# Some Macroeconomic Consequences of the Demographic Transition

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UC Berkeley
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Thanks to Andy mason and NTA country teams

Data from

# Main points

1. **Demographic transition** first raises support ratio, then with population aging reduces it.
2. Per capita consumption is proportionate to **Support ratios**, other things equal. “First dividend”, pop aging.
3. Longer life, lower fertility, slower pop growth and older population all raise **capital/labor ratio**, raising labor productivity. “Second dividend”.
4. This depends on importance of **assets vs transfers**.
5. Lower fertility goes with greater investment in **human capital** per child, raising labor productivity.

Data from

# Latin American NTA team leaders

- Brazil: Cassio M. Turra and Bernardo Lanza Queiroz
- Chile: Dirk Jaspers and Jorge Bravo; (Tim Miller, Mauricio Holz)
- Uruguay: Marisa Bucheli
- Mexico: Iván Mejía Guevara and Juan Enrique García
- Cost Rica: Luis Rosero Bixby

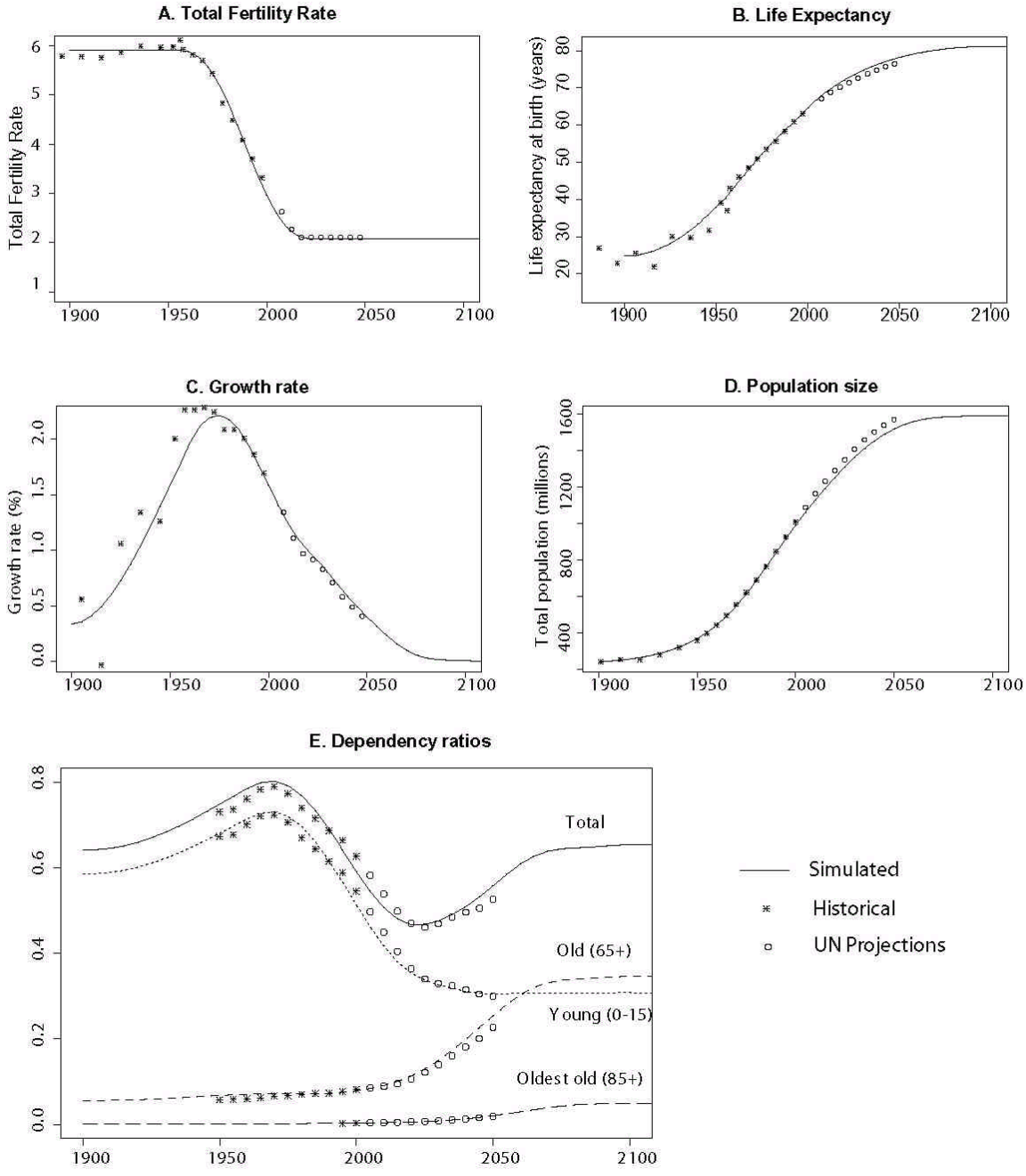
Data from

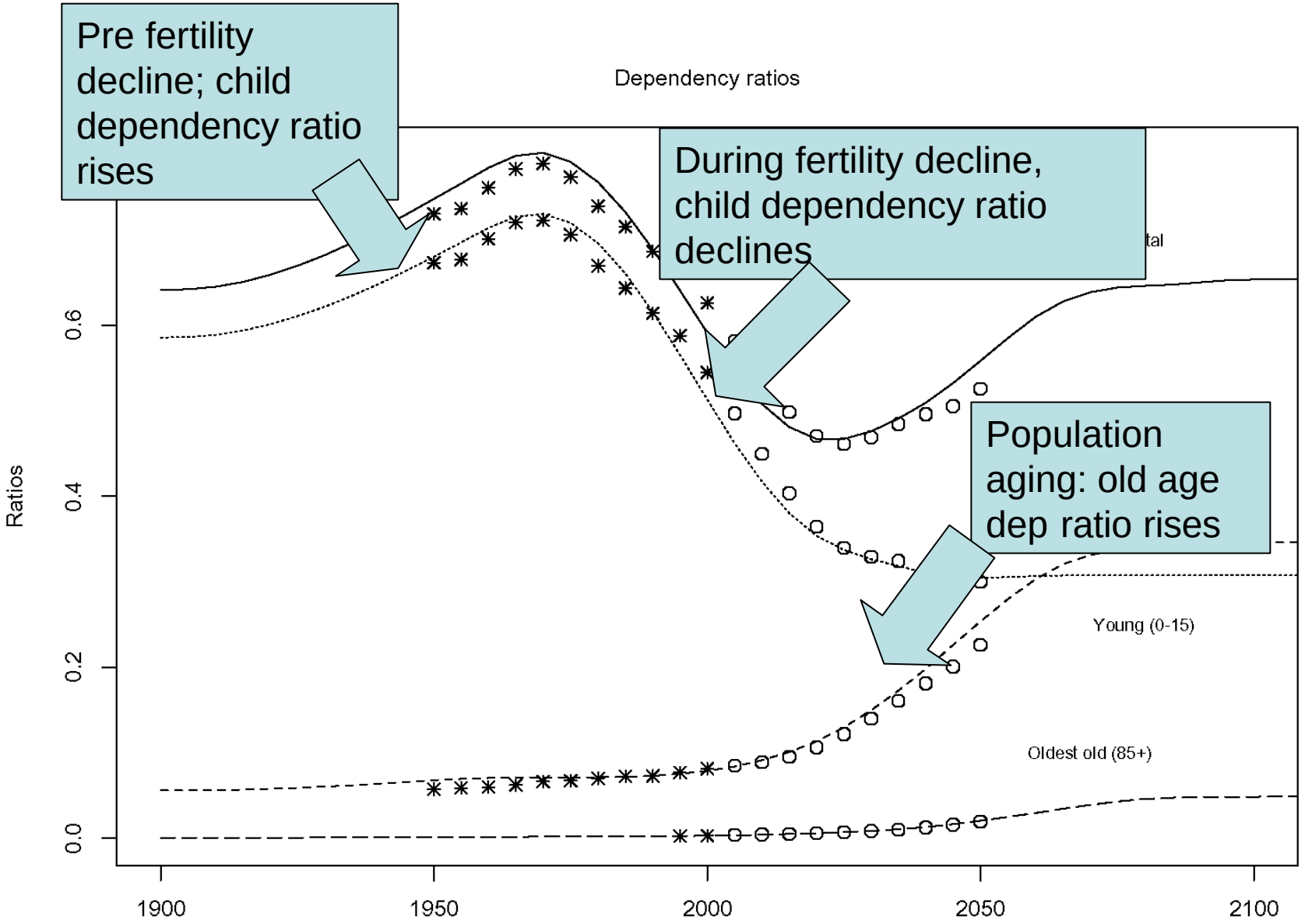
# I. The Demographic Transition

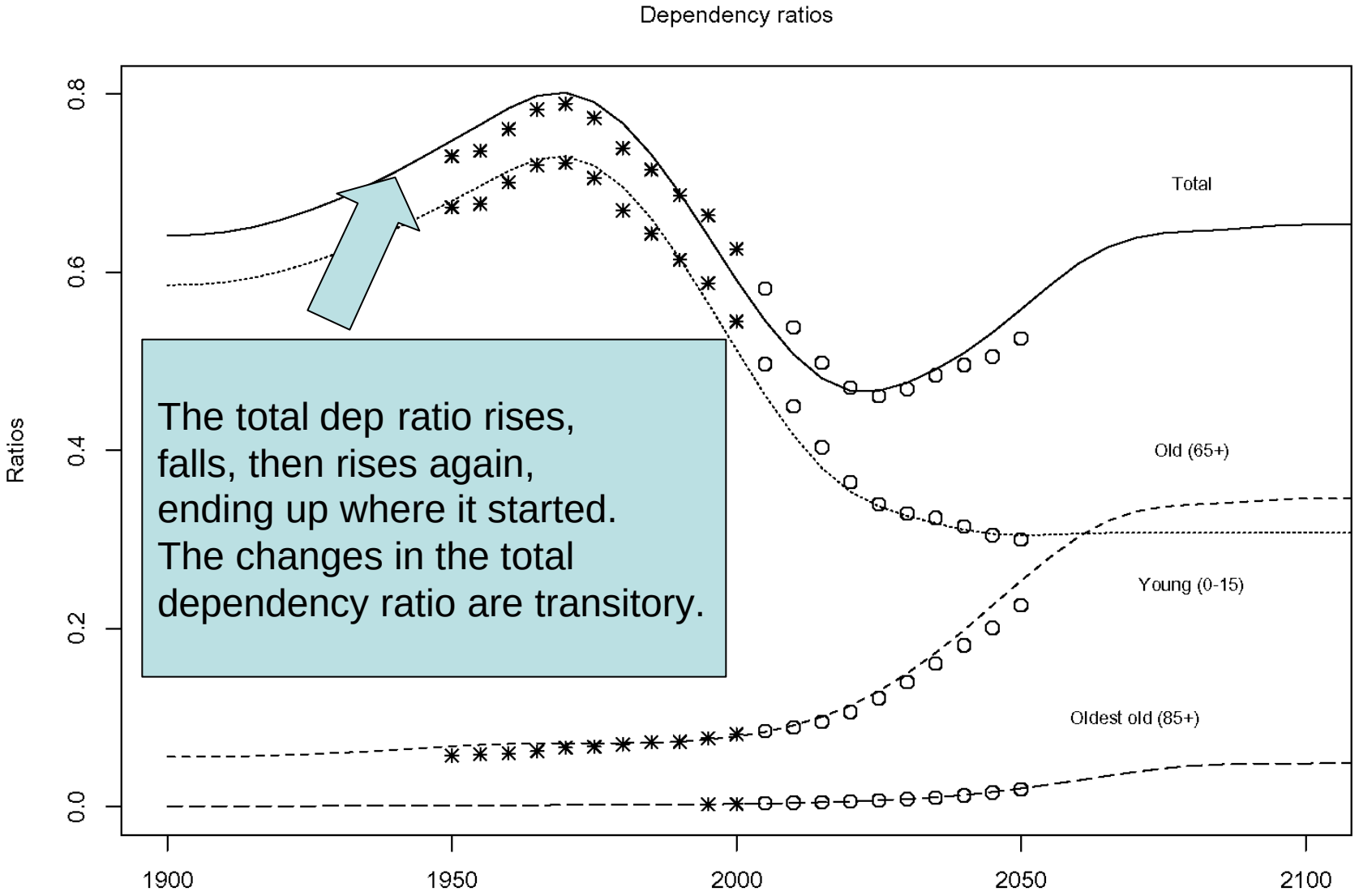
- A classic illustration: The transition in India, 1890-2100.
- Mixture of historical estimates, UN projections, and simulation based on fitted variations with time.

