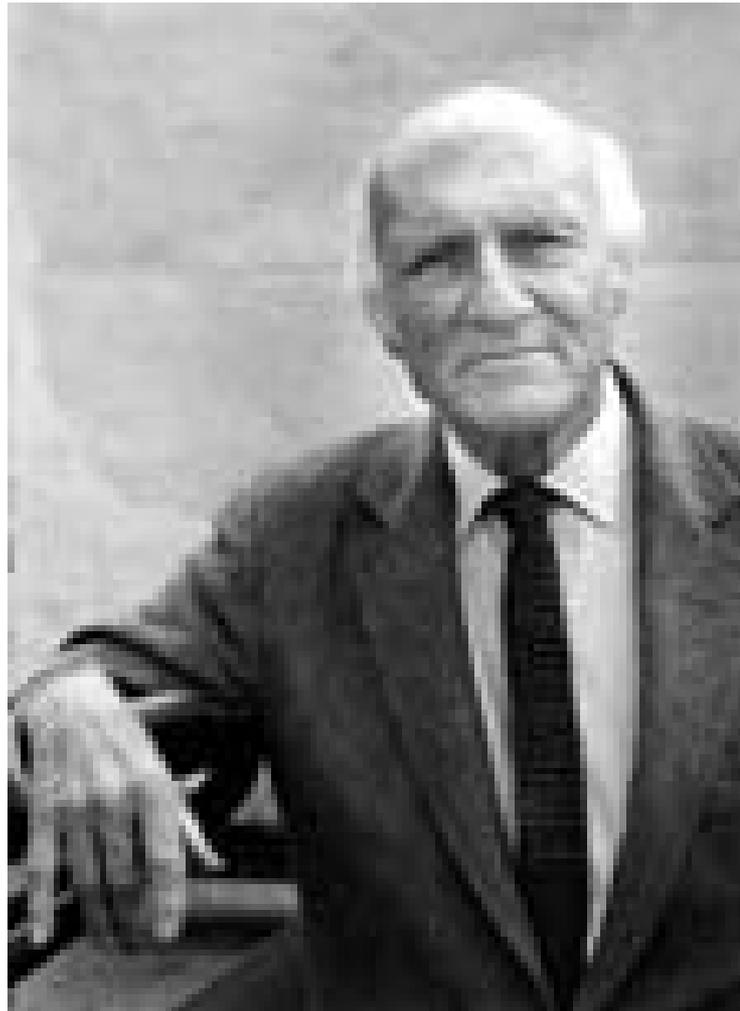


A Study of Human Population Growth

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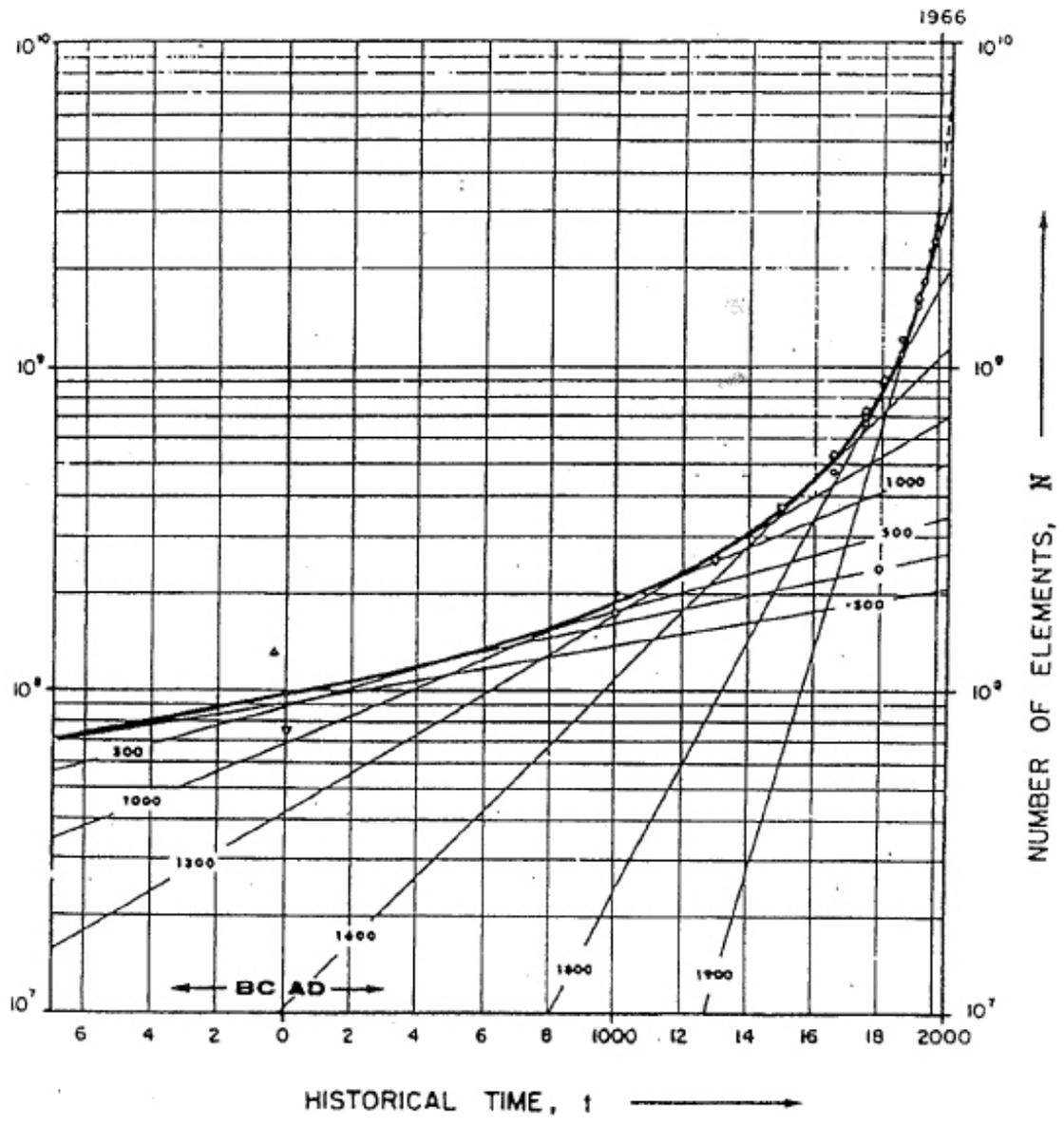
Washington, DC

