Econ 210a: 2023-02-15 We 13:00 PST: DeLong: Industrial Revolution

- **Robert C. Allen.** 2011. "Why the Industrial Revolution Was British: Commerce, Induced Invention and the Scientific Revolution." *Economic History Review* 64 (May): 357-384. <https://www-jstor-org.libproxy.berkeley.edu/stable/41262428>

- **Stephen Nicholas & Richard H. Steckel.** 1991. "Heights and Living Standards of English Workers during the Early Years of Industrialization, 1770–1815." *Journal of Economic History* 51 (December): 937–957. <https://www.jstor.org/stable/pdfplus/2123399.pdf>

- **Simon Kuznets.** 1971. "Modern Economic Growth: Findings and Reflections." Nobel Prize Lecture. <https://www.nobelprize.org/prizes/economic-sciences/1971/kuznets/lecture/>

Guesses & Major Features

Guesses at Global Longest-Run Global Economic Growth

Date	Real Income/ Capita y	Popula- tion P (millions)	Total Income Y (billions)	Ideas Stock Level H	Ideas Growth Rate h		Population Growth n	Efficiency- Growth g
-8000	$1,200	2.04	$2.4	0.037	0.003%	Neolithic revolution	0.006%	0.000%
-6000	$900	5.09	$4.6	0.043	0.009%	"Tribal" mode of production	0.046%	-0.014%
-4000	$900	10.5	$9	0.062	0.018%	Final start of "urbanization"?	0.036%	0.000%
-3000	$900	15	$14	0.075	0.018%	Start of Bronze-Literacy age	0.037%	0.000%
-1500	$900	37	$33	0.117	0.030%	Bronze-Literacy mode of pro	0.060%	0.000%
-1000	$900	50	$45	0.136	0.030%	Start of Iron age	0.060%	0.000%
-400	$900	103	$93	0.195	0.060%	"Ancient" mode of domination	0.120%	0.000%
150	$900	200	$180	0.272	0.060%	High Antiquity	0.121%	0.000%
800	$900	240	$216	0.297	0.014%	Late-Antiquity Pause	0.028%	0.000%
1000	$900	296	$266	0.330	0.052%	Feudal mode of production	0.105%	0.000%
1500	$900	500	$450	0.429	0.052%	Commercial-Gunpowder-Empi	0.105%	0.000%
1770	$1,100	750	$825	0.643	0.149%	Imperial-Commercial Revolutio	0.150%	0.074%
1870	$1,300	1299	$1,689	1.000	0.442%	Steampower mode of produc	0.550%	0.167%
1930	$3,000	1909	$5,727	3.000	1.714%	Second-Industrial-Revolution	0.641%	1.394%
1975	$6,000	3678	$22,069	9.000	2.269%	Mass-Production mode of pr	1.457%	1.540%
2020	$12,000	7566	$90,794	27.000	2.342%	Global-Value-Chain mode of	1.603%	1.540%
2100	$50,000	10000	$499,990	129.333	1.958%	? Into the Future?	0.349%	1.784%