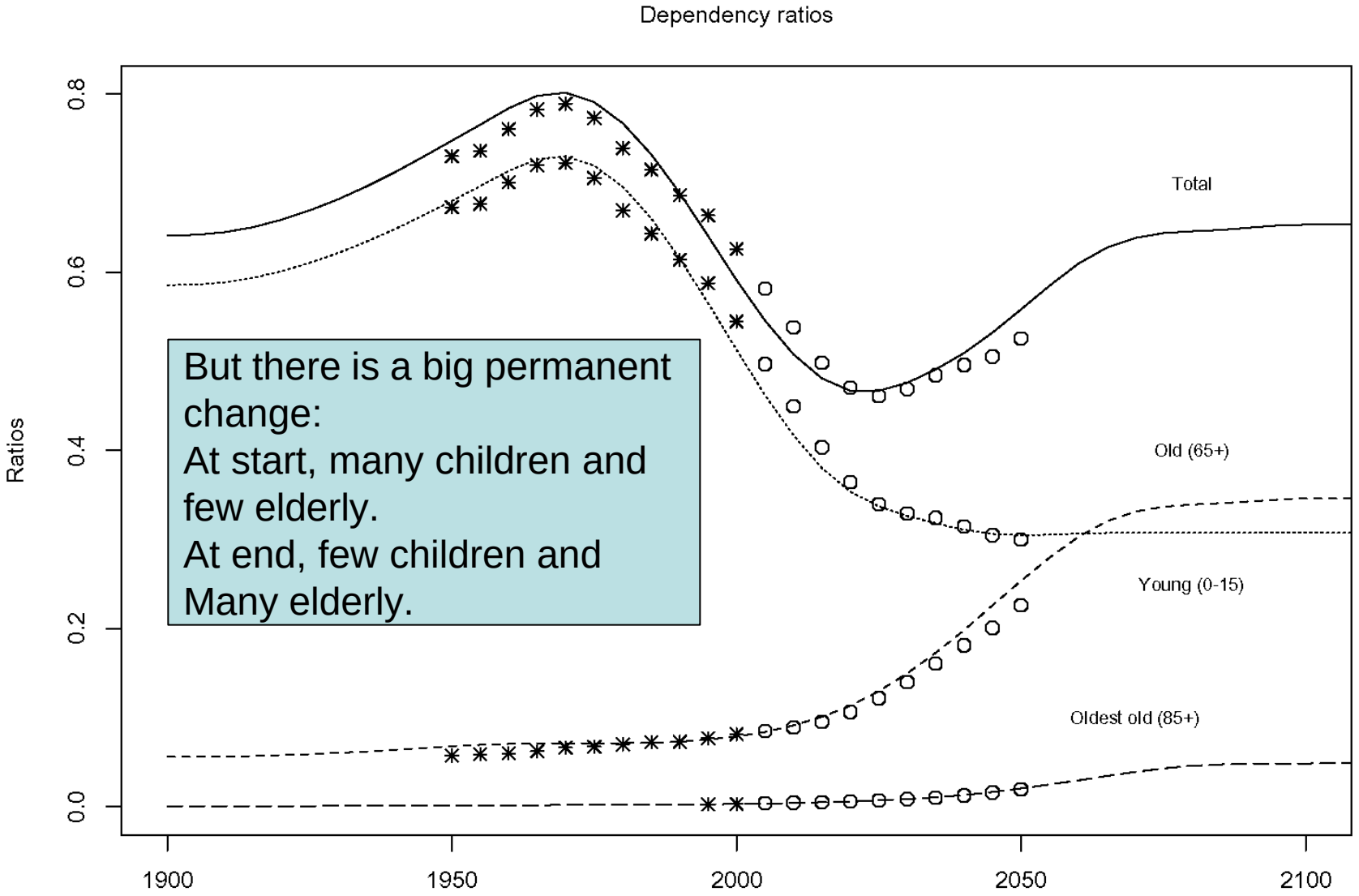
Data from

# A Classic Demographic Transition: Actual and Projected for India and Simulated, 1900-2100




Pre fertility decline; child dependency ratio rises
Dependency ratios
During fertility decline, child dependency ratio declines
tal
Population aging: old age dep ratio rises
Young (0-15)
Oldest old (85+)
Ratios
0.0
0.2
0.4
0.6
1900
1950
2000
2050
2100


Dependency ratios
Ratios
0.0
0.2
0.4
0.6
0.8
1900
1950
2000
2050
2100
Total
Old (65+)
Young (0-15)
Oldest old (85+)
The total dep ratio rises,
falls, then rises again,
ending up where it started.
The changes in the total
dependency ratio are transitory.


Dependency ratios
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1900
1950
2000
2050
2100
Total
Old (65+)
Young (0-15)
Oldest old (85+)
But there is a big permanent change:
At start, many children and few elderly.
At end, few children and Many elderly.

# Comments on simulation

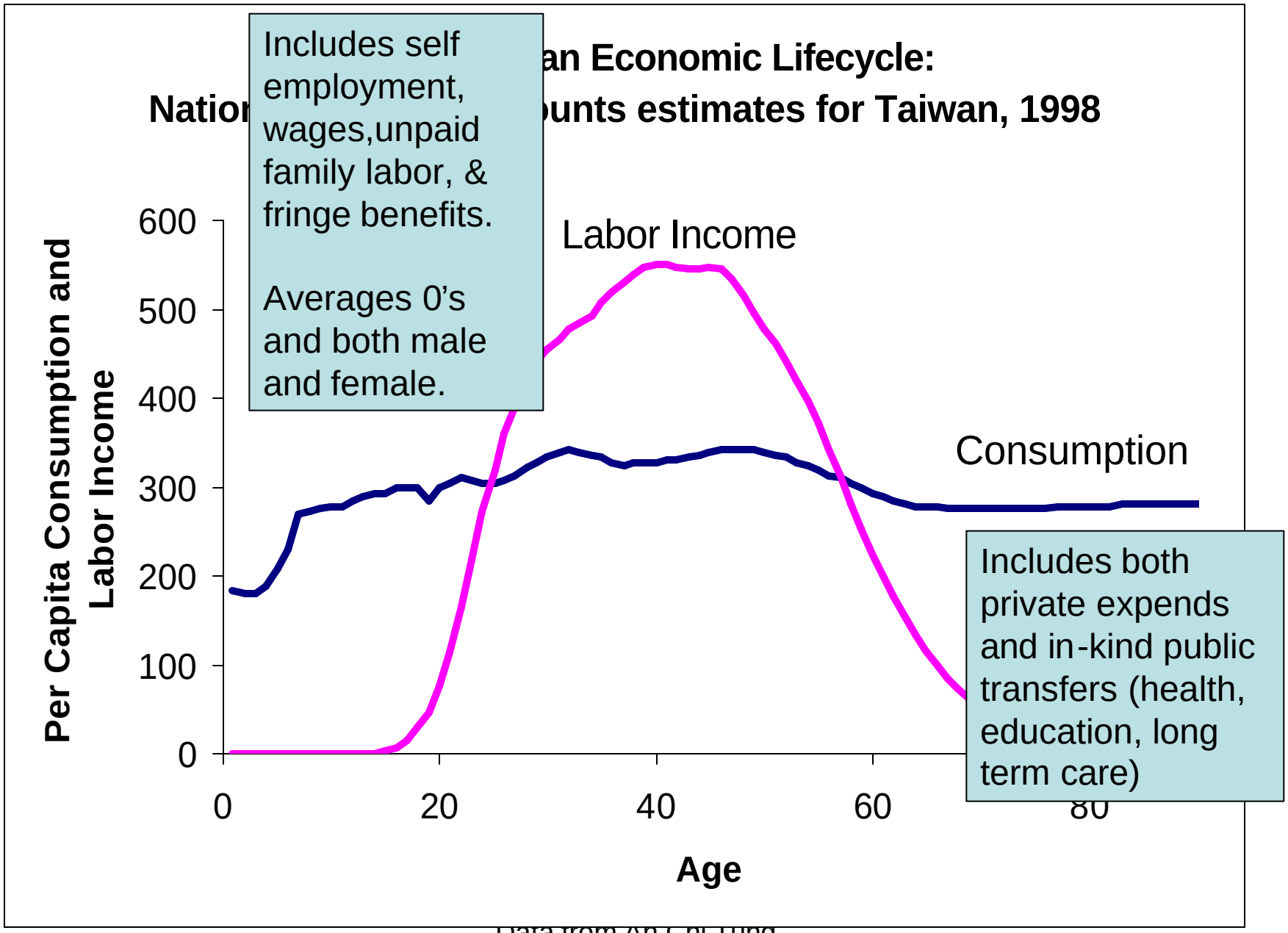
- Assumed TFR stabilized at 2.1; but often has declined below replacement.
- Assumed $e_0$ stopped rising at 80, but many countries already above this.
- Some countries experienced important baby booms and busts which distort this classic shape.
- Many countries now have declining populations and declining working age pops.

