

# Econ 135: Lecture 27: 7. Conclusion: Review and Future

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for presentation: Th 2020-06-06

Original course by Melissa Dell (Harvard Econ 1342), revised by Brad DeLong

<<https://github.com/braddelong/public-files/blob/master/econ-135-lecture-27.pptx>>

<[https://www.icloud.com/keynote/0oLtY2dZ5V0\\_8A97uFNTi0olg](https://www.icloud.com/keynote/0oLtY2dZ5V0_8A97uFNTi0olg)>

# Discussion

## The Past and the Future:

- What strikes you as important here?

# Review and Future Trends

## 27. Th May 7: 7. Review and Future:

### Readings:

- Robert Allen (2011): *Global Economic History: A Very Short Indtroduction* <<https://delong.typepad.com/files/allen-geh.pdf>>

### Materials:

- Readiness:
- Slides: <<https://github.com;braddelong/public-files/blob/master/econ-135-lecture-27.pptx>>
- Review:
- Discussion:
- Text:
- Problem Set:

# Background: Economic Growth

## The eagle's-eye view:

- Three accelerations from agrarian-age norm: x 6.5, x 3.5, x 4.5
- I got into this business in the 1980s: Paul Romer then argued a fourth acceleration was on the way
- Did not happen (yet?)

## Longest-Run Global Economic Growth (2019)

Date	ideas Level H	Total Real World Income Y (billions)	Average Real Income per Capita y (per year)	Total Human Population L (millions)	Rate of Population and Labor Force Growth n	Rate of Efficiency-of-Labor Growth g	Rate of Ideas-Stock Growth h
-1000	16.8	\$45	\$900	50	0.060%	0.000%	0.030%
1500	53.0	\$450	\$900	500	0.073%	0.000%	0.036%
1770	79.4	\$825	\$1,100	750	0.150%	0.074%	0.149%
1870	123.5	\$1,690	\$1,300	1300	0.550%	0.167%	0.442%
2020	2720.5	\$90,000	\$11,842	7600	1.177%	1.473%	2.061%

03:15 of audio in this slide group; 2:00 here

# Features of Modern Economic Growth

## As conventionally measured:

- Ideas growth of 2.1%/yr:
  - Doubling time of 33 years
  - More change in one year than in 50 in the agrarian age
  - Enormous growth in global inequality
- Driven by:
  - Industrial research lab: routinization & rationalization of invention & innovation
  - Modern corporation: routinization & rationalization of the deployment of ideas
  - Globalization
    - Transport
    - Communications
    - Migration
  - Demographic transition
- American ascendancy: “the furnace where the future is being forged”

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## Global Growth: The Advanced West (2019)

Date	ideas Level H	Total Real Income Y (billions)	Average Real Income per Capita y (per year)	Total "West" Population L (millions)	Rate of Population and Labor Force Growth n	Rate of Efficiency-of-Labor Growth g	Increasing Resources p	Rate of Ideas-Stock Growth h
-1000	15.0	\$1.80	\$900	2	0.069%	0.000%	0.000%	0.035%
0	23.7	\$4.50	\$900	5	0.092%	0.000%	0.000%	0.046%
800	30.0	\$7.20	\$900	8	0.059%	0.000%	0.000%	0.029%
1500	58.9	\$25.00	\$1,000	25	0.163%	0.015%	0.000%	0.096%
1770	101.0	\$105.00	\$1,400	75	0.407%	0.125%	0.257%	0.200%
1870	252.0	\$490.00	\$2,800	175	0.847%	0.693%	0.405%	0.914%
2020	8439.5	\$40,000.00	\$50,000	800	1.013%	1.922%	0.175%	2.341%

# Catch Our Breath...

- Ask a couple of questions?
- Make a couple of comments?
- Any more readings to recommend?



# How Is Allen's Picture Different from the One I Have Painted?

## Starts in 1500: Mercantilism, Catch-Up, Big Push

- Three accelerations from agrarian-age norm: x 6.5, x 3.5, x 4.5
- I got into this business in the 1980s: Paul Romer then argued a fourth acceleration was on the way
- Did not happen (yet?)
- 1870-present the story of the greatest growth surge and also the greatest divergence

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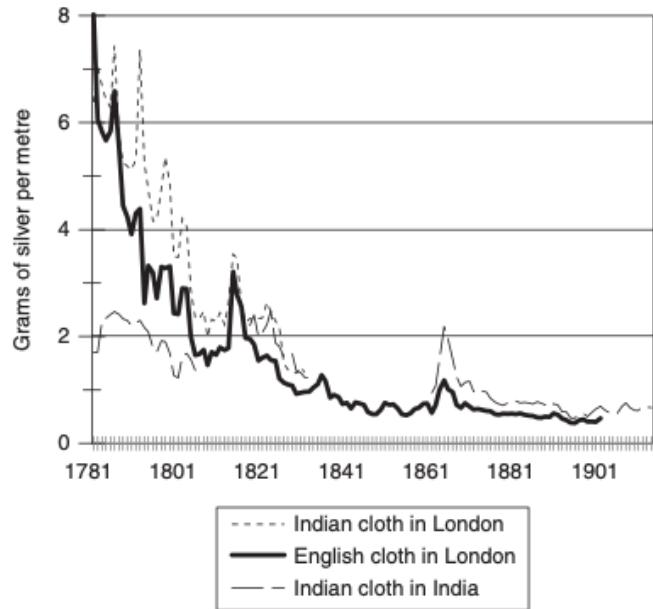
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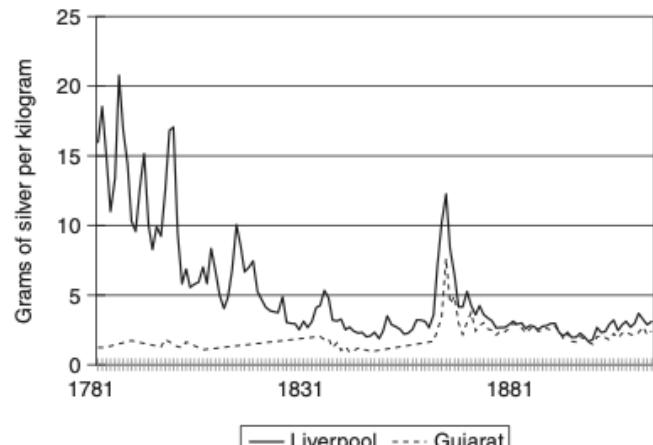
# Allen's Story: Underdevelopment of the Global South

Falling transportation costs led to greater economic integration:

- Comparative advantage thus led industry to migrate to the global north...
- Could only be resisted by the standard development strategy:
  - Internal improvements
  - Banks
  - Universal education
  - External tariffs
- Colonies could not follow this strategy
- Not all independents tried to grasp it
  - Not all that tried to grasp it succeeded



12. Real price of cotton

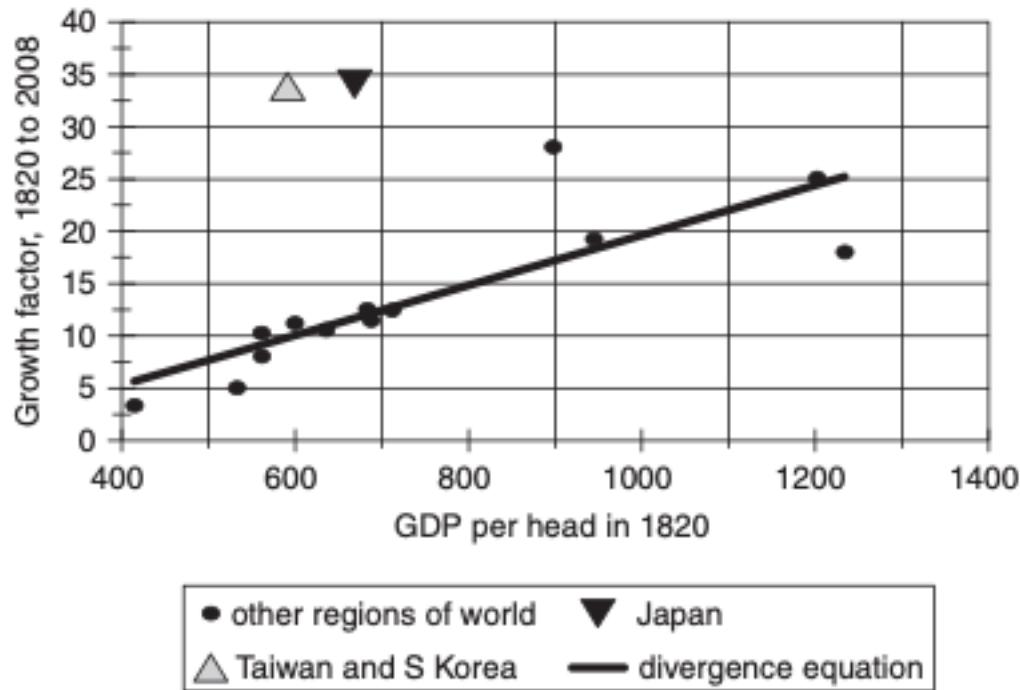


13. Real price of raw cotton

# The Great Divergence since 1820

**Countries x 3 richer in 1820 are x 15 richer today:**

- With East Asia being the only region that has significantly and strikingly broken the curve
- And North America a secondary outlier
  - Britain falls behind
  - Hard to believe that this is some underlying factors showing through
  - Instead, being poor must have set in motion processes to make you poorer
  - What were they?



