

Population Projections & Forecasts

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Projection v Forecasting

Projection: illustrates future scenario under explicit assumptions

Forecast: includes probabilities, likelihood of different outcomes, usually the assessors best guess of what will happen

outline

Why do we care

Some history, limits to growth, etc

Methods: sources of data, projection methods

Contrasting predictions for world

Why do we care about population?

Why do we care about population?

ITAP, environmental impacts;

Possible overshoot/overpopulation

Running out of resources, or swamping economic growth

Planning

water and food supplies, where to build infrastructure, taxes, pension plans....

Business investments

Possible benefits: R&D, etc

Kaya Identity

$$F = P \times \frac{G}{P} \times \frac{E}{G} \times \frac{F}{E}$$

F = global CO₂ emissions, P = population, G = GDP, E = Energy Use

Not hard to figure out that if we're trying to reduce CO₂ emissions by 80% and population doubles, the job gets harder;

if resources/technology fixed then standard of living declines

BUT possible advantages to larger population (more innovation etc), questionable limits to innovation

Population Control

Interesting, somewhat hysterical/biased read: The War
Against Population by Kasun

1970's US: "Population: The Problem Is Us"

There are too many people in the world. We are
running out of space. We are running out of
energy... running out of food. And, although too few
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Created by Smithsonian Institution

200 AD

Tertullian in Carthage (probably $<1\text{E}6$ people):

“What most frequently meets our view (and occasions complaint), is our teeming population. Our numbers are burdensome to the world, which can hardly support us... In very deed, pestilence, and famine, and wars, and earthquakes have to be regarded as a remedy for nations, as the means of pruning the luxuriance of the human race”

Uncomfortable paternalism shading into eugenics

US AID in 1970's explicitly concentrated committed to
“control of population growth

Jimmy Carter's farewell address: called for “courage and
foresight” to meet the grave problem of overpopulation

Eugenics: prevent the multiplication of “bad stocks,”
improve the human race;

Margaret Sanger, founder of Planned Parenthood: “ask the
government to... take the burden of the insane and
feebleminded from your back. Sterilization for these is the
solution”

Non-alarmists

At-least-plausible calculations by Roger Revelle and Colin Clark estimating carrying capacity closer to 35-40 billion people

Sources of data

US census, first in world started in 1790

George Washington complained that the first was likely an undercount

Vital statistics: births, deaths, marriages tracked by states, usually only logged with county-level precision, compiled by National Center for Health Statistics

Census Bureau also makes estimates and projections

World: according to UN over 97% of countries conduct a census, which is the main source of data

Major techniques

How would you go about making projections?

Major Techniques

Trend Extrapolation

cheap

can miss shifts in major underlying factors

Cohort Component Method

Structural Methods

Expert Judgement/Subjective Methods

Cohort Component Method

Components of population change (birth, mortality, migration) projected for *cohorts* of people