Data from

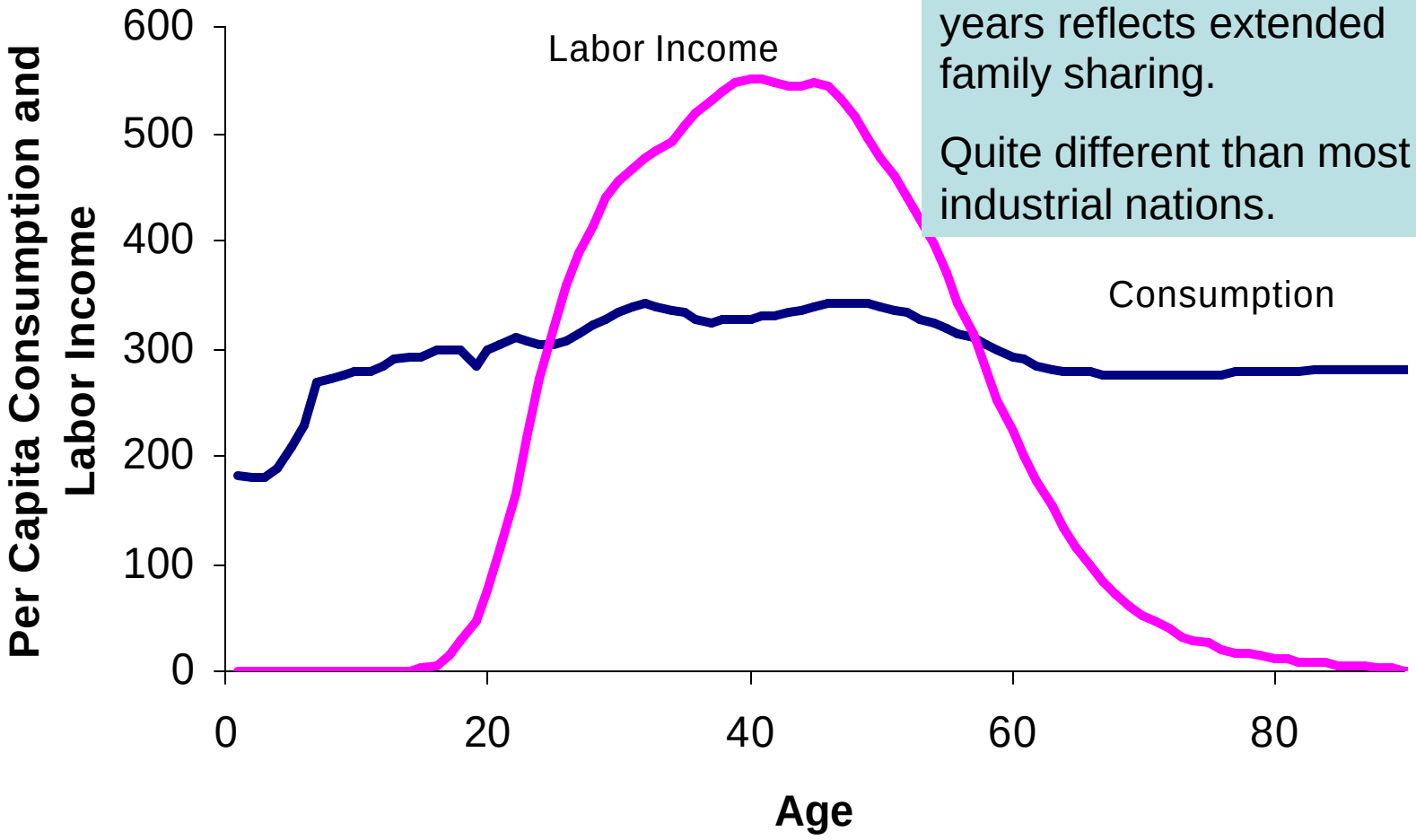
# II. The economic life cycle:

- Age profiles of consumption and labor income
- Use estimates from the National Transfer Accounts project, or NTA.
- Consumption patterns are quite similar for Third World countries in Asia and Latin America.
- Consumption in Industrial populations looks different.

Data from


Nation
an Economic Lifecycle:
unts estimates for Taiwan, 1998
Includes self employment, wages,unpaid family labor, & fringe benefits.
Averages 0's and both male and female.
Labor Income
Consumption
Includes both private expends and in-kind public transfers (health, education, long term care)
Per Capita Consumption and Labor Income
600
500
400
300
200
100
0
0
20
40
60
80
Age
Data from An-Chi Tung

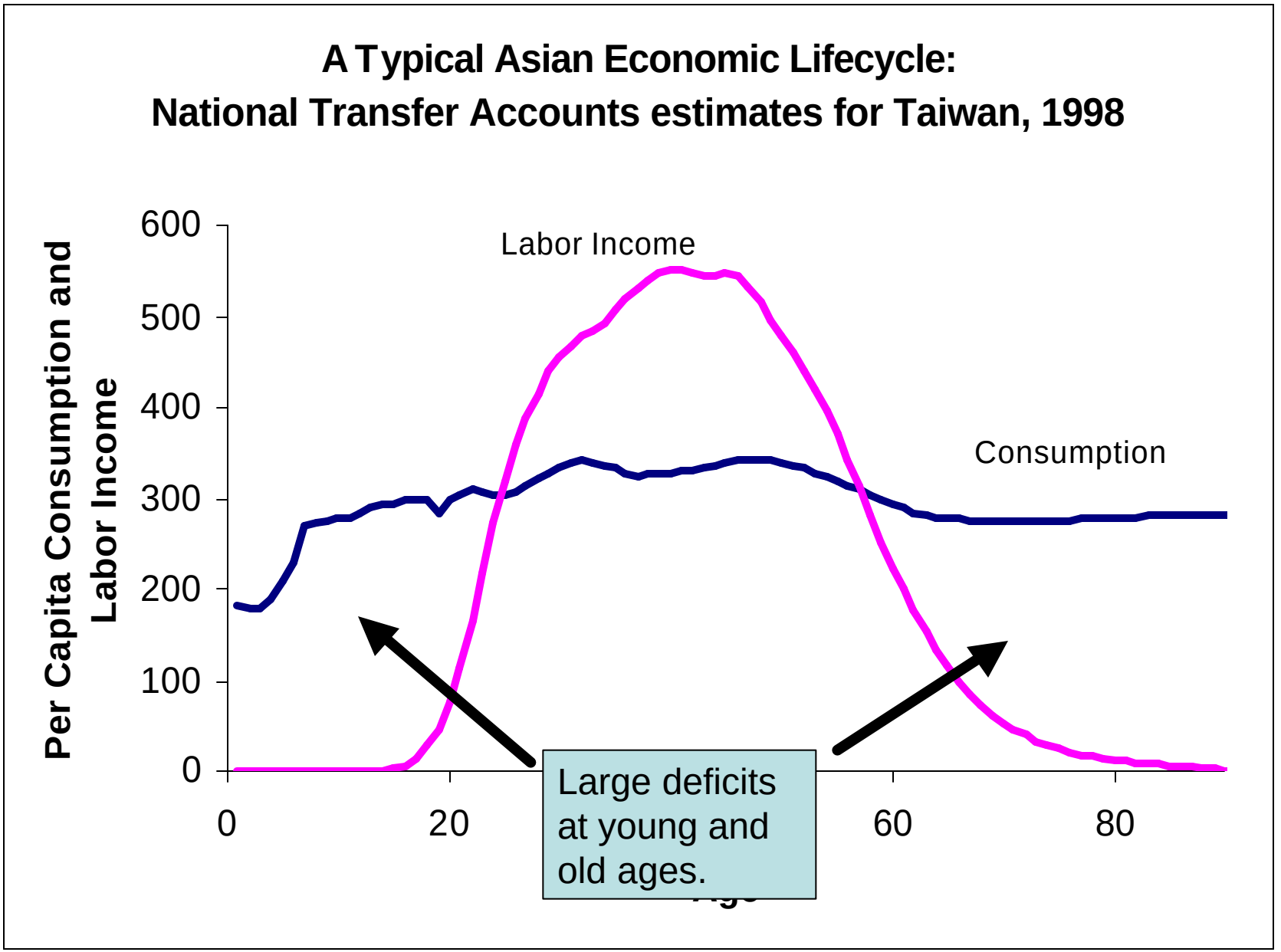
## A Typical Asian Economic Lifecycle:
## National Transfer Accounts estimates for Taiwan, 1998




Flat cons age profile in adult years reflects extended family sharing.

Quite different than most industrial nations.

