University of Zurich[UZH]

Agent-based Financial Economics
Lesson 7: Equality

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"What I cannot create, I do not understand."

- Richard Feynman

Today

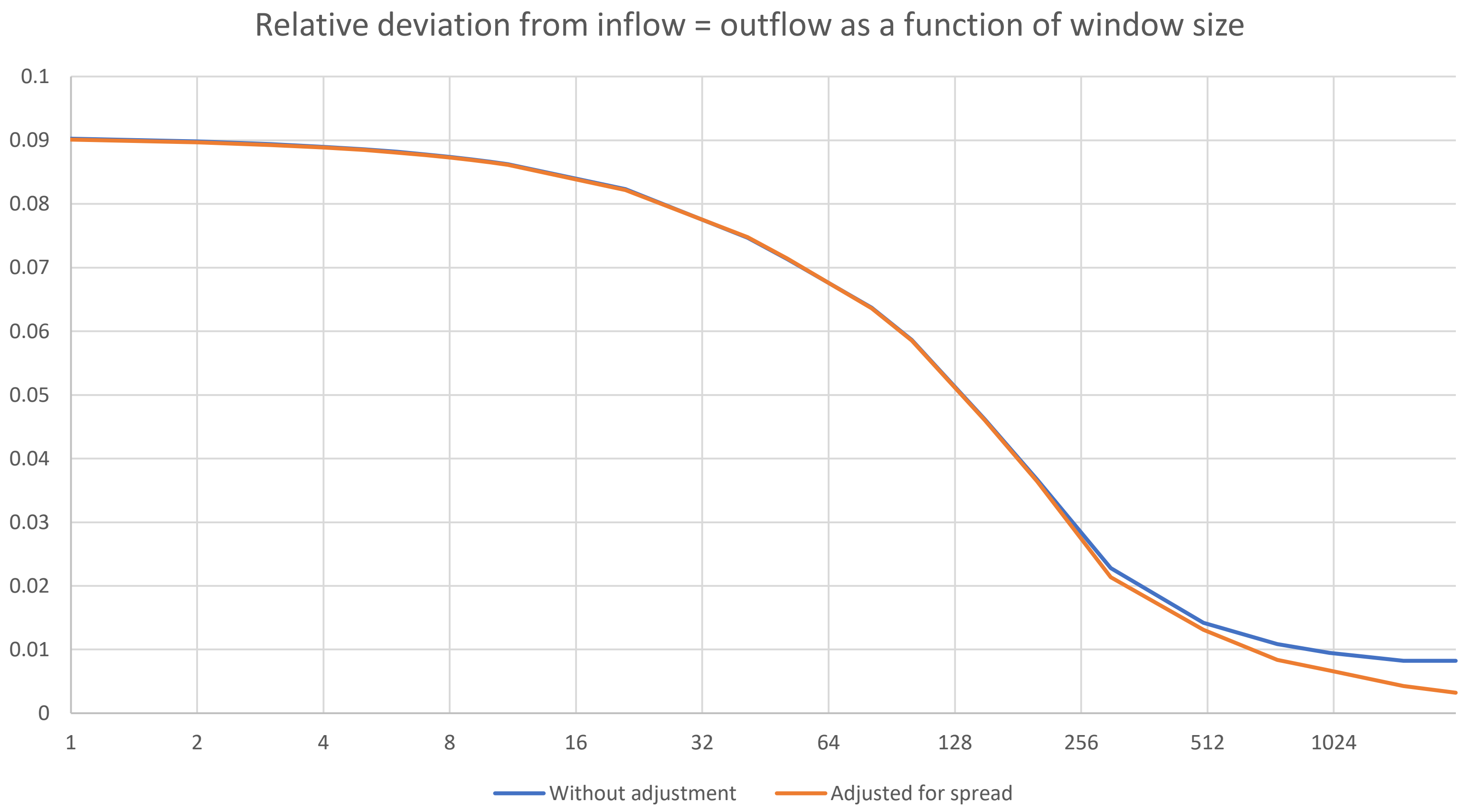
- Principle of positive expressions
- Discussion of exercise 6
- Gini coefficient
- Club of Rome model
- Exercise 7: Equality

Principle of Positive Expressions

- Why “equality” and not “inequality”?
- Human brain is bad at parsing negatives.
- Compare:
  “If the street is not wet, there cannot be rain.” vs. “If there is rain, the street is wet.”
  Logically equivalent, but the latter is much easier to understand.
- Compare:
  if (!list.isEmpty()) { doSomething() };
  if (list.hasSome()) { do Something() };
- Compare:
  “Do you mind if I sit here?” (People usually say “Yes”, when they actually don’t mind…)
  “May I sit here?” (A yes is always a yes.)

→ Using positive expressions makes your programs more readable and helps with human interaction.

Exercise 6 – Flow



$$\frac{1}{\delta}\sum_{i=t}^{t+\delta} inflow_i \approx \frac{1}{\delta}\sum_{i=t}^{t+\delta} outflow_i$$

The larger the window of the rolling average, the smaller the relative difference between inflow and outflow.

In the long run, inflow = outflow holds pretty well, especially when adjusting for the spread, which effectively is a fee paid to the market maker.

Exercise 6 – Flow

Task 1: Does inflow and outflow add up?

Including the market maker, inflow = outflow holds in the model (it must by definition). However, excluding the market maker, the inflow exceeds the outflows by about 1% in the long run.

Where does that money go?

→Note that this 1% corresponds to the spread, the missing money is the trading profits of the market maker!

→Inflows should be adjusted downwards by 1% as this money should be considered «trading fees» paid to the market maker.

Exercise 6 – Flow

Could simply regress:

$P_{t+1} = a + b P_t + c$ inflow + d outflow

This yields an excellent t-stat (over 1000!). It says that the price today is an excellent predictor for the price tomorrow. Is this useful?

Not very, if we want to make money, we actually want to know about the returns, and not the absolute prices!