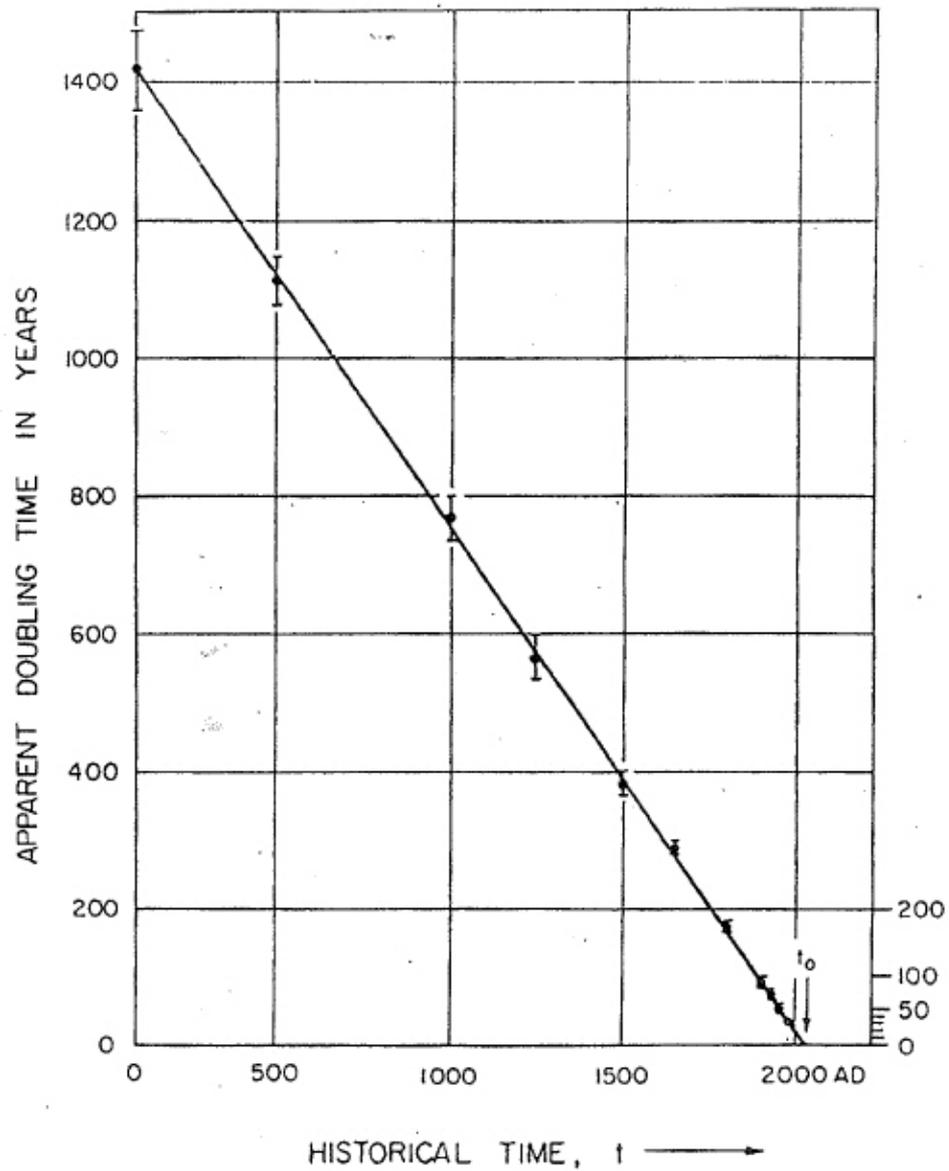


Heinz von Foerster

Origin of Heinz's interest

- Heinz responded to a request for proposals for a mathematical model of white blood corpuscle populations
- He decided to do also a study of a communicating population