## 1. The great divergence

# Allen's Numbers

The degree of fit is remarkable:

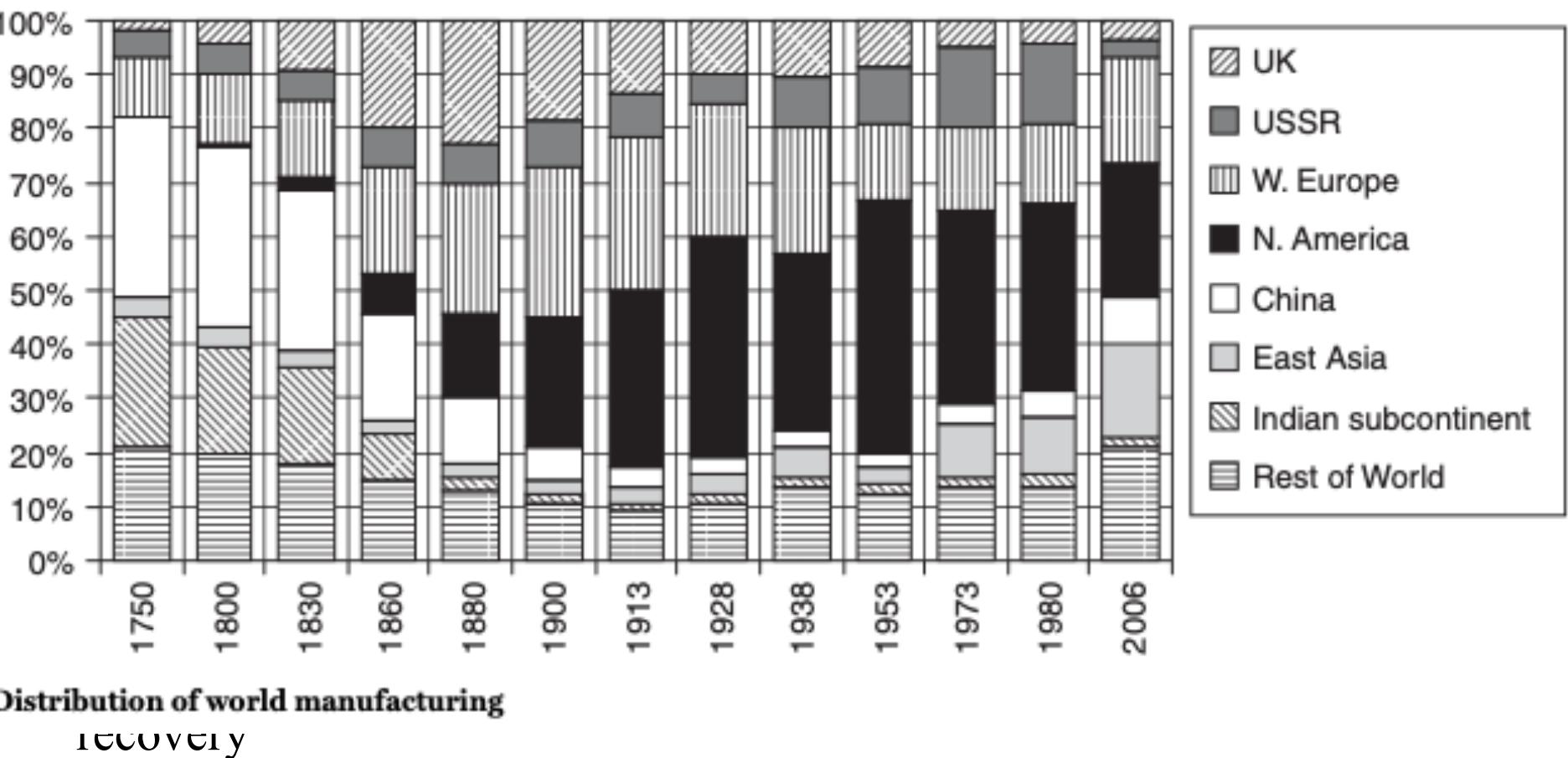
- As said before, the Pacific rim, North America, & Britain are the only significant outliers here...
- Otherwise, differences scale up:
  - Threefold becomes fifteenfold
  - Twofold becomes four fold

Table 1. GDP per person around the world, 1820–2008

	1820	1913	1940	1989	2008
Great Britain	1706	4921	6856	16414	23742
Netherlands	1838	4049	4832	16695	24695
Other Western Europe	1101	3608	4837	16880	21190
Mediterranean Europe	945	1824	2018	11129	18218
Northern Europe	898	2935	4534	17750	25221
USA, Canada, NZ, Australia	1202	5233	6838	21255	30152
Eastern Europe	683	1695	1969	5905	8569
USSR	688	1488	2144	7112	7904
Argentina, Uruguay, Chile	712	3524	3894	6453	8885
Other Latin American countries	636	1132	1551	4965	6751
Japan	669	1387	2874	17943	22816
Taiwan & S Korea	591	835	1473	8510	20036
China	600	552	562	1834	6725
Indian Sub-continent	533	673	686	1232	2698
Other east Asia	562	830	840	2419	4521
Middle East & North Africa	561	994	1600	3879	5779
Sub-Saharan Africa	415	568	754	1166	1387
World	666	1524	1958	5130	7614

GDP measures the total output of goods and services in an economy as well as the total income generated by it. In this table, GDP is valued in 1990 US dollars so the volume of production (real income) can be compared over time and across space.  
Note: Great Britain includes Northern Ireland from 1940

# The Rise (and Fall) of British and Then American Manufacturing



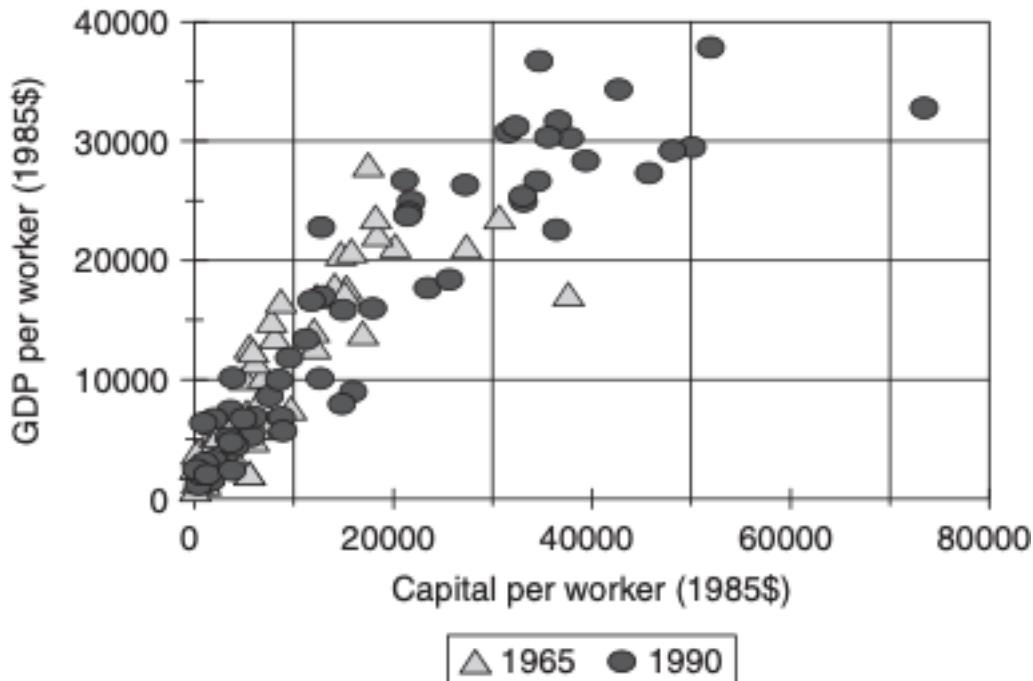
Distribution of world manufacturing  
1750-2006

- But India has not recovered

# Does Allen Have an Explanation of Why the Poor Are Still Poor?

**Not really:**

- He points to the capital-productivity correlation
- But much of it is endogenous
- It is much too strong to be causal
  - Should be 1-3, not 1-1...