Also, note that approximately c = -d, so it seems it is only the difference that matters. Let's analyze the following hypothesis:

$r_t = a$ (inflow – outflow)

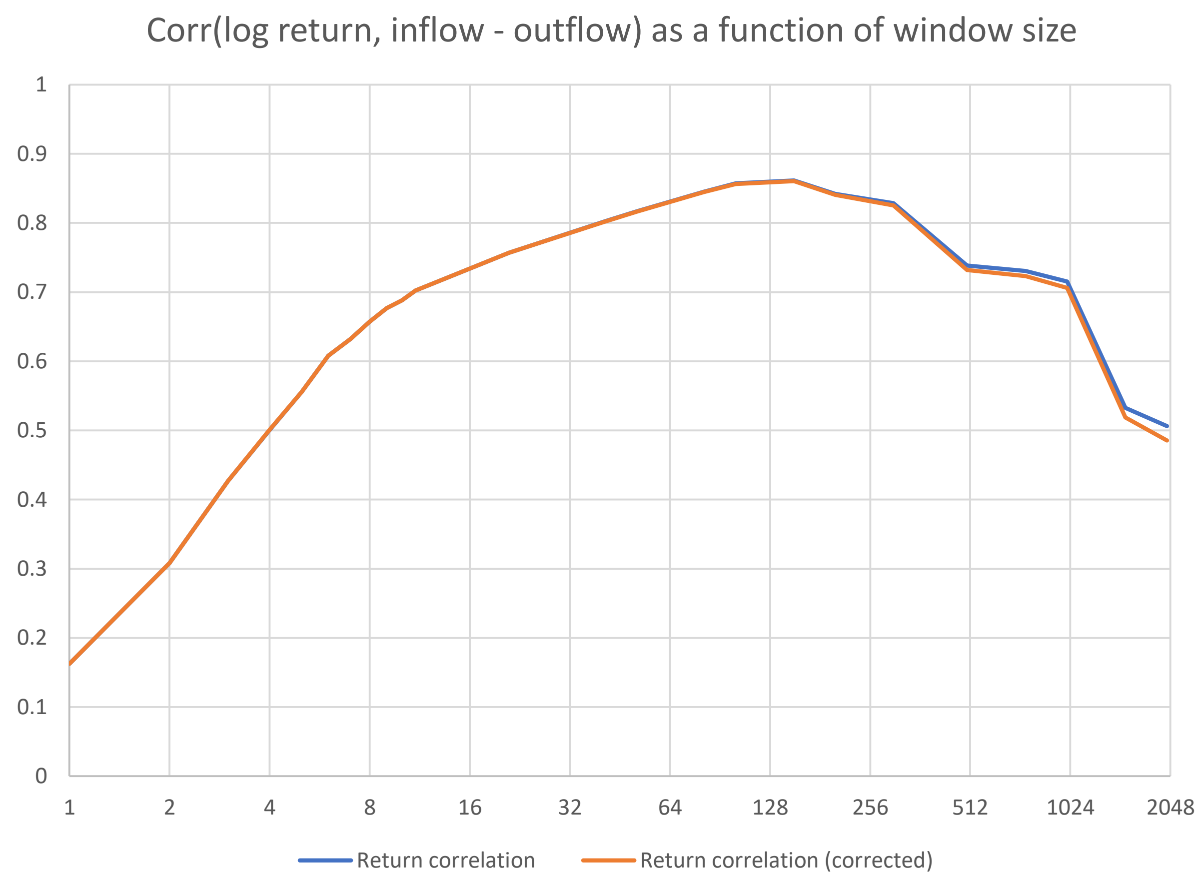
Exercise 6 – Flow

Especially for larger windows of the rolling average, net inflow correlates well with returns.

Note that when having a single variable, correlation corresponds to R-squared.

For a rolling window size of 50, we get a t-stat of about 100! Without using a rolling average window, the t-stat is “only” about 13.

→ Using a rolling window average can help in reducing noise.



Lesson 6: Flow

The following regression explains returns pretty well:

$$\mathrm{r}_t = a(inflow_t - outflow_t)$$

Or, alternatively, one could say that we observe:

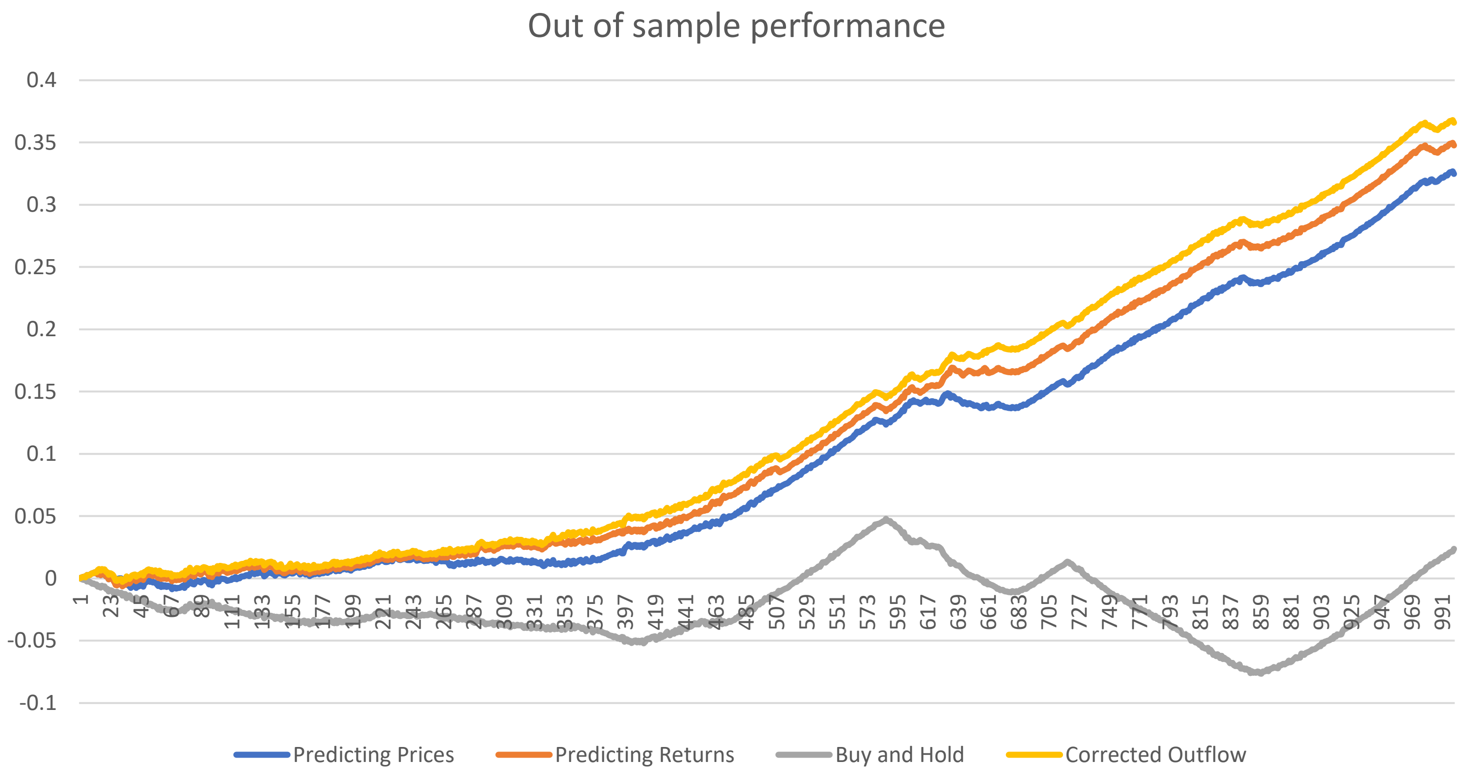
$$\frac{dp}{dt} \propto (in_t - out_t)$$