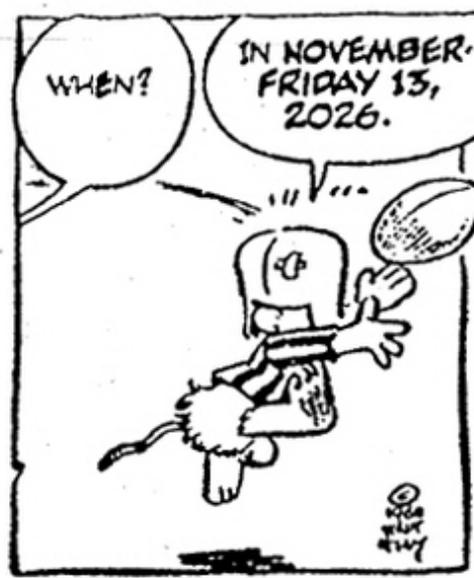


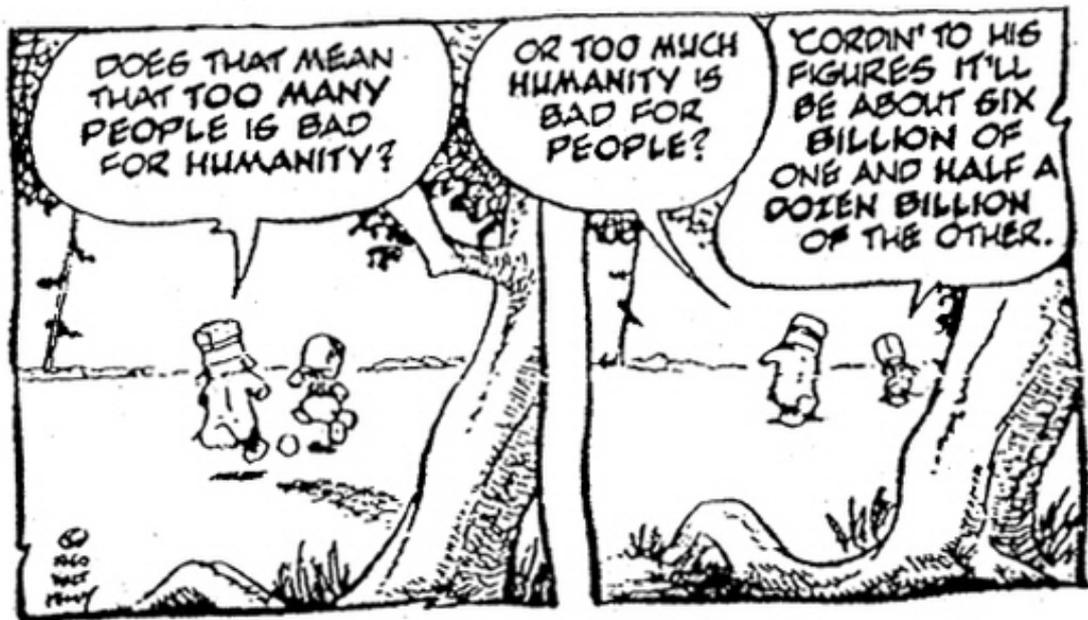
The Doomsday Study

- Study a communicating population
- Gather data, eliminate redundancy
- Plot on semi-log paper to reveal a rising or falling growth rate
- Convert the growth rate to doubling time
- Extrapolating the falling doubling time indicated an infinite growth rate early in the 21st century

The Doomsday Equation

$$N = \frac{1.79 * 10^{11}}{(2026.87 - t)^{0.99}}$$







Criticism from demographers 1

Robertson, Bond, and Cronkite expressed concern that the equation “may be taken too seriously” and claimed that it is “obvious