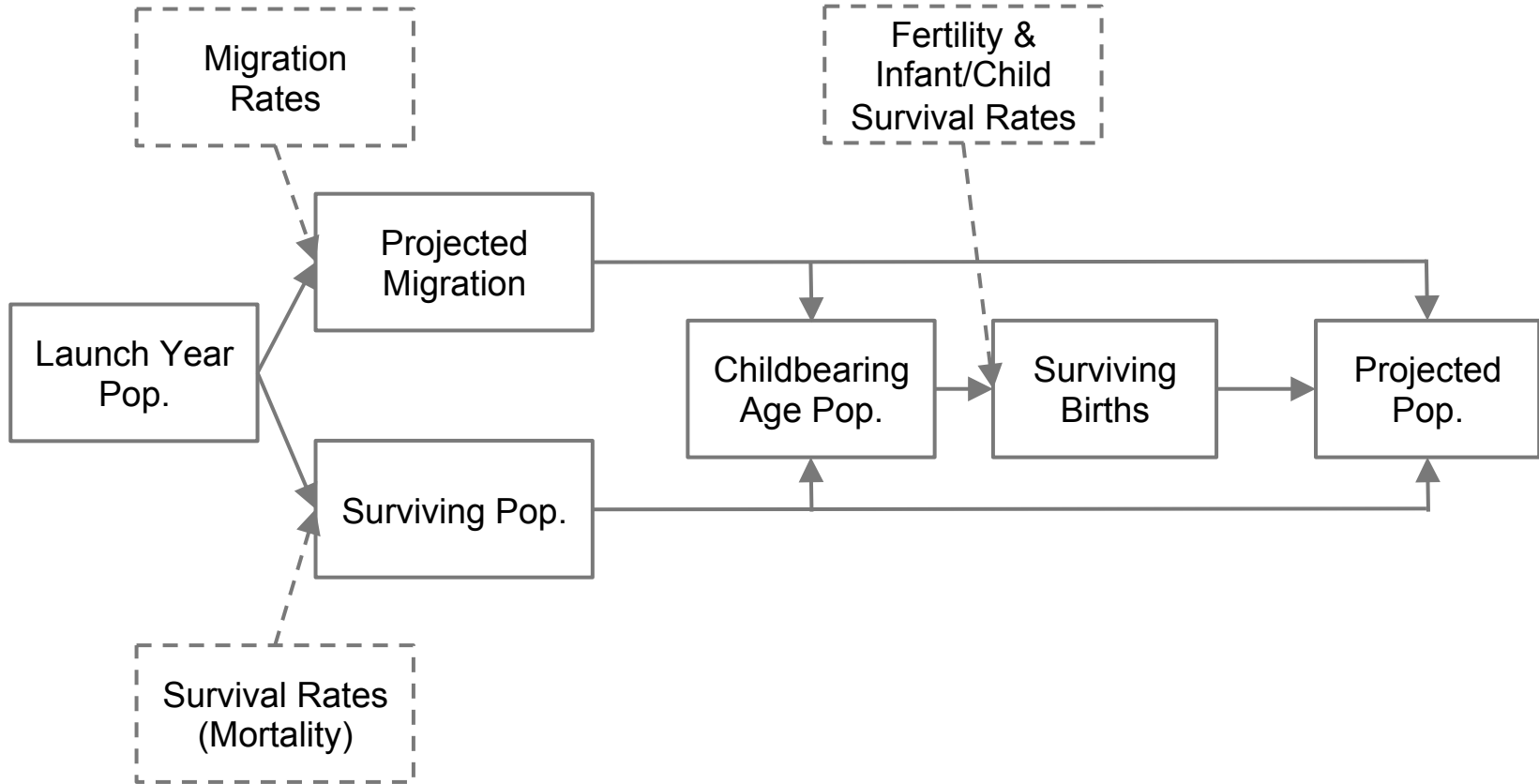
Cohorts were initially defined by year of birth, now include gender, race, ethnicity, etc

very useful for projecting changes in