Plain data: t-stat 4.65, coefficient 0.0000012, R2 0.085
2-day average: t-stat 13, coefficient 0.0000016, R2 0.23
5-day average: t-stat 29, coefficient 0.0000016, R2 0.47
10-day average: t-stat 45, coefficient 0.0000017, R2 0.64
100-day average: t-stat 71, coefficient 0.0000016, R2 0.79

Having a simulation, we could generate arbitrary amounts of data, thereby pushing up the t-stat as high as we want as long as there is a non-zero correlation.
→ Statistical significance does not imply colloquial significance (the effect could be very small)

Exercise 6 – Flow

Can we leverage this insight on our toy stock market? Yes!



Yes, **disregarding dividends**, we can nicely outperform the buy and hold strategy.

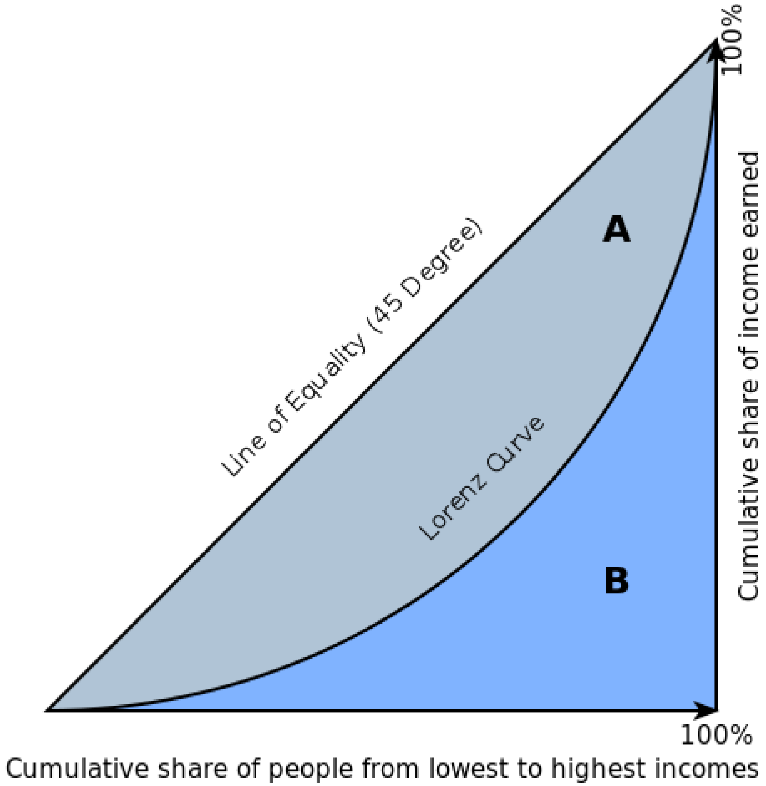
"Predicting prices" strategy goes long whenever the direct regression on prices predicts an increase, and short otherwise.
"Predicting returns" does the same when the return regression predicts a positive return.
"Corrected outflow" does the same using the a metric of inflow that is adjusted for the market maker's spread and known prices.

Note that the rule with the t-stat of 1000 does not perform better than the rule with the t-stat of 13.
Might be interesting to also run a probit regression on whether to go long or short.