1. **The Neolithic Revolution** from -8000 to -6000
2. **The glacial pace of technological progress in the past**—1870 to 2010 we saw, in an average year, 200 times the *h* of the early Agrarian Age. (And, of course, growth from a much, much higher pace.) Nevertheless, the **large cumulative magnitude of technological progress**.
3. **The acceleration of growth in the early Agrarian Age** -6000 to the year 1
4. **The Late-Antiquity Pause** from 150 to 800
5. **The Mediæval Recovery**
6. **The Imperial-Commercial Age** step-up in growth over 1500 to 1770.
7. **The British Industrial Revolution Age** from 1770 to 1870.
8. **Modern Economic Growth** from 1870 to 2010.
9. **The Population Explosion and Demographic Transition** from 1770 to 2100.
10. **Whatever is going on now**—if global warming and other problems do not interrupt Modern Economic Growth, what do we have to look forward to for the world of 2100?
11. **Is this a misguided intellectual enterprise**—focusing on H, and taking it to be something real and important rather than a distracting mental-fictional cloud-castle that does more to confuse than to enlighten us?
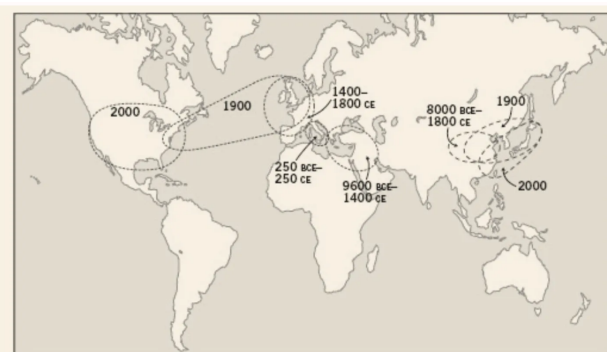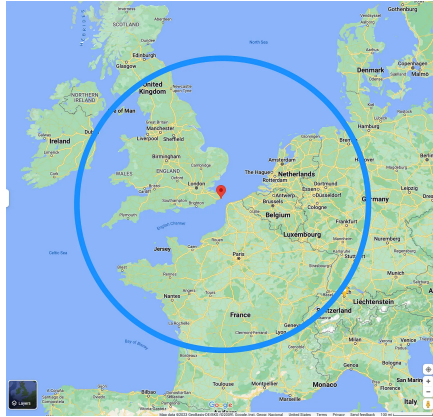

"The West"

Figure 2.4. The shifting locations of the Eastern and Western cores. Map by Michele Angel.

"Western Thought & Civilization"

"Dover Circle"-Plus

The "Dover Circle"-Plus

Date	Ideas Growth Rate h	Ideas Stock Level	Real Income/Capita y	Population P (millions)	Total Income Y (billions)	Ideas Growth Rate h	Population Growth n	Efficiency-Growth g	Increasing Resources ρ
800	0.022%	0.240	$900	8	$7.20	0.022%	0.044%	0.000%	0.000%
1500	0.096%	0.471	$1,000	25	$25.00	0.096%	0.163%	0.015%	0.000%
1770	0.200%	0.807	$1,400	75	$105.00	0.200%	0.407%	0.125%	0.257%
1870	0.914%	2.013	$2,800	175	$490.00	0.914%	0.847%	0.693%	0.405%
2010	2.514%	67.989	$50,000	800	$40,000.00	2.514%	1.086%	2.059%	0.175%

- A region that is nowheresville in 800…

- But the heavy plow and the iron axe transform it into a high-value agricultural region after 800…

- And divergence happens…

More Guesses…

The "Dover Circle"-Plus

Date	Ideas Growth Rate h	Ideas Stock Level	Real Income/Capita y	Population P (millions)	Total Income Y (billions)	Ideas Growth Rate h	Population Growth n	Efficiency-Growth g	Increasing Resources ρ
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2010	2.514%	67.989	$50,000	800	$40,000.00	2.514%	1.086%	2.059%	0.175%

- Ideas-stock generation the Big Enchilada…
- But also: "resource engrossment"
- Settlement…
- Emulation…
- Purchase, theft, unequal exchange, other forms…
  - Plus: feedback from empire on *institutions*…
  - Plus: feedback from empire on *investment*…

Breaking Through: The World

Breaking Through
- The world
  - Tripling of ideas growth around 1500, then another tripling around 1770, then x4.5 around 1870

Midterm
- 2022-02-18 to 2022-02-27
- No other assigments that week: review & reflect
  - Structured repetition to keep your brain from dumping information
- Three short answers: 1000 words total

Date	Technological Ideas-Stock Growth Rate h	Technological Ideas Stock Level H (1870 = 1)	Average Annual Real Income per Capita y	Total Human Population P (millions)	Total Real World Income Y (billions)
-48000	0.002%	0.011	$1,200	0.2	$0.24
-8000	0.003%	0.036	$1,200	2	$2.4
-6000	0.009%	0.043	$900	5	$4.5
-3000	0.018%	0.074	$900	15	$14
-1000	0.030%	0.136	$900	50	$45
150	0.060%	0.272	$900	200	$180
800	0.014%	0.297	$900	240	$216
1500	0.052%	0.429	$900	500	$450
1770	0.149%	0.643	$1,100	750	$825
1870	0.442%	1.000	$1,300	1300	$1,690
2010	2.159%	20.557	$11,600	6900	$80,040

