly-line ( $A$ ) to continuous-process (or batch) methods ( $C$ )	$\uparrow$	$\uparrow$	$\uparrow$

$K$  = capital stock.

$L_s$  = skilled or more-educated labor.

$L_u$  = unskilled or less-educated labor.

a. The prediction is obtained when  $(\lambda_F^k/\lambda_H^k) < [(1 - \alpha_F)/(1 - \alpha_H)] \cdot (r_H^*/r_F^*)$ . That is, considering the restrictive case discussed in the text of equal  $r^*$  for  $H$  and  $F$ , the prediction is correct only if the higher  $K^*$ -intensity for the  $H$  technology is outweighed by the greater use of  $K$  in the creation of  $K^*$  in the  $F$  technology.

b. The impact of (a) on  $[K/(L_s + L_u)]$  is ambiguous in the case when  $[L_s/(L_s + L_u)]$  declines.

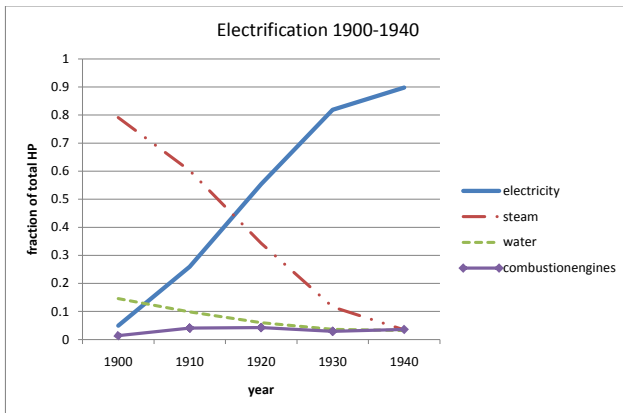
c. The prediction holds in the restrictive case of equal  $r^*$  for  $H$  and  $F$ . When the  $r^*$ s differ, the condition is  $(r_H^*/r_F^*) < [(\alpha_F/\alpha_H)] \cdot [(1 - \alpha_H)/(1 - \alpha_F)] \cdot (\lambda_F^1/\lambda_H^1)$ .

# Technology-Skill Complementarities

- To think about the ways technological change can impact demand for skilled and unskilled labor, let's consider electrification
- Specifically, we'll take a look at "Taking Technology to Task" by Rowena Gray (2013, Explorations in Economic History)
- Gray is focused on electrification in the United States and its impact on the workforce
- The central question is whether demand for skilled workers relative to unskilled workers changed as firms switched from water and steam power to electricity

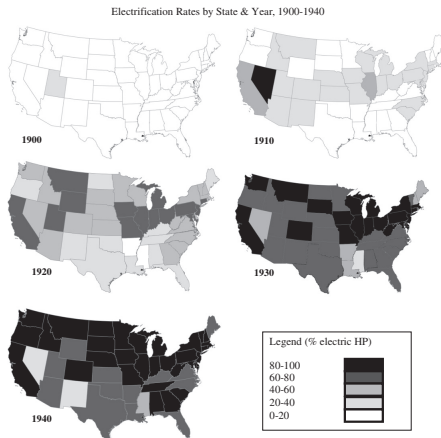


# Electrification and the Demand for Skill



Notes: The data are from the Censuses of Manufactures, 1900-1939. Water refers to power created at the firm level with their own water wheels, steam refers to power created at the firm level in steam engines, and electricity refers to power created either at the firm level and that was converted to electricity, or purchased electricity.

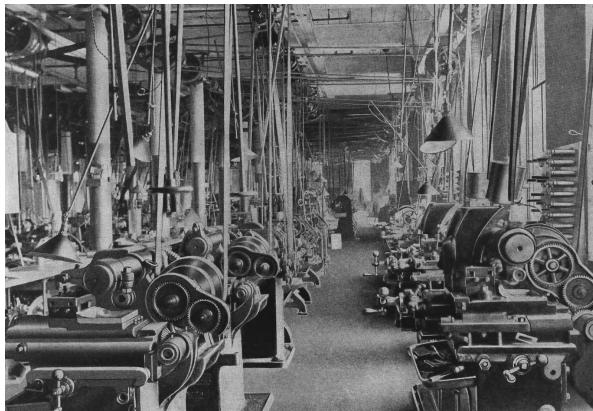
# Electrification and the Demand for Skill



Notes: Data are from the Censuses of Manufactures for each census year. Electrification is measured as % of total horsepower that comes from electricity.

Fig. 2. Electrification rates by state & year, 1900-1940.