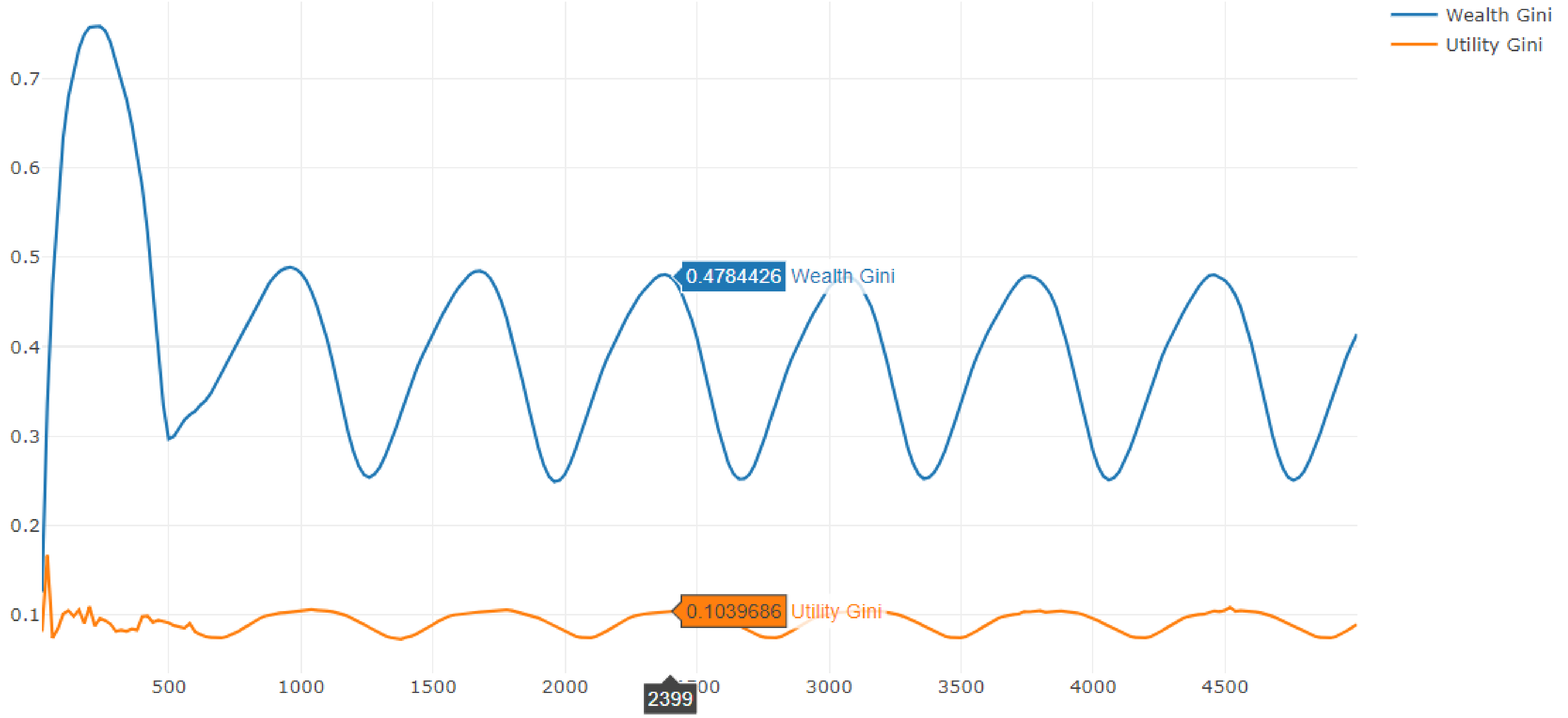
New Metric: GINI Coefficient

Gini = A / (A+B) = 2 A = 1 – 2 B
(Because A+B = 0.5)

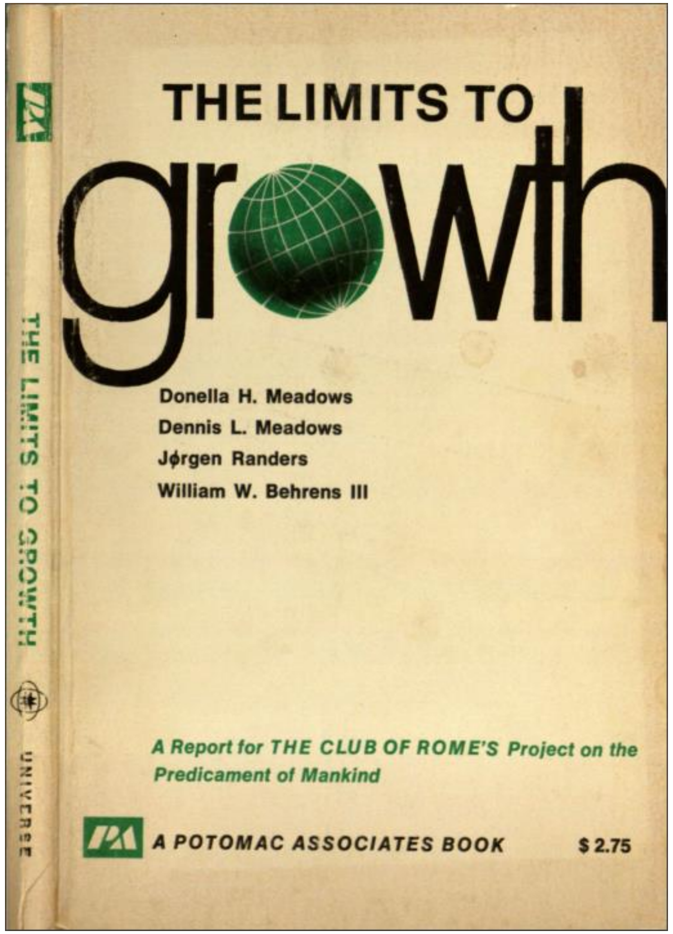
$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2\sum_{i=1}^{n}\sum_{j=1}^{n} x_j} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n\sum_{i=1}^{n} x_i}$$



Gini-coefficient in Exercise 6



Club of Rome: Limits to Growth



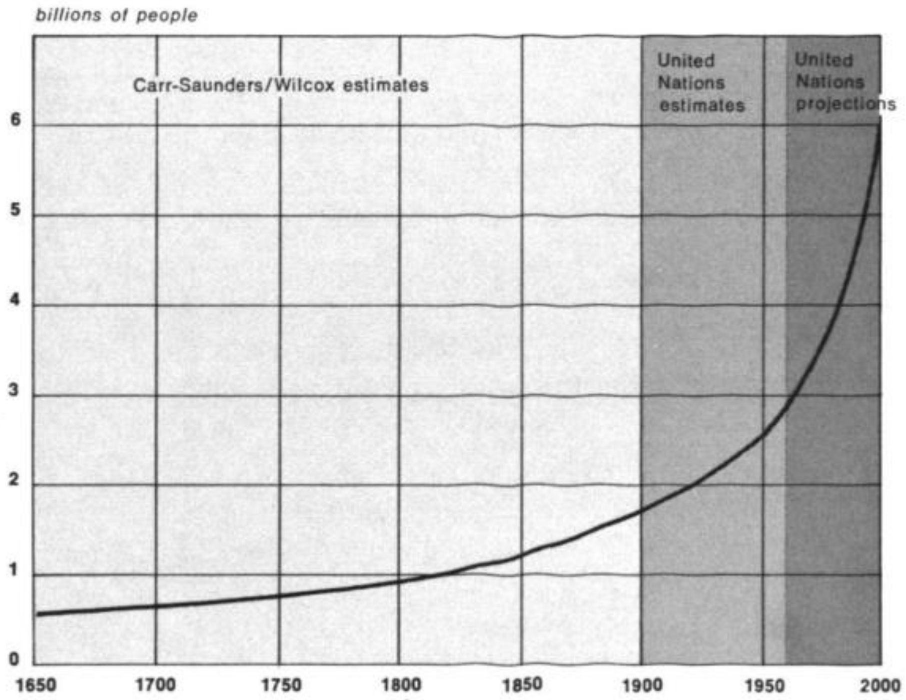
- Hugely influential book from 1972
- Based on System Dynamics (not agent-based, but also exhibits non-linear endogenous dynamics)
- Start of the green movement: recycling, outlawing DDT, etc.
- Pessimistic predictions
- PDF available from: www.clubofrome.org/report/the-limits-to-growth

Club of Rome: Limits to Growth

Caused a paradigm shift: awareness that we can destroy the planet.