racial diversity, age distributions, etc

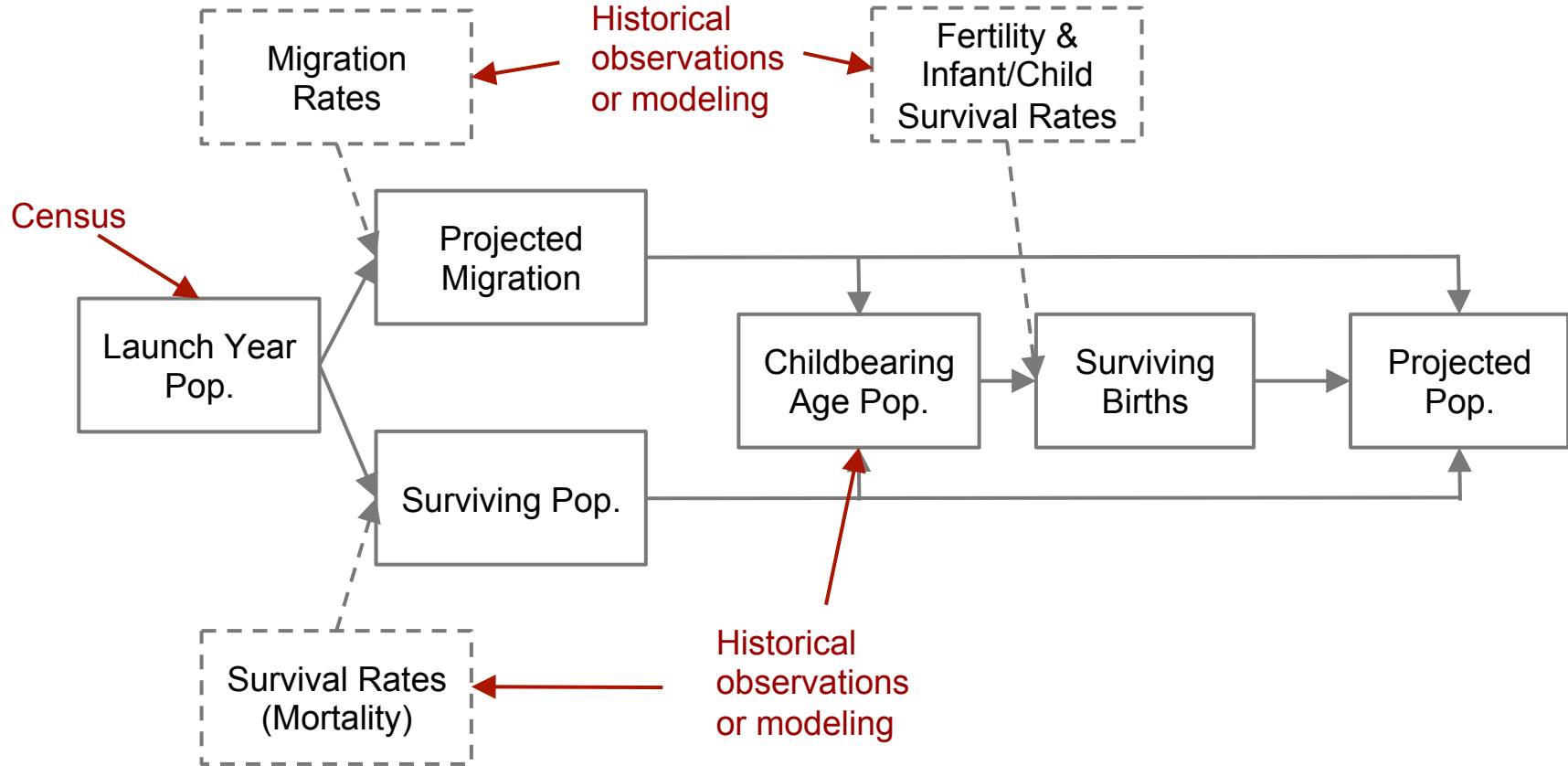
By far the most prevalent for nation, state, local estimates, origins in 1890 or earlier