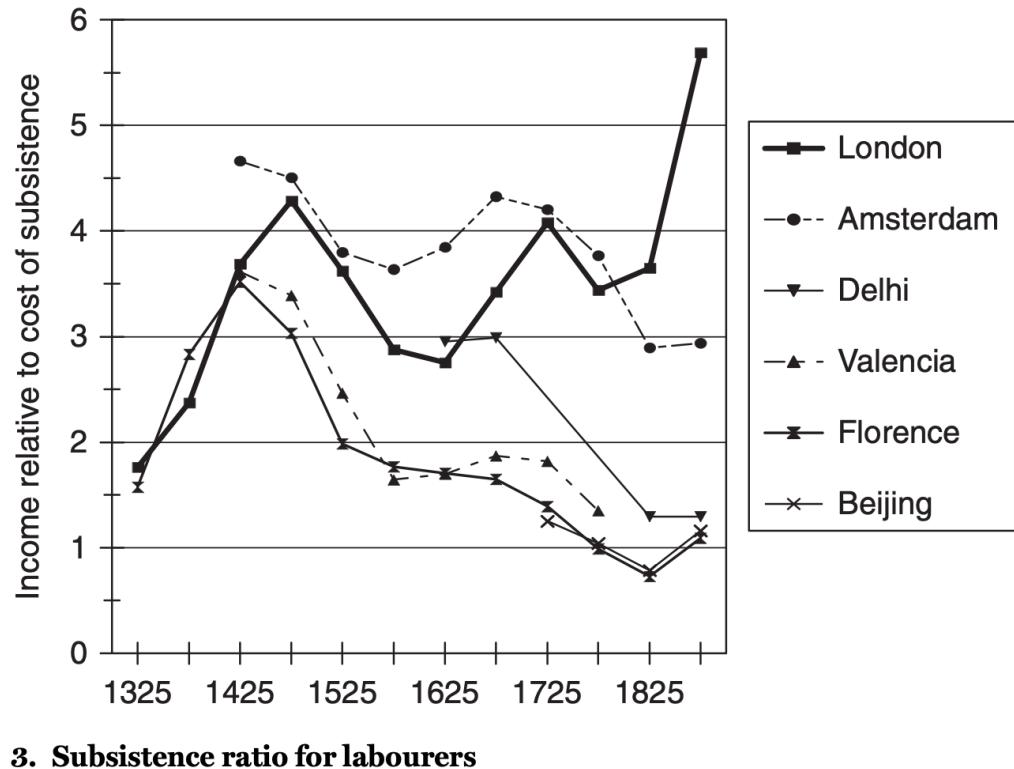


8. World production function

# Northwest Europe Had a Substantial Edge from 1725

## Not the European marriage pattern:

- More easily traced to mercantile prosperity than to anything else
- And it is that boost that then ramified substantially...



# Human Capital as a Key Link

**Putting a large chunk of your population in school by itself made up for a number of sins:**

- But colonies could not do so
- And Islamic countries were late in doing so—especially as far as girls were concerned
- Nevertheless, there is great cause for hope in what has gone on since 1960

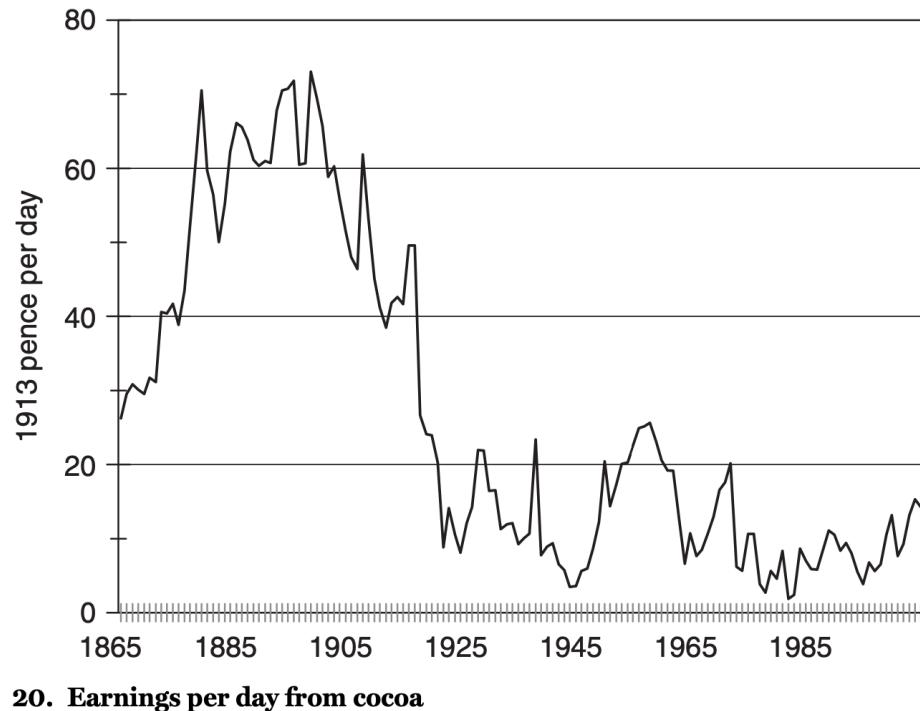
Table 6. Percentage of the population in school

	Japan	Indonesia
1870	2.5	0.1
1880	6.7	0.1
1900	10.8	0.4
1913	14.1	1.1
1928	17.5	2.8
1940	19.7	3.4
1950	22.3	7.0
1973	17.2	13.6
1989	18.8	23.9

# Getting Stuck in Primary Products

**It's not just that  
“tropical” products  
faced competition:**

- It is that it was not really possible to automate and mechanize very much
- By contrast, manufacturing and materials handling were very mechanizable...



# The Future?

We have come a long way:

- Where are we likely to go next?



# First: Back Up & Review

## What Would the World Look Like Today?:

- Without Commercial Revolution/Industrial Revolution/Modern Economic Growth?
- What if 1500-today had been like 0-1500?



# What Would the World Look Like Today without Commercial Revolution/Industrial Revolution/Modern Economic Growth?

- 1500-present like 0-1500...
- Growing technological competence
  - Zeng He
  - Infante Dom Enrique and Bartolomeu Dias
- But Malthusian dynamics
- 720 million people
- GDP per capita of \$750/yr
- Technologies...
  - 0-1500 TP about 0.03%/yr
  - Technologies of 1590 or so—“Elizabethan”; late Ming; early Mughal

## In the Shadow of Malthus

Year	Population (Millions)	GDP per Capita (\$2015)	Total World GDP (\$2015 Billions)
-8000	5	\$750	\$4
-1000	50	\$750	\$38
0	170	\$750	\$128
1500	500	\$750	\$375
1800	750	\$1000	\$750
1900	1500	\$2000	\$3000
2000	6200	\$7700	\$47740
2015	7400	\$10000	\$74000

# Why Escape? Why Modern Economic Growth?

- Useful ideas: five important prerequisites:
  - Resources
  - Science
  - Technology
  - A market economy
  - Profits to be made from productive innovation
- Escape from Malthus
- Nurturing its continuation—and noting its fragility—perhaps the most important goal, and the most important lesson
- And here we get into astronomy and the Fermi paradox

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# The Future: Simple Extrapolation

- Population maxes out at 9 billion...
- GDP/L growth of 2%/year carries the world to...
  - \$60K in \_\_\_\_ years
  - \$240K in \_\_\_\_ years
  - \$1M in \_\_\_\_ years
- GDP/L growth of 0.5%/year carries the world to...

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# To Your iClickers...

From 2000 to 2015  
the rate of growth in  
GDP per capita  
around the globe was  
about?

- A. 0.34% per year
- B. 1.7% per year
- C. 2.0% per year
- D. 0.20% per year
- E. None of the above

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# To Your iClickers...

A rate of growth of 1.7% per year gives us a doubling time of about...

- A. 32 years
- B. 57 years
- C. 41 years
- D. 98 years
- E. None of the above

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# To Your iClickers...

A rate of growth of 1.7% per year gives us a thousand-fold time of about...

- A. 4100 years
- B. 410 years
- C. 41 years
- D. 41000 years
- E. None of the above

## In the Shadow of Malthus

Year	Population (Millions)	GDP per Capita (\$2015)	Total World GDP (\$2015 Billions)
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# To Your iClickers...

At a rate of growth of 1.7% per year, world GDP per capita in 3000 would be about...