that such a theory has no relation to reality and is of no value whatever in predicting future populations.”

Criticism from demographers 2

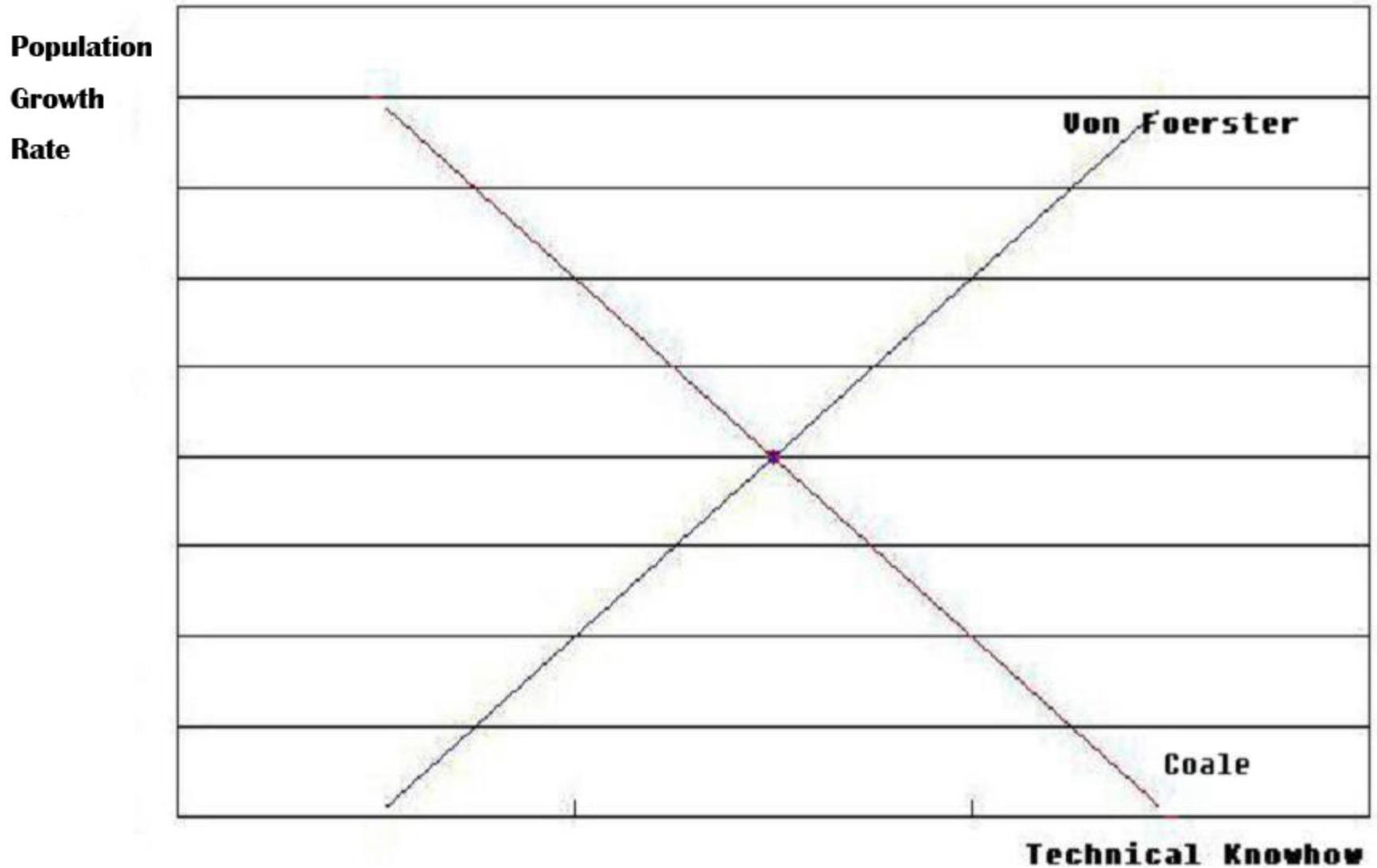
- Shinbrot wrote that the article “would be too ridiculous to comment on if it were not such an outstanding example of the inadmissible use of mathematics to prop up a manifestly absurd conclusion.”
- Von Foerster, *et al.*, replied that in the scientific community “support of a hypothesis is gained through compatibility with experimental observation rather than by arguments about what should be the case or what should not be the case.”

