Age, Intergenerational Transfers, and Demographic Dividends

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38th Summer Seminar on Population

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Central Issue

- How is economic growth influenced by demographic changes during and after the demographic transition
  - Fertility
  - Mortality
  - Age structure
  - Population growth
- Essential to understanding other issues
  - Generational equity
  - Fiscal impact of changes in age structure

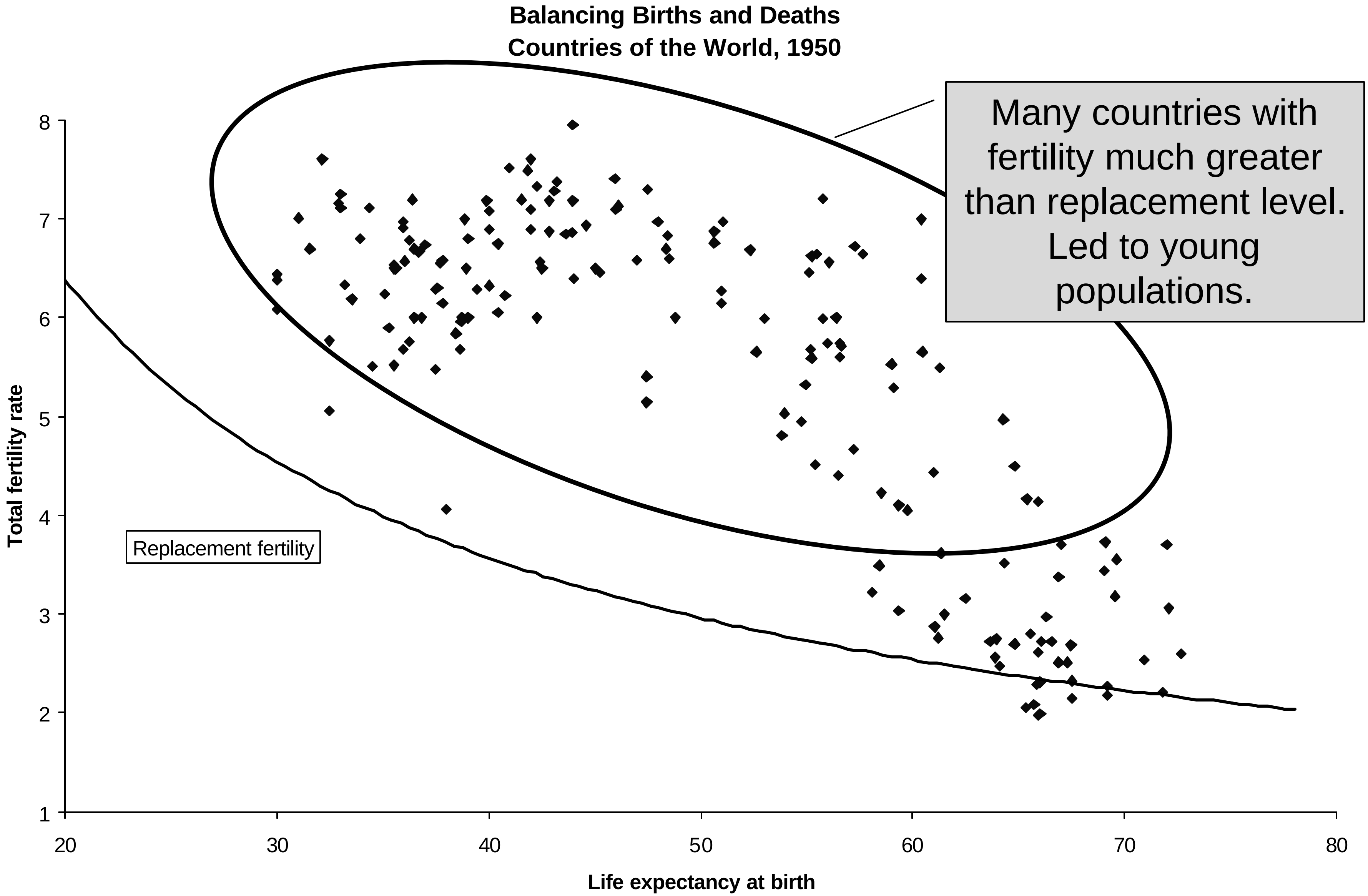
Outline of talk

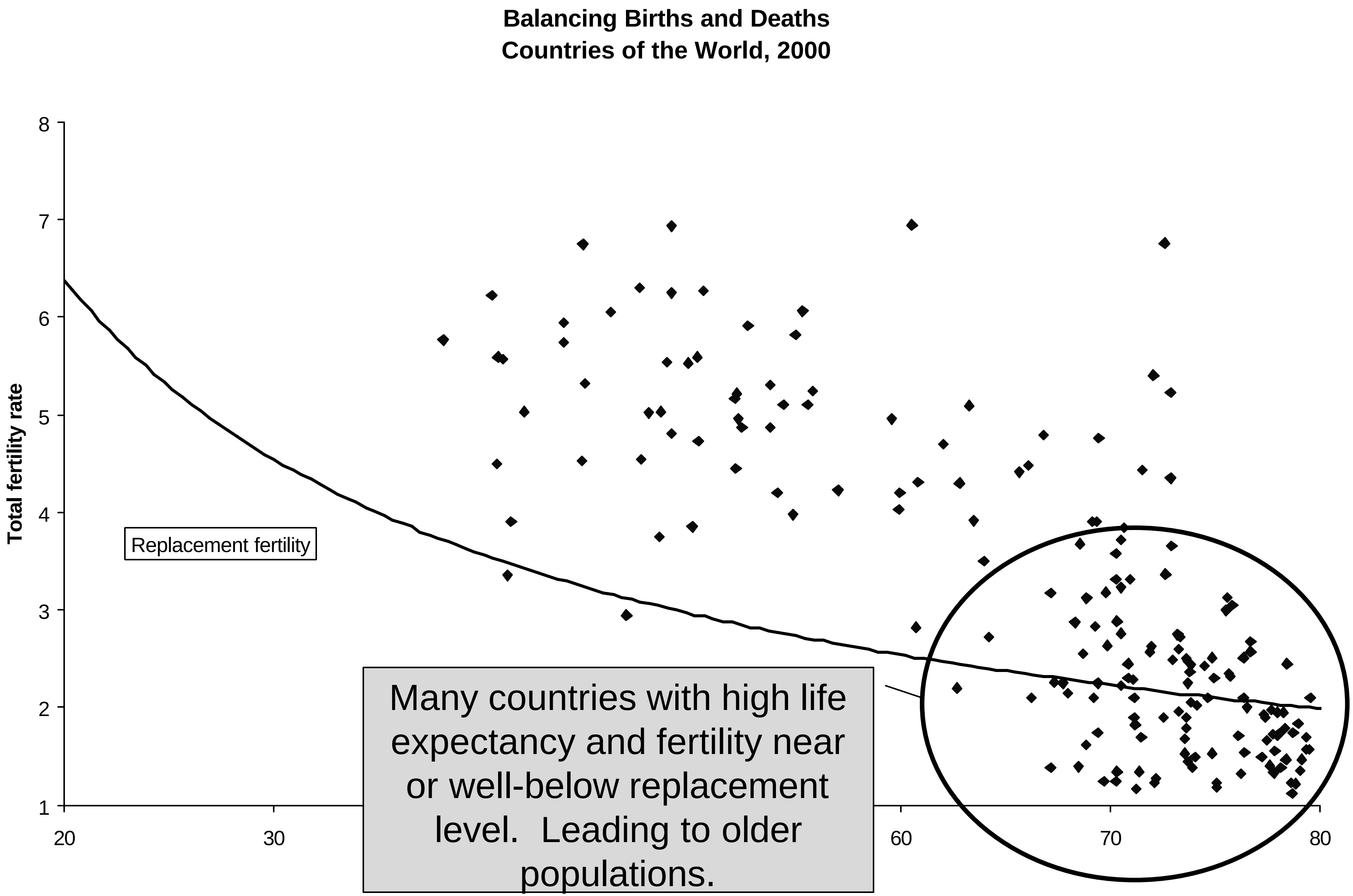
I. The demographic transition
II. Growth models and population: A Review
III. Growth models with realistic age
IV. Simulation models and Demographic Dividends
V. Conclusions

I. The Demographic Transition

Demographic Transition and Age Structure

- Prior to the transition birth and death rates are high
- Death rates begin to decline, concentrated at younger ages
- Number of surviving children increases relative to the adult population
- Fertility rate begins to decline, leading to a decline in the relative number of surviving children
- With a lag, large cohorts of children become adults leading to an increased share in the working-age population.
- With a greater lag, large cohorts of children become elderly and further declines in fertility and mortality (now at older ages) lead to an increased share at older ages.


Balancing Births and Deaths
Countries of the World, 1950
Many countries with fertility much greater than replacement level. Led to young populations.
Replacement fertility
Total fertility rate
Life expectancy at birth
8
7
6
5
4
3
2
1
20
30
40
50
60
70
80


Balancing Births and Deaths
Countries of the World, 2000
Total fertility rate
8
7
6
5
4
3
2
1
20
30
60
70
80
Replacement fertility
Many countries with high life expectancy and fertility near or well-below replacement level. Leading to older populations.