Level of sophistication can vary significantly

Cohort Component Method

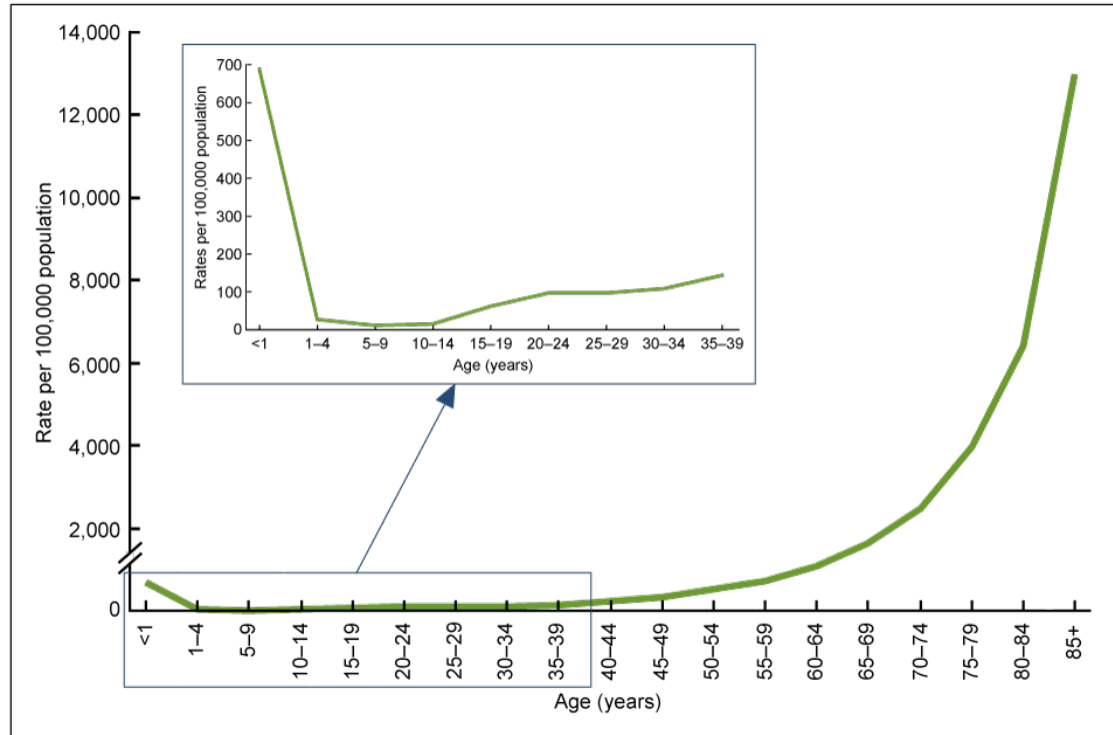


Cohort Component Method



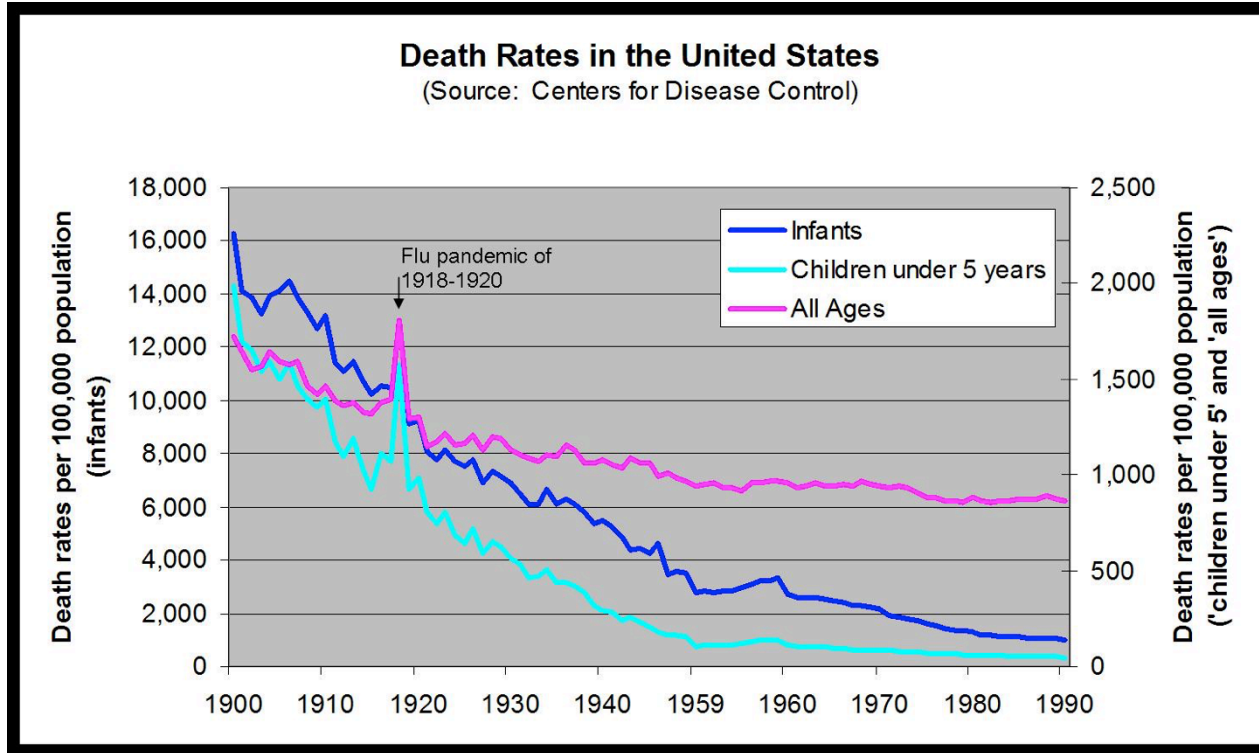
Mortality

Figure 2. Age-specific death rates: United States, preliminary 2007



SOURCE: National Vital Statistics System, Mortality.

Mortality



Projecting Mortality

Assume a constant rate (not common)