Club of Rome: Limits to Growth

Figure 5 WORLD POPULATION

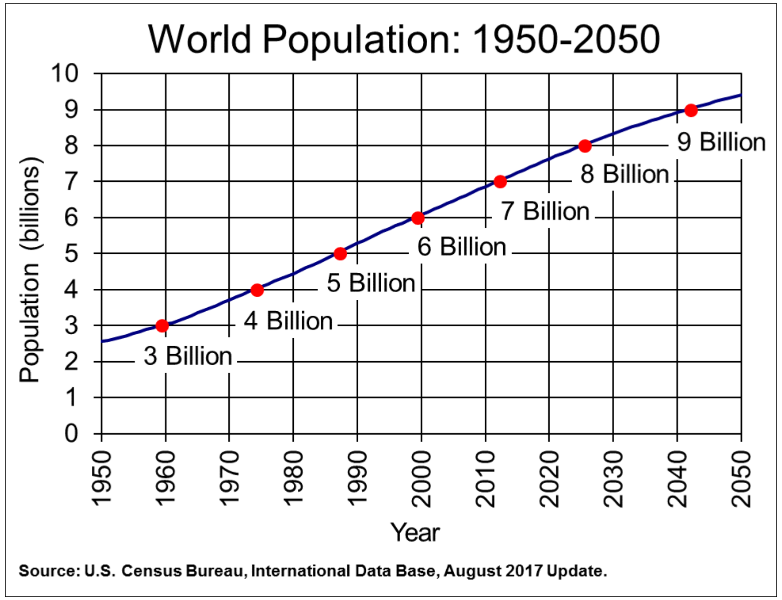


World population since 1650 has been growing exponentially at an increasing rate. Estimated population in 1970 is already slightly higher than the projection illustrated here (which was made in 1958). The present world population growth rate is about 2.1 percent per year, corresponding to a doubling time of 33 years.

SOURCE: Donald J. Bogue, *Principles of Demography* (New York: John Wiley and Sons, 1969).

Some estimates have been excellent.
Prediction for world population in the year 2000 has been spot on.

Current outlook



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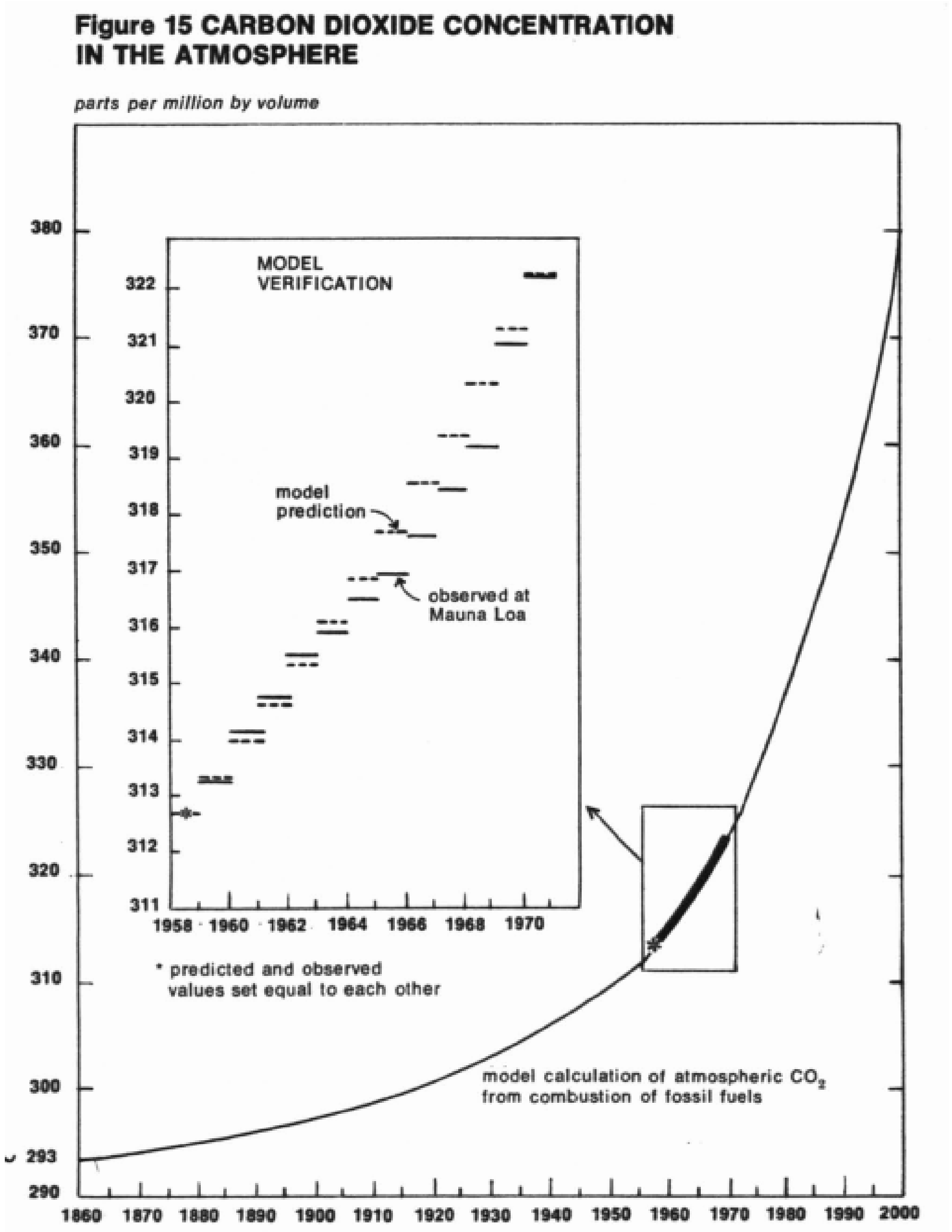
Also prediction for CO2 concentration in atmosphere was excellent.