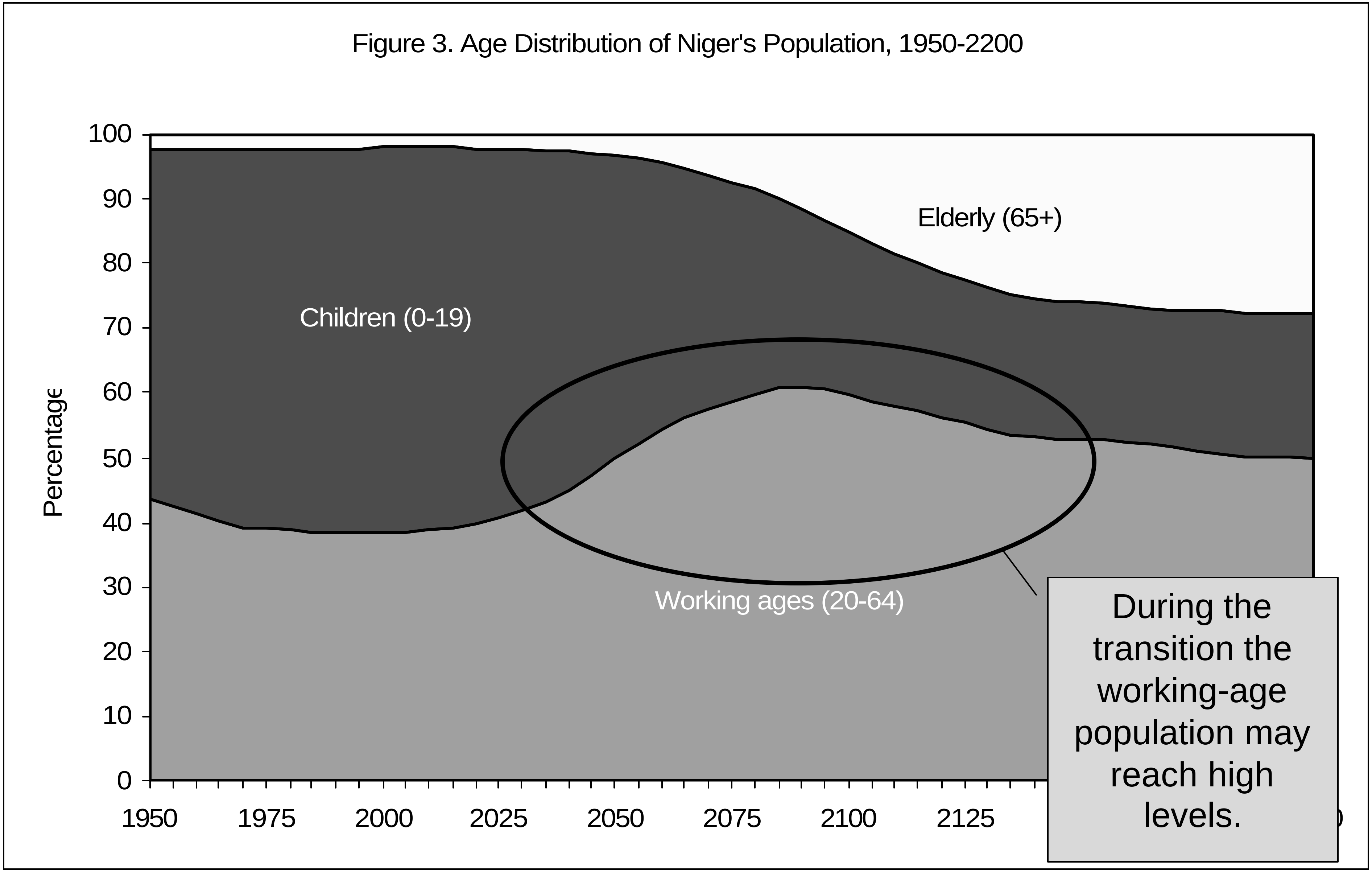
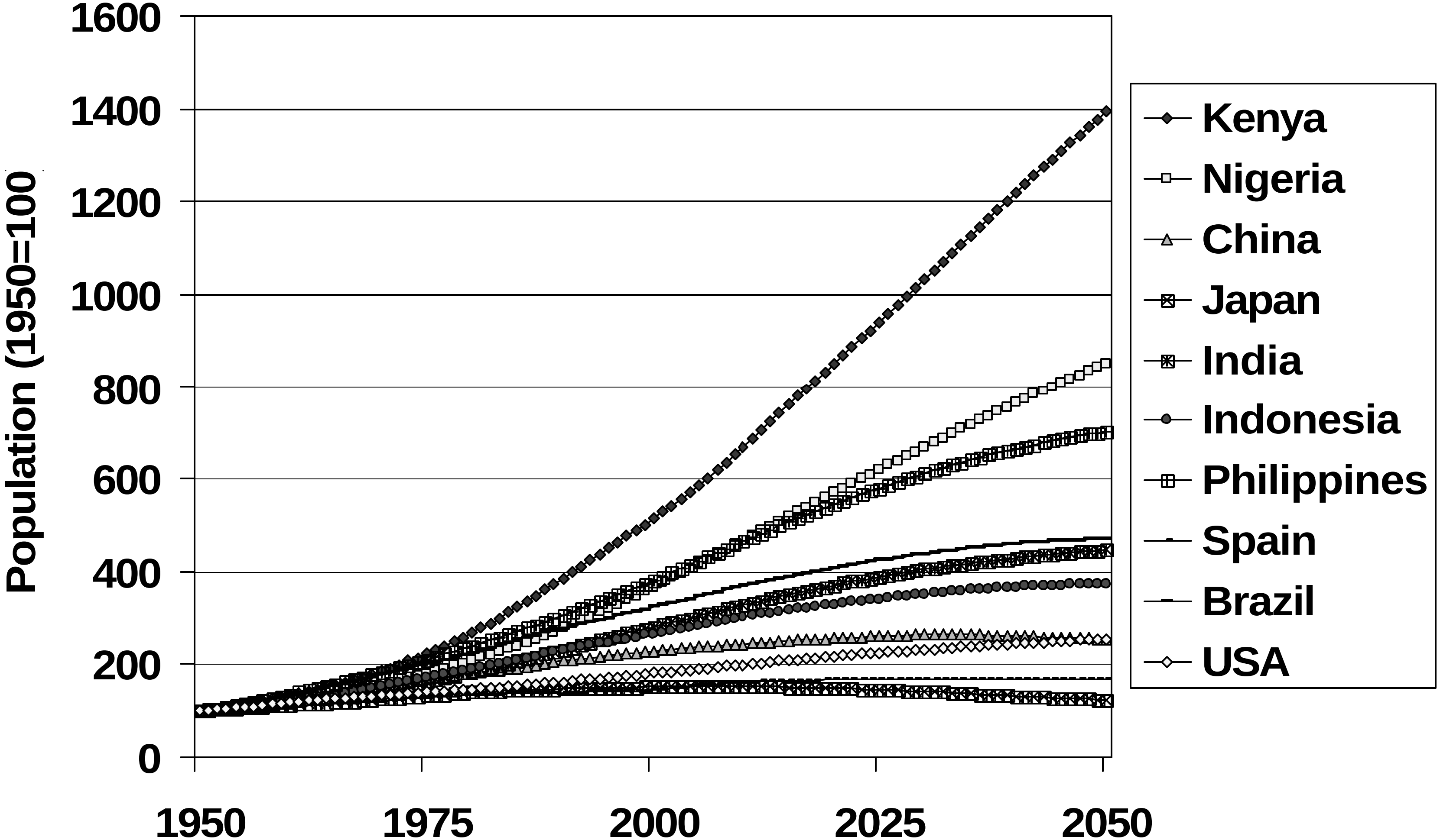


Figure 3. Age Distribution of Niger's Population, 1950-2200
Percentage
100
90
80
70
60
50
40
30
20
10
0
1950
1975
2000
2025
2050
2075
2100
2125
Elderly (65+)
Children (0-19)
Working ages (20-64)
During the transition the working-age population may reach high levels.

Demographic Transition and Population Growth

- Prior to the transition births and deaths were roughly in balance – very gradual and erratic population growth.
- Decline in death rates at the beginning of the transition led to population growth.
- Population growth slowed when birth rates began to decline more rapidly than death rates.
- When decline in death rates is concentrated at older age, further decline has relatively little effect.
- Fertility below replacement level (approximately 2 births per woman) is now leading to population decline in many industrialized countries.

Population Trend, Selected Countries



Source: UN Population Prospects 2006.

II. Growth Models and Population: A Review

The Neo-Classical Model

- Closed economy
- Output depends on capital and labor
- Saving rate is constant and exogenous
- Labor force growth rate is constant and exogenous
- No age structure and, hence, no dependents in the population.

The Neo-classical Result

- Output per worker (Y/L) increases with capital per worker (K/L).
- Change in K/L depends on the saving rate and the rate of growth of the labor force (L).
- For a given saving rate, an increase in the labor force growth rate leads to a lower K/L because a larger share of saving must be devoted to capital widening (equipping new workers) and less can be devoted to capital deepening (increasing capital per worker).
- In steady state, a decline in the labor force growth rate leads to an increase in output per worker.

Source: Solow 1956

The Golden Rule Elaboration

- Golden rule growth is achieved when – for a given population growth rate – consumption is at the highest obtainable level.
- The saving rate adjusts to achieve that level.
- A decrease in the labor force growth rate, with saving adjusting to maintain golden rule growth, leads to an increase in steady-state consumption per worker.

Source: Phelps 1961.

Introducing Simple Age Structure (old dependents) into the Growth Model

- Slower population growth leads to capital deepening, but it also leads to a large dependent elderly population.
- Thus, lower population growth leads to an increase in output per worker but a decline in workers per capita (L/N).
- Samuelson hypothesized that these two effects might lead to an optimal population growth rate at which per capita lifetime consumption is maximized.

Source: Samuelson 1975.

The Deardorff Comment

- Deardorff showed that for a wide variety of model parameters, Samuelson's "optimal" population growth rate was actually the population growth rate at which lifetime consumption was at a minimum (among golden rule cases).
- The relationship between lifetime consumption and population growth is U-shaped.
- As the population growth rate approaches the depreciation rate, the steady-state golden rule lifetime consumption rate increases without limit.

Source: Deardorff 1976.

Samuelson's *mea culpe*

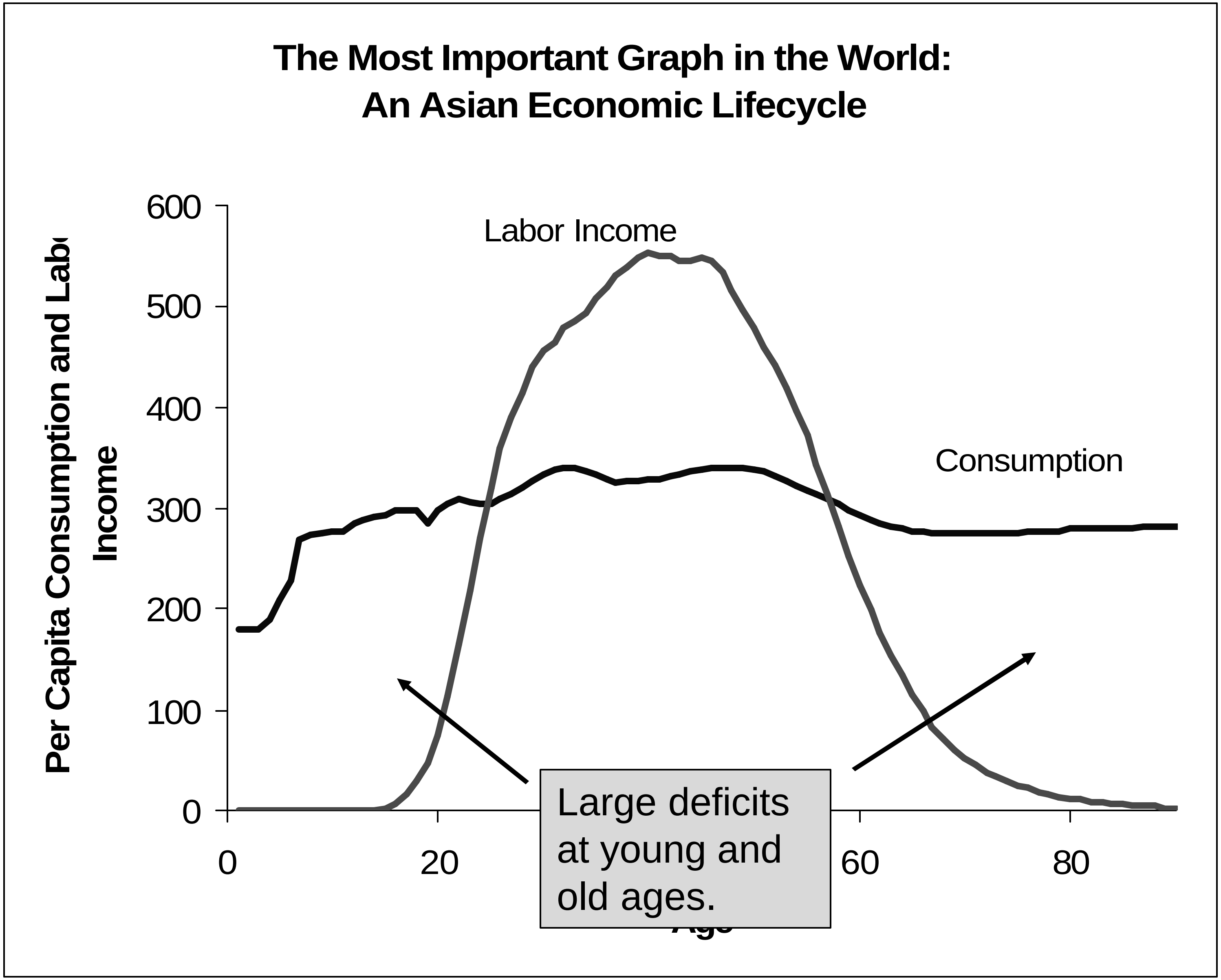
- Deardorff is correct.
- Some of his conclusions follow from unrealistic features of the neoclassical model.
  - Very rapid population growth leads to very lower output and consumption per worker. But very high consumption at old ages is possible because of the very low old-age dependency ratio, more than makes up for the loss.
  - As population decline approaches the depreciation rate, capital per worker and output per worker increase without limit.
- Samuelson's conjecture: a population growth rate may be locally, if not globally, optimal.
- Samuelson's conjecture has not – to our knowledge – been addressed.

