Lecture Notes 3: Population, Development and Economic Growth

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Week 3: Population, Development and Economic Growth[

- Changes in pop affect consumption needs and productive capacity of economy
- If Labor only factor of production, CRS → double Labor means double Y → y constant
- If more inputs, than increasing Labor decreases capital per worker, land per worker….
- This is the rational for including pop in models that attempt to explain income per capita.
- SIZE of population versus GROWTH rate of population

- *SIZE*: important in a context of fixed natural resource

- *GROWTH rate*: important when there are other producible inputs (capital).

Example: Japan and Kenya

- Japan: between 1980 and 2000, population growth – a low rate of 0.4% per year

- But population density in 2000 was very high, 338 per squared kilometer.

- Kenya, population growth over 1980-2000 was very high, 3.0% per year

- But, by year 2000 population density was still low, only 53 people per squared kilometer.

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Figure 1:

- Reveals a striking relationship between population growth and income per capita.
- Fully understanding this relationship is complicated:

Causality 1: high population growth leads a country to be poor

Causality 2: being poor leads to high population growth

Causality 3: Other factors led may led country to be rich and have low population growth.

1. Population Over Long Run

Figure 2: size of population from year 10,000 BC.

- Striking: small population for most of history
- Striking: slow pop growth for most history:

Between 10,000 BC and 0 - only .04% per year, 1% every 25 years

Between 0 and 1800 - .09% per year

Only in last 200 years pop growth has taken off:

- 0.6% in 19th century

- 0.9% in the first half of 20th century

- 1.8% over the last 50 years.

- Population growth is a relatively new phenomenon historically.

1.2 The Malthusian Model

- Malthus (1766-1834): An explanation for historical constancy of pop:

 - Basic assumption: positive potential fertility. Example: the Hutterites,

- Limitation factor: limited available resources – fixed amount of land.

- The smaller pop/land ratio, the better off people would be.

- The better off people were, the faster population would grow.

- As pop grew, land/pop would fall, and people would become poorer.

This poverty would limit population growth.

Land/pop declines => y declines => pop declines => Land/pop increase => y increase => pop increase => Land/pop declines =>…..

Eventually reach income that is consistent with constant population.

- Malthus's model not purely biological: beyond limited by resources, fertility control in an attempt to prevent poverty: "positive check" versus "preventive check."

Figure 3: A graphical representation of the Malthusian model:

- A stable steady state is stable: no matter what a country's initial level of population, it will end up at the steady state.

Figure 4:

- The effect of a change in the environment (productivity, e.g irrigation or a new crop or new land): countries with higher productivity will not have higher living standards, but only more people.

- Consistent historical episodes: China in year 1000 AD, the introduction of the potato into Ireland.

- What was Malthus's idea for escape from the trap? "moral restraint":

Figure 5:

1.3 The Breakdown of the Malthusian Model

- Living standards have risen dramatically.

Figure 1: contrary to Malthus's prediction, positive relationship:

- Rich countries have *lowest* pop growth, why?

The two mechanisms, pop = f (y) and y = f (land), have weakened:

- Growth in income due to technological progress

- Improvements in y did not lead to large increases in pop growth

Figure 6: Economic growth faster then pop growth, y up continuously.

In late 19^{th} century a puzzle: as Gy accelerated, pop growth began to fall.

This pattern was repeated in many countries all over world.

We will discuss later what explains this pattern and development.

4.2 Population Growth in the Solow Model

Does population still affect income per capita? Yes, for two reasons:

1. Higher pop still means a shortage of resources such as land.
2. *Growth rate* of pop dilutes physical capital, a decline in y: **capital dilution**.

Extend the Solow model to incorporate the effect of pop growth and capital dilution.

(1) $$\Delta k = \gamma f(k) - \delta k$$

Define *n* as the growth rate of the labor force:

(2) $$\Delta k = \gamma f(k) - \delta k - nk = \gamma f(k) - (\delta + n) k$$

and in equilibrium Δk=0, which implies that

(3) $$k^{ss} = \left[\frac{\gamma A}{\delta + n}\right]^{\frac{1}{1-\alpha}}$$

Steady state: **Figure 7**. Raising population growth.