Singularities as warnings

- Von Foerster, *et al.*, explained that “singularities” occur quite commonly in nature (e.g., air pressure at Mach 1, voltage breakdown in gaseous conduction, temperature and magnetic susceptibility).
- Such expressions (when a parameter increases rapidly beyond all bounds) indicate instability and warn of a breakdown in the system’s structure.

..... If we apply “Coale’s Law” of the inverse relationship of population density with growth rate and technological knowhow -- as suggested in his letter -- to the development of the human population as a whole over the last couple of millennia, we arrive at the peculiar conclusion that either Stone Age man was a technological wizard who carefully removed his technological achievements so as not to upset his inferior progeny , or that -- if he was at the level at which most of us believe he was -- our population dwindled from once astronomical size to the mere three billions of today (Von Foerster, *et al.*, 1961, June, p.1932).

Two very different interpretations of trends



Sources of data

- Demographers use estimates of future fertility and mortality in making forecasts
- Cohort analysis, used by demographers, involves summing up estimates of future events
- Von Foerster, *et al.*, extrapolated data from the past

On predictions

- Demographers base forecasts on fertility and mortality (first derivative)
- Von Foerster, *et al.*, pointed to coalitions and noted that two people jointly can do things that the two independently are never able to achieve (second derivative)
- Higher derivatives produce better forecasts

Table 1

Low, Medium, and High World Population Projections (in billions)
for A.D.2000, made by the U.N. in four different years and
derived from the Doomsday Equation (Von Forester, *et al.* , 1962)

Projection	Estimate in 1950	Estimate in 1957	Estimate in 1958	Estimate in 1959	Doomsday Equation
Low			4.88		6.44
Medium	3.20	5.00	5.70	6.20	6.91
High			6.90	7.00	7.40

Post hoc population growth

- Von Foerster showed in 1962 that estimates of world population in future years converge toward the doomsday estimate as the date in question approaches
- Umpleby showed in 1989 that estimates of world population in a specific year, such as 1975, continue to rise after the date in question has passed

Table-2

Estimates of human population in billions as a function of time
(United Nations, 1951, 1966, 1982, 1985, 1986, 1989)

Year in Question	1951 Est.	1963 Est.	1973 Est.	1982 Est.	1984 Est.	1988 Est.	Doomsday Equation
1950	<u>2.406</u> *	2.517	2.501	2.504	2.516	2.515	2.432
1955		2.731	2.722	2.746	2.751	2.751	2.599
1960	2.731	<u>2.988</u> *	2.986	3.014	3.019	3.019	2.792
1965		3.281	3.288	3.324	3.334	3.336	3.015
1970		3.592	<u>3.610</u> *	3.683	3.693	3.698	3.277
1975		3.944	3.968	4.076	4.076	4.080	3.650
1980	3.277	4.330	4.374	<u>4.453</u> *	4.450	4.450	3.969
1985		4.746	4.816	4.842	<u>4.837</u> *	4.854	4.438
1990		5.188	5.280	5.248	5.246	<u>5.292</u>	5.033
1995		5.648	5.763	5.769	5.678	5.766	5.814
2000		6.130	6.254	6.127	6.122	6.251	6.844