# Electrification and the Demand for Skill



# Electrification and the Demand for Skill

- Electrification didn't just change the power source, it let companies reorganize the factory changing the nature of factory work
- Gray uses the *Estimates of Worker Traits for 4,000 Jobs* (1956) manual for job rating experts
- This lets her identify the task content of various occupations
- The idea is to then look at whether how the ratio of these tasks changed with the introduction of electricity
- Note that this is a little different than what Goldin and Katz are looking at

# Electrification and the Demand for Skill

Appendix C contains additional information about Physical Demands.

Number	Heading	Physical Demands
1	St	Strength
2	Cl	Climbing
3	Ba	Balancing
4	St	Stooping
5	Kn	Kneeling
6	Co	Crouching
7	Cw	Crawling
8	Re	Reaching
9	Ha	Handling
10	Fi	Fingering
11	Fe	Feeling
12	Ta	Talking
13	He	Hearing
14	TS	Tasting/Smelling
15	NA	Near Acuity
16	FA	Far Acuity
17	DP	Depth Perception
18	Ac	Accommodation
19	CV	Color Vision
20	FV	Field of Vision

# Electrification and the Demand for Skill

Appendix D contains additional information about Environmental Conditions.

Number	Heading	Environmental Condition
1	We	Exposure to Weather
2	Co	Extreme Cold
3	Ho	Extreme Heat
4	Hu	Wet and/or Humid
5	No	Noise Intensity Level
6	Vi	Vibration
7	AC	Atmospheric Conditions
8	MP	Proximity to Moving Mechanical Parts
9	ES	Exposure to Electrical Shock
10	HE	Working in High, Exposed Places
11	Ra	Exposure to Radiation
12	Ex	Working with Explosives
13	TC	Exposure to Toxic or Caustic Chemicals
14	Ot	Other Environmental Conditions

# Electrification and the Demand for Skill

## Absence or Presence of Physical Demand and Environmental Condition Components

Code	Frequency	Definition
N	Not Present	Activity or condition does not exist.
O	Occasionally	Activity or condition exists up to 1/3 of the time.
F	Frequently	Activity or condition exists from 1/3 to 2/3 of the time.
C	Constantly	Activity or condition exists 2/3 or more of the time.

# Electrification and the Demand for Skill

## Social Research

## 11.03

DOT Code	DOT Title/DOT Industry Designation(s)	S	Physical Demands																		Environmental Conditions															
			V	S	C	B	S	K	C	C	R	H	F	T	H	T	N	F	D	A	C	F	W	C	H	H	N	V	A	M	E	H	R	E	T	O
		P	t	i	a	n	e	w	e	a	i	e	c	c	S	A	A	P	c	V	V	e	o	o	u	i	C	P	S	e	a	x	C	I		
052.067-014	DIRECTOR, STATE-HISTORICAL SOCIETY (profess. & kin.)	8	S	N	N	N	N	N	N	F	F	O	N	F	F	N	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
052.167-010	DIRECTOR, RESEARCH (motion picture; radio-tv broad.)	8	S	N	N	N	N	N	N	O	O	O	N	F	F	N	F	N	N	N	O	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
101.167-010	ARCHIVIST (profess. & kin.)	8	S	N	N	N	N	N	N	F	F	F	N	F	F	N	F	N	F	N	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

## 11.03.04 Occupational

166.267-034	JOB DEVELOPMENT SPECIALIST (profess. & kin.)	5	S	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
166.267-026	RECRUITER (military ser.)	5	L	N	N	N	N	N	N	N	O	O	O	N	C	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
166.267-010	EMPLOYMENT INTERVIEWER (profess. & kin.)	6	S	N	N	N	N	N	N	N	O	F	O	N	F	F	N	F	N	O	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
166.267-018	JOB ANALYST (profess. & kin.)	6	L	N	N	N	N	N	N	N	F	F	F	N	F	F	N	F	N	F	N	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N
166.267-022	PRISONER CLASSIFICATION INTERVIEWER (profess. & kin.)	7	S	N	N	N	N	N	N	N	O	O	O	N	F	F	N	O	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
166.267-038	PERSONNEL RECRUITER (profess. & kin.)	7	S	N	N	N	N	N	N	N	F	F	O	N	C	C	N	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
166.267-042	EMPLOYEE RELATIONS SPECIALIST (profess. & kin.)	7	S	N	N	N	N	N	N	N	F	F	O	N	C	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
166.067-010	OCCUPATIONAL ANALYST (profess. & kin.)	7	L	N	N	N	N	N	N	N	F	F	O	N	F	F	N	F	N	N	O	O	N	N	N	N	N	N	N	N	N	N	N	N	N	N
099.167-010	CERTIFICATION AND SELECTION SPECIALIST (education)	8	S	N	N	N	N	N	N	N	F	F	F	N	F	F	N	F	N	F	N	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N