Source: Samuelson 1976.

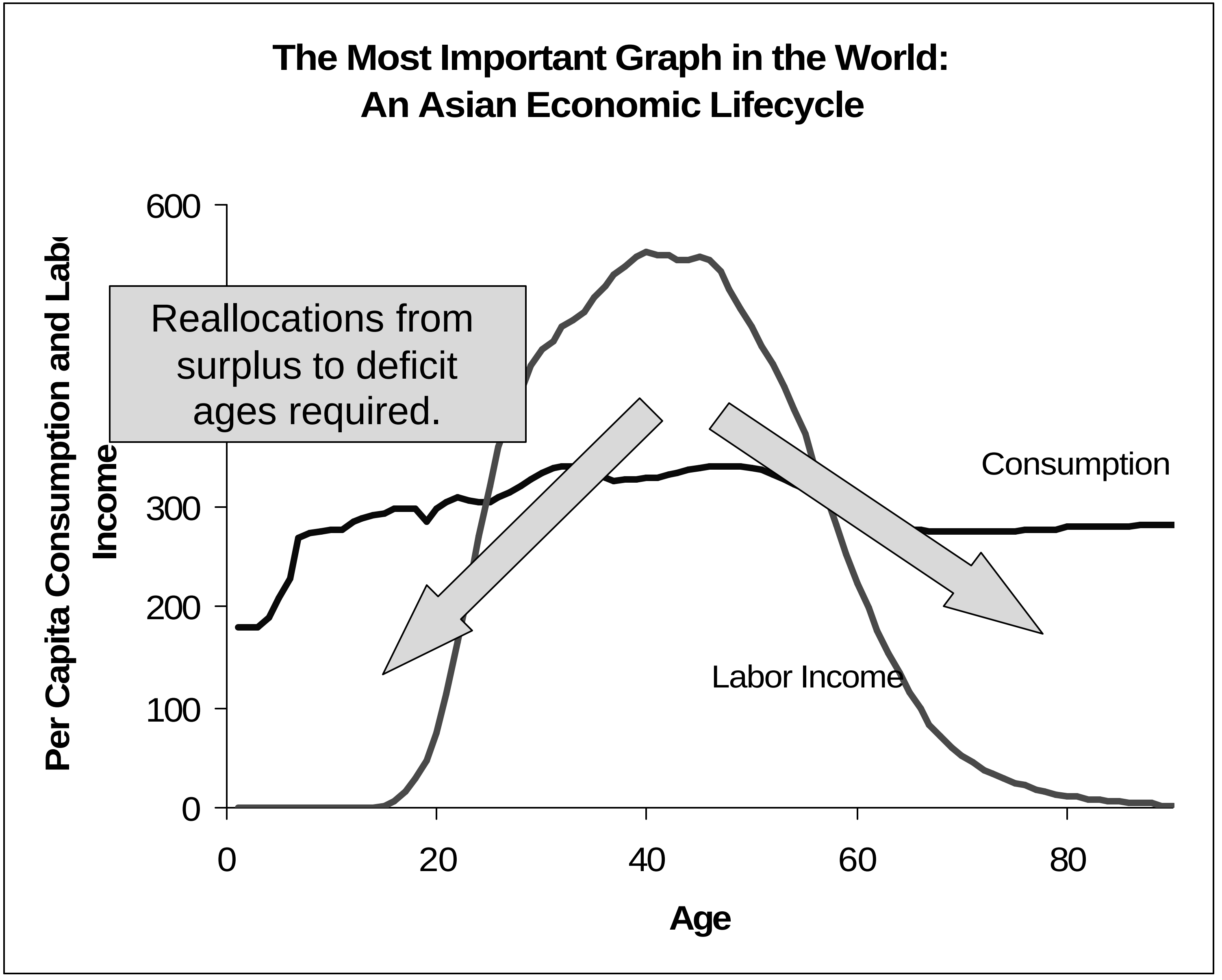
III. Growth Models with Realistic Age

A Realistic Treatment of Age Structure and the Economic Lifecycle

- Population has two groups that are dependent – children and the elderly.
- Extent of dependency varies by age.
- Dependency varies across countries depending on the culture, the social institutions, etc.
- Can we incorporate some of this rich and important detail into growth models?



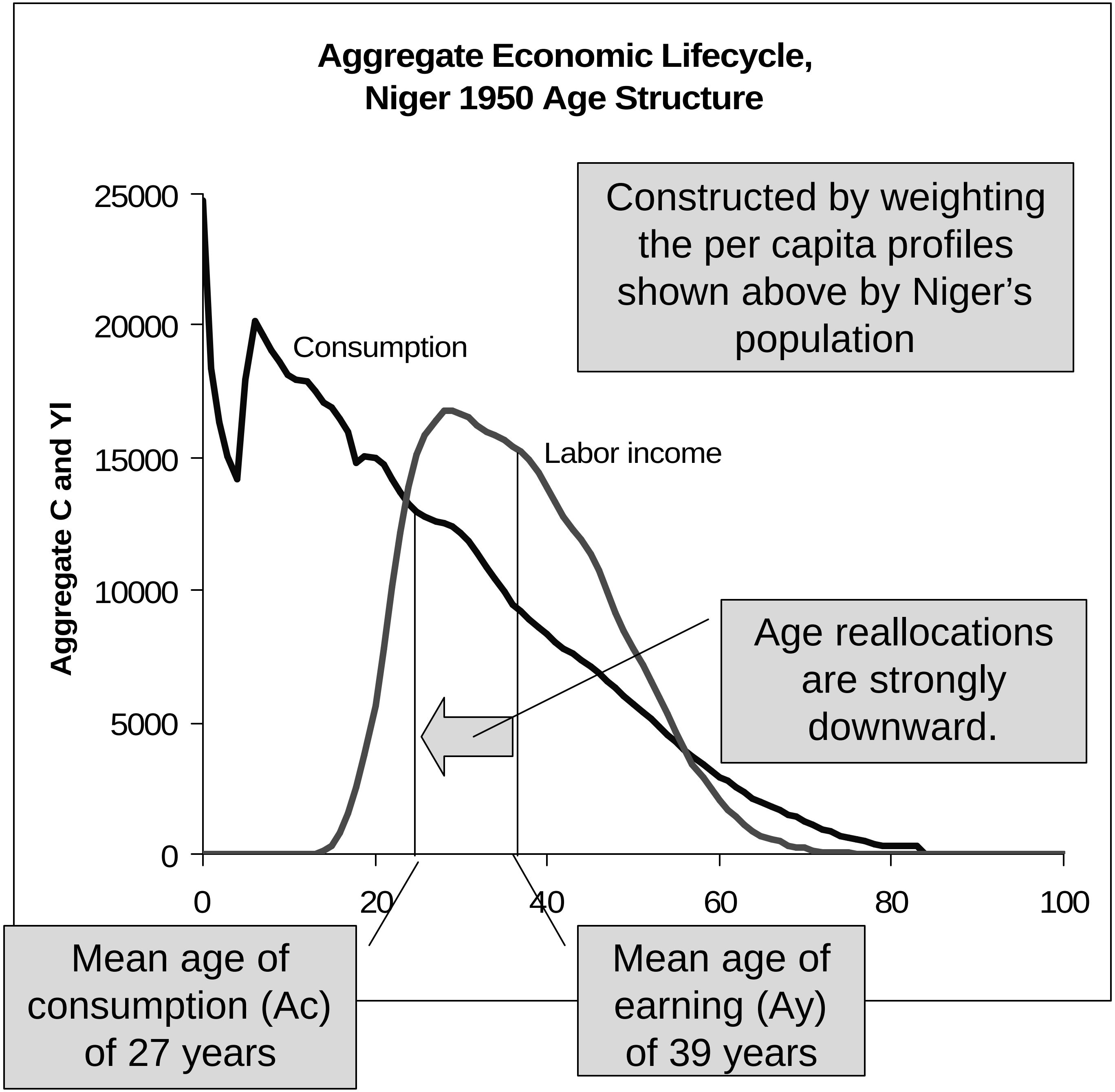
The Most Important Graph in the World:
An Asian Economic Lifecycle
Per Capita Consumption and Labo
Income
600
500
400
300
200
100
0
0
20
60
80
Age
Labor Income
Consumption
Large deficits at young and old ages.