- A. \$187,100,000,000,000,000 per year
- B. \$187,100 per year
- C. \$37,420,000,000 per year
- D. \$187,100,000,000 per year
- E. None of the above

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# How Fast Has GDP per Capita Worldwide Been since 1900?

1900: \$2000 US per capita

2015: \$10000 US per capita

- A. 1.4%/year
- B. 4.3%/year
- C. \$70/year
- D. 50 years
- E. None of the above

# If Per Capita GDP Growth Continues at Its 1.7%/year 2000-2015 Pace...

...when will the world average—which was \$10000/year in 2015—attain the \$60000/year that was the U.S. value in 2015?

- A. About 2060
- B. About 2120
- C. About 2600
- D. It cannot be calculated from the information given
- E. None of the above

# If Per Capita GDP Growth Continues at Its 1.7%/year 2000-2015 Pace...

...when will the world average—which was \$10000/year in 2015—attain the \$240000/year that was my household's value in 2015?

- A. About 2140
- B. About 2200
- C. About 3000
- D. It cannot be calculated from the information given
- E. None of the above

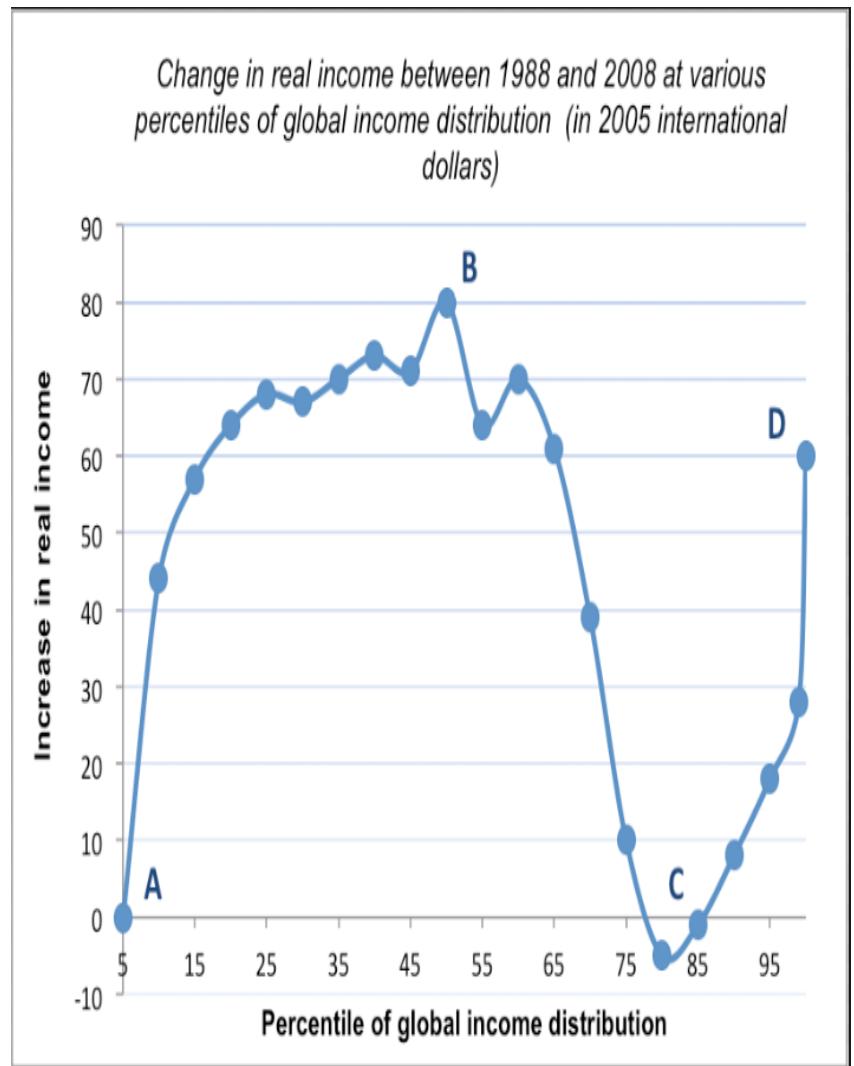
# If Per Capita GDP Growth Continues at Its 1.7%/year 2000-2015 Pace...

...when will the world average—which was \$10000/year in 2015—attain the value of \$1000000/year

- A. About 2220
- B. About 2280
- C. About 5000
- D. It cannot be calculated from the information given
- E. None of the above

# The Near Future

- What happens next?
- The Good: Finally, since 1970 some signs of global catch-up
- The Bad:
  - Robert Gordon's predictions of greatly slowed growth
  - Where are our flying cars?
- Extrapolating growth is hazardous...



# 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



# The Great Filter?

- Astronomy and the Fermi Paradox
- The Drake Equation
  - 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>



# **Big Ideas: Lecture 27: Review and Future**

**Takeaways from this lecture:**

# Catch Our Breath...

- Ask a couple of questions?
- Make a couple of comments?
- Any more readings to recommend?



# Notes, etc....



# Where We Think We Are with Coronavirus

**Brad DeLong**

**2020-05-06**

<<https://www.icloud.com/keynote/0YKEi7HeOrVGvKYtt9FEqH7nA>>

<<https://github.com;braddelong/public-files/blob/master/coronavirus.pptx>>

# Simple Extrapolations and Inferences

## Where we think we are, as of We May 6, 2020:

- We still do not know: no random panel
- I have my extrapolations: perhaps 9M cases?
- Time to distinguish between Greater New York and the rest of the country?

Coronavirus Extrapolations									
Date	Deaths	Inferred Cases = Deaths x 100 Lagged 2 Weeks	Cases = 1.5 x Cases(-3)	Cases = 3 x Cases(-3)	Cases = 6 x Cases(-3)	Cases = 12 x Cases (-3)		Confirmed Cases	Inferred Cases/Confirmed Cases
2020-05-06	74371	8,910,958	9,578,400					1,237,633	7.2
2020-04-30	63856	8,322,175	7,535,400					1,095,023	7.6
2020-04-23	50236	7,437,100	5,192,550	10,385,100				886,442	8.4
2020-04-16	34617	6,385,600	2,506,800	5,013,600	10,027,200			639,664	10.0
2020-04-09	16712	5,023,600	913,200	1,826,400	3,652,800	7,305,600		432,132	11.6
2020-04-02	6088	3,461,700	194,400	388,800	777,600	1,555,200		216,721	16.0
2020-03-26	1296	1,671,200	30,900	61,800	123,600	247,200		69,194	24.2
2020-03-19	206	608,800	6,150	12,300	24,600	49,200		9,415	64.7
2020-03-12	41	129,600	1,800	3,600	7,200	14,400		1,312	98.8
2020-03-05	12	20,600	150	300	600	1,200		159	129.6
2020-02-27	1	4,100						59	69.5
2020-02-20		1,200						15	80.0
2020-02-13		100						14	7.1
2020-02-06								12	0.0
2020-01-30								5	0.0
								1	0.0

<https://www.icloud.com/numbers/0EzBEAgAQojAip4VJWYWIWICQ>

audio time

Coronavirus Cases:

**3,780,522**

[view by country](#)

Deaths:

**261,703**

Recovered:

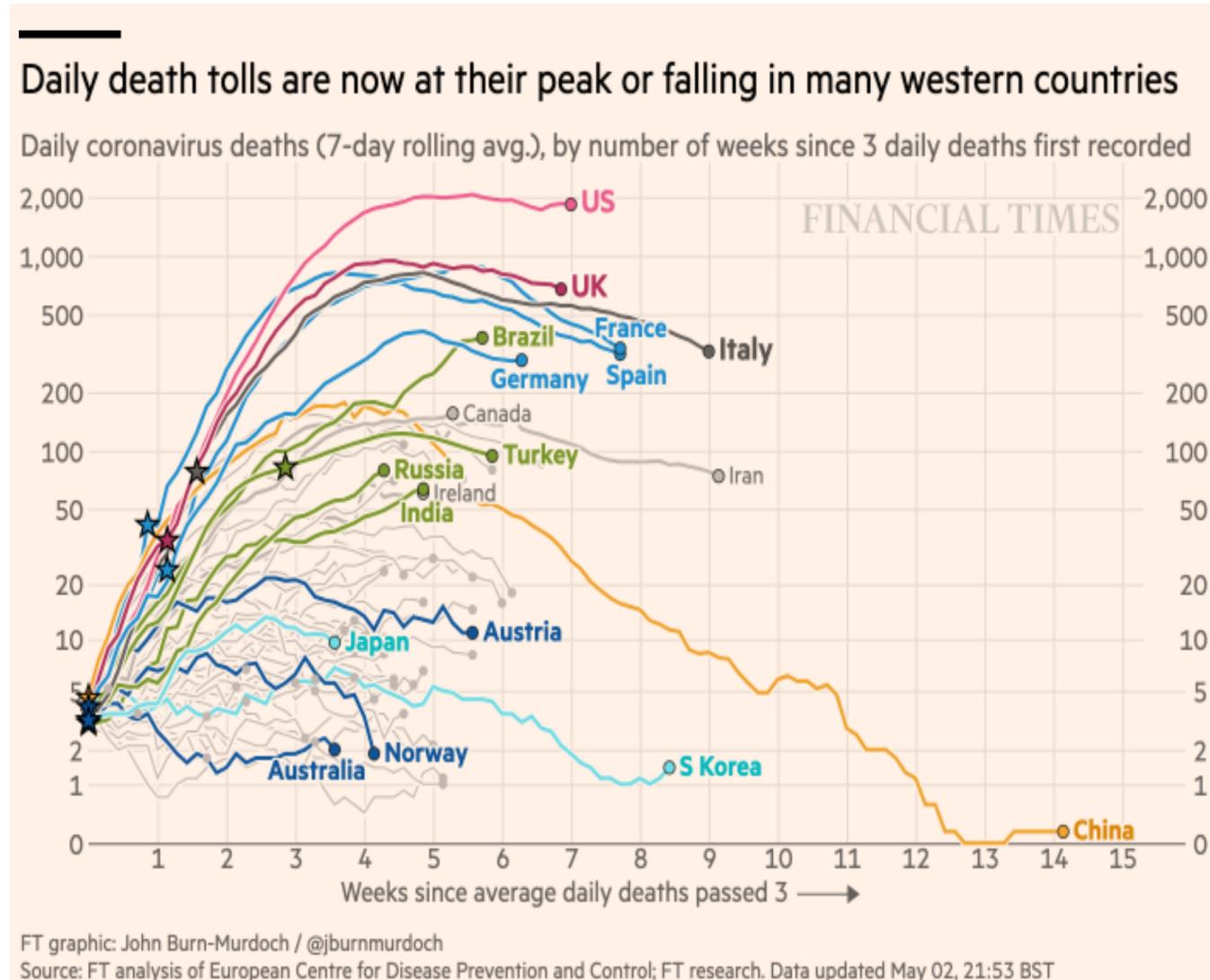
**1,275,536**

## Coronavirus Extrapolations

# The United States Is Alone in Doing No More than Flattening the Death Line

And that is including New York:

- And odds are that the U.S. daily death curve is about to start heading northeast again
- How far and how fast will it move?
- Cases x 150 during March
- Cases x 3 during April
- Am I wrong to expect a doubling outside New York in May?

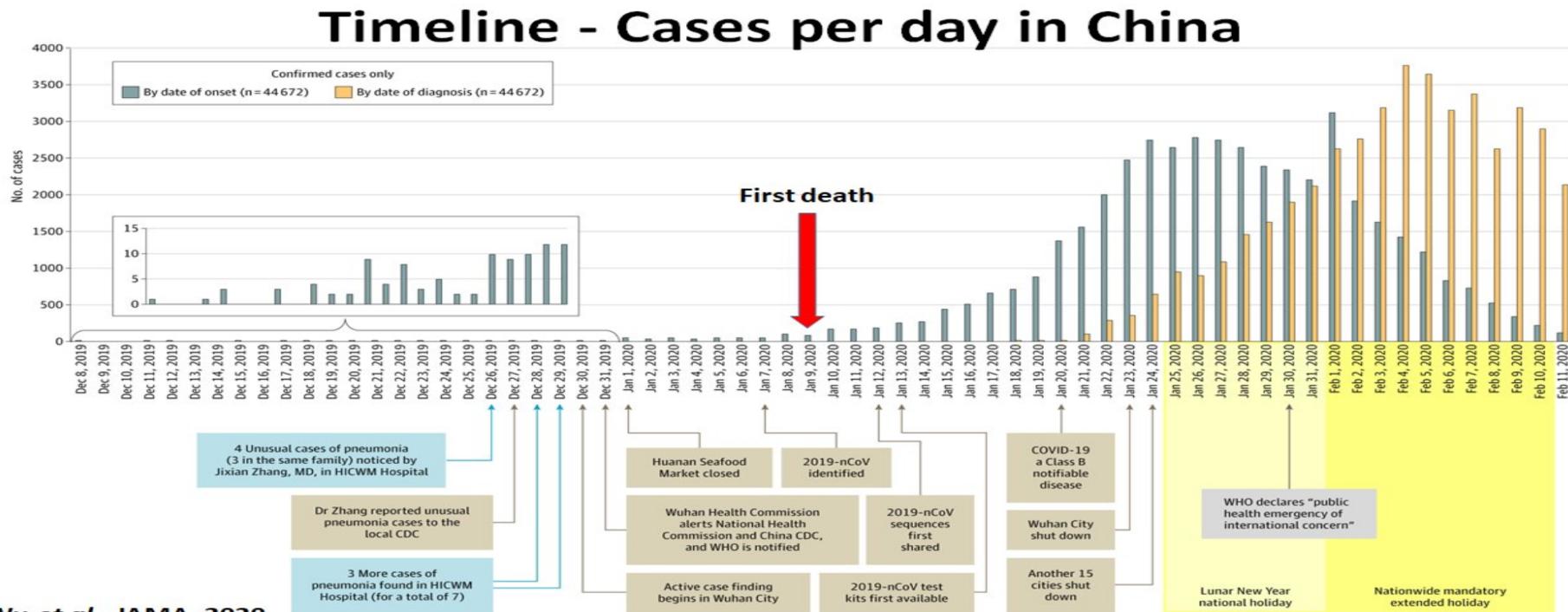


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# What We Think Happened in Wuhan

## Wuhan beat it quickly—we think

- Shut down Wuhan when there were 200 cases per day
- Seems to have been a good choice



Wu et al., JAMA, 2020

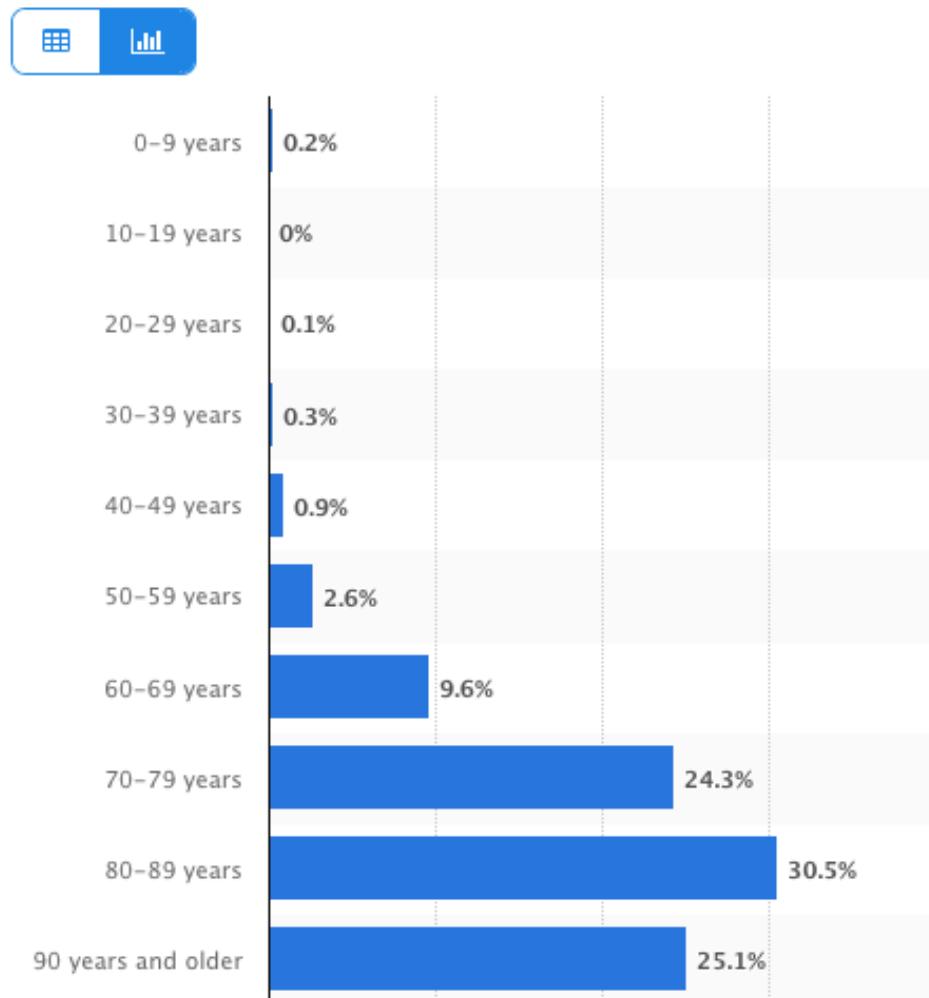
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# Death for Geezers!