Current level: around 400 ppm



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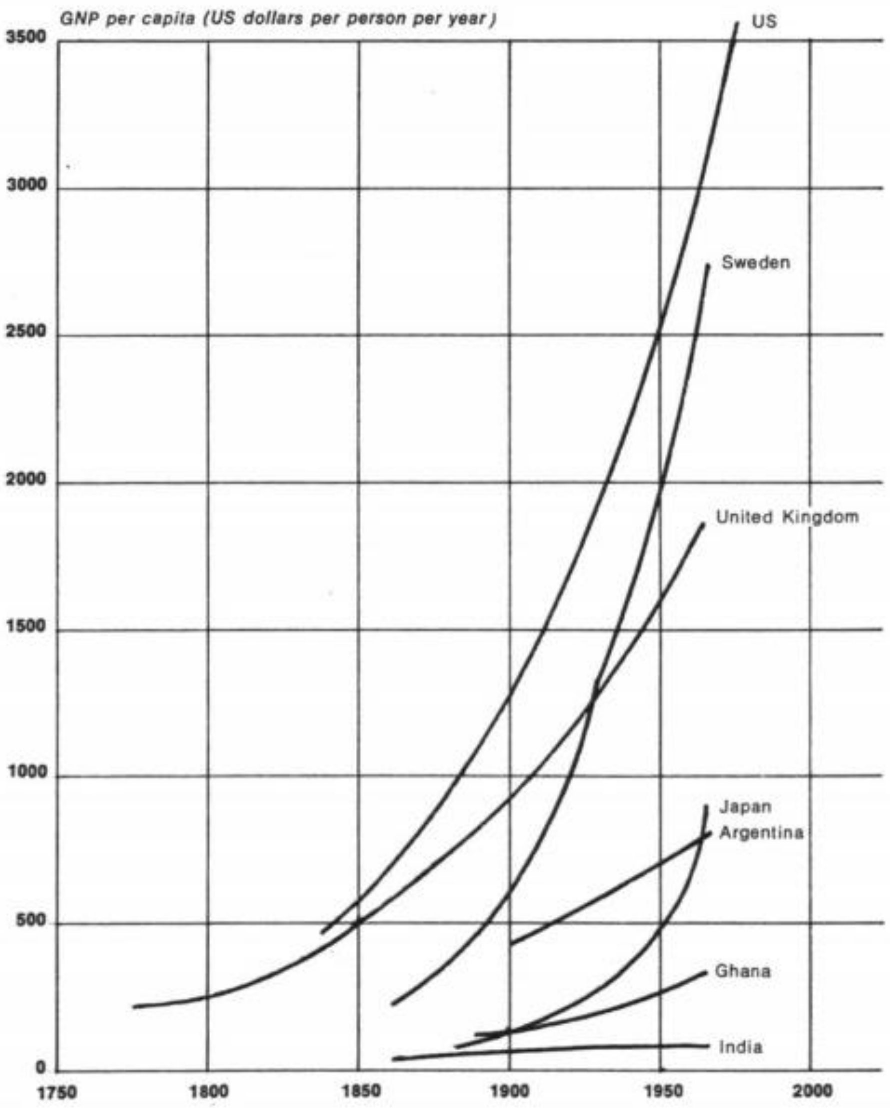
Basic observation: things are growing exponentially.

Table 2 ECONOMIC AND POPULATION GROWTH RATES

Country	*Population (1968) (million)*	*Average annual growth rate of population (1961–68) (% per year)*	*GNP per capita (1968) (US dollars)*	*Average annual growth rate of GNP per capita (1961–68) (% per year)*
People's Republic of China *	730	1.5	90	0.3
India	524	2.5	100	1.0
USSR *	238	1.3	1,100	5.8
United States	201	1.4	3,980	3.4
Pakistan	123	2.6	100	3.1
Indonesia	113	2.4	100	0.8
Japan	101	1.0	1,190	9.9
Brazil	88	3.0	250	1.6
Nigeria	63	2.4	70	—0.3
Federal Republic of Germany	60	1.0	1,970	3.4

Figure 7 ECONOMIC GROWTH RATES



The economic growth of individual nations indicates that differences in exponential growth rates are widening the economic gap between rich and poor countries.

SOURCE: Simon Kuznets, *Economic Growth of Nations* (Cambridge, Mass.: Harvard University Press, 1971).

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Basic observation: things are growing exponentially.

What if we extrapolate this?

Table 3 EXTRAPOLATED GNP FOR THE YEAR 2000

Country	*GNP per capita (in US dollars*)*
People's Republic of China	100
India	140
USSR	6,330
United States	11,000
Pakistan	250
Indonesia	130
Japan	23,200
Brazil	440
Nigeria	60
Federal Republic of Germany	5,850

* Based on the 1968 dollar with no allowance for inflation.

1 USD from 1968 corresponds to 7 USD from 2017.

US estimate is okayish (57k vs 77k). Others are way off.

Actual vs Club of Rome estimate:
China: 8k vs 0.7k → Underestimated China
Russia: 9k vs 42k → Overestimated Russia
Japan: 39k vs 160k
Nigeria: 2.2k vs 0.4k
Germany: 42k vs 42k
Brazil: 8.6k vs 3k
Indonesia (now 3.5k) overtook Pakistan (now 1.5k)