## 11.03.05 Economic

050.067-010	ECONOMIST (profess. & kin.)	8	S	N	N	N	N	N	N	O	O	F	N	F	F	N	F	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
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# Electrification and the Demand for Skill

DOT Code	DOT Title/DOT Industry Designation(s)	S V P	Physical Demands										Environmental Conditions										
			V	S	C	B	S	K	C	R	H	F	F	T	H	T	N	F	D	A	C	F	F
			I	L	A	T	N	O	W	E	A	E	A	S	A	A	P	C	V	V	V	V	V
823.131-014	RIGGER SUPERVISOR (radio-tv broad.; tel. & tel.)	7	L	O	O	O	O	N	F	F	F	F	N	F	N	F	N	F	O	O	N		
869.134-014	SUPERVISOR, ADJUSTABLE-STEEL-JOIST-SETTING (construction)	7	L	O	N	N	N	N	N	F	F	O	N	F	F	N	F	N	N	N			
619.361-010	FORMER, HAND (any industry)	7	M	N	O	N	N	O	N	F	F	N	N	N	N	F	N	O	O	N	N		
619.362-014	ROLL OPERATOR I (any industry)	7	M	N	O	N	N	O	N	F	F	O	N	N	N	F	N	O	F	N	N		
619.380-018	SPRING REPAIRER, HAND (automotive ser.)	7	M	N	O	N	N	O	N	F	F	F	N	N	N	F	N	O	O	N	N		
693.281-014	PATTERNMAKER (metal prod., nec)	7	M	N	N	N	N	N	N	F	F	O	N	N	N	F	N	N	N	N			
705.381-010	DIE BARBER (machine shop)	7	M	N	N	N	N	N	N	F	F	F	N	N	N	F	N	N	N	N			
709.381-014	MODEL BUILDER (furniture)	7	M	N	N	N	N	N	N	F	F	F	N	N	O	N	F	N	F	O	N		
709.381-030	ORGAN-PIPE MAKER, METAL (musical inst.)	7	M	N	N	O	N	O	N	F	F	F	N	N	N	N	F	N	F	N	N		
723.361-010	MODEL MAKER, FLUORESCENT LIGHTING (light. fix.)	7	M	N	N	N	N	N	N	F	F	F	O	N	N	N	F	F	F	N	N		
801.361-022	TANK SETTER (petrol. & gas)	7	M	O	O	O	O	N	F	F	F	F	N	F	F	N	F	N	N	N			
801.381-014	FITTER (machine shop)	7	M	N	N	O	N	O	N	F	F	F	N	N	N	N	F	N	F	O	N		
804.281-010	SHEET-METAL WORKER (any industry)	7	M	N	N	F	N	N	N	F	F	O	O	N	O	N	F	N	F	O	N		

# Electrification and the Demand for Skill

- Gray breaks tasks down into four categories: manual, dexterity, clerical and managerial
- Census of population data gives the occupational distributions across states and years for 1900 to 1940
- Census of manufacturing data provides measures of the percentage of horsepower coming from electricity
- Thus Gray can test whether increases in electricity usage are related to changes in the mix of tasks or skills demanded by employers

# Electrification and the Demand for Skill

Table 4  
Baseline OLS results.

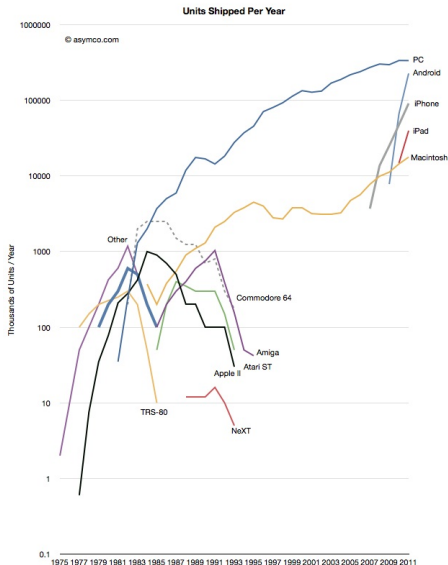
	Dexterity/manual		Clerical/dexterity		Clerical/manual + dexterity		Managerial/manual + dexterity	
	Full sample	Product. Workers	Full sample	Product. Workers	Full sample	Product. Workers	Full sample	Product. Workers
Elecrate	-.23*** (.06)	-.22*** (.07)	.30*** (.08)	.31*** (.10)	.18*** (.07)	.20*** (.08)	.18*** (.07)	.19** (.08)
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	.85	.86	.86	.84	.88	.88	.91	.91
Obs.	250	250	250	250	250	250	250	250