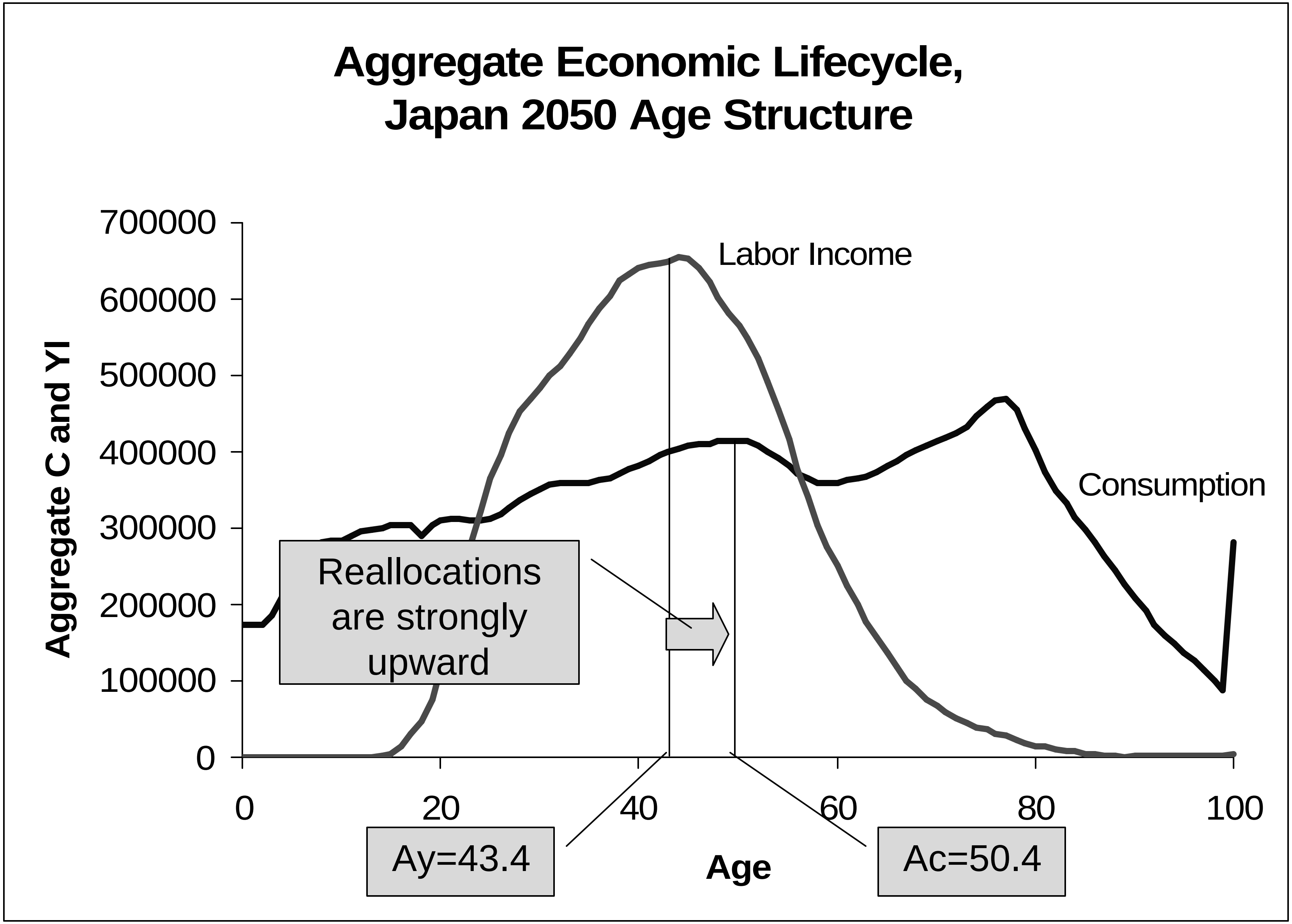
The Most Important Graph in the World:
An Asian Economic Lifecycle
Per Capita Consumption and Labo
Income
600
300
200
100
0
0
20
40
60
80
Age
Reallocations from surplus to deficit ages required.
Consumption
Labor Income

The Aggregate Lifecycle

- Incorporates the per capita economic lifecycle and the population age structure.
- In a young (low income) population, this leads to large reallocations of resources in a downward direction.
- In an old (high income) population, this leads to large reallocations of resources in an upward direction.

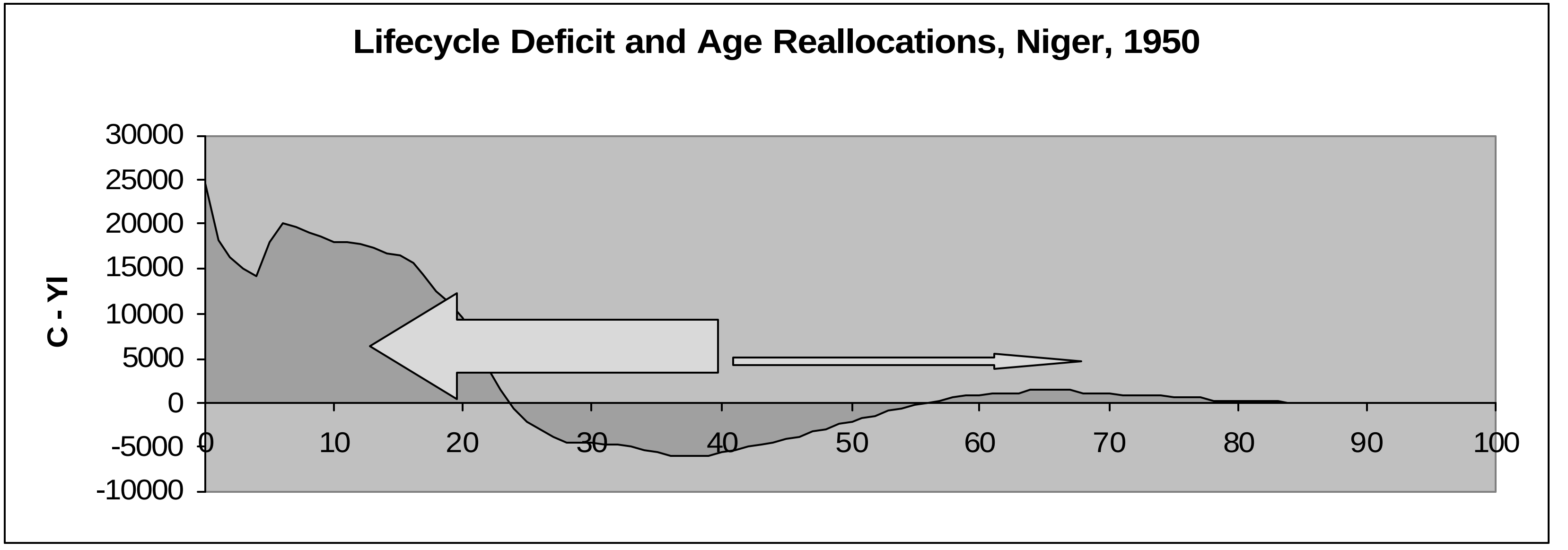


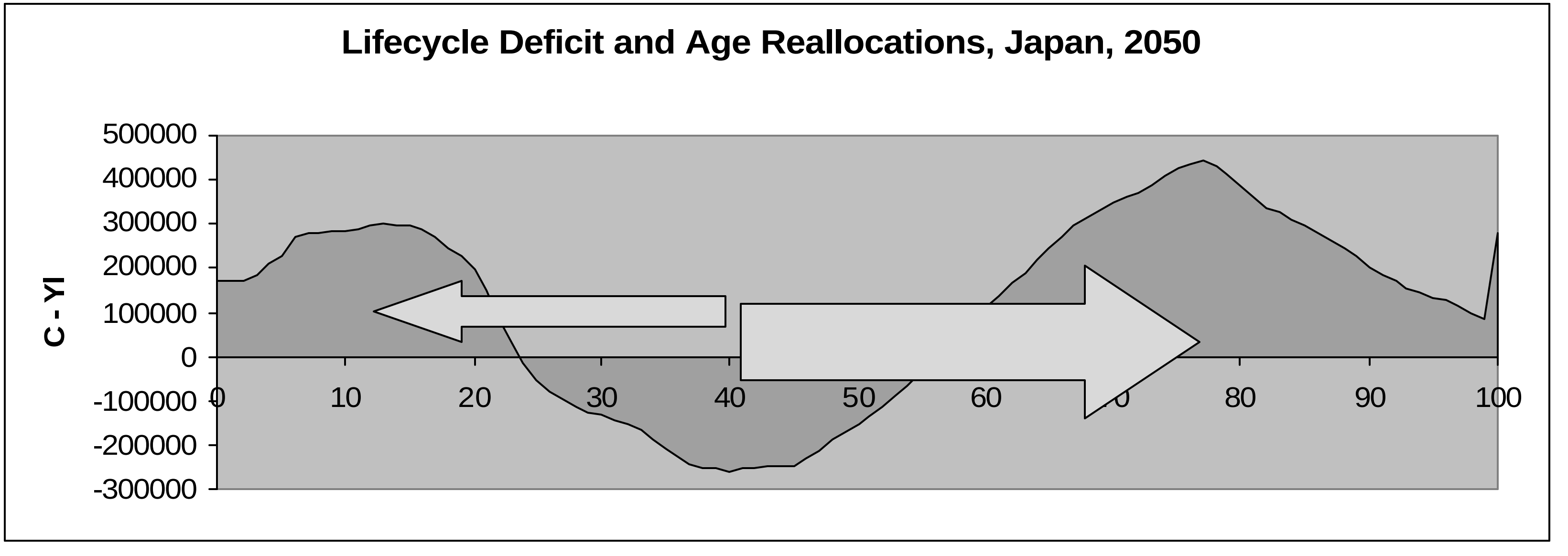
Aggregate Economic Lifecycle,
Niger 1950 Age Structure
Constructed by weighting the per capita profiles shown above by Niger's population
25000
20000
15000
10000
5000
0
Aggregate C and YI
Consumption
Labor income
Age reallocations are strongly downward.
0
20
40
60
80
100
Mean age of consumption (Ac) of 27 years
Mean age of earning (Ay) of 39 years


Aggregate Economic Lifecycle,
Japan 2050 Age Structure
700000
600000
500000
400000
300000
200000
100000
0
Aggregate C and YI
Labor Income
Consumption
Reallocations are strongly upward
0
20
40
60
80
100
Age
Ay=43.4
Ac=50.4

Downward and Upward Flows

- The net flows summarized by the mean ages of consumption and labor income combine two countervailing flows:
  - Downward flow from working ages to child ages
  - Upward flow from working ages to old ages
- The relative importance of these two flows changes substantially over the demographic transition.


Lifecycle Deficit and Age Reallocations, Niger, 1950
C - YI
30000
25000
20000
15000
10000
5000
0
-5000
-10000
0
10
20
30
40
50
60
70
80
90
100


Lifecycle Deficit and Age Reallocations, Japan, 2050
C - YI
500000
400000
300000
200000
100000
0
-100000
-200000
-300000
0
10
20
30
40
50
60
80
90
100

Implications for Wealth

Lee has shown that given golden rule steady state growth, the wealth W(z) associated with any flow z across age groups is equal to:

$$W_z = Z\left[A_{\text{inflow}} - A_{\text{outflow}}\right]$$

A_{inflow} – mean age of the inflows ($ weighted)

A_{outflow} – mean age of the outflows ($ weighted)

Z – annual flow of the variable in question.

Where wealth is the present value of inflows less the present value of outflows.