This model can explains potentially why high population growth leads to lower y.

2.1 An empirical analysis

Assume again a Cobb-Douglass production function:

(1) $$f\left(k\right) = Ak^{\alpha}$$

(2) $$\gamma Ak^{\alpha} = \left(n+\delta\right)k$$

(3) $$k^{ss} = \left[\frac{\gamma A}{\delta + n}\right]^{\frac{1}{1-\alpha}}$$

(4) $$y^{ss} = Ak^{ss^{\alpha}} = A^{\frac{1}{1-\alpha}}\left[\frac{\gamma}{\delta + n}\right]^{\frac{\alpha}{1-\alpha}}$$

(5) $$y_i^{ss} = A^{\frac{1}{1-\alpha}}\left[\frac{\gamma}{\delta + n_i}\right]^{\frac{\alpha}{1-\alpha}}$$

(6) $$y_j^{ss} = A^{\frac{1}{1-\alpha}}\left[\frac{\gamma}{\delta + n_j}\right]^{\frac{\alpha}{1-\alpha}}$$

(7) $$\frac{y_i^{ss}}{y_j^{ss}} = \left[\frac{\delta + n_j}{\delta + n_i}\right]^{\frac{\alpha}{1-\alpha}}$$

Assume: depreciation rate=5%, n_i =0% and n_j =4%, α=1/3, use these values in (7):

$$\frac{y_i^{ss}}{y_j^{ss}} = \left[\frac{0.05+0.04}{0.05+0.00}\right]^{\frac{1}{2}} = \frac{3}{\sqrt{5}} \approx 1.34 \qquad (8)$$

If zero pop growth > y 34% higher than if pop growth 4%

Very small difference relative to differences in Figure 1.

Result sensitive to value of α. If $\alpha = 2/3$ => $\frac{y_i}{y_j} = 3.24$

Still not large as differences in actual data.

Example: Gambia (pop growth 4.1%) and Japan (0.3%), y differ by 17 times.

Still, differences explained by population growth are significant.

Not expect to explain all of differences in y

We already saw that Investment differences explain some of the y differences.

3. Explaining Population Growth

Population as an *endogenous* variable (as in the Malthusian model).

In the Solow model population growth is *exogenous.*

What is the origin of differences in population growth rates?

The demographic transition: the process by which the demographic characteristics of the economy are transformed as a country develops.

Demographic transition is complete in DC, still ongoing DEVC

3.1 Mortality Transition

The decline in prevalence of death.

The **survivorship function**: probability alive at different ages.

Figure 8: Survivorship functions since 1780.

Dramatic decline in mortality at young ages.

Use the survivorship function to calculate **life expectancy at birt**h:

π (i) - the probability alive at age *i* , *T* oldest possible age:

Life expectancy at birth = $\sum_{i=0}^{T} \pi(i)$

Also, LE at birth equal area under the survivorship function.

In Sweden in 1780=38.5 years, in 1780=79.0

- **Figure 9**: LE in DC, no improvement before 18th century.

- **Figure 10**: LE in DEVC, more rapid than in DC.

India: LE up from 26.9 in 1930 to 55.6 in 1980.

France: LE up from 27.9 in 1755 to 56.7 in 1930.

Also, Mortality Transition in DEVC occurring at low income.

Explaining the Mortality Transition

- Improvements in the standard of living, quantity and quality of food.
- Decline in chronic malnourishment, improved resistance to disease.
- Improvements in public health: water and sanitation.
- Better medical treatments in curing diseases.
- These improvements occurred sequentially.

Fogel Robert: Nutritional status explains 90% of mortality decline in England and France, 1775-1875:

- Modern sewage and water in 19^{th} reduced incidence of diseases such as cholera and typhus.
- In 20^{th} improved medical treatment improved life expectancy.
- In DEVC: changes arrived all at once, before and after World War II

3.2 Fertility Transition

A**ge-specific fertility rat**e, F(i):

The average number of births in a given year by women of a given age.