Review: Breaking Through: Dover Circle

Breaking Through
- The 300-mile radius Dover Circle
  - One of 2.5 western European core areas (Iberia, Northern Italy)
  - No place special in -1000, 0, 800, or even 1500 (save for precision metalworking & gunpowder military)
  - Doubling of ideas growth around 1500, than x4.5 around 1770, then x2.5 around 1870
  - Plus resource engrossment: +0.25%/year growth of resources since 1500
- Pulls the rest of the world with it:
  - substantially 1500-1770,
  - partially 1770-1870, and
  - substantially (but, not yet, catchup!) 1870-2020

Date	Ideas-Stock Growth h	ideas Level H	Annual Real Income per Capita y	Population P (millions)	Total Real Income Y (billions)
-48000					
-8000	0.000%	0.0	$1,200	0.1	$0.12
-6000	0.003%	0.0	$900	0.2	$0.18
-3000	0.015%	0.1	$900	0.5	$0.45
-1000	0.035%	0.1	$900	2	$1.80
150	0.048%	0.2	$900	6	$5.40
800	0.022%	0.2	$900	8	$7.20
1500	0.096%	0.5	$1,000	25	$25.00
1770	0.200%	0.8	$1,400	75	$105.00
1870	0.914%	2.0	$2,800	175	$490.00
2010	2.514%	68.0	$50,000	800	$40,000.00

Allen

- **Robert C. Allen.** 2011. "Why the Industrial Revolution Was British: Commerce, Induced Invention and the Scientific Revolution." *Economic History Review* 64 (May): 357-384. <https://www-jstor-org.libproxy.berkeley.edu/stable/41262428>

  - Britain had a unique wage and price structure in the eighteenth century, and that structure is a key to explaining the inventions of the industrial revolution.

  - British wages were very high by international standards, and energy was very cheap.

  - This configuration led British firms to invent technologies that substituted capital and energy for labour.

  - High wages also increased the supply of technology by enabling British people to acquire education and training.

  - Britain's wage and price structure was the result of the country's success in international trade, and that owed much to mercantilism and imperialism.

  - When technology was first invented, it was only profitable to use it in Britain, but eventually it was improved enough that it became cost-effective abroad.

  - When the 'tipping point' occurred, foreign countries adopted the technology in its most advanced form.

Subsistence Basket Wages

- Britain had uniquely high real wages
  - Why? Northwest European marriage pattern?
  - Why? Yeoman smallholder legacy of the Bubonic Plague?
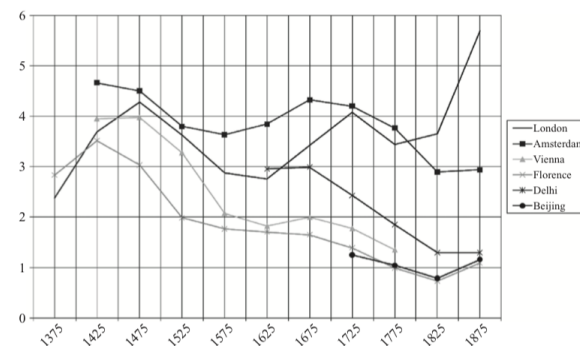 - Why? The British navy and the British empire and the fiscal-military state?

Figure 2. *Subsistence ratio for labourers: income relative to cost of subsistence basket*

Energy Prices

- Britain—not London so much as Newcastle, and Manchester—had a uniquely cheap real price of energy
- Why? Coal at the surface?
- Why? Coal on navigable water?
- Why? Wet coal mines?
- Only in Britain would the first generation of steam engines be both (a) useful and (b) profitable[?]
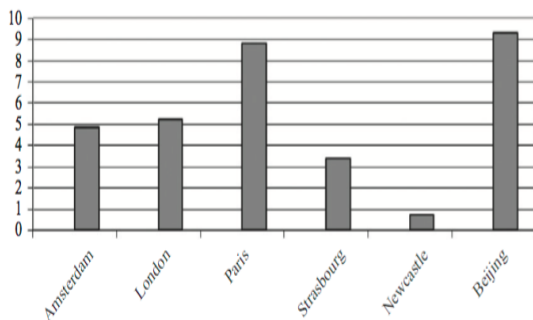- Eighteenth-century Lancashire the only escape from Malthusian agrarian poverty[?]