Lifecycle Wealth

- Steady-state golden rule lifecycle wealth is:

$$W = c(A_c - A_{y_l})$$

Illustrati			
	Ac	Ayl	W
Niger	27	39	-12c
Ja			7c

Niger has a large lifecycle debt because it is obligated to provide support to future generations.

Japan has large lifecycle wealth because a) it has accumulated assets to fund pensions; or b) it has created programs that will require large transfers from future generations.

Lifecycle Child Wealth (T_k)

- This value is the debt that people who are currently alive “owe” to those who have not yet been born.
- The debt is overwhelmingly in the form of an unfunded obligation to make transfers to unborn children. Hence, it is transfer wealth (or debt).
- Average age of inflow (perhaps 10) is well below the average age of the outflow (perhaps 40). Hence, child lifecycle wealth is negative and large in Niger 1950.

Lifecycle Pension Wealth (W_p)

- In Japan, the average age of inflow (perhaps 80) is well above the average age of the outflow (perhaps 50). Hence, lifecycle pension wealth will be positive and large in Japan in 2050.
- This is the wealth on which the 2050 population will rely during its retirement years.
- It comes in two forms: transfer wealth and capital.

$$W_p = T_p + K.$$

- Transfer wealth is the present of value of net transfers, e.g., from Social Security. It is the flip side of the implicit debt imposed on future generations.
- In golden-rule case, K and T are endogenous.

The Effect of Population Growth: Realistic Treatment of Age

- Assume golden-rule steady state.
- Closed economy.
- Let C be the present value of life time consumption (c(x)) discounted at rate r and survival weighted (l(x)).

$$C = \int_0^w e^{-rx} l(x) c(x) dx$$

Effect of population on golden rule steady-state lifetime consumption

Capital dilution effect

$$\frac{d\ln(C)}{dn} = -\frac{k}{c} + A_c - A_{y_l}$$

The effect of age structure – equal to the mean age of consumption less the mean age of labor income.

Source: Arthur and McNicoll 1978.

Mean Ages of Consumption and Labor Income

- If $Ac-Ayl < 0$, the age structure effect reinforces the capital dilution effect, i.e., a decline in n leads to higher C. Niger case?
- This condition is likely to be met in populations with high rates of child dependency and, hence, a very early mean age of consumption.
- If $Ac-Ayl > 0$, the age structure effect offsets the capital dilution effect; the effect of n on C is ambiguous. Japan case?
- This condition is likely to be met in populations with high rates of old-age dependency and, hence, a very late mean age of consumption.

Effect of population on golden rule steady-state lifetime consumption

$$\frac{d\ \ln\left(C\right)}{dn} = A_c - A_{y_l} - \frac{k}{c}$$

$$= \frac{W}{c} - \frac{k}{c} = \frac{T}{c}$$

If transfers to children exceed transfers to the elderly, as measured by transfer wealth, slower population growth leads to an increase in lifetime consumption.

Only comparing across golden rule steady states.

Source: Willis (1988); Lee (1994)

Summary

- Slower population growth is beneficial because it leads to capital deepening.
- Age structure also matters
  - Dependent populations lead to transfers
  - If transfers to children dominate, slower population growth offers a further benefit.
  - If transfers to the elderly dominate, further declines in population growth may not be beneficial.

Qualifications

- Closed economy: Trade, international capital flows, and immigration are widespread.
- Steady state: During demographic transition countries are NOT in steady state.
- Golden rule growth: Actual saving is insufficient to produce golden rule growth. Will population change push countries closer to or further away from golden rule by affecting saving?

Directions for further research

- Dynamics of population growth and age structure
- Economic lifecycle – consumption and labor income
- Support systems
  - Transfers, both public and private (familial)
  - Saving and dis-saving

IV. Simulation models and demographic dividends

The Consumption Identity

Consumption per effective consumer

Output per effective producer

$$\frac{C(t)}{N(t)} \equiv c(t)\frac{Y^l(t)}{L(t)}\frac{L(t)}{N(t)}$$

Consumption as a fraction of labor income

Support ratio: effective producers per effective consumer

In Growth Terms

$$gr\left[\frac{C(t)}{N(t)}\right] \equiv gr\left[c(t)\right] + gr\left[\frac{Y^{l}(t)}{L(t)}\right] + gr\left[\frac{L(t)}{N(t)}\right]$$

where $gr[\ \ ]$ is the growth rate.

The Support Ratio

$$\frac{L(t)}{N(t)} = \frac{\sum_{a=0}^{w} g(a)P(a,t)}{\sum_{a=0}^{w} f(a)P(a,t)}$$

$g(a)$ - productivity age profile

$f(a)$ - consumption "needs" age profile

$P(a,t)$ - population

First Dividend

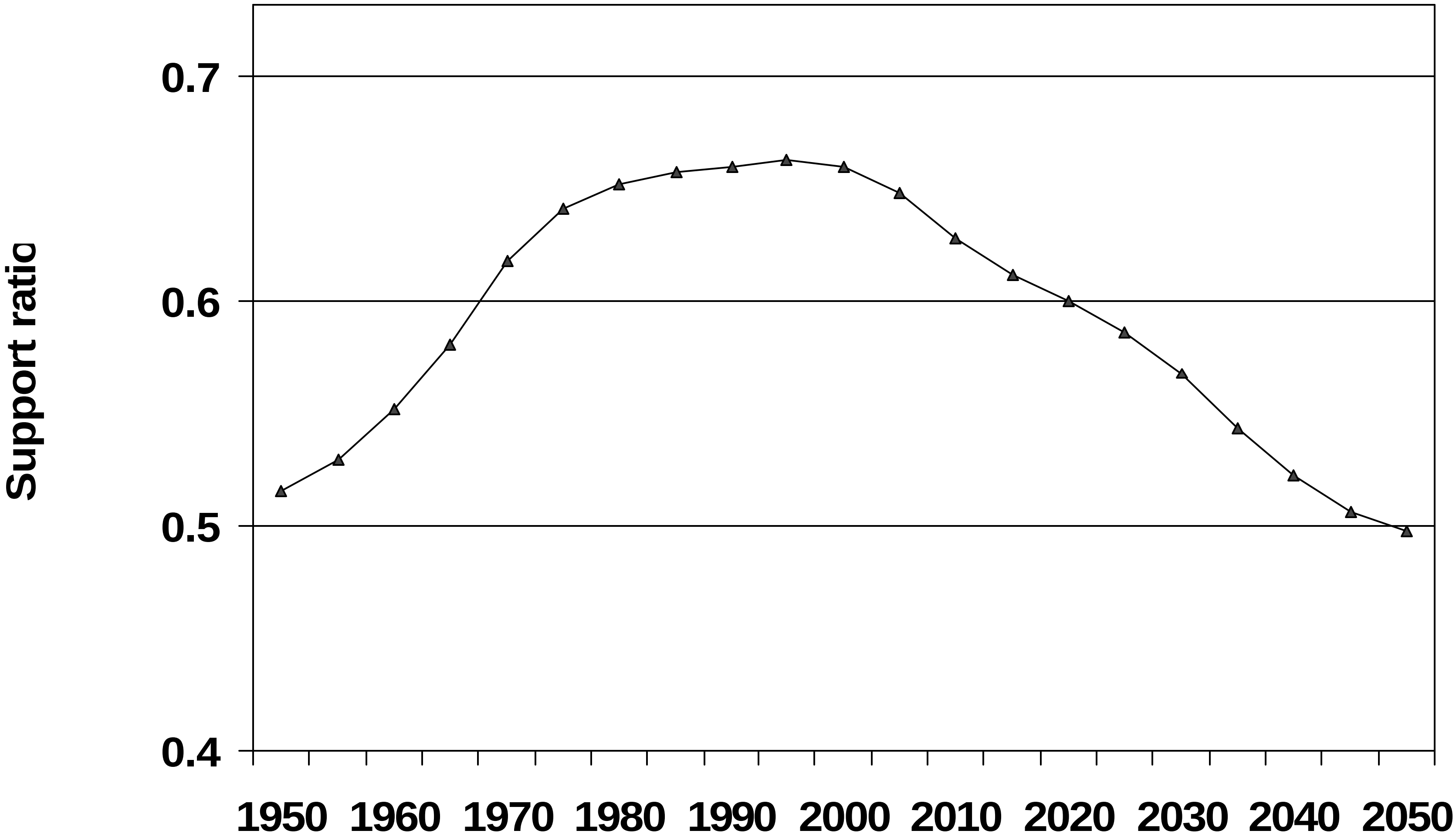
$$\frac{C(t)}{N(t)} \equiv c(t)\frac{Y^l(t)}{L(t)}\frac{L(t)}{N(t)}$$

Changes in the support ratio holding other factors constant.

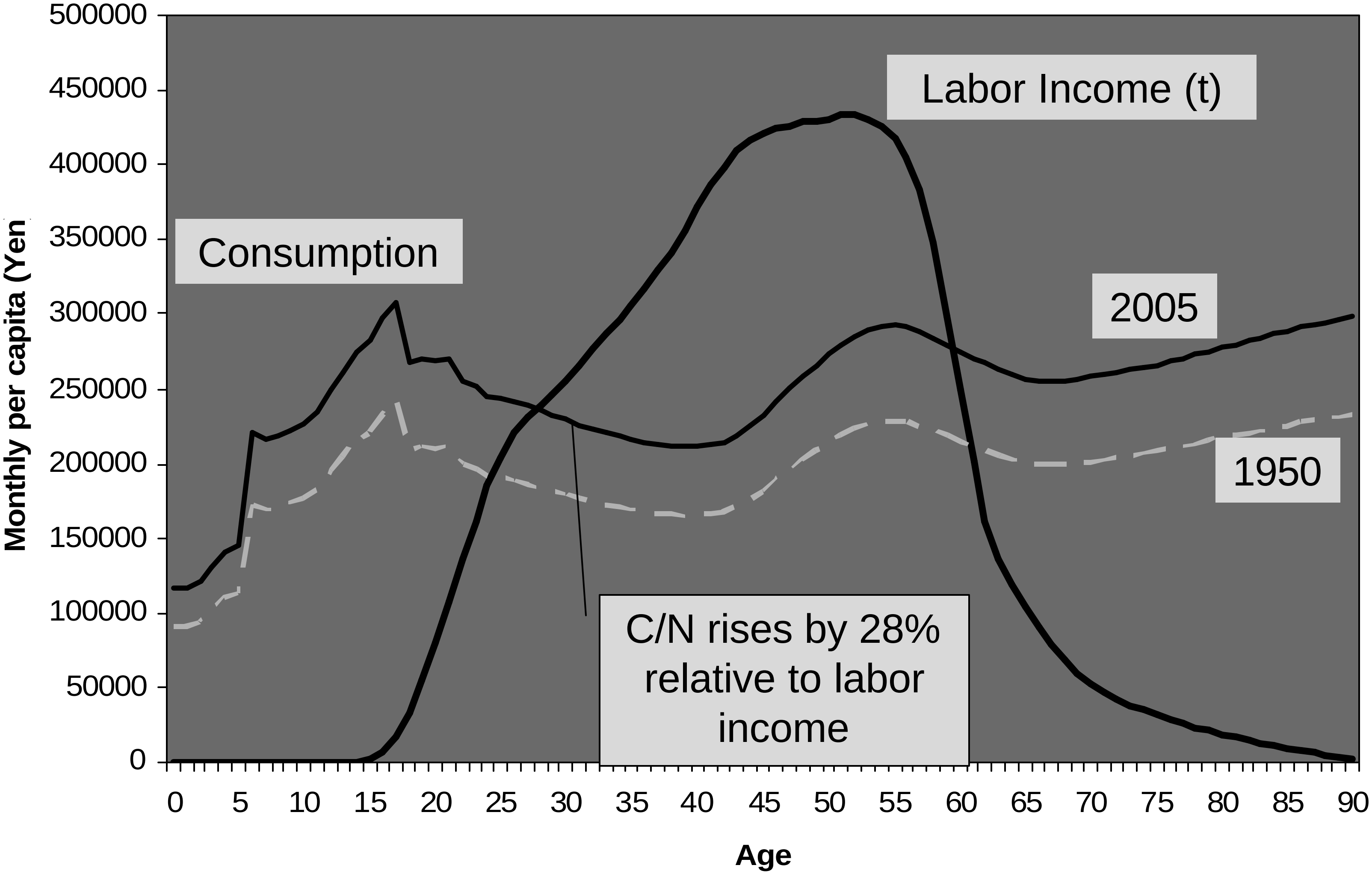
In growth terms:

$$gr\left[\frac{C(t)}{N(t)}\right] \equiv gr\left[\frac{L(t)}{N(t)}\right].$$

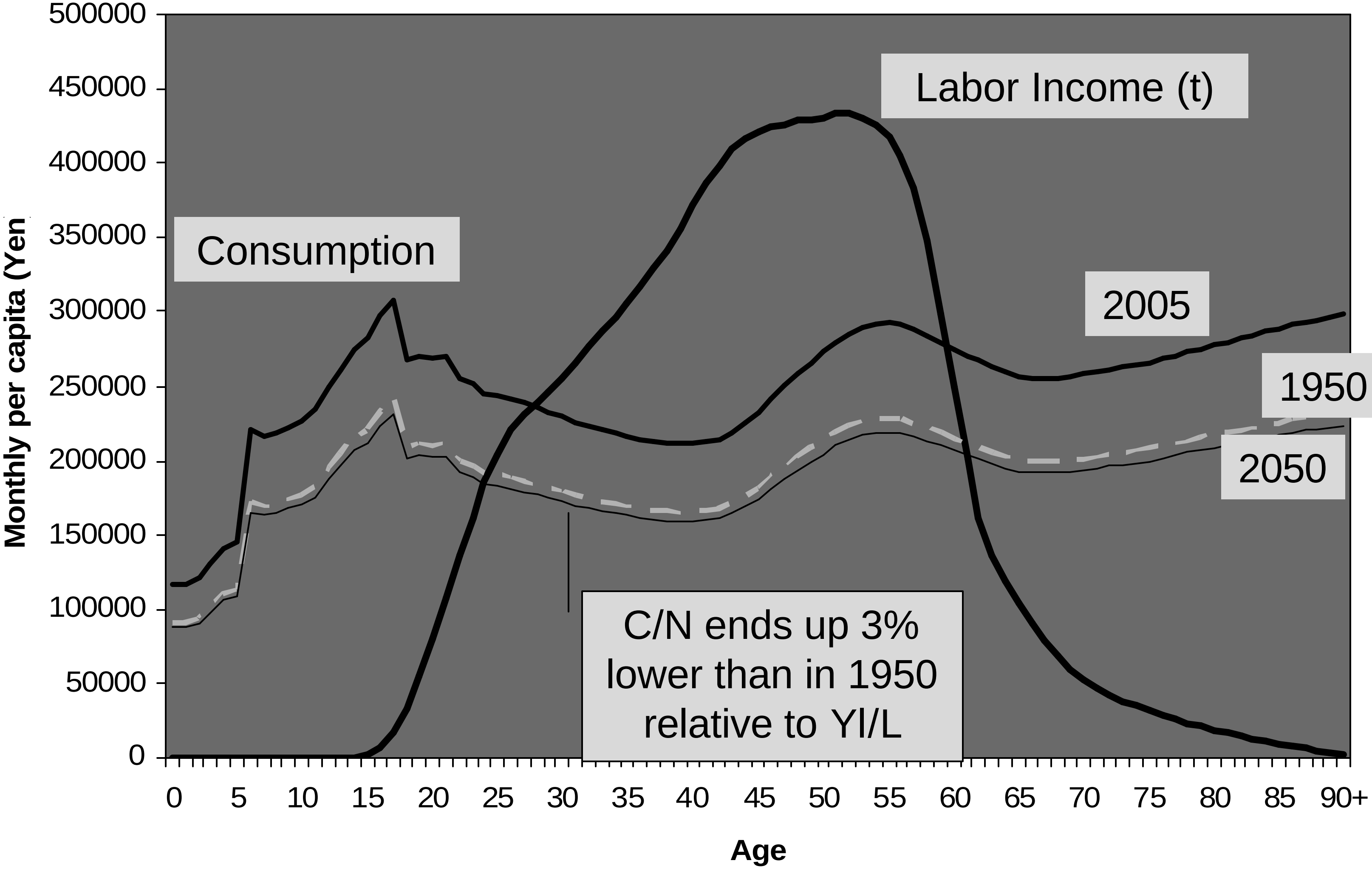
Support Ratio, Japan, 1950-2050



Japan’s First Dividend, 1950-2005



The End of Japan's Dividend



	First Dividend Period	Annual increase in per capita income	Total increase in per capita income
Japan	1950-1995	0.5%	27.8%
China	1970-2015	0.8%	45.6%
India	1975-2045	0.4%	35.2%
US	1970-2000	0.4%	11.4%

Net Effect of the Support Ratio, 1950 - 2050

	Percentage change in support ratio, 1950-2050
Japan	-3.5%
China	5.5%
India	27.4%
US	-8.2%

First Dividend Summary

- Demographic transition leads to favorable change in age structure (increase in support ratio).
- If the saving rate is held constant, consumption increases relative to labor income by the same percentage as the support ratio – the First Dividend.
- The First Dividend is transitory.

The Second Dividend

- First dividend creates a “window of opportunity”.
- Rise in support ratio makes it possible to increase per capita consumption and the saving rate at the same time.
- Population aging leads to an increase in the demand for wealth to meet pension needs.
- If workers save more (increase asset-based reallocations), higher consumption is possible even after the first dividend period has come to an end.

The Simulation Model

- Small open economy
- Labor-augmenting technological growth with age-varying productivity that does not change over time.
- Consumption
  - Varies by age reflecting tastes, needs, etc., including altruism.
  - No bequests.

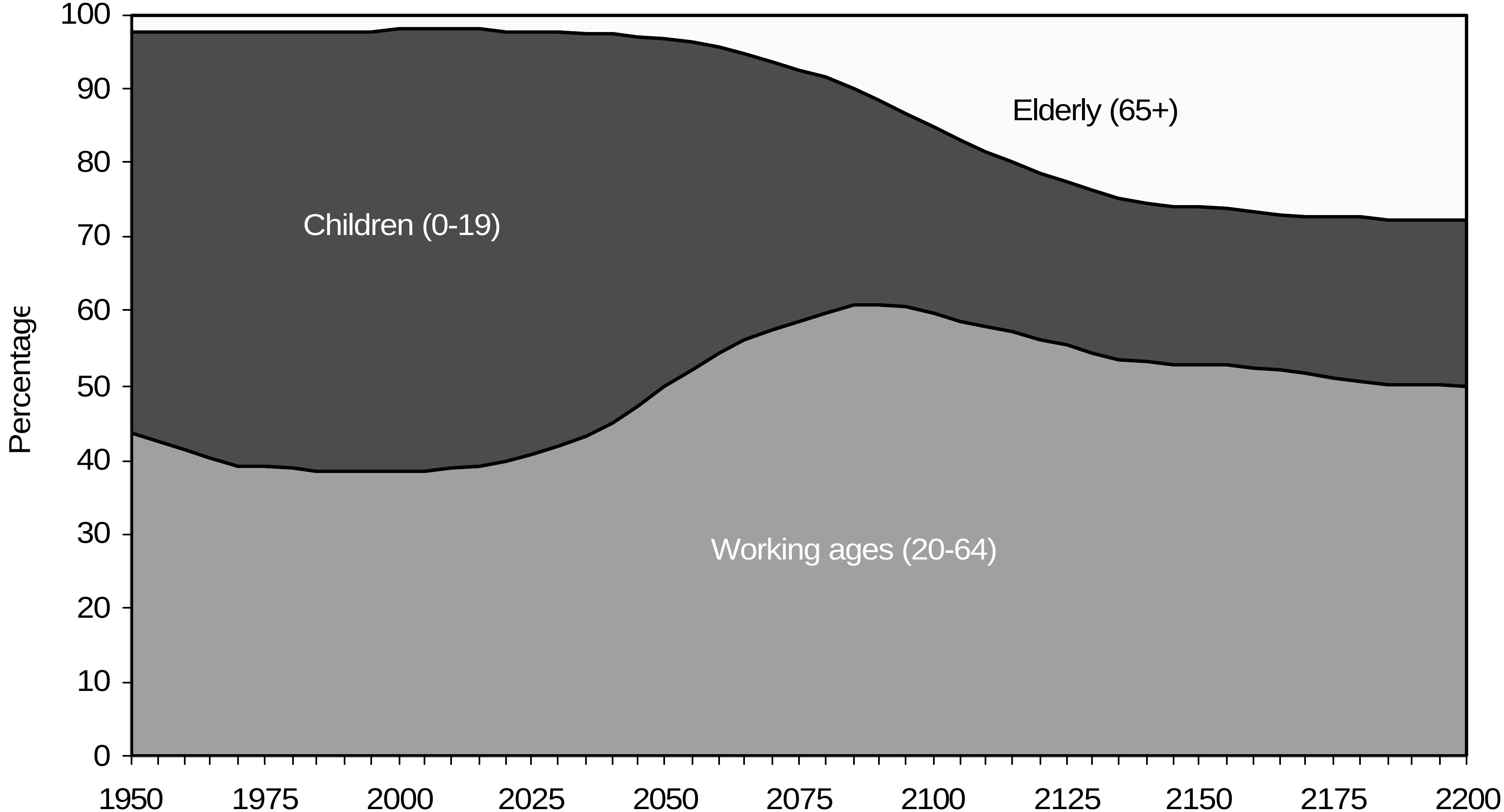
The Simulation Model (II)

- Reallocations to children consist of
  - Private transfers from parents
  - Public transfers from taxpayers (tax on labor income).
- Reallocations to old age consist of
  - Transfers
  - Asset-based reallocations (i.e. saving)
  - Assume that old-age transfer wealth is a constant fraction of lifecycle pension wealth.
- Shape of cross-sectional age profiles of consumption and labor income are fixed but shift over time.