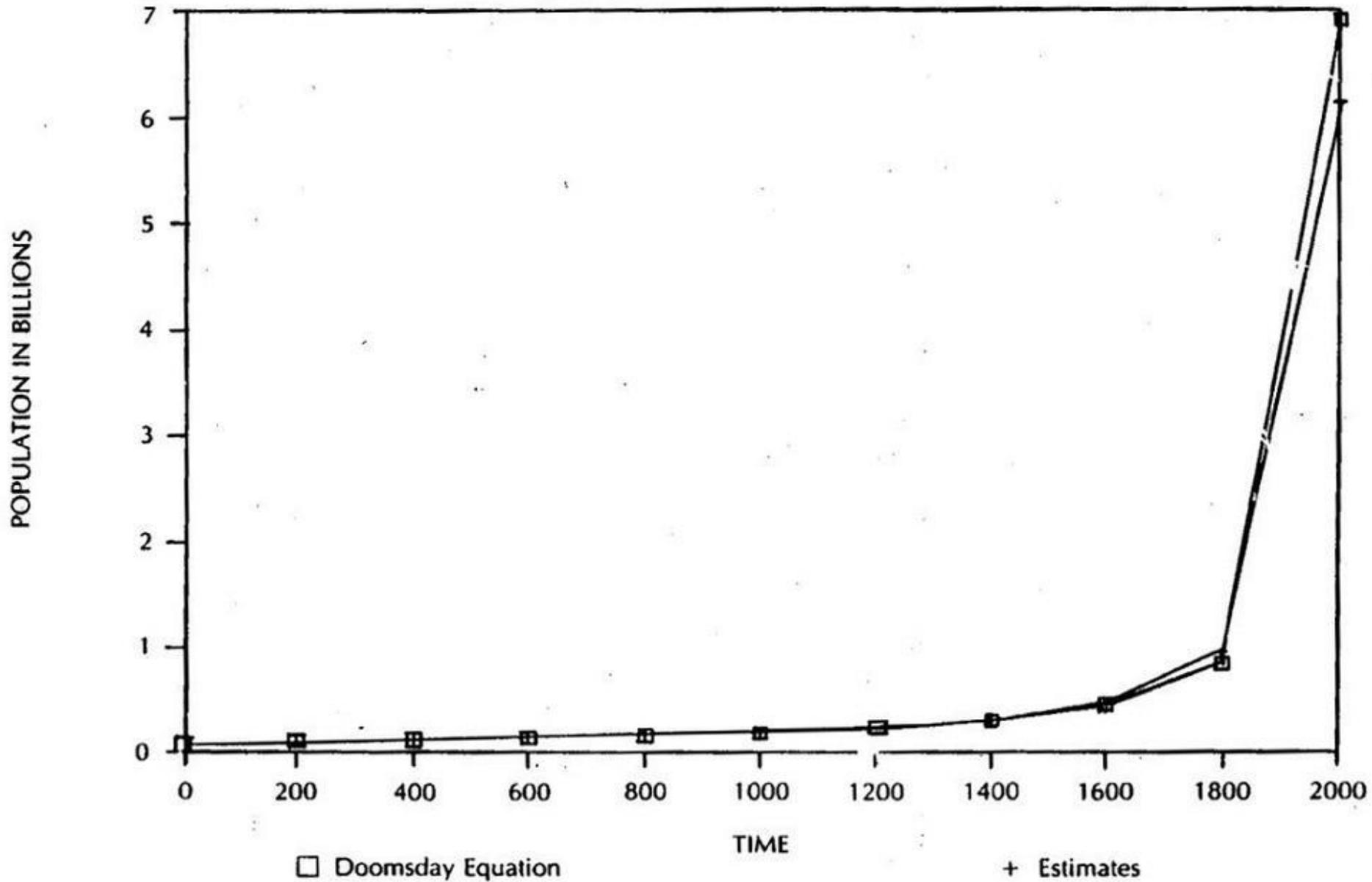
Demographers vs. Nat'l Sci.