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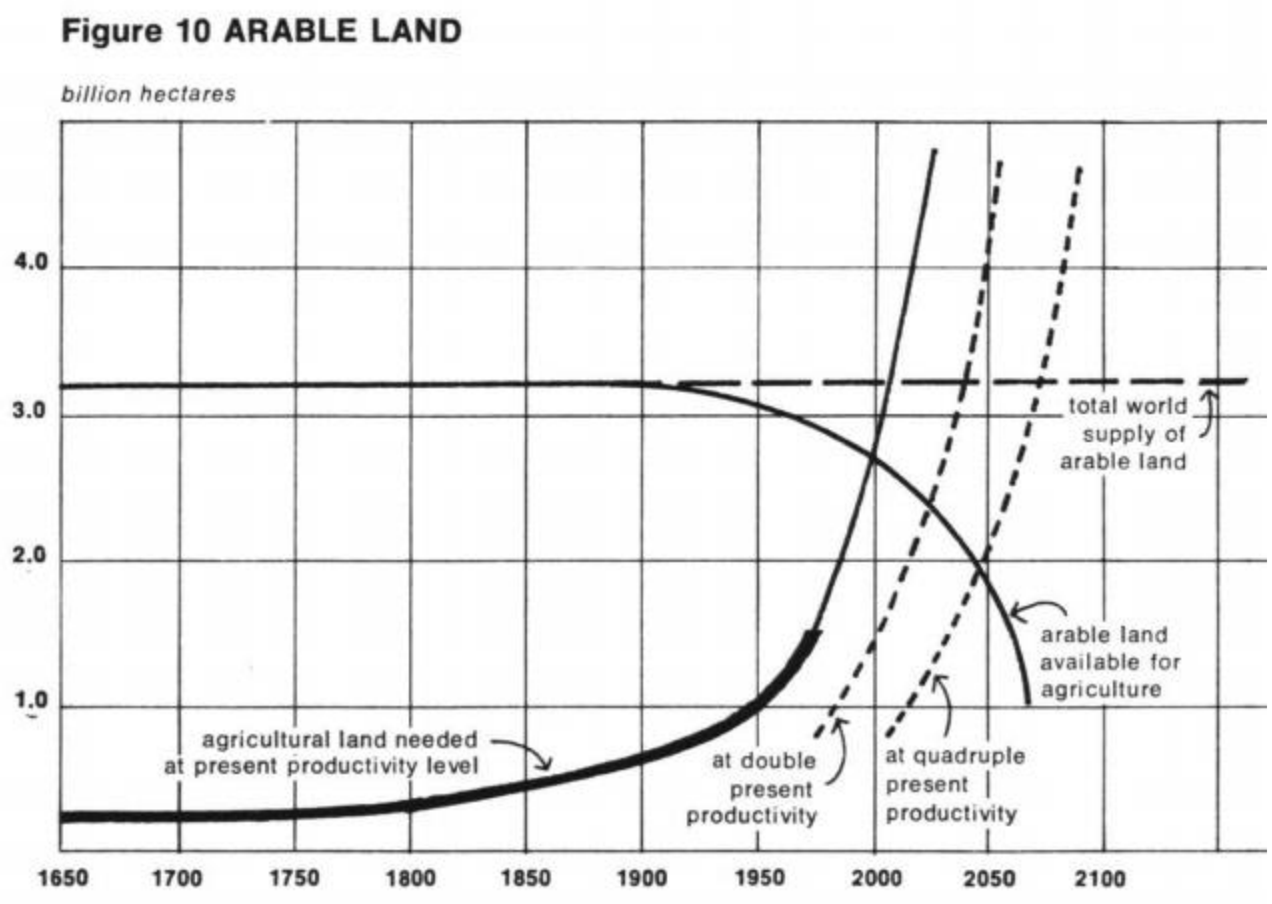
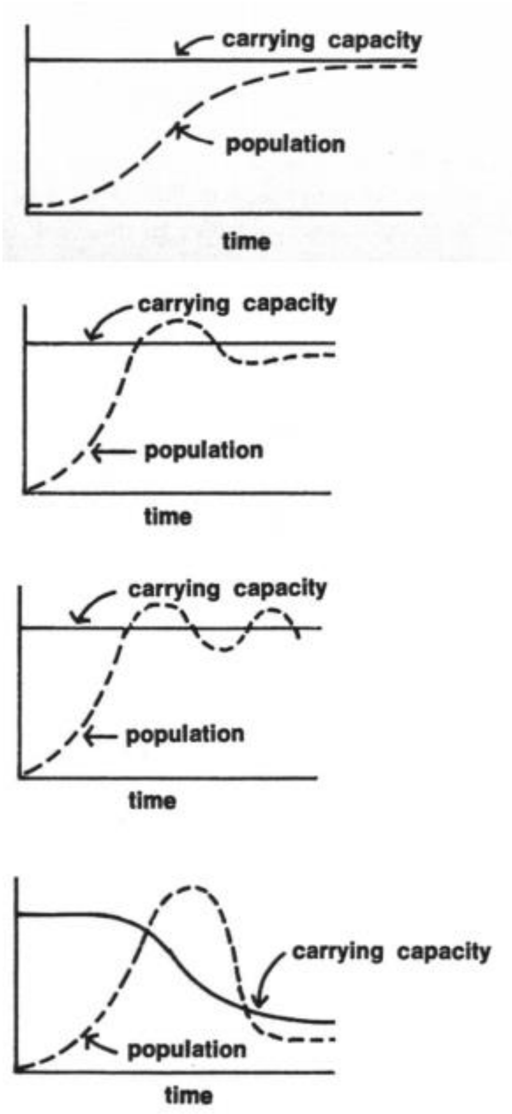
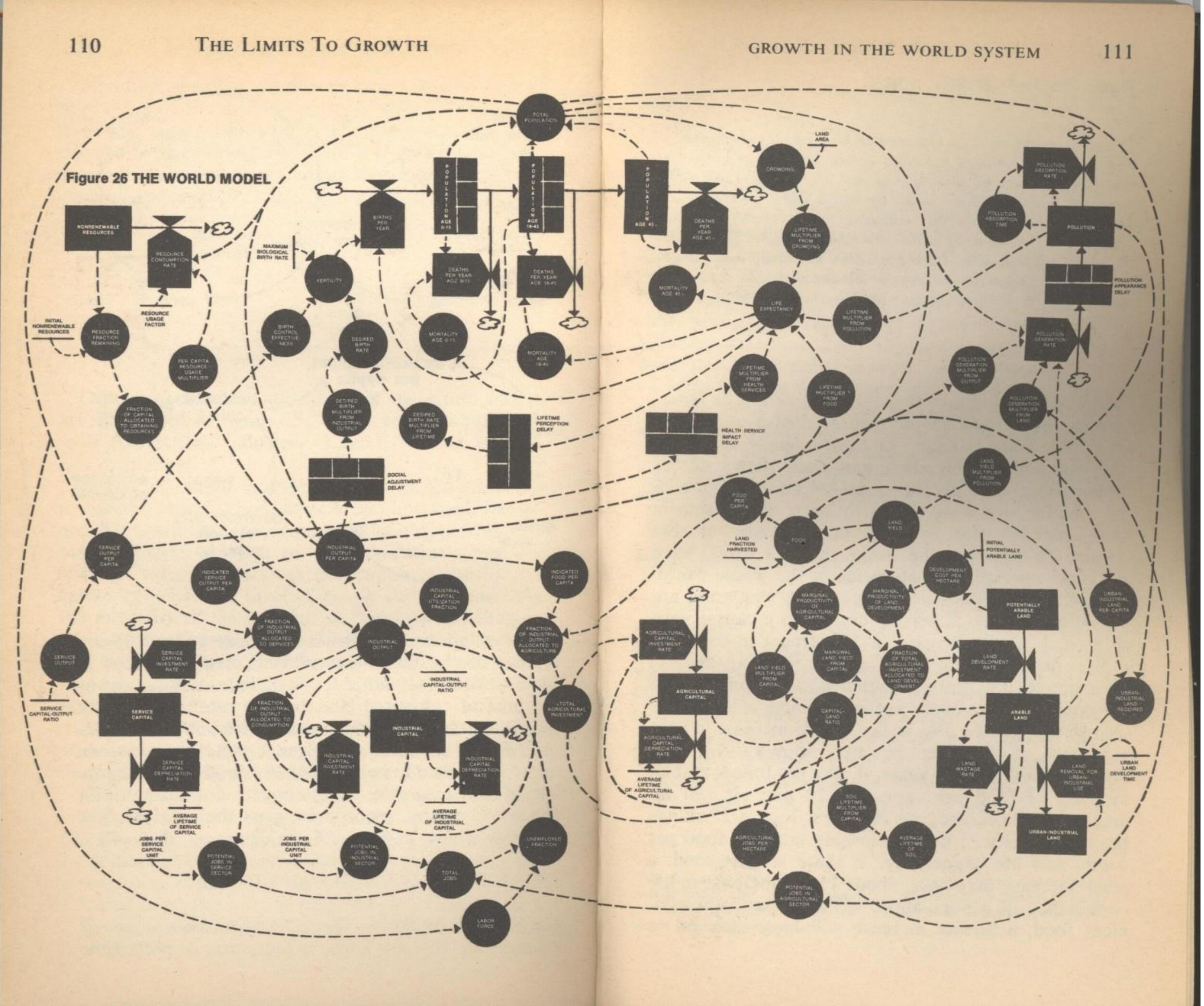