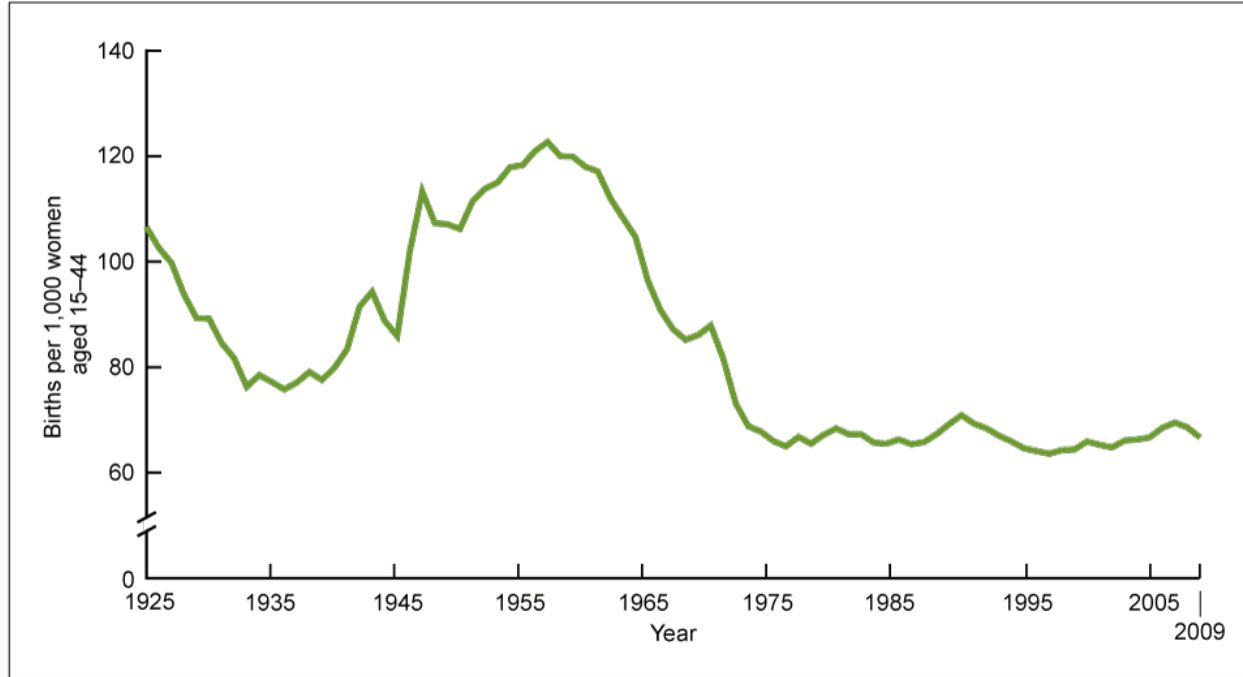
Extrapolate (very common, everything from linear to time series models)

Targeting - assume it will move towards the mortality rate of some target group

Cause-delay - assume some cause of death will be eliminated

Fertility

Figure 1. Fertility rate: United States, 1925–2009



NOTES: Data for 2009 are preliminary. Access data table for Figure 1 at: http://www.cdc.gov/nchs/data/databriefs/db60_tables.pdf#1.

SOURCE: CDC/NCHS, National Vital Statistics System.

Fertility

Treated similarly to mortality: extrapolate trends, etc

Easterlin hypothesis: better economic prospects -> have more children -> children face more competition so their prospects decline -> they have less children -> prospects improve....

Migration

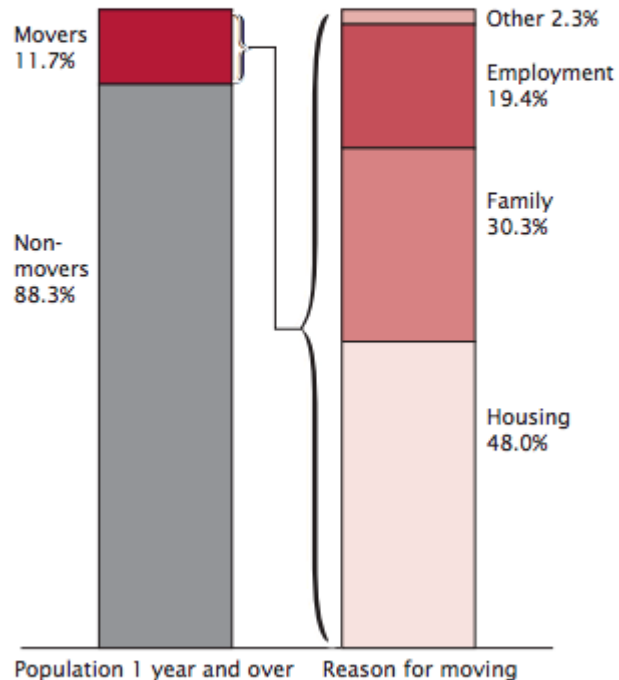
Can be quite complex if trying to project populations of different regions, model movement between them