Figure 5. *Price of energy, early 1700s*

11

Permanent Agrarian Age World

What if there had been no Commercial Revolution?

- What would we have to eliminate from our world?
  - The New World & the Columbian Exchange
  - Merchant republics & constitutional monarchies
  - Printing as transformative for intellectual life?
- Is this plausible?
- Rate of ideas growth settles at 0.035%/yr = 0.7%/ generation
  - Doubling time of 2000 years
- World today of 1/10 population, $2.50/day
  - Population growing at glacial pace

Permanent Agrarian Scenarios

Date	Human Population (millions)	Income per Capita (per year)	World Product (billions)	Rate of Population and Labor Force Growth n	Rate of Efficiency-of-Labor Growth g	Rate of Ideas-Stock Growth h
-48000	1	$1,200	$1			
-8000	3	$1,200	$4	0.003%	0.000%	0.0014%
-3000	15	$900	$14	0.032%	-0.006%	0.0103%
-1000	50	$900	$45	0.060%	0.000%	0.0301%
0	170	$900	$153	0.122%	0.000%	0.0612%
800	300	$900	$270	0.071%	0.000%	0.0355%
1500	500	$900	$450	0.073%	0.000%	0.0365%
1770	609	$900	$548	0.073%	0.000%	0.0364%
1870	655	$900	$589	0.073%	0.000%	0.0364%
2020	730	$900	$657	0.073%	0.000%	0.0364%
2100	774	$900	$696	0.073%	0.000%	0.0364%
2200	832	$900	$749	0.073%	0.000%	0.0364%

Gunpowder Empire World

What if things had stuck at the Commercial Revolution?

- What would we have to eliminate from our world?
  - Coal or the British Empire
  - Science, tinkering, and nature manipulation?
- Is this plausible?
- Global rate of ideas growth of 0.15%/yr = 4%/generation, broadly shared
  - Doubling time of 500 years
- World today of 1/5 our population, $3/day

Gunpowder Empire Scenarios

Date	Human Population (millions)	Income per Capita (per year)	World Product (billions)	Rate of Population and Labor Force Growth n	Rate of Efficiency-of-Labor Growth g	Rate of Ideas-Stock Growth h
-48000	1	$1,200	$1			
-8000	3	$1,200	$4	0.003%	0.000%	0.0014%
-3000	15	$900	$14	0.032%	-0.006%	0.0103%
-1000	50	$900	$45	0.060%	0.000%	0.0301%
0	170	$900	$153	0.122%	0.000%	0.0612%
800	300	$900	$270	0.071%	0.000%	0.0355%
1500	500	$900	$450	0.073%	0.000%	0.0365%
1770	750	$1,100	$825	0.150%	0.074%	0.1494%
1870	895	$1,169	$1,047	0.177%	0.061%	0.1494%
2020	1402	$1,169	$1,639	0.299%	0.000%	0.1494%
2100	1780	$1,169	$2,081	0.299%	0.000%	0.1494%
2200	2400	$1,169	$2,806	0.299%	0.000%	0.1494%

Steampunk World

What if there had been no Industrial Revolution?

- What would we have to eliminate from our world?
- Post-1870 speedup of STEM labor force growth
- Industrial research lab to rationalize & routinize & modern corporation to deploy ideas
- Globalization?
- Is this plausible?
- Stepping-on-toes & low-hanging-fruit
- Arguments that it was inevitable lead to expectations of further growth accelerations—which we have not had
- World settles at ideas growth of 0.44%/yr—12%/generation
  - doubling time of 150 years
- World today of 2.7 billion, $5/day
- World reaches today's population in 2200