Data from An-Chi Tung

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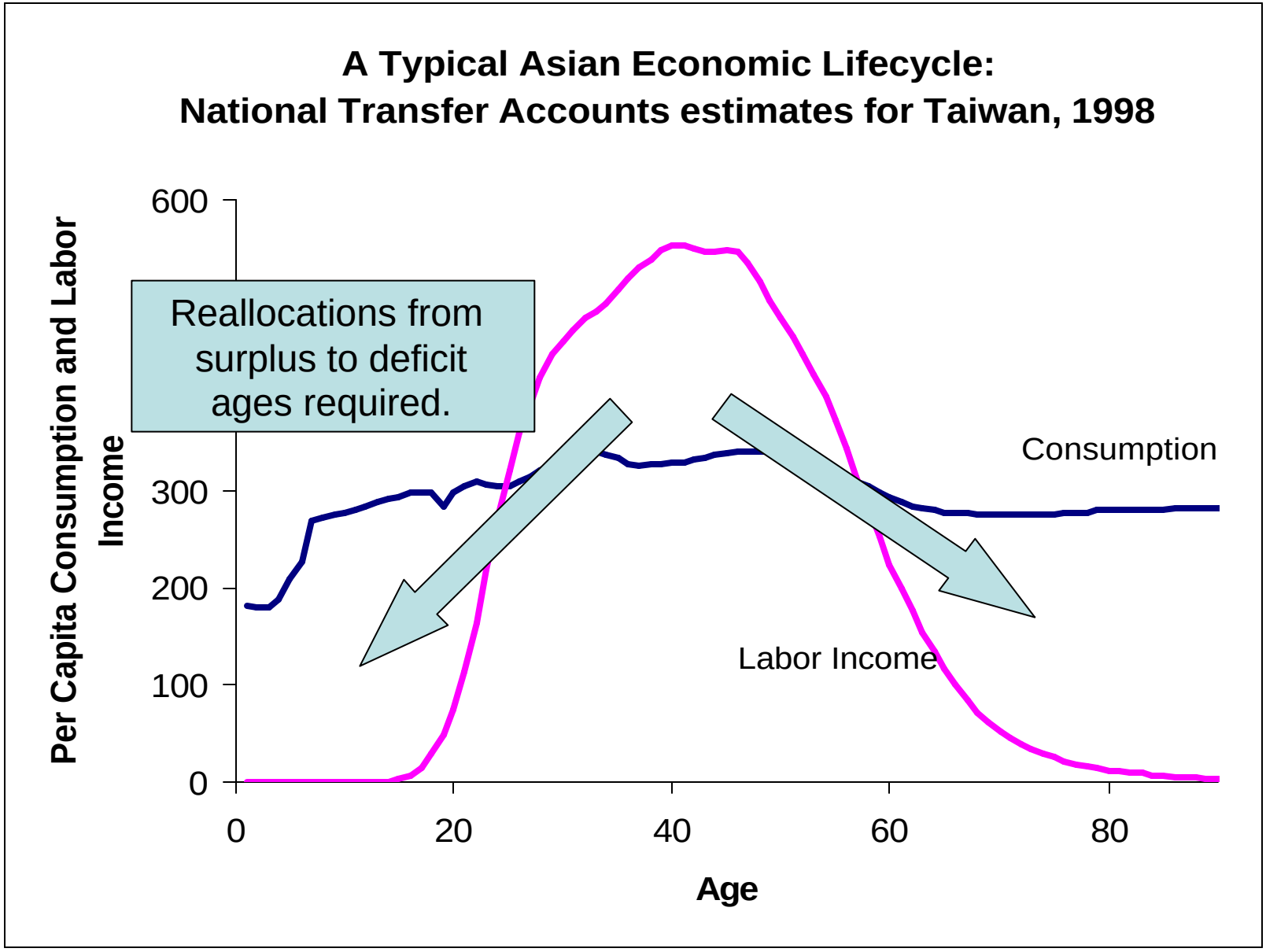


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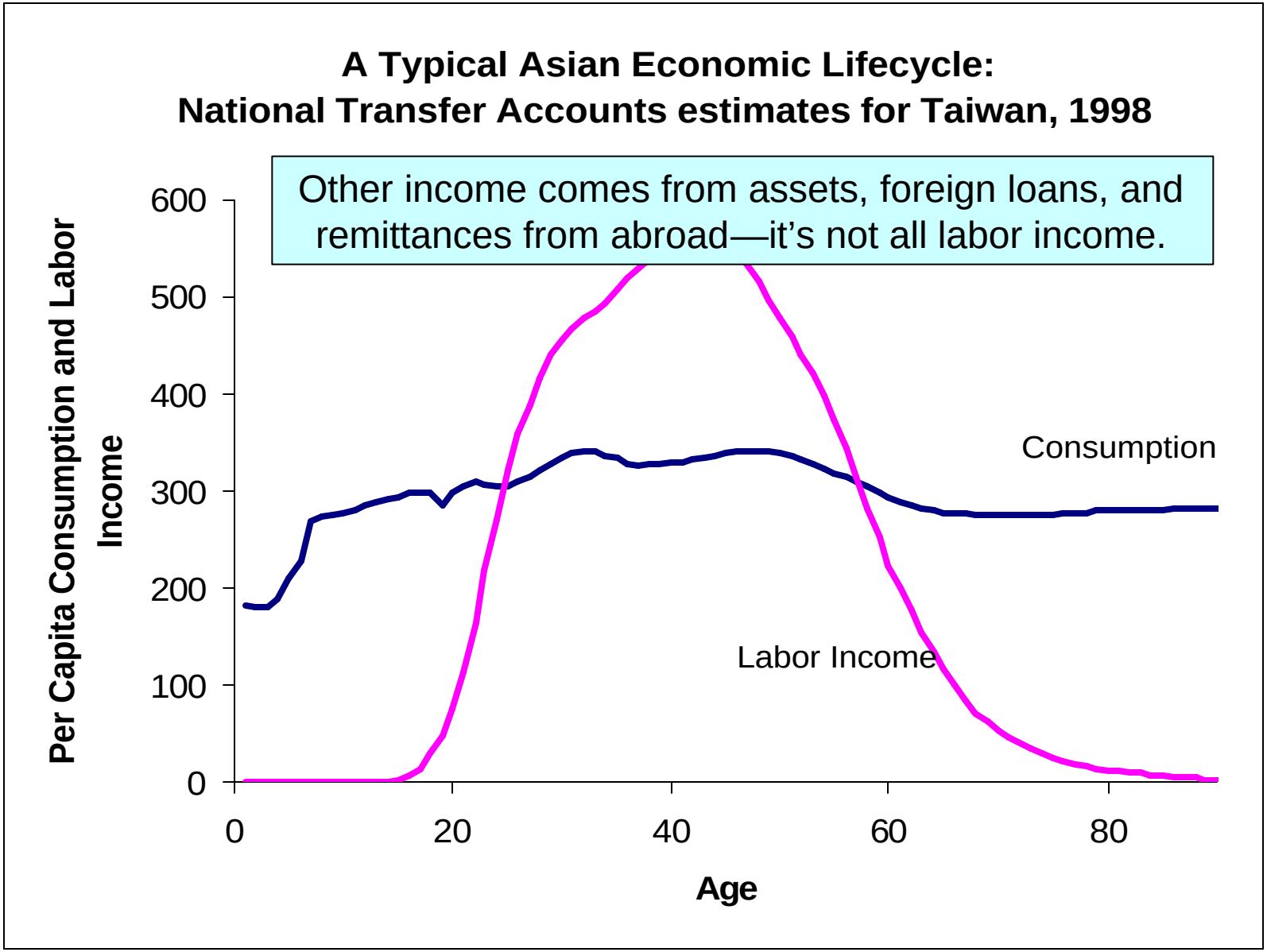


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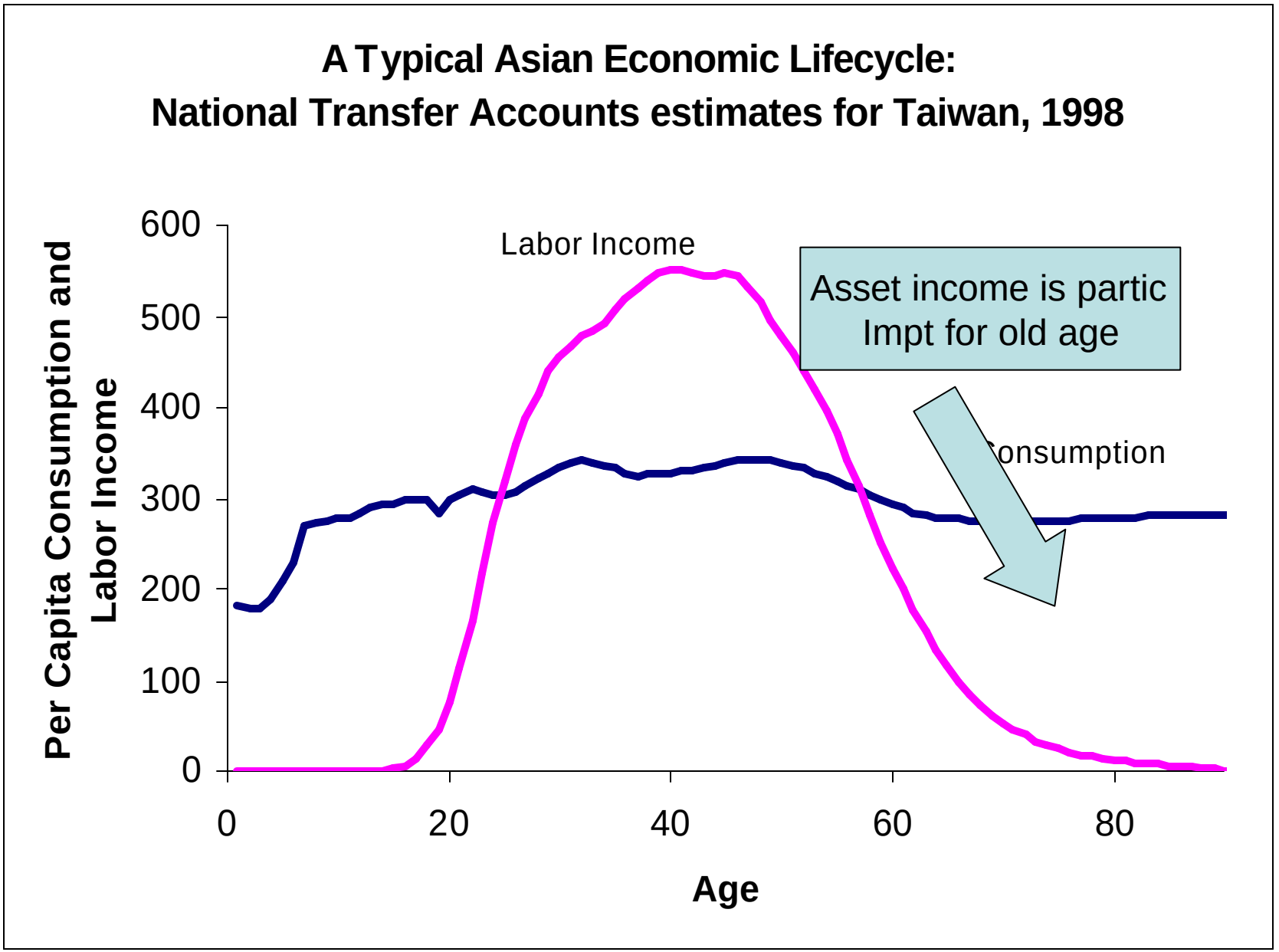
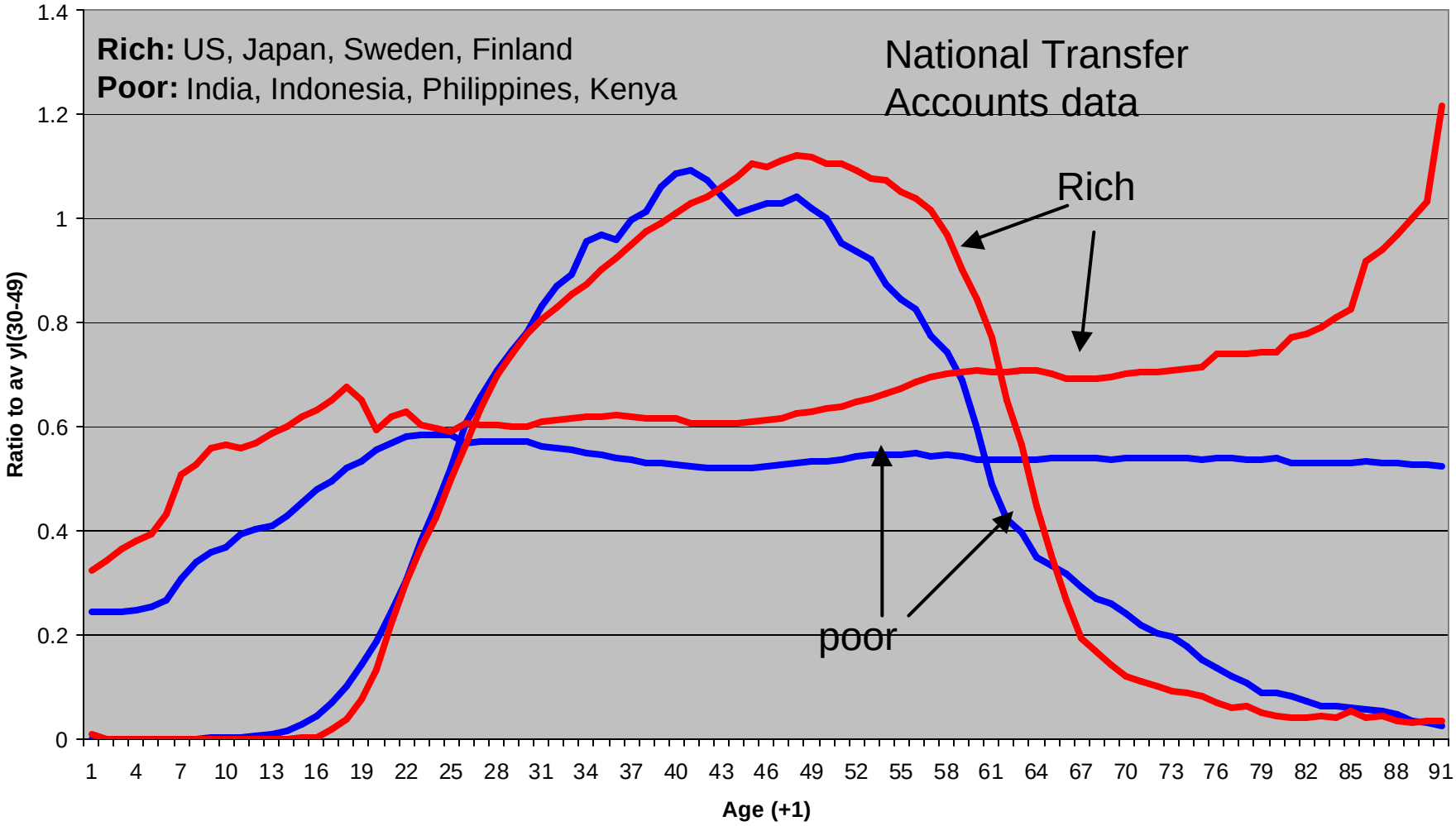