Can be fairly simple if describing only, for example, net immigration for US

Migration

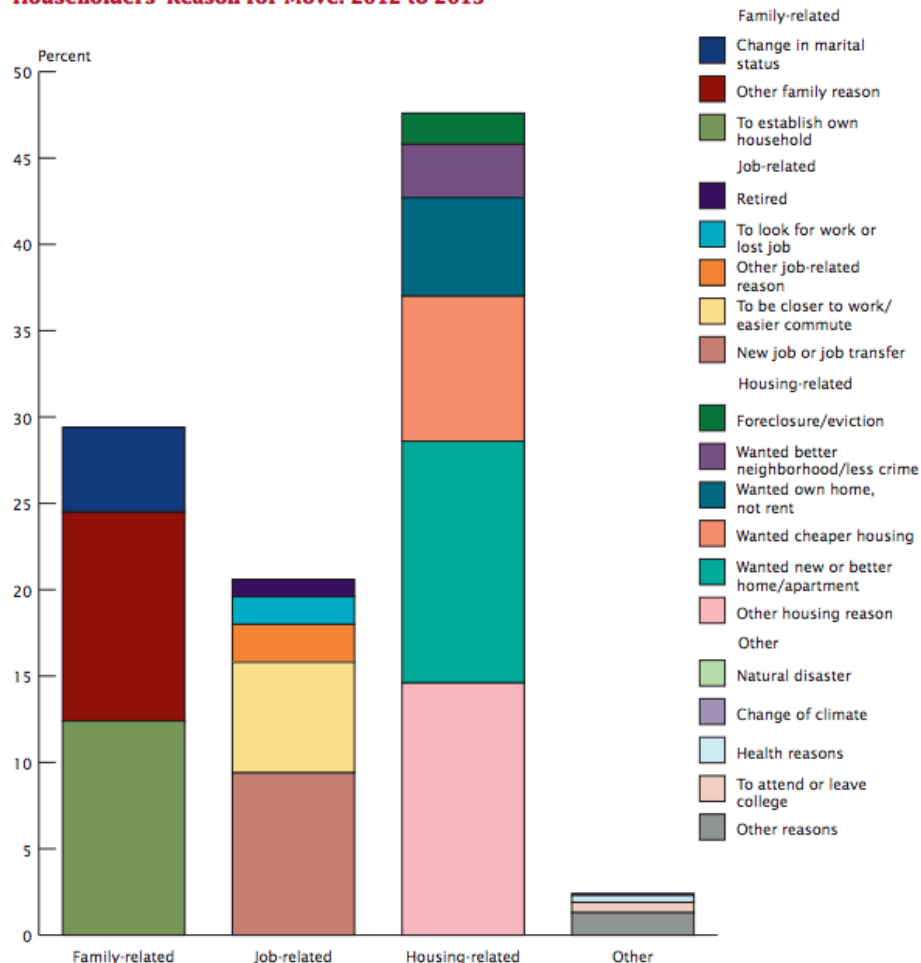
Figure 1.

How many people moved and what was their main reason for moving? In the United States, 35.9 million people moved between 2012 and 2013.



Source: U.S. Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2013.

Figure 2.
Householders' Reason for Move: 2012 to 2013



Source: U.S. Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2013.

Trend Extrapolation

Can be very inexpensive and simple; done by
Abraham Lincoln and Ben Franklin

Curve fitting: linear, geometric, exponential
Autoregressive integrated moving averages

Mark Twain on Extrapolation

In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oölitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upwards of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact.

Structural Models

Suppose we built a new freeway into sparsely populated areas around Boston, what would happen to population there?
Usually focused on migration, employment, and income

Comparing Methods

Cost, speed, data demands, ease of use and ease of explanation matter

Little data to indicate that more sophisticated forecasts are more accurate

Forecasts usually worse when: trying to go far into future; population is declining or growing quickly; trying to forecast small area

Accuracy

According to Smith, Tayman, Swanson 2001, about 6 comparisons indicating no advantage for complex models, 1 indicating advantage

“simple” meaning linear or exponential extrapolation, cohort component being most complex

However DT notes that these are mostly studies of state-level projections in the US