Club of Rome warning: Regardless of how accurate our predictions are, with exponential growth, we will hit some natural limits sooner or later! This cannot go on forever!



Types of dynamics.



The “Limits to Growth” world model.

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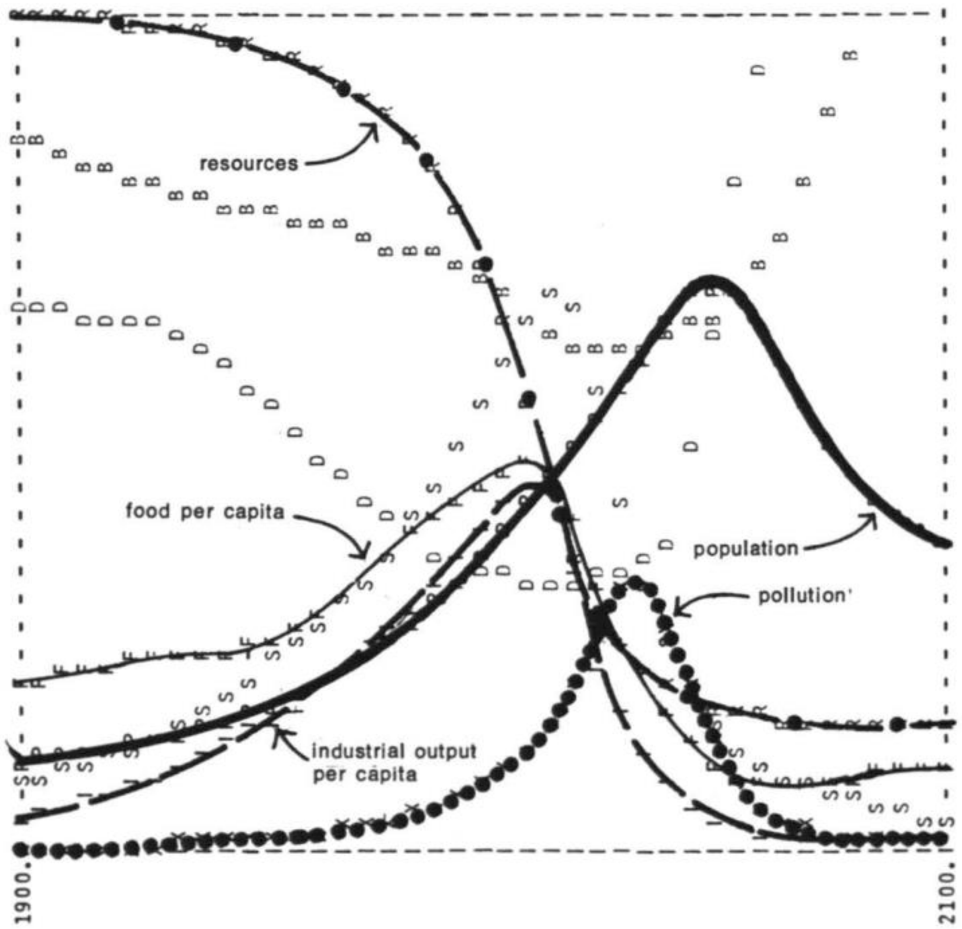
Figure 35 WORLD MODEL STANDARD RUN



The "standard" world model run assumes no major change in the physical, economic, or social relationships that have historically governed the development of the world system. All variables plotted here follow historical values from 1900 to 1970. Food, industrial output, and population grow exponentially until the rapidly diminishing resource base forces a slowdown in industrial growth. Because of natural delays in the system, both population and pollution continue to increase for some time after the peak of industrialization. Population growth is finally halted by a rise in the death rate due to decreased food and medical services.

→ Turned out to be overly pessimistic. Underestimated inventiveness of firms and free innovation, i.e. adjustment to less resource usage as they got more expensive. Did not foresee the "digital age". Instead, they called for the creation of "supranational institutions" to manage population and capital growth…

You can play with the model online on:
insightmaker.com/insight/1954/The-World3-Model-A-Detailed-World-Forecaster

Current Setting: Consumer

→ Look at code

Exercise 7 – Equality

See exercise 7 on github:

https://github.com/meisser/course/blob/master/exercises/journal/exercise07-task.md