Simulating the Last Demographic Transition

- Population of Niger 1950 – 2300
  - Highest TFR in the World in 2000 (7.9) declining to replacement in 2080
  - Life expectancy at birth: 36.2 in 1950-55; 44.3 in 2000-2005; 61.4 in 2045-50; 90 in 2300.
  - Lets us see the entire demographic transition

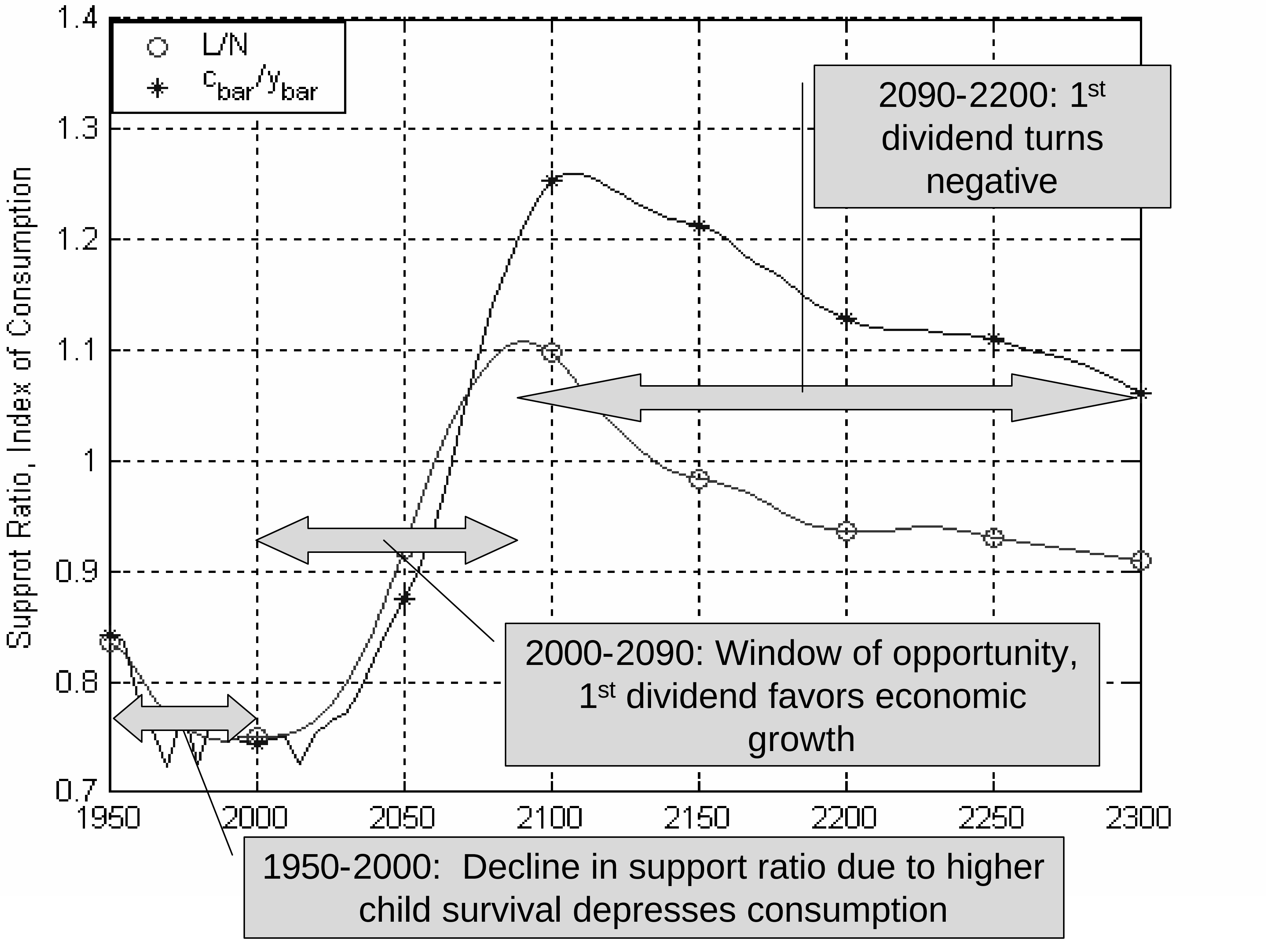
Figure 3. Age Distribution of Niger's Population, 1950-2200



Baseline Assumptions

Productivity growth	1.5%
Depreciation rate	3.0%
Discount rate	3.0%
Interest rate	6.0% → 4.2%
Age profiles	Taiwan 1977
Familial share of transfers to children	0.67
Pension transfers as a share of pension wealth	0.35

Source: Mason and Lee 2006.



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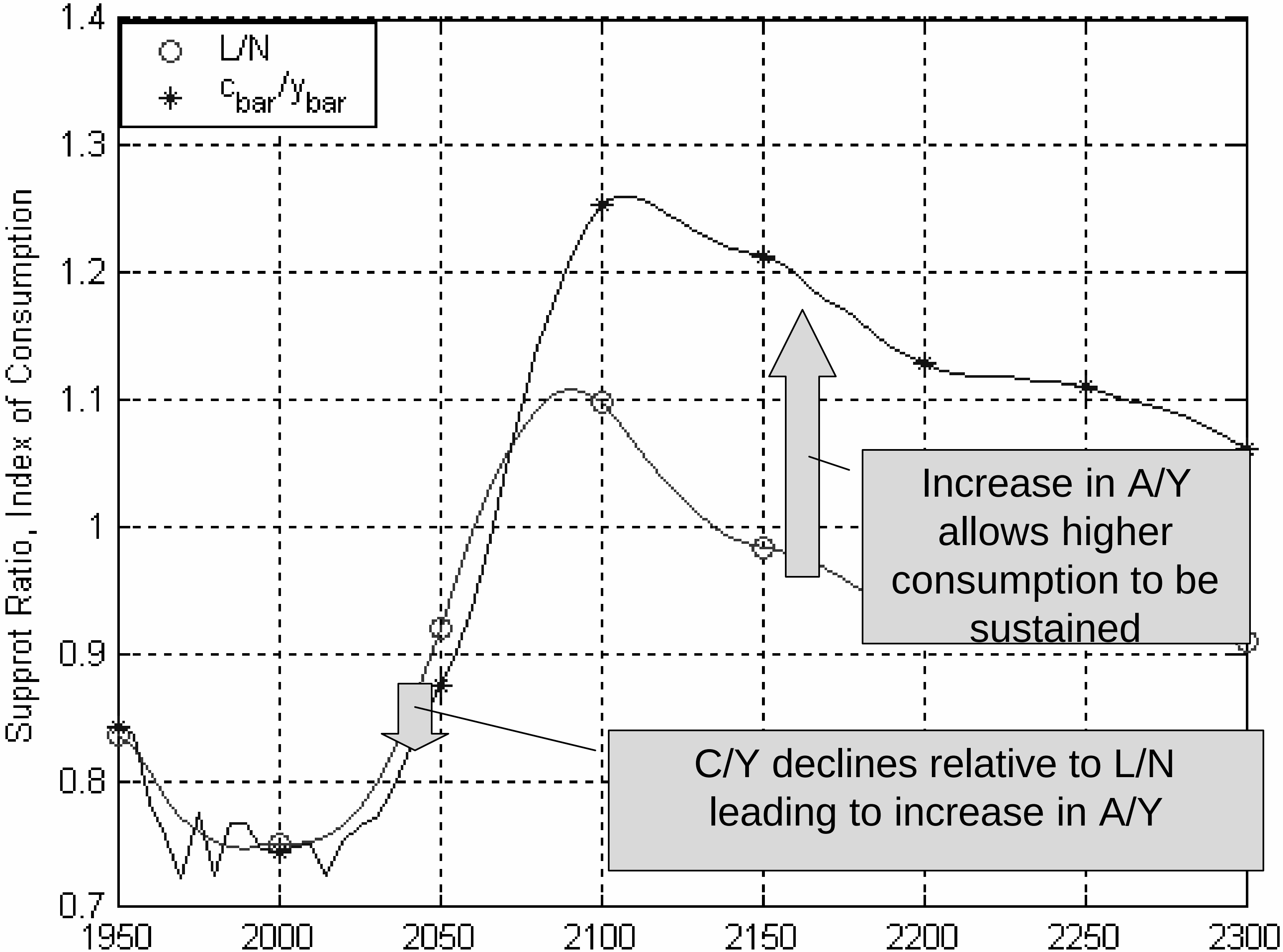

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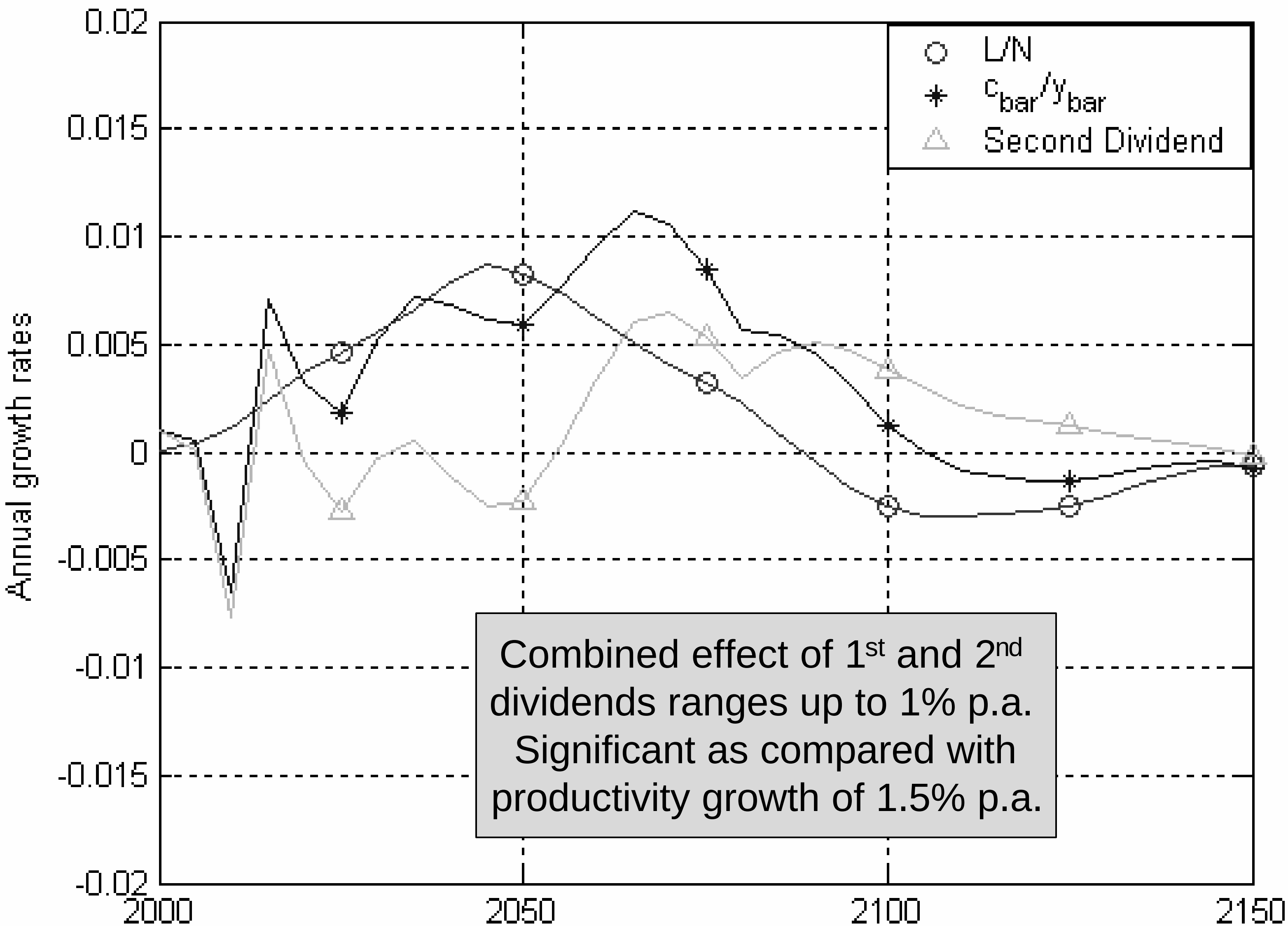