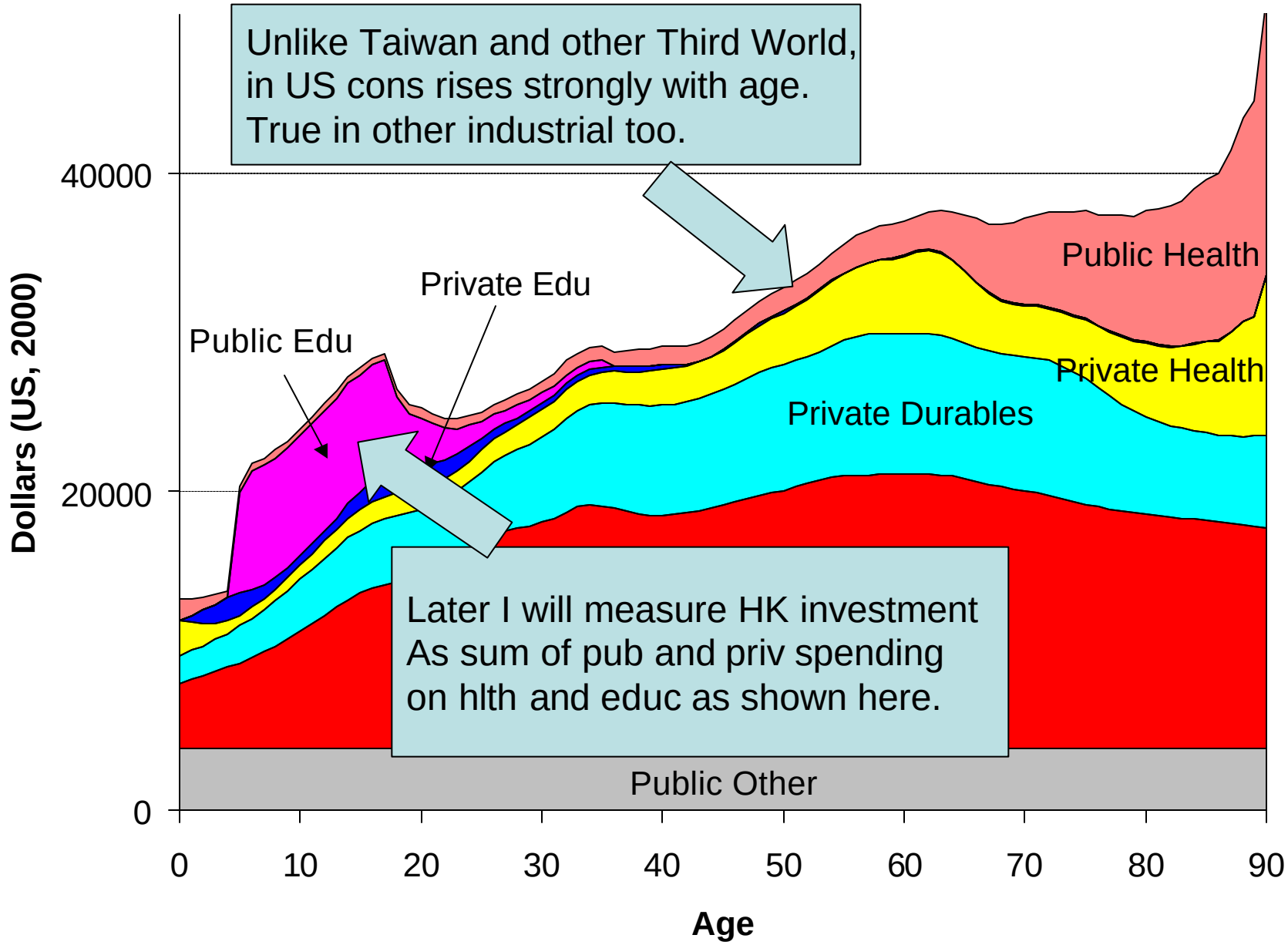

Data from An-Chi Tung

## Age Profiles of Labor Income and Consumption: averaged for Four Rich and Four Poor Countries (Relative to average labor income)




Data from

# Components of US Consumption, 2003



# Many policy possibilities to change the age profiles

- Change the age profile of labor income
  - Later retirement
  - Earlier entry into labor force
  - Higher female labor force participation
  - Reform seniority system
- Change the age profile of consumption
  - In many industrial nations, the elderly consume much more than younger adults.
  - Makes population aging more costly
  - Role of public transfer policy: pensions, health care, long term care
- Change the demographic trends: immig, fert

- Levels of age profiles change fast with economic development.
- Shapes of age profiles change slowly,
- Are broadly similar across countries at very different levels of development.

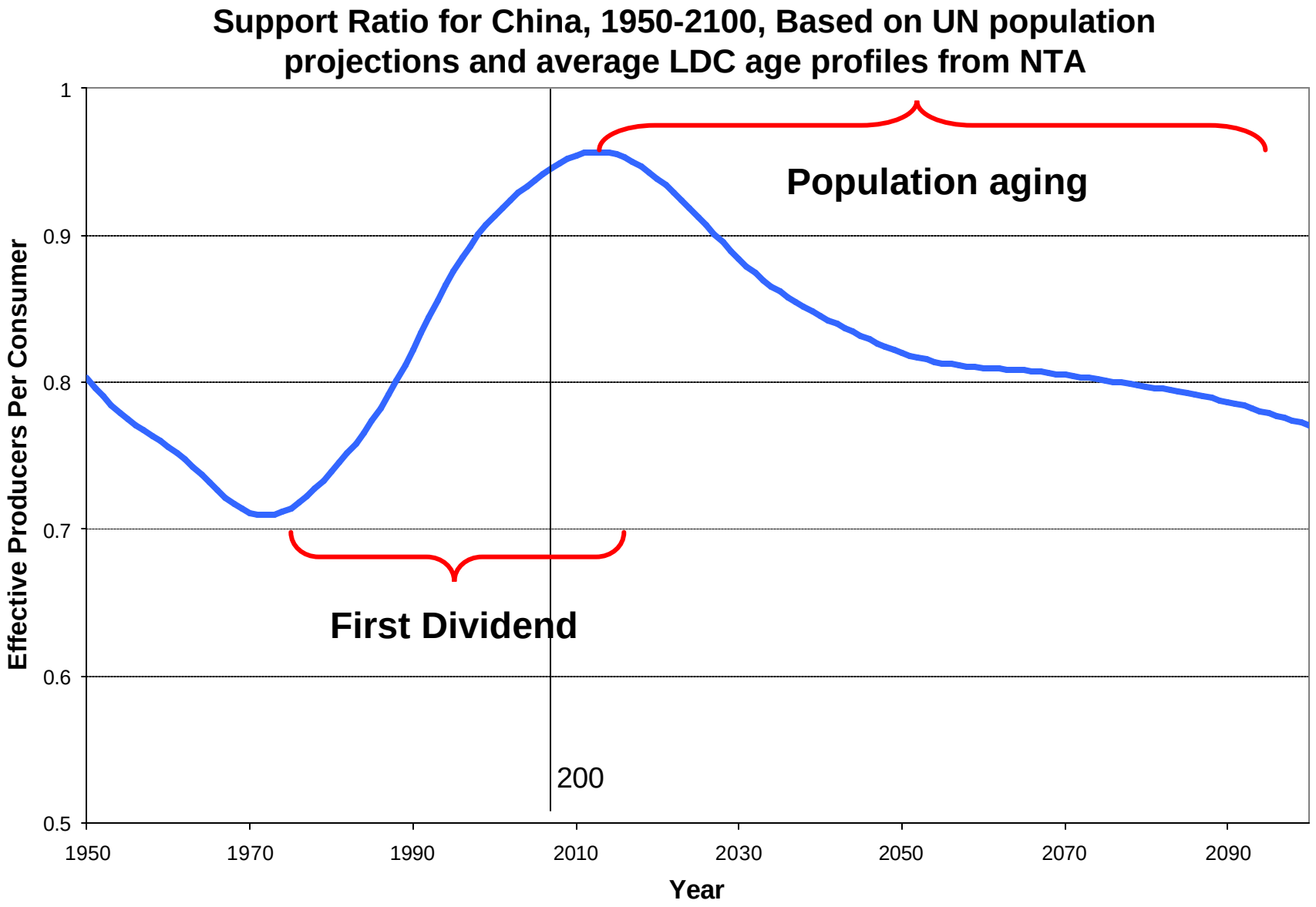
# III. Dependency and Support

- Concern about pop aging is mostly about old age dependency.
- Sharpest concerns for age-sensitive public sector programs
  - pensions
  - health care
  - Long term care
- But should place these in broader context
  - Full range of public programs
  - Private consumption
- Use shape of estimated profile I just showed.