## Mortality for the Youngs low...

- It can be a (very bad) flu for them—for you students...
- Morbidity...
- For olders: 3% in your 50s, 9% in your 60s
  - And a doubling—or is it 5%?—mortality for the asthmatic
  - And a doubling—or is it 5%?—mortality for the overweight
  - And an extra ???? if you have high blood pressure
  - And an extra ???? if you have high blood sugar

Coronavirus (COVID-19) death rate in Italy as of April 17, 2020, by age group

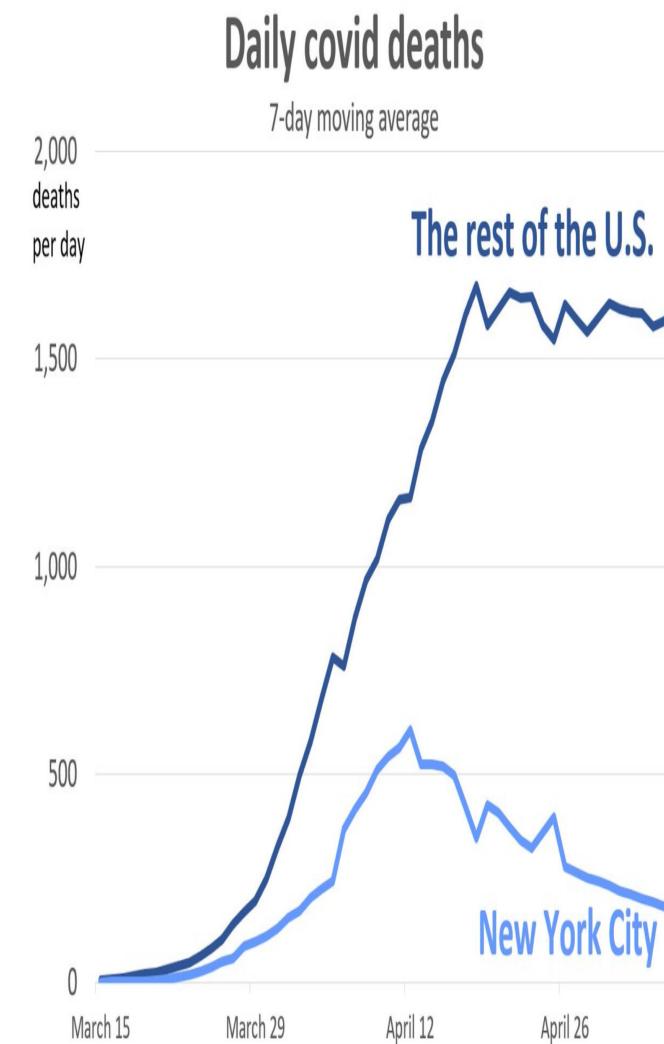
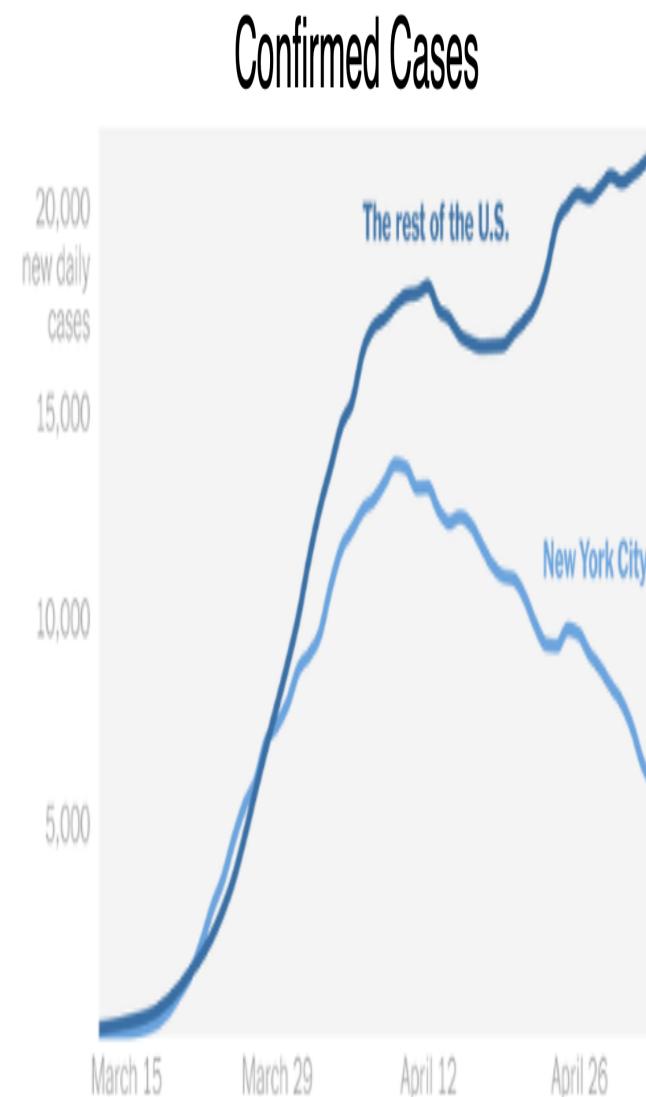


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# Separating New York City

**New York City is well past its first epidemic peak:**

- The rest of the country is not
- Perhaps 20% of the population of New York City has been brushed by the virus
- Perhaps 2.5% of the country has been brushed by the virus
- “Reopening” elsewhere will produce a lot of bad stuff



audio time

# Integrating Public Health with Economics

## Best thing I have read, still:

- Comes from Jim Stock <<https://www.jimstock.org>>
- Jim Stock: *Coronavirus Data Gaps and the Policy Response* <<https://drive.google.com/file/d/12MV466ZZy5xHir4xdPhoTrL1oO8CbZU-/view>>:

- The basic SIR epidemiological model of contagion
- What policy should be hinges on the coronavirus non-testing rate
- Estimates in the epidemiological literature range from 0.18 to 0.86.
- That is a case-catching rate of no less than 1/7—half of what extrapolations from 1% suggest
- Does that mean we are dealing with a 2% virus?

$$\Delta S_t = -\beta I_{t-1} \frac{S_{t-1}}{N}$$

$$\Delta R_t = \gamma I_{t-1},$$

$$\Delta I_t = \beta I_{t-1} \frac{S_{t-1}}{N} - \gamma I_{t-1}$$

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Figure 1. Two policy-induced paths of  $R_0$