- Changes in population are a function of fertility and mortality
- Population has increased because deaths have declined faster than births
- Development leads to declining pop. growth rates
- Fertility and mortality are influenced by communication
- The rate of growth has increased because the size of the coalition has increased
- World population has increased as devel. has increased

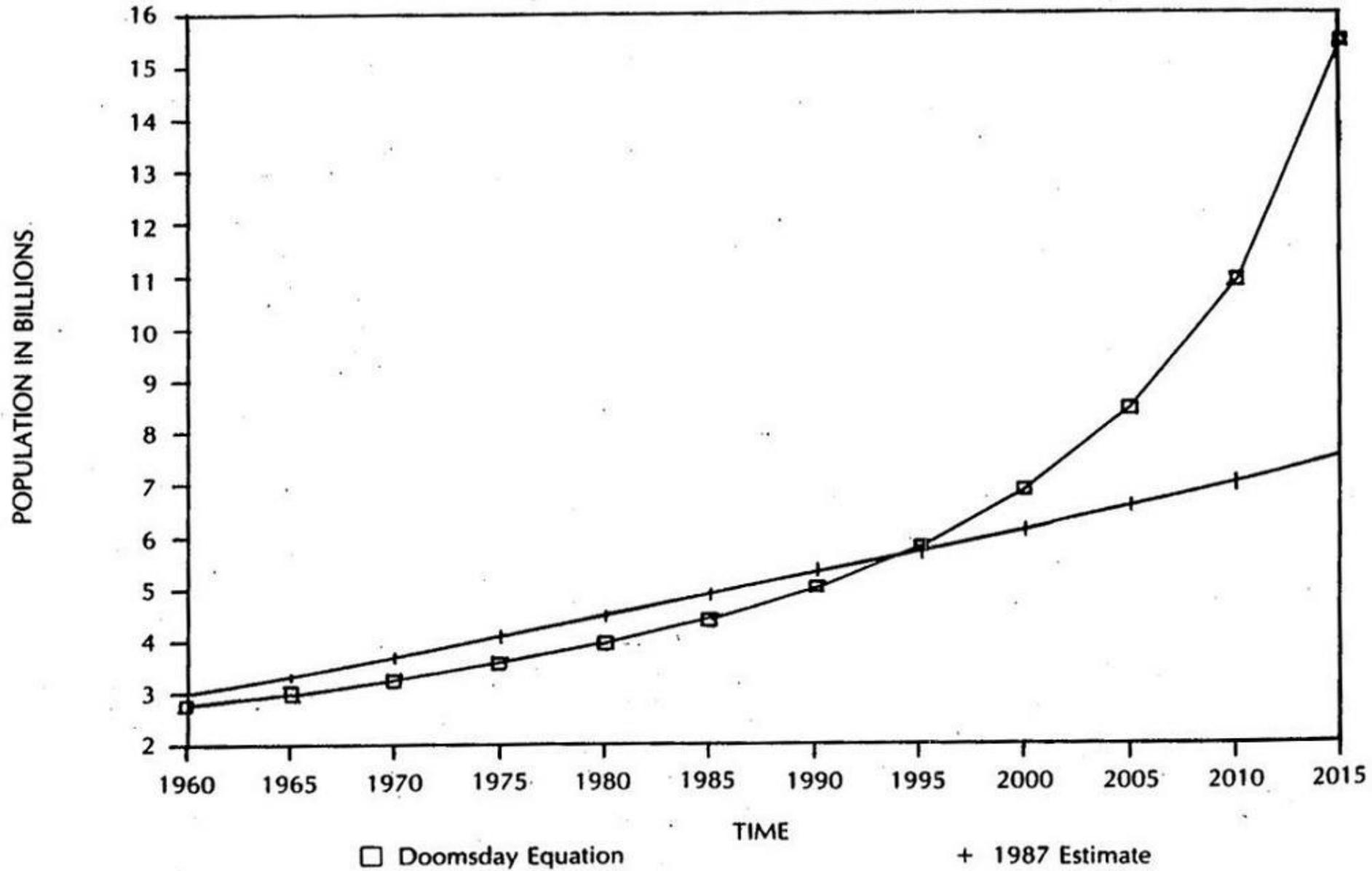
Demographers vs. Nat'l. Sci. 2

- Human beings, like other species, are limited by their envir.
- An infinite pop. and infinite growth rates are absurd and imposs.
- Est. of pop. should be based on est. of future fertility and mortality rates
- Human beings are unique in their ability to enlarge their envir.
- Singularities in rel. btw variables are common and warn of instability
- Est. for future dates should be based on computed rates of ch.

World Population 0 A.D. to 2000 A.D.



World Population 1960 to 2015



Conclusions

- Demographers and natural scientists have different ways of making projections
- Other scientists assume demographers are operating like natural scientists
- Doomsday Equation estimates were too low for $\frac{1}{2}$ of its lifetime, 33 years and too high for $\frac{1}{2}$ of his lifetime, 33 years

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