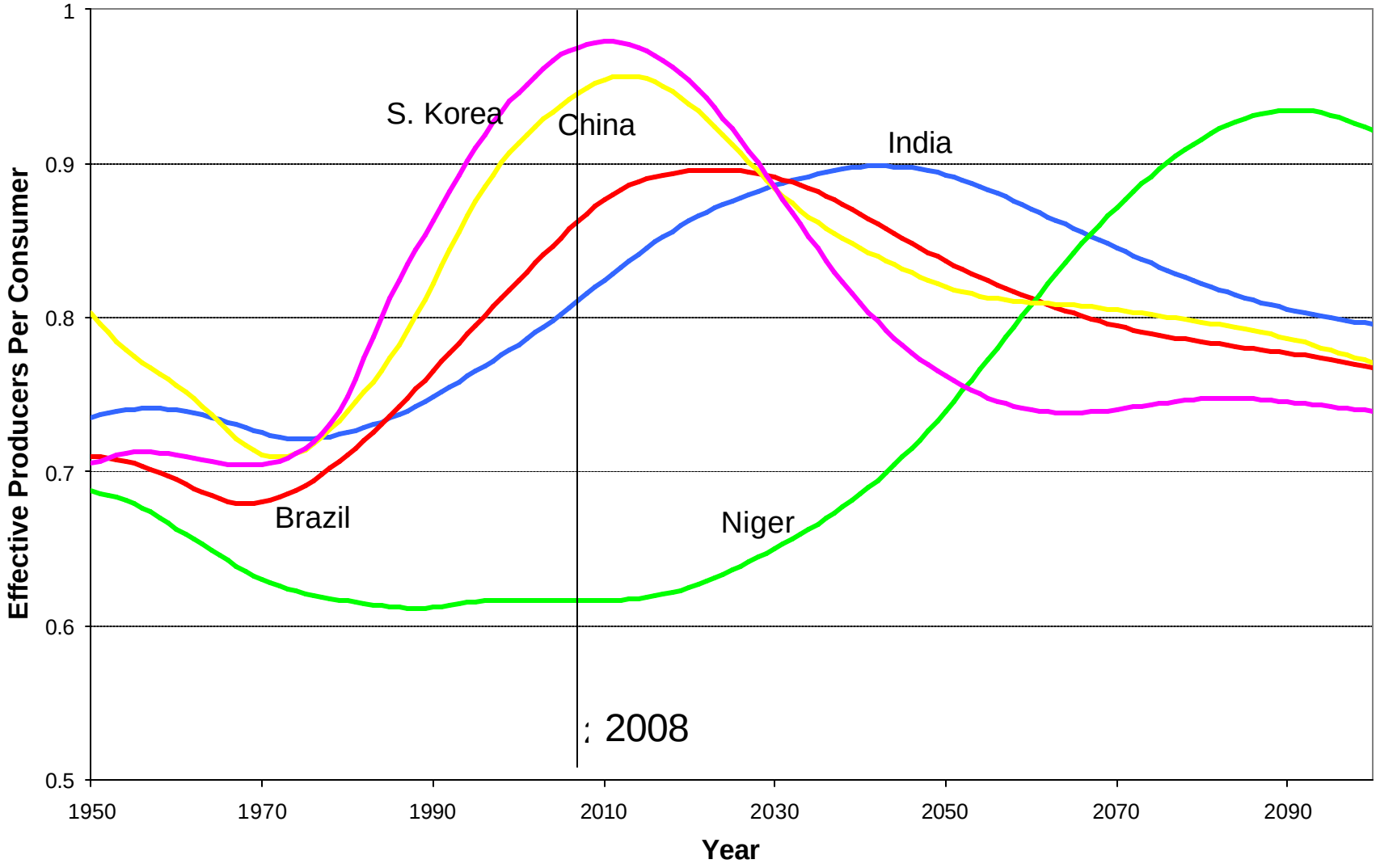
# Support Ratios

- Effective labor is weighted sum of pop using labor income age profile.
- Effective consumers is similar.
- Ratio of effective labor to effective consumers is the “Support Ratio”.
- Other things equal, consumption per effective consumer is proportional to the support ratio.

$$\text{Support Ratio} = \frac{\text{Effective Workers}}{\text{Effective Consumers}} = \frac{\sum_0^w Pop(x)\, y_l(x)}{\sum_0^w Pop(x)\, c(x)}$$


Support Ratio for China, 1950-2100, Based on UN population projections and average LDC age profiles from NTA
Effective Producers Per Consumer
1
0.9
0.8
0.7
0.6
0.5
Population aging
First Dividend
200
1950
1970
1990
2010
2030
2050
2070
2090
Year

**Support Ratios for Five Less Developed Countries, 1950-2100, Based on UN population projections and average LDC age profiles from NTA**



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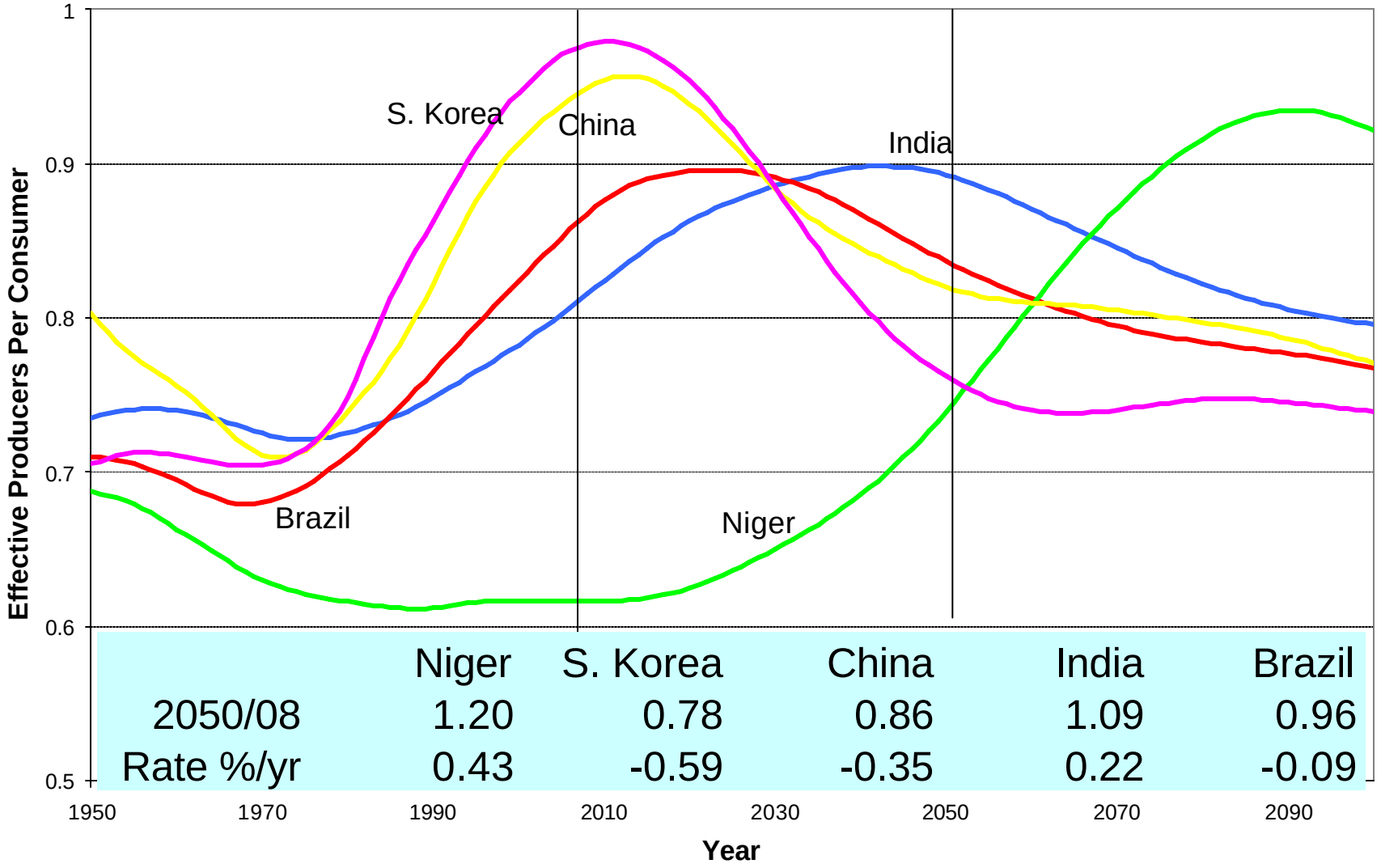
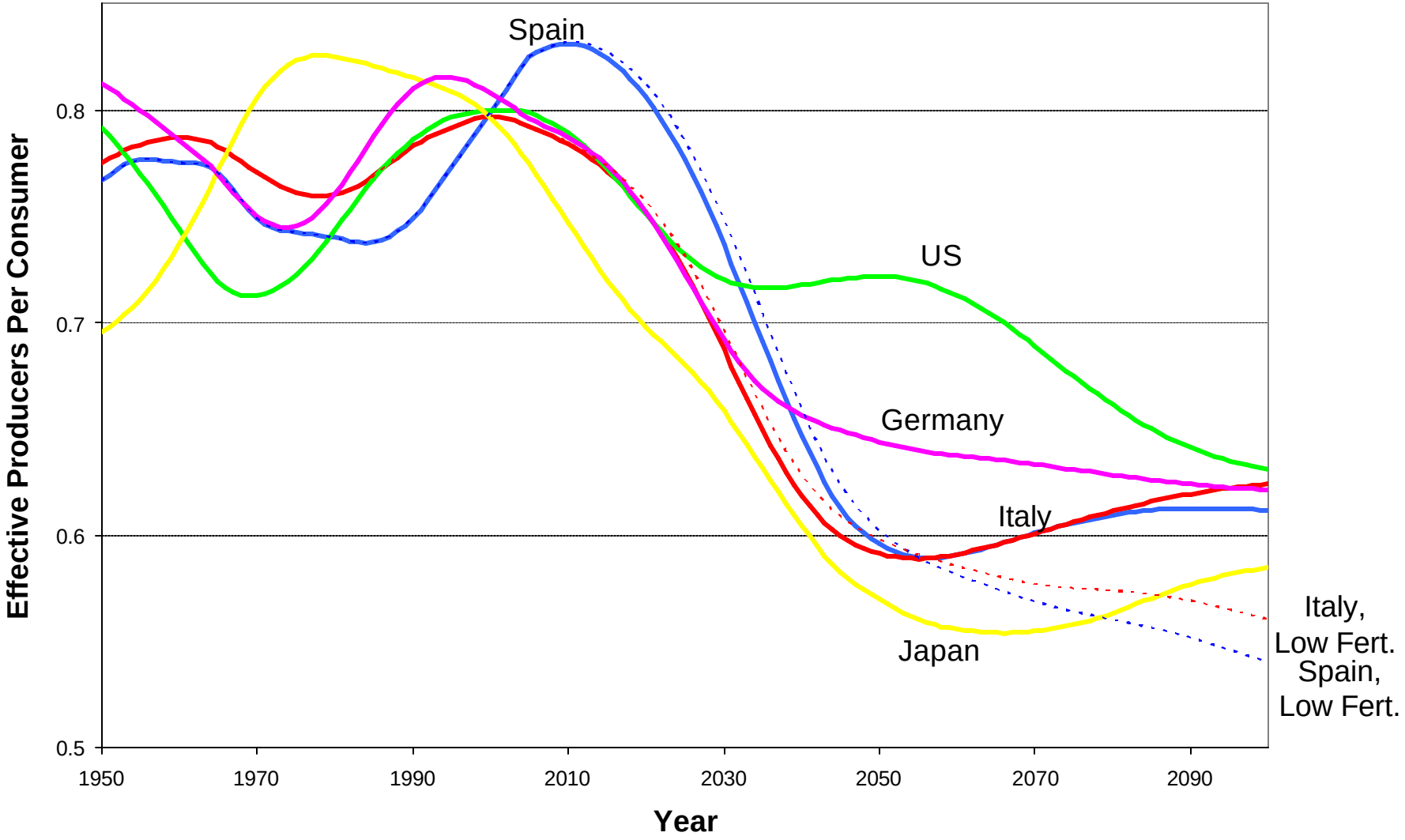