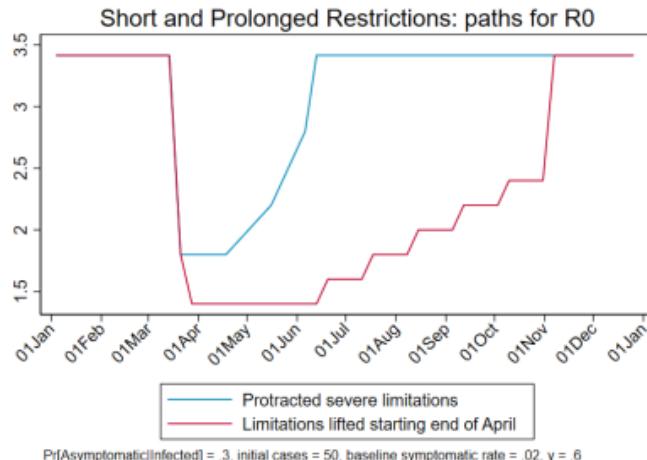


Figure 2. High asymptomatic rate, short-duration policy

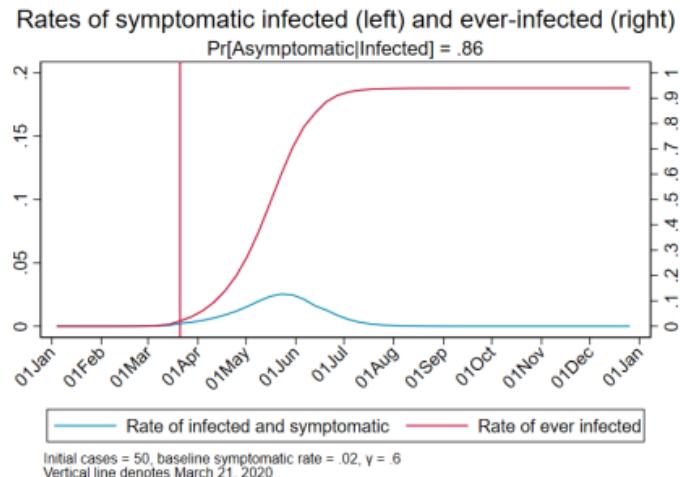


Figure 3. Low asymptomatic rate, short-duration policy

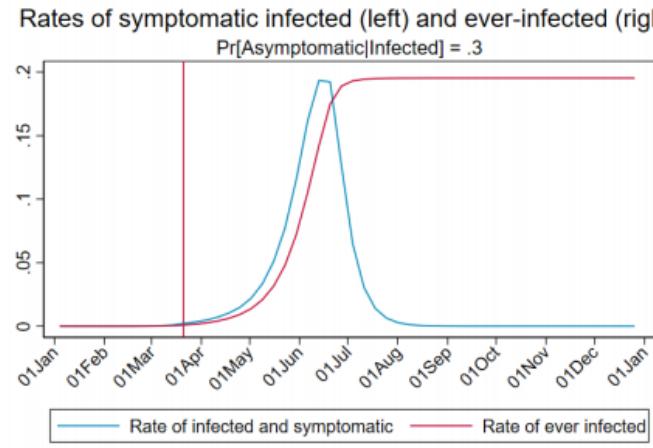
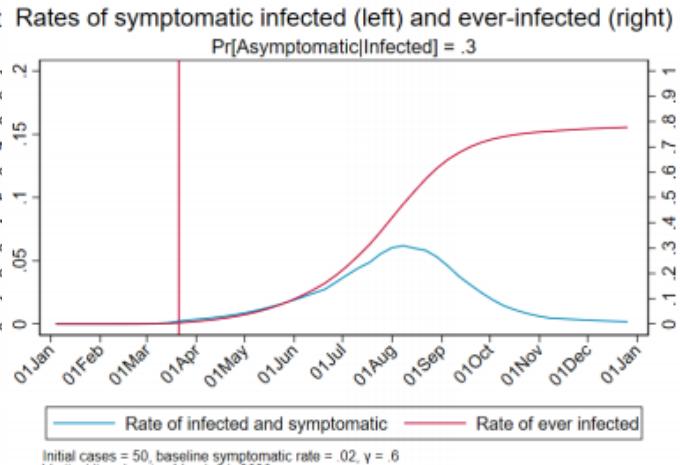


Figure 4. Low asymptomatic rate, severe long-duration policy

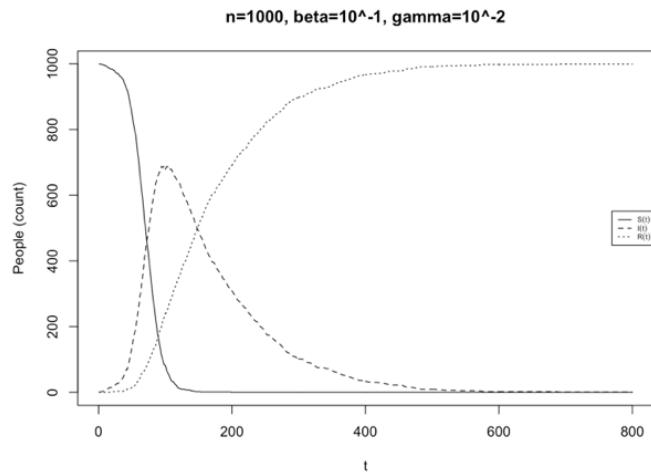


# Second Best: Epidemic Models

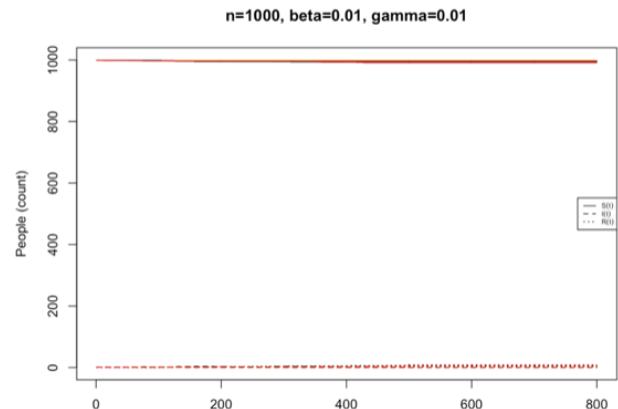
## A requested special topic:

- Written and presented by Cosma Shalizi
- Of Carnegie-Mellon University
- <[http://www.stat.cmu.edu/~cshalizi/dm/20/lectures/special/epidemics.html#\(1\)](http://www.stat.cmu.edu/~cshalizi/dm/20/lectures/special/epidemics.html#(1))>
- 36-462/662, Spring 2020
- 16 April 2020 (Lecture 25)

### What One Simulation Looks Like



### What If We Make Contagion Harder?



# Bringing the Economy Back Up from Anæsthesia

## Major issues:

- Certificates of immunity:
  - Which requires test, test, test:
    - And not just disease virus tests
    - Presence-of-antibodies tests
- How quickly can we match the immune with public-contact jobs?
- What jobs can be done with minimal infection risk?
- What minimal-infection substitutes can we find for previous jobs?
- How quickly can restrictions be relaxed without the virus coming roaring back?
- How do we avoid having the market give a “shutdown” signal to enterprises we in fact want restarted?
  - Which is pretty much all of them
- How much of the potential caseload do we want to push out beyond the vaccine-arrival date?

**ALL THESE QUESTIONS ARE ANSWERABLE IF WE LEARN THE ASYMPTOMATIC HENCE NON-TESTED RATE!!**

# Keeping the Economy from Crashing During the Lockdown

**Nick Rowe: We have a 50% output cut in 100% of the sectors:**

- A temporary 100% output cut in 50% of the sectors (what the Coronavirus does) is very different from a 50% output cut in 100% of the sectors
- Nick's thought experiment:
  - In three months we are going to invent unobtanium:
    - Substantial intertemporal substitutability
    - Plus lower cross-good contemporaneous substitutability
    - Hence high desired savings rate now
  - Flex-price market thus produces a nominal rate at the zero lower bound and a high inflation rate over the next three to six months
  - Plus liquidity-constrained workers in affected sectors see their demand go to zero immediately
  - Can we get there? Should we get there? What should we do instead?
  - We need a good RBC economist: are there any?...

<[https://worthwhile.typepad.com/worthwhile\\_canadian\\_initi/2020/03/relative-supply-shocks-unobtainium-walras-law-and-the-coronavirus.html](https://worthwhile.typepad.com/worthwhile_canadian_initi/2020/03/relative-supply-shocks-unobtainium-walras-law-and-the-coronavirus.html)>

audio time

# Keeping the Economy from Crashing During the Lockdown II

**Nick Rowe:**

- <[https://worthwhile.typepad.com/worthwhile\\_canadian\\_initi/2020/03/relative-supply-shocks-unobtainium-walras-law-and-the-coronavirus.html](https://worthwhile.typepad.com/worthwhile_canadian_initi/2020/03/relative-supply-shocks-unobtainium-walras-law-and-the-coronavirus.html)>
- Plus: to extend the thought experiment:
  - We just lost the ability to make “unobtainium”
  - So we *should* be substituting leisure for work, and moving workers into relatively unproductive labor, making the commodities we can still produce right now
  - How should relative prices move as a result? How should we make them move?

**Plus: distributional issues**

**Plus: bankruptcy and credit chain issues**

# References

## Directly cited here:

- **Financial Times** (2020): Coronavirus Tracked: The Latest Figures as the Pandemic Spreads <<https://www.ft.com/coronavirus-latest>>
- **Nick Rowe** (2020): *Relative Supply Shocks, Unobtainium, Walras' Law, and the Coronavirus* <[https://worthwhile.typepad.com/worthwhile\\_canadian\\_initi/2020/03/relative-supply-shocks-unobtainium-walras-law-and-the-coronavirus.html](https://worthwhile.typepad.com/worthwhile_canadian_initi/2020/03/relative-supply-shocks-unobtainium-walras-law-and-the-coronavirus.html)>
- **Jim Stock** (2020): *Coronavirus Data Gaps and the Policy Response* <<https://drive.google.com/file/d/12MV466ZZy5xHir4xdPhoTrL1oO8CbZU-/view>>

## What I am watching:

- **Jim Stock** (2020): *Coronavirus Data Gaps and the Policy Response* <<https://drive.google.com/file/d/12MV466ZZy5xHir4xdPhoTrL1oO8CbZU-/view>>
- **Max Roser & Hannah Ritchie**: *Coronavirus Disease (COVID-19)* <<https://ourworldindata.org/coronavirus>>...
- **Worldometer**: *Coronavirus Update (Live)* <<https://www.worldometers.info/coronavirus/>>...
- **FT Coronavirus Tracker** <<https://www.ft.com/content/a26fbf7e-48f8-11ea-aeb3-955839e06441>>
- **Josh Marshall's COVID Twitter List** <<https://twitter.com/i/lists/1233998285779632128>>
- **NEJM Group**: *Updates on the Covid-19 Pandemic* <[http://m.n.nejm.org/nl/jsp/m.jsp?c=%40kxNtXckRDOq8oG0jJvAXsIzN4mPECIPhltxoTSdTU9k%3D&cid=DM89089\\_NEJM\\_COVID-19\\_Newsletter&bid=173498255](http://m.n.nejm.org/nl/jsp/m.jsp?c=%40kxNtXckRDOq8oG0jJvAXsIzN4mPECIPhltxoTSdTU9k%3D&cid=DM89089_NEJM_COVID-19_Newsletter&bid=173498255)>; 'From the New England Journal of Medicine, NEJM Journal Watch, NEJM Catalyst, and other trusted sources...'