Steampunk Scenarios

Date	Human Population (millions)	Income per Capita (per year)	World Product (billions)	Rate of Population and Labor Force Growth n	Rate of Efficiency-of-Labor Growth g	Rate of Ideas-Stock Growth h
-48000	1	$1,200	$1			
-8000	3	$1,200	$4	0.003%	0.000%	0.0014%
-3000	15	$900	$14	0.032%	-0.006%	0.0103%
-1000	50	$900	$45	0.060%	0.000%	0.0301%
0	170	$900	$153	0.122%	0.000%	0.0612%
800	300	$900	$270	0.071%	0.000%	0.0355%
1500	500	$900	$450	0.073%	0.000%	0.0365%
1770	750	$1,100	$825	0.150%	0.074%	0.1494%
1870	1300	$1,300	$1,690	0.550%	0.167%	0.4421%
2020	2878	$1,696	$4,880	0.530%	0.177%	0.4421%
2100	5838	$1,696	$9,900	0.884%	0.000%	0.4421%
2200	7871	$1,696	$13,348	0.884%	0.000%	0.4421%

The Drake Equation

- The number of civilizations in the galaxy is the product of
  - R^*, the rate of star formation
  - f_p, the fraction of stars with planets,
  - n_e, habitable planets per star,
  - f_l, fraction that develop life,
  - f_i, fraction of living planets with intelligent, civilized life,
  - f_c, fraction that communicate, and
  - L, how long civilizations last
- Astronomy and the Fermi Paradox

- We got $R^* \approx 1$ (or more)
- f_p, and $n_e \approx 1$
- If f_l, f_i, and $f_c \approx 10\%$
- $N = L \times 10^{-3}$
  - $(N \leq 1) \Leftrightarrow (L \leq 10^3)$
  - i.e., Earth will spend only 1000 years with civilized life…

- The Great Filter
  - But see: Sandberg, Drexler, and Org <https://arxiv.org/pdf/1806.02404.pdf>

Nicholas & Steckel

- **Stephen Nicholas & Richard H. Steckel.** 1991. "Heights and Living Standards of English Workers during the Early Years of Industrialization, 1770–1815." *Journal of Economic History* 51 (December): 937–957. <https://www.jstor.org/stable/pdfplus/2123399.pdf>

We employed data on the heights of English and Irish male convicts transported to Australia to assess the living standards of workers between 1770 and 1815. Falling heights of urban- and rural-born males after 1780 and a delayed growth spurt for 13- to 23-year-old boys revealed declining living standards among English workers during the Industrial Revolution. This conclusion was supported by the fall in English workers' heights relative to that of convicts transported from Ireland. Significant urban-rural and regional variations in English living standards were revealed by using regression techniques.

Was the Industrial Revolution a Good Thing for Those Caught in It?
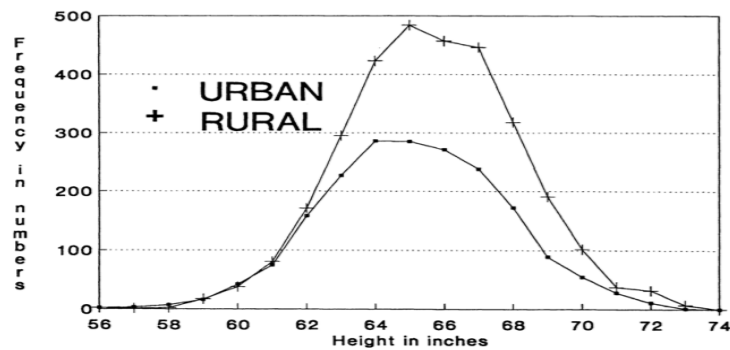

FIGURE 1

HEIGHT FREQUENCY FOR URBAN AND RURAL MALE ENGLISH WORKERS
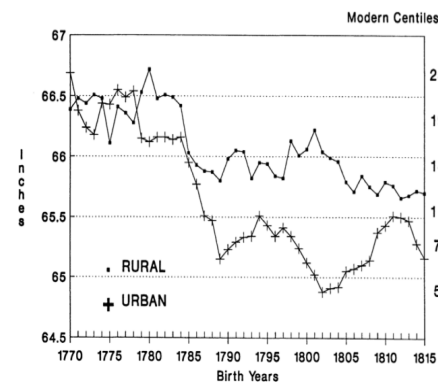(23 TO 49 YEARS)