Notes: The dependent variable is specified in the first row. The explanatory variables are specified in the first column. *manual + dexterity* is a simple average of the manual and dexterity variables. *managerial* is an average of the *clerical* variable, with the *dealingwithpeople* and *direction, control* and *planning* task indicator variables. The method of estimation is Ordinary Least Squares, weighted by the *person weight* variable from IPUMS. Standard errors are shown in parentheses and were clustered at the state level. The full sample contains information on all workers 12–70, while Product. Workers include only those with factory-floor level occupations \*\*\* denotes significance at the 1 percent level; \*\* denotes significance at the 5 percent level and \* denotes significance at the 10 percent level.

# Electrification and the Demand for Skill

- What Gray finds is what economists refer to as the 'hollowing out' of the skill distribution
- This is the notion that 20th century technological change has increased demand for very low skilled jobs and very high skilled jobs but reduced demand for skilled blue collar workers
- Similar arguments about a hollowing out of the skill distribution have been made with regards to the rise of computers

# Technology-Skill Complementarities



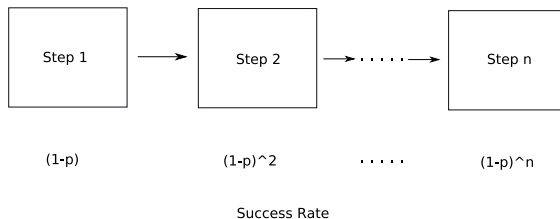
# Technology-Skill Complementarities

## HOW GOOGLING HAS REPLACED NEEDLE AND THREAD

Top 20 skills essential to know	Top 20 skills no longer essential to know
1 Googling	1 Darning
2 Operating a mobile phone	2 Knitting
3 Connecting WiFi	3 Polishing the brass/silver
4 Online banking	4 Baking fresh bread
5 Learning to cook	5 Putting up a tent
6 Being able to turn off the water at the mains	6 Writing postcards
7 Knowing what goes in which recycling bin	7 Sewing
8 Knowing about privacy settings online	8 Knowing the phone numbers of friends
9 Using a calculator	9 Servicing the car yourself
10 Using a self-service checkout	10 Understanding pounds and ounces
11 Searching and applying for jobs online	11 Dinner party etiquette
12 Using Google maps	12 Writing letters
13 Updating/installing computer programmes	13 Speaking a foreign language
14 Being able to use sat-nav	14 Knowing capital cities
15 Touch typing	15 Understanding feet and inches
16 Re-heating food in the microwave	16 Putting up a shelf
17 Checking in online prior to getting to the airport	17 Learning car journeys in advance/ knowing how to get from A to B
18 Uploading photographs	18 Being able to change a tyre
19 Communicating via Facebook	19 Neat handwriting
20 Changing settings on the thermostat	20 Knowing how to spell long words

<http://www.dailymail.co.uk/news/article-2413664/Forget-darning-baking-fixing-car-skills-REALLY-need-21st-century-setting-satnav-putting-rubbish-right-bin.html>

# Getting Back to the Great Divergence



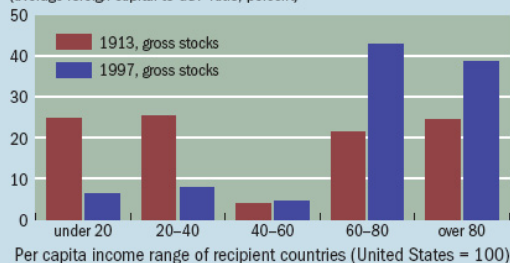
# Getting Back to the Great Divergence

Chart 2

## Who benefits?

Foreign capital used to flow to poor countries, but now flows mostly to rich countries.

(average foreign capital to GDP ratio, percent)



Source: Obstfeld and Taylor, 2004.



# Technology and the Great Divergence

- So why is a low-skilled labor force problematic with modern technology?
- Modern production process are complex, one worker messing up can have dramatic impact on output
- Technology has also evolved in ways that favor high skill workers
- This isn't just about engineering skill, many sectors now require computer and communication skills
- There are new service sector jobs that may require less skill but may also require geographical (or cultural) proximity
- So the path of technological change has created bigger benefits for high-skilled countries and potentially left low-skilled countries behind