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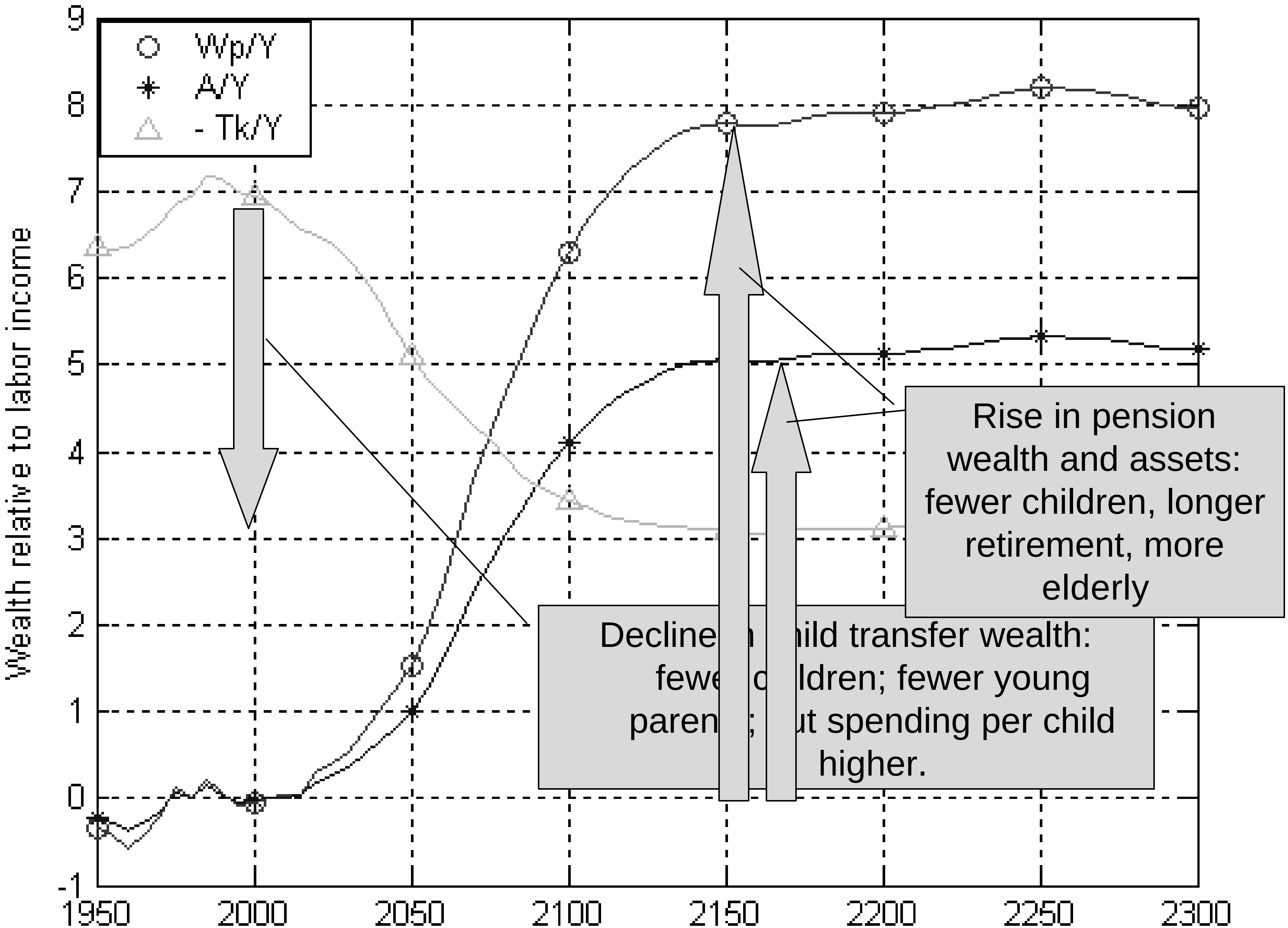

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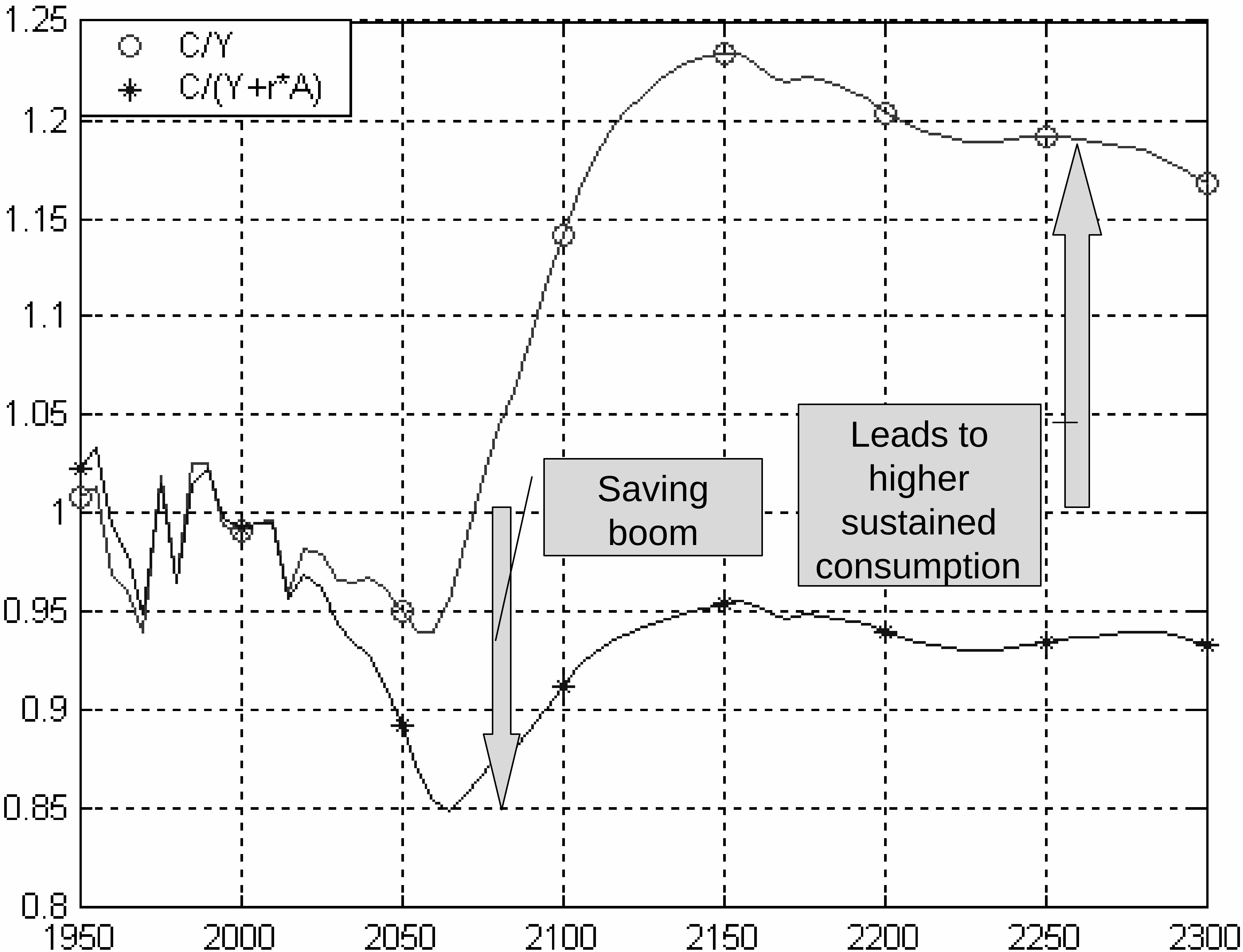

The Demographic Dividends

- First Dividend
  - Leads to 50% increase in consumption per equivalent adult
  - Dividend period (window of opportunity) lasts for 70 years
  - First dividend is ultimately transitory – by 2200 support ratio is only 10% above its 1950 level

The Demographic Dividends

- The Second Dividend
  - First dividend is being capitalized: consumption depressed by about 5% until near the end of the first dividend period
  - Adds almost 20% to consumption at the peak and thereafter
- Combined effect of the two dividends: explains 25% of growth from 2030-2090.

Sensitivity Analysis

- US economic lifecycle leads to greater assets, higher consumption in the short-run, but lower consumption in the long-run
- Increase in pension transfer wealth has a very large effect, more than proportional, on wealth and adversely affects consumption.

Effects of Population Depend on Two Features of the Economy

- Economic Lifecycle – extent to which economic resources are shifted from prime adult ages to young and old ages.
- Reallocation System – the economic mechanisms used to shift resources across the lifecycle.
- National Transfer Accounts provide the information required.

V. Conclusions

- Economic effect of population depend on
  - Population growth rate
  - Population age structure
- Population age structure matters because those in the working ages support children and the elderly
- A more complete understanding requires detailed information about
  - Economic lifecycle
  - Support system

V. Conclusions

- Implications of population for economic growth are essential to understanding implications:
  - Poverty
  - Intergenerational equity
  - Fiscal issues, e.g., the viability of public pension programs

V. Conclusions

- Not considered here, but important is how population change influences investment in human capital.
- This issue will be explored in the future.