Future Directions

machine learning

integrated expert judgement

fancier sophisticated models with better GIS
data, etc

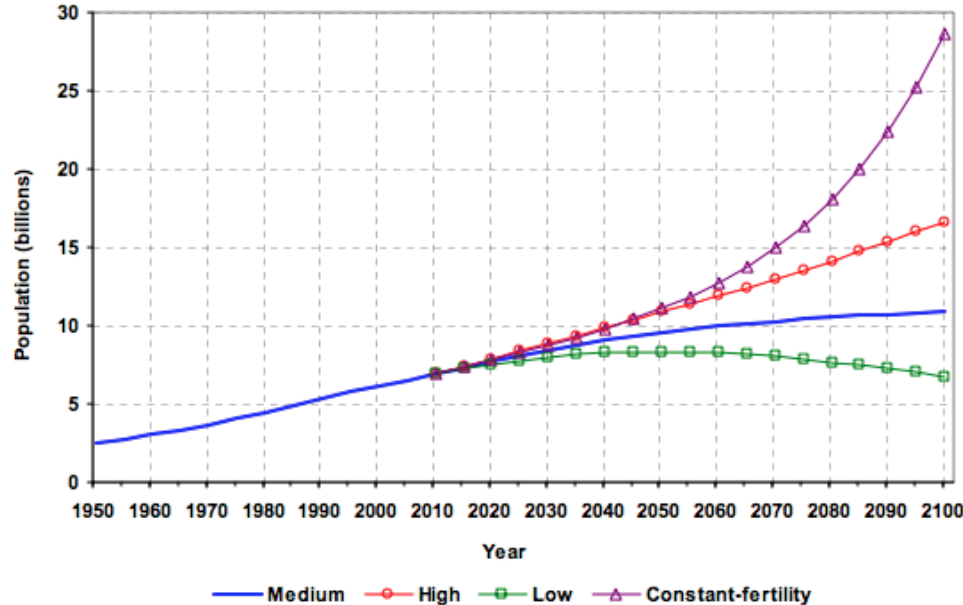
World Projections

Oneill (2001) Guide to Global Population Projections is great

Who makes them: UN, World Bank, US Census Bureau, Int'l Institute for Applied Systems Analysis, Population Reference Bureau

UN World Population Prospects

Figure 1. Population of the world, 1950-2100, according to different projections and variants



Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2013).
World Population Prospects: The 2012 Revision. New York: United Nations.

Lutz 2001: The End of Population Growth

assumes fertility peaks relatively quickly, quicker than UN does

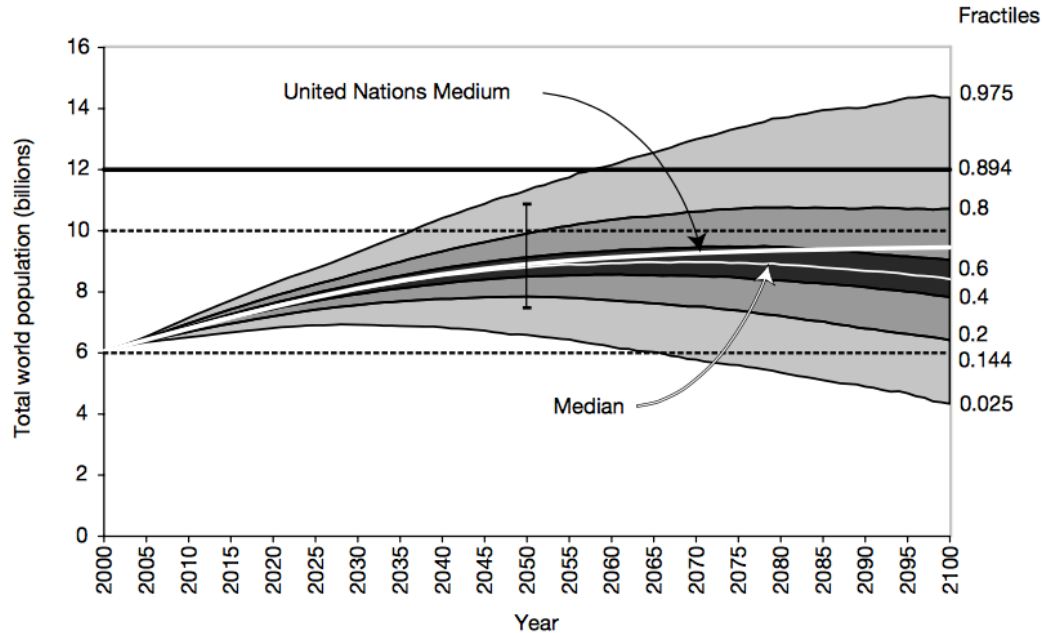
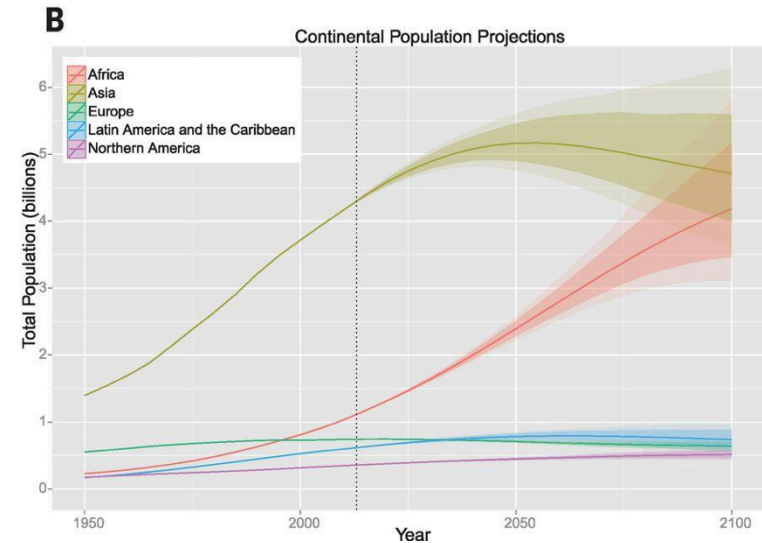
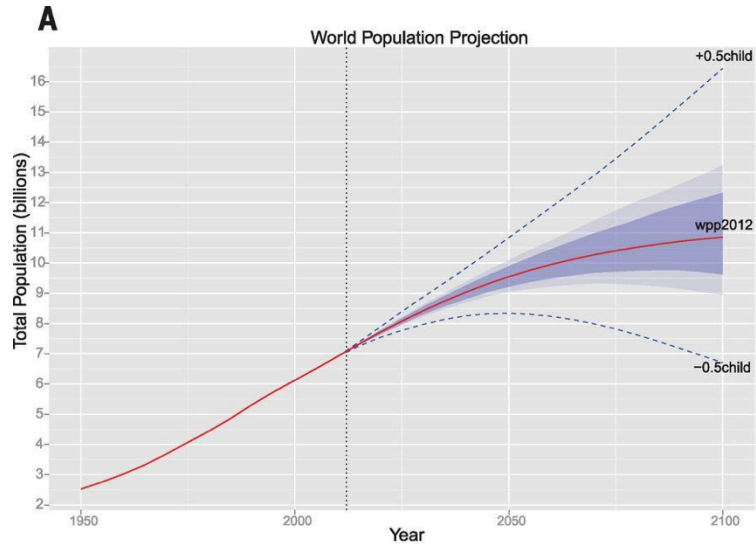