| | Niger | S. Korea | China | India | Brazil |
|---|---|---|---|---|---|
| 2050/08 | 1.20 | 0.78 | 0.86 | 1.09 | 0.96 |
| Rate %/yr | 0.43 | -0.59 | -0.35 | 0.22 | -0.09 |

**Support Ratios for Five More Developed Countries, 1950-2100, based on UN long term population projections and the NTA age profile for the US.**



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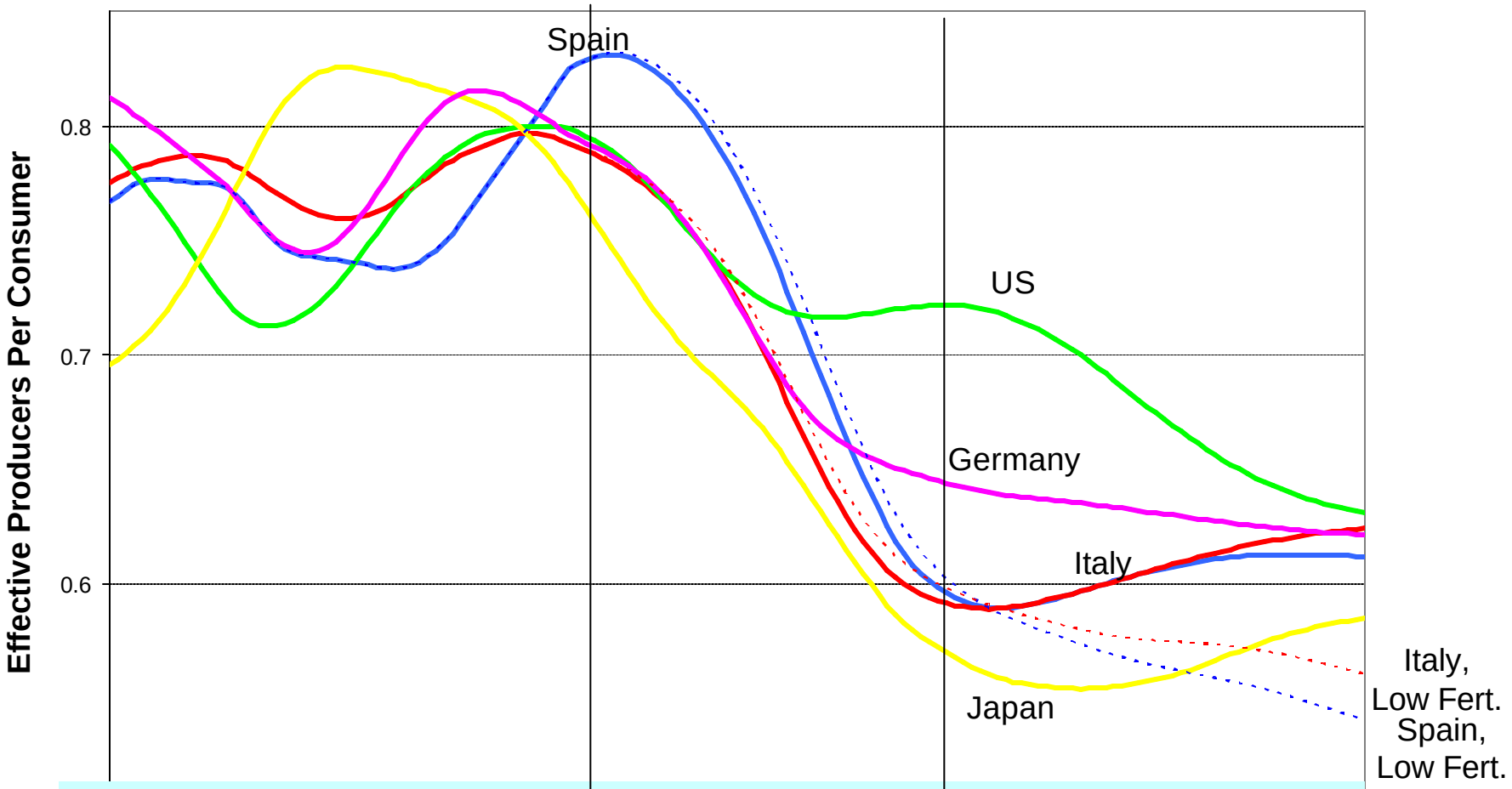
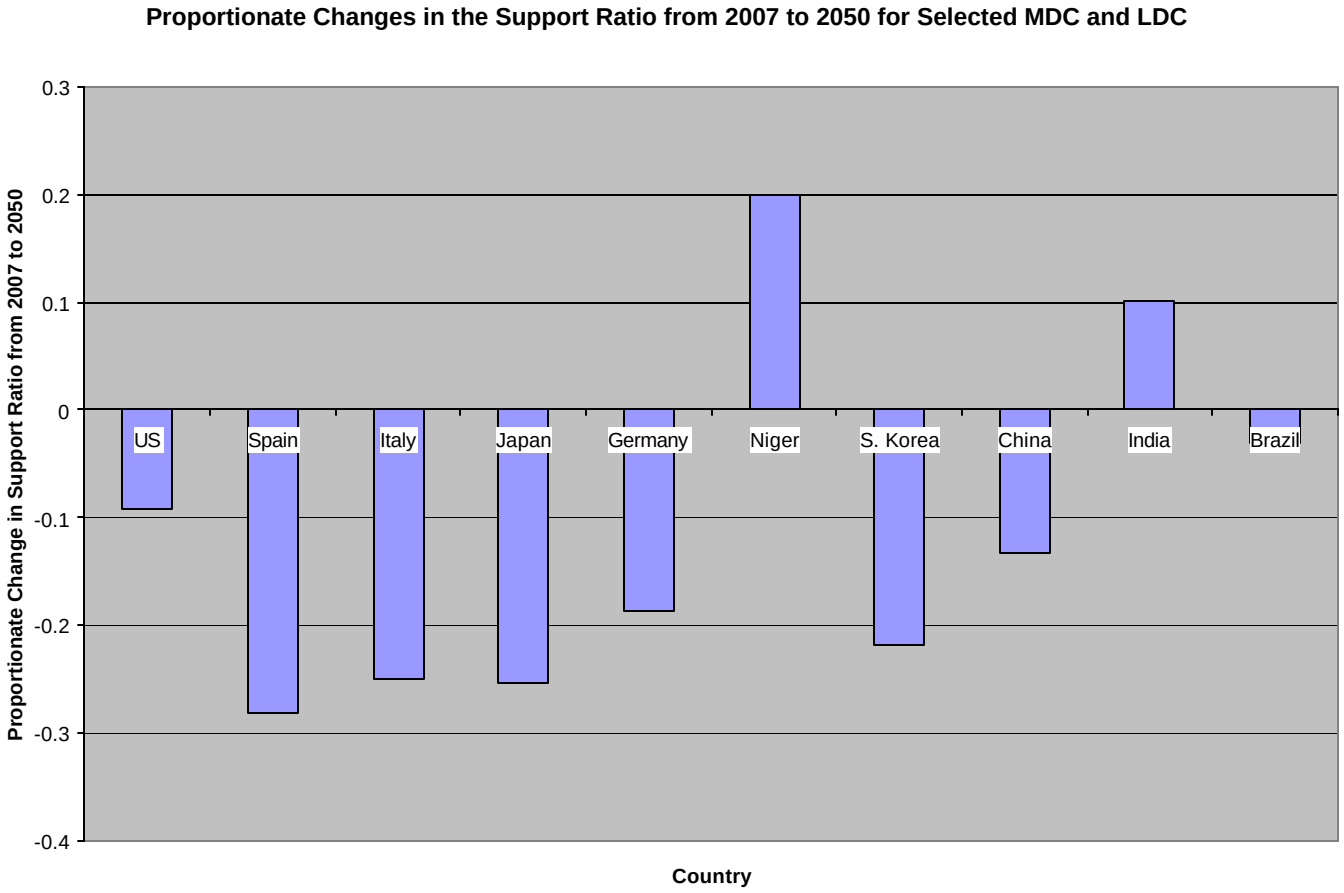



| | US | Spain | Italy | Japan | Germany |
|---|---|---|---|---|---|
| 2050/08 | 0.91 | 0.72 | 0.75 | 0.75 | 0.81 |
| Rate %/yr | -0.2 | -0.8 | -0.7 | -0.7 | -0.5 |