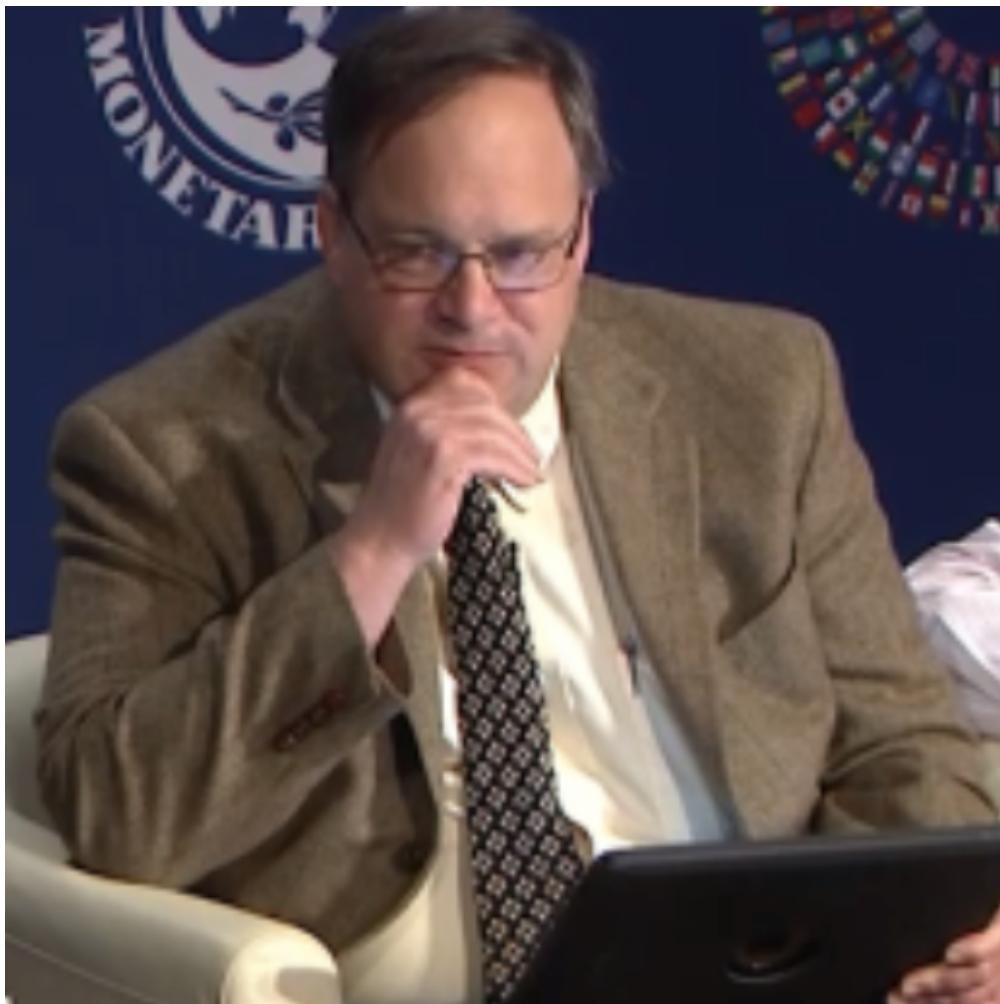
# Catch Our Breath...

## Continue the Discussion:

- Ask a couple of questions?
- Make a couple of comments?
- Any more readings to recommend?

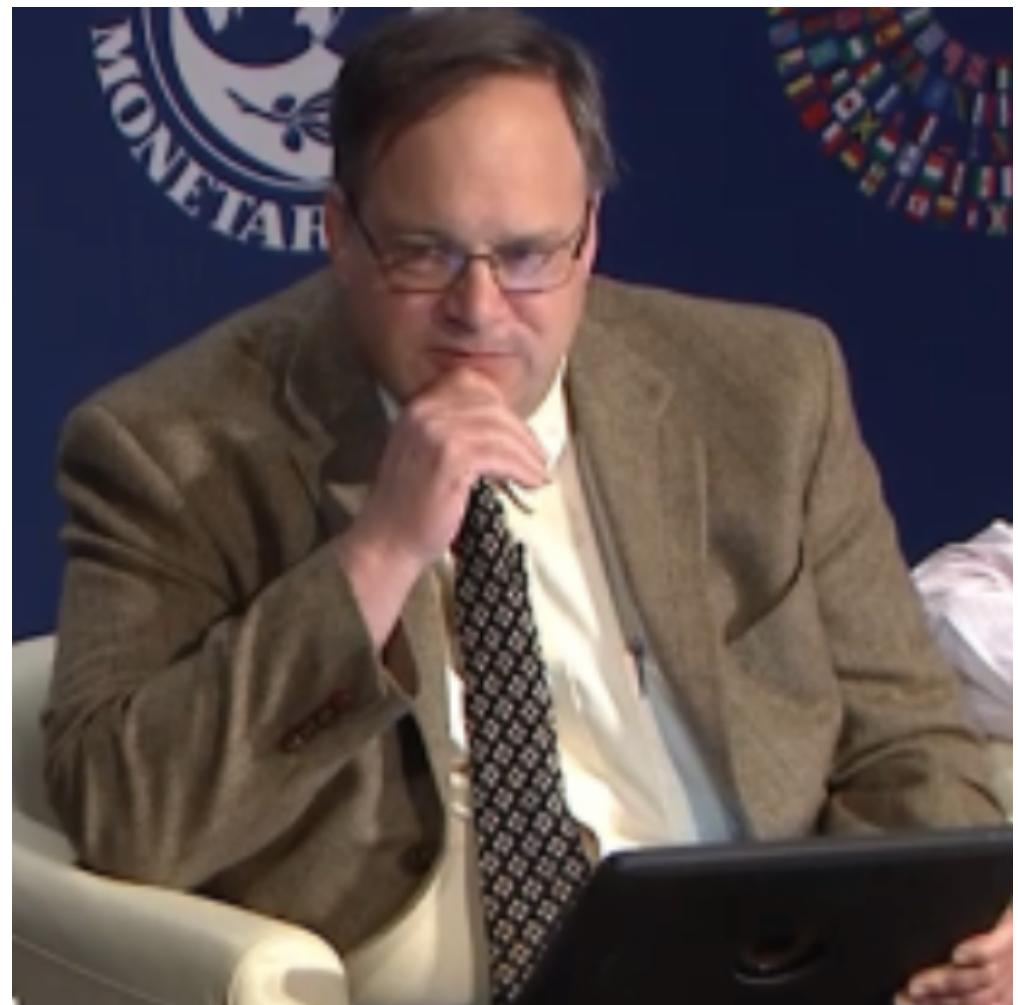
## Files:

- <<https://www.icloud.com/keynote/0YKEi7HeOrVGvKYtt9FEqH7nA>>
- <<https://www.bradford-delong.com/2020/04/coronavirus.html>>
- github:<<https://github.com;braddelong/public-files/blob/master/coronavirus.pptx>>
- <https://github.com;braddelong/public-files/blob/master/coronavirus.pdf>>
- html file: <<https://www.bradford-delong.com/2020/04/coronavirus.html>>
  - html edit: <<https://www.typepad.com/site/blogs/6a00e551f08003883400e551f080068834/post/6a00e551f080038834025d9b3bd66a200c/edit>>
- <<https://delong.typepad.com/files/2020-04-01-coronavirus.pdf>>



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# Notes



# 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  $0.035\%/\text{yr} = 0.7\%/\text{generation}$ 
  - 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%