Figure 11: US and Nigeria fertility,1999.

Total fertility rate (TFR): the number of children a woman have if experienced the current age-specific fertility rates:

$$\text{TFR} = \sum_{i=0}^{T} F(i)$$

TFR: area under the age specific fertility rates curve.

TFR US = 2.1, TFR Nigeria = 6.0.

Figure 12: TFR US since 1860.

TFR fell from 5 to 2, no smooth trend, Baby Boom 1946-64, similar in DC.

TFR decline in DEVC took less time:

TFR decline from 5 to 3: US from 1862-1925, Indonesia 1975-1990.

3.3 The Interaction of Fertility and Mortality

TFR in Europe/US was high but pop growth was never as high as in DEVC, why?

The survivorship function - $\pi(i)$, age-specific fertility rate - $F(i)$,

NRR- the expected # of girls for a woman, **net rate of reproduction.**

$$\text{NRR} = \frac{1}{2}\sum_{i=0}^{T}\pi(i)F(i)$$

It is also the factor by which the number of girls in each generation will increase.

NRR=1, constant population, zero pop growth,

NRR=2, Number of girls, and thus population, doubles every generation.

If mortality reduced, say all woman instead of half survived their reproductive years:

NRR would double!

Figure 13: mortality and fertility interaction in Sweden.

NRR=1.20 in 1780, 1915 and 1965 but TFR and MR were very different.

NRR>1 because of mismatch in timing of MR and TFR decline.

4.4 Explaining the Fertility Transition

- Health and children are more desirable as income rise.
- Why, then, as income per capita increased, fertility declined?

4.1 Reduced Fertility: The Means

Birth control methods:

- Vaginal suppositories in 1850 BC,
- The Bible mentions the use of withdrawal to avoid conception,
- Ancient Greek medical texts discuss contraceptive potions, barriers, and suppositories, rhythm method and techniques for abortion.
- Abandonment of children from Greek time to the Middle Ages
- Late Marriage: median age at first marriage in 17th century Britain was 28 for men and 27 for women.
- In many cultures, long period of breast-feeding suppress fertility, (in Indonesia, 1999, median is 24 months)

Last two centuries: improved technology of fertility control:

- Improved condoms - invention of vulcanized rubber in 1844,
- The cervical cap - 1838, diaphragm - 1882, IUD –1909,
  Contraceptive pill - 1960s.
- Changes in the attitudes of society and gov toward fertility control.
- First US family planning clinic, 1916 - arrested on obscenity charges.
- In 1965, Supreme Court's decision: anti-contraception laws in the US ruled unconstitutional. Europe: policies hostile toward birth control .

DEVC: since World War II: policies to encourage fertility restriction.

- China's "one-child" policy, 1979, TFR 5.99 in 1965-70, 1.76 in 1995.
- India, 1970s sterilizations, unpopular, halted.
- Mexico, India, Indonesia: education and persuasion.
- Indonesia, 70s and 80s, free contraceptives and educational materials: birth control up from 400,000 couples in 1972 to 18.6 million in 1989,TFR from 5.6 to 3.4 children per woman.
- Ethiopia: opposed family planning, religious and ethnic reasons, 1975-1995, TFR rose from 5.2 to 7.4.

Does availability of contraceptives explain fertility transition?

- In Europe the major fertility decline achieved before modern contraception widely available:

Ex: British TFR decline, early 20th cent, only 16% used contraception,

- DEVC post-World War II decline in fertility coincide with increased use of birth control: 1960-1998, rate of contraceptive prevalence rose from 9% to 55%.

- This fact does not prove causal effect of *availability* of contraceptives.

- Causal estimated effect suggest that contraceptives explain 10%- 40% of the decline,

- The rest of the decline in fertility is explained by changes in *desired* fertility – that is, in the number of children that families wanted to have: **Figure 14**.