Five-Year Moving Averages

FIGURE 3

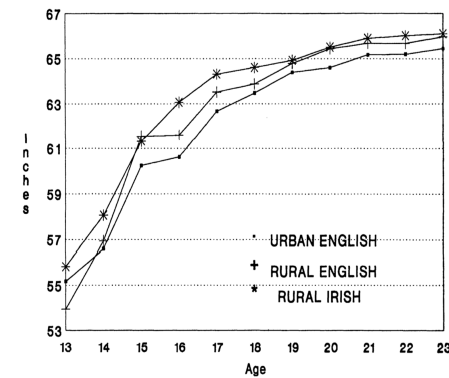HEIGHT PROFILE OF ENGLISH WORKERS 23 TO 49: 5-YEAR MOVING AVERAGE

FIGURE 2

AVERAGE HEIGHT BY AGE OF ENGLISH AND IRISH WORKERS

Kuznets

Simon Kuznets. 1971. "Modern Economic Growth: Findings and Reflections." Nobel Prize Lecture. <https://www.nobelprize.org/prizes/economic-sciences/1971/kuznets/lecture/>

• Six characteristics of modern economic growth have emerged:

1. High rates of growth of per capita product and of population

2. The rate of rise in productivity, i.e. of output per unit of all inputs, is high, even when we include among inputs other factors in addition to labor

3. The rate of structural transformation of the economy is high

4. The closely related and extremely important structures of society and its ideology have also changed rapidly. Urbanization and secularization come easily to mind.

5. One world in the sense in which this was not true in any pre-modern epoch

6. The spread of modern economic growth, despite its worldwide partial effects, is limited…

1800-1975: Life Expectancy & Real Annual Income per Capita
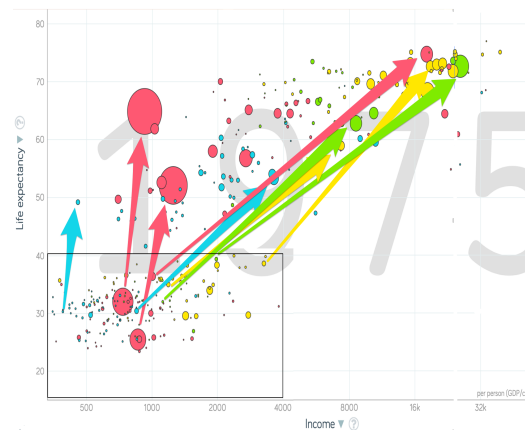
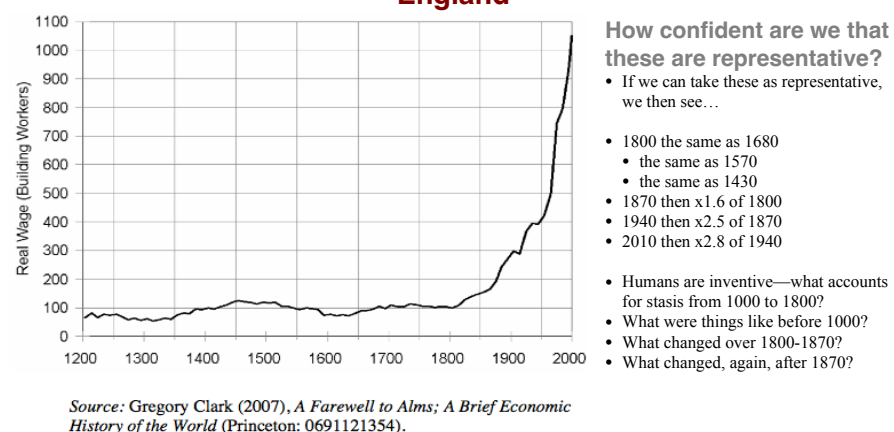**Although the map is not the territory…**
• 1800 in the box…
• Progress in life expectancy…

• America (1980 → 25900, x13.1) &
• Brazil (1120 → 8600, x7.7)

• Britain (3280 → 18900, x5.8) &
• Turkey (1190 → 7860, x6.6)

• Japan (1000 → 18700, x18.7),
• India (863 → 1250, x1.4), &
• China (736 → 924, x1.3)