Figure 2 Forecasted distributions of world population sizes (fractiles). For comparison, the United Nations medium scenario (white line), and 95 per cent interval as given by the NRC¹¹ on the basis of an ex post error analysis (vertical line in 2050) are also given.

Gerland 2014 End of Growth Unlikely this Century

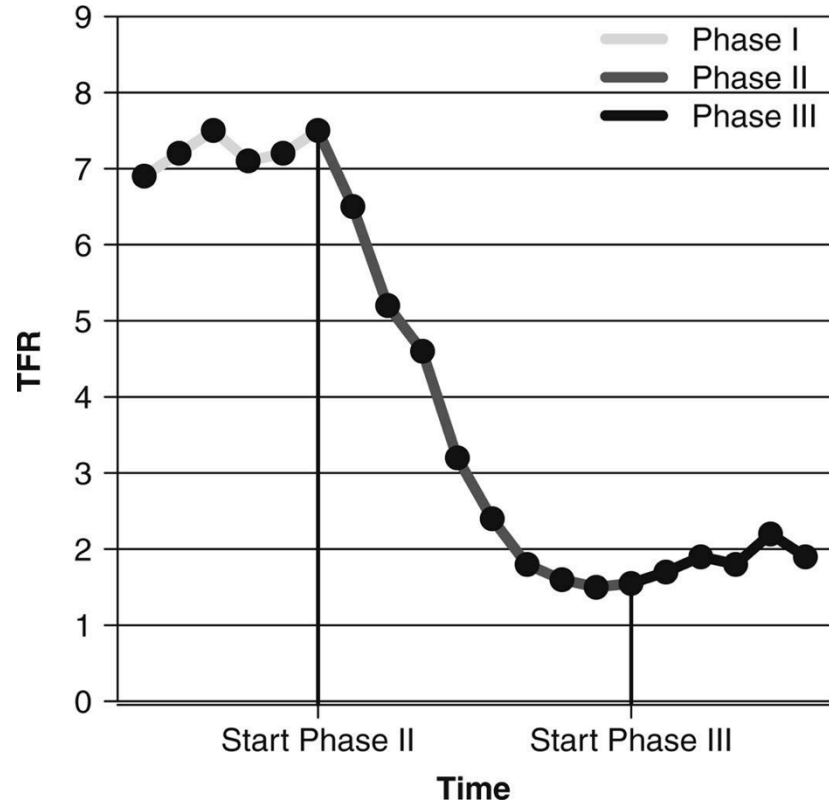


“innovations” in methods

3 phase fertility
model

Bayesian
estimates of
fertility,
mortality, etc

Results still look
pretty similar to
DT



Conclusions

We can do a decent job for fairly stable populations on short time scales

Be careful of black swan events

Most analysts project something like 9-12 billion as peak global population

Good reason to think that's well below any hard carrying capacity, though it's arguable whether it's a good thing

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