- Small differences between desired and actual TFR: limited scope for reducing fertility in DEVC through better provision of contraceptives.

- Focus should be: why desired fertility falls?

4.2 Reduced Fertility: The Motives

- The Effect of Mortality Reduction,

- Desired fertility: Number of children that survive, reduced MR lower fertility,

- It takes time to recognize that MR fell > lag to adjust their fertility.

- Replacement versus Hoarding, gender preferences

Income and Substitution Effects

- why doesn't fertility *rise* as income rises?

- Income growth raises the *price* of children: children demand for parents' time, **opportunity cost** of time – wage a parent could earn.

Figures 15-16.

N - # of children, C - all market goods, w - wage per unit of time:

Indifference curve, set of combinations of *N* and C with same utility.

- Over the course of economic development wages rise, but also *relative* wage of women rise, In US 1890-1988: women relative wage up from 46% to 67% of men's wages.

- This effect was reinforced by the rise in the education of women and also because the incentive to invest in girls education rises.

- Education effect on controlling fertility.

An Economic Model of the Demand for Children

Demonstrate how income and substitution effects interact in determining the optimal number of children.

HH derive utility from the number of children, N, and from consumption of other goods, C.

HH is endowed with one unit of time, working for real wage w or raising children

The time required to raise a single child is z.

The HH has a utility function defined over children and consumption:

$$(1) \quad C = W\left(1 - zN\right)$$

$$(2) \quad U\left(N, C\right) = \left(N^{\rho} + C^{\rho}\right)^{\frac{1}{\rho}}$$

$$(3) \quad U = \left(N^{\rho} + W^{\rho}(1 - zN)^{\rho}\right)^{\frac{1}{\rho}}$$

$$(4) \quad \frac{dU}{dN} = o = \left(N^{\rho} + W^{\rho}(1 - zN)^{\rho}\right)^{\frac{1}{\rho}-1} \times \left(N^{\rho-1} - zW^{\rho}(1 - zN)^{\rho-1}\right)$$

$$(5) \quad \frac{dN}{dW} = \left(\frac{\rho}{\rho - 1}\right)\frac{zW^{\rho-1}(1 - zN)^{\rho-1}}{N^{\rho-2} + z^{2}W^{\rho}(1 - zN)^{\rho-1}}$$

The sign of this expression depends on the value of ρ :

If it is less than zero then an increase in w will lead to a rise in N,

If it is greater then zero then higher w will mean fewer children.

This parameter is also realted to the elasticity of substituiton between N and C according to the equation:

$$(6) \quad \sigma = \frac{1}{1-\rho}$$

$\rho < 0 \Rightarrow \sigma < 1,$ low elasticity, higher w leads to more N

$\rho > 0 \Rightarrow \sigma > 1,$ high elasticity, higher w leads to less N

$\rho = 0 \Rightarrow \sigma = 1,$ constant elasticity, not defined

because it involves division by zero. At the limit, as ρ approach zero the CES function approaches a Cobb-Douglass function: N and C wi a power of 1/2. This function has the property that income and subsistution exactly cancle out, so that a change in the wage has no effect on the number of children. Shown in panel B of figure 16.

Resources Flows Between Parents and Children

- The economic benefits from children decline as the economy develop.
- The cost of children rises.
- IN DEVC children often work at young age,
- Support parents in old age – no other sources of old-age support available,
- Producing children (sons) is an economic necessity.
- IN DC financial markets developed, people save for old age.
- This change in relative costs & benefits of children is part of the explanation of the decline in desired fertility.
- Obviously, it is not a complete explanation.

Parents today spend much more on their children than in the past.

Why? Quality-Quantity Trade-offs

- Investments in the *quality* of the child:

- Higher quality > higher wages > better old age providers,

- Higher quality > happier children > happier parents.

- Change in the mix of quality and quantity > declined fertility:

- Development reduces mortality > improved incentive to invest in child education

- Development increases the return to education > increased incentive to educate children.