• Nigeria (851 → 3550, x4.2) &
• Mozambique (390 → 457, x1.2)

Digression: 1975-2020: Life Expectancy & Real Annual Income per Capita

No longer gross "divergence"…

- The Brazils (8600 → 14500, x1.7), Turkeys (7340 → 25500, x3.5), Nigerias (3620 → 5300, x1.5), & Mozambiques (457 → 1210, x2.6) on average match the growth performance of the Americas (25900 → 57500, x2.2), Britains (18900 → 40400, x2.1), & Japans (18700 → 40100), x2.1…
  - But no "convergence" either

- However, India: WOW! (1250 → 7630, x6.1)

- And China (896 → 18100, x20.2): WOW OH WOW OH WOW!!!! NOTHING LIKE THIS EVER BEFORE EVER!!!!!!!!
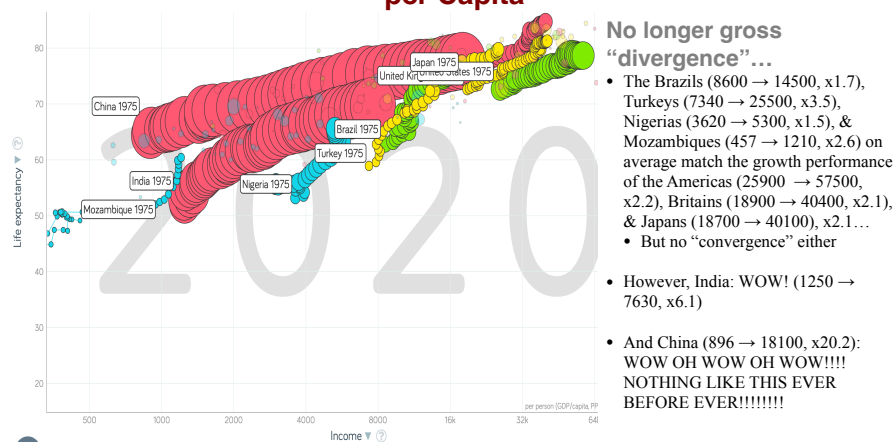
Reference: Guestimated Real Wages of Construction Workers in England

Source: Gregory Clark (2007), *A Farewell to Alms; A Brief Economic History of the World* (Princeton: 0691121354).

How confident are we that these are representative?

- If we can take these as representative, we then see…

- 1800 the same as 1680
  - the same as 1570
  - the same as 1430
- 1870 then x1.6 of 1800
- 1940 then x2.5 of 1870
- 2010 then x2.8 of 1940

- Humans are inventive—what accounts for stasis from 1000 to 1800?
- What were things like before 1000?
- What changed over 1800-1870?
- What changed, again, after 1870?

MEG as Continuation?

- Modern growth continues many older trends, if in greatly accelerated form...

- Mass application of technological innovations, which constitutes much of the distinctive substance of modern economic growth, is closely connected with the further progress of science, in its turn the basis for additional advance in technology...

- The sovereign state, with authority based on loyalty and on a community of feeling plays a crucial role in peacefully resolving such growth-induced conflicts.

  - But this and other services of the national state may be costly in various ways, of which intensified nationalism is one and other effects are too familiar to mention.

Kuznets on LDCs

- Two major groups of factors appear to have limited the spread of modern economic growth.

  1. First, as already suggested, such growth demands a stable, but flexible, political and social framework, capable of accommodating rapid structural change and resolving the conflicts that it generates, while encouraging the growth-promoting groups in society. Such a framework is not easily or rapidly attained

  2. Second, the increasingly national cast of organization in developed countries made for policies toward other parts of the world that, while introducing some modern economic and social elements, were, in many areas, clearly inhibiting

- Generalizations about less developed countries must be carefully and critically scrutinized in the light of this wide variety of conditions and institutions.

- The growth position of the less developed countries today is significantly different, in many respects, from that of the presently developed countries on the eve of their entry into modern economic growth.

- Substantial economic advance in the less developed countries may require modifications in the available stock of material technology, and probably even greater innovations in political and social structure.

- It will not be a matter of merely borrowing existing tools, material and social; or of directly applying past patterns of growth, merely allowing for the difference in parameters.