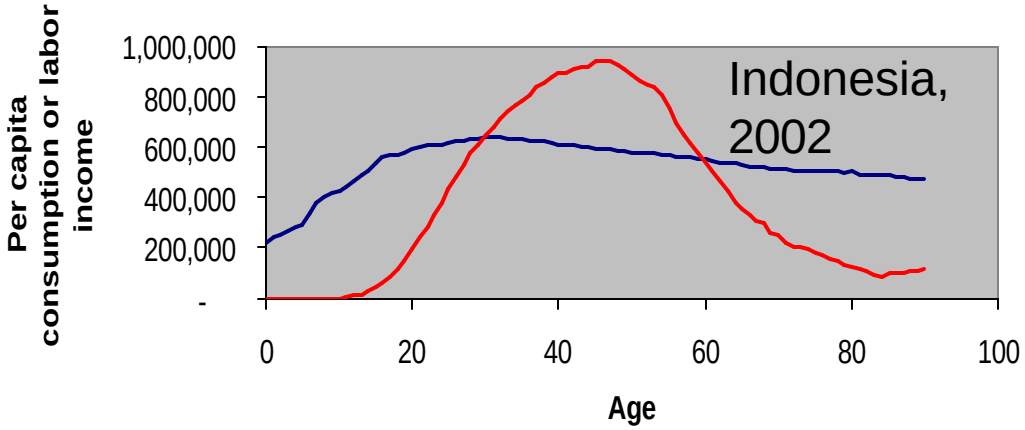
# Proportionate Changes in the Support Ratio from 2007 to 2050 for Selected MDC and LDC

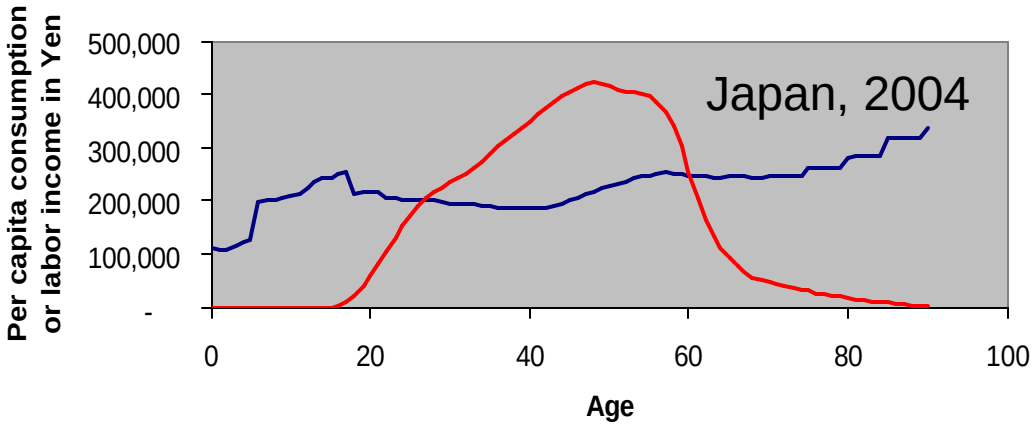


# IV. Further on Interage Flows of Income

- Comparison of Japan and Indonesia

# ***Per capita*** consumption and labor income by age for Indonesia and Japan

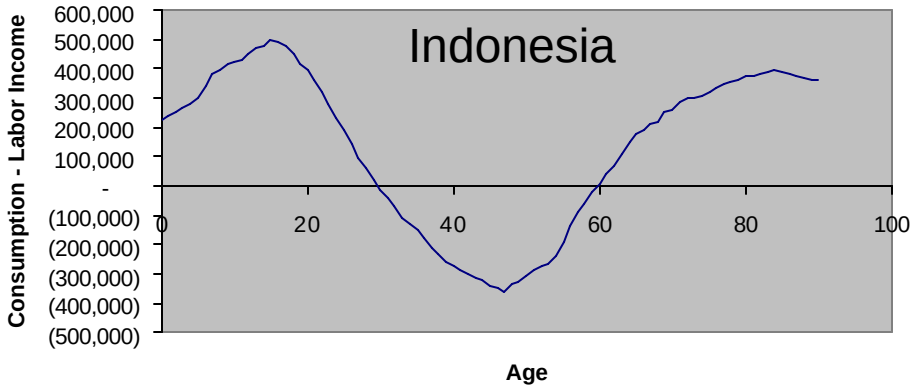


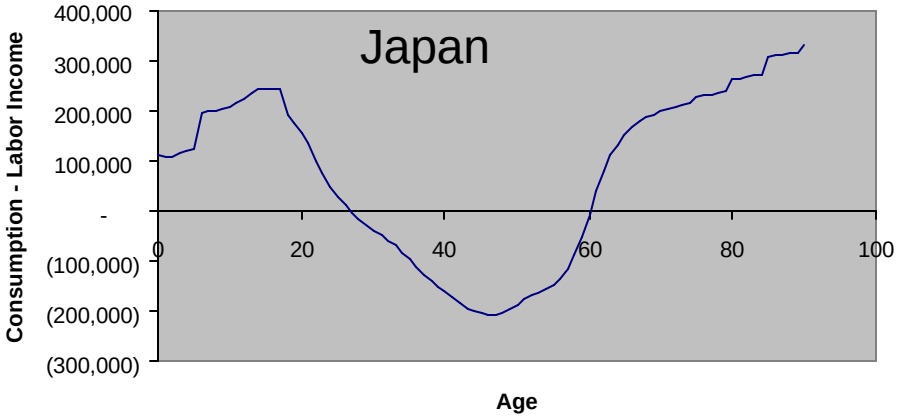




- Differences in consumption
  - Education in Japan
  - Rising consumption in old age in Japan

Data from Maliki (Indonesia) and H. Ogawa (Japan)

# Per Capita Life Cycle Deficit: $c(x)-y_l(x)$

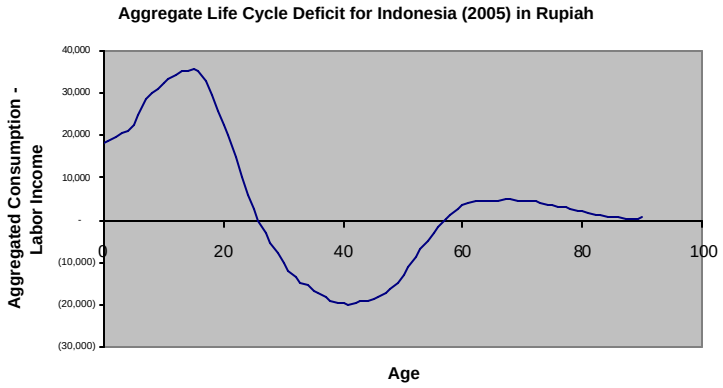


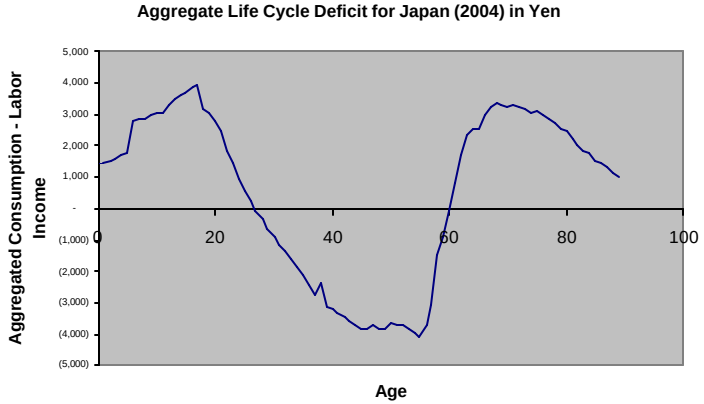




- Because these are per capita, they don't convey the macro patterns of flows.
- To appreciate the full implications, we must take the population age distributions into account.

Data from Maliki (Indonesia) and
H. Ogawa (Japan)

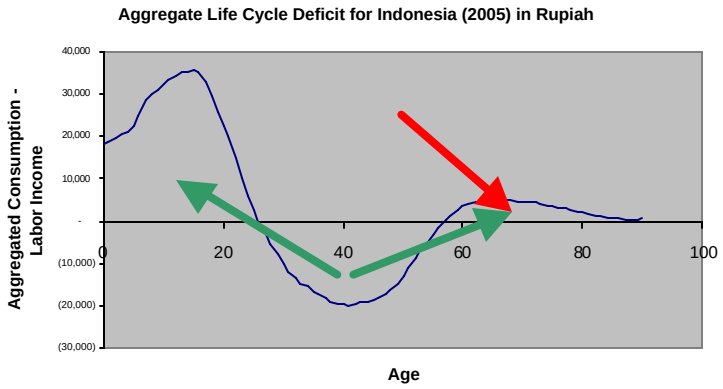
# Here are the aggregate flows: population by age times per capita age profiles

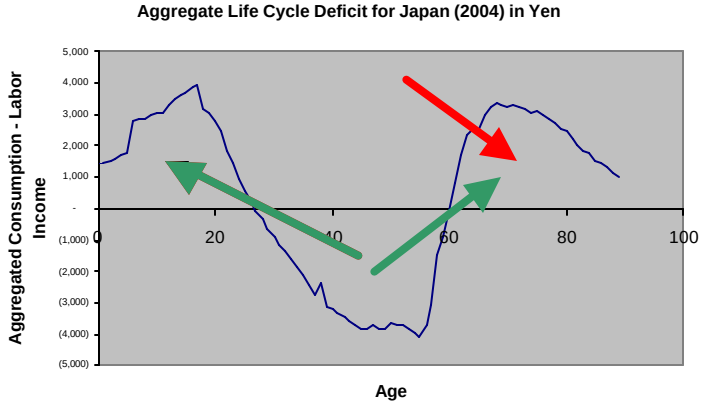



Data from Maliki (Indonesia) and
H. Ogawa (Japan)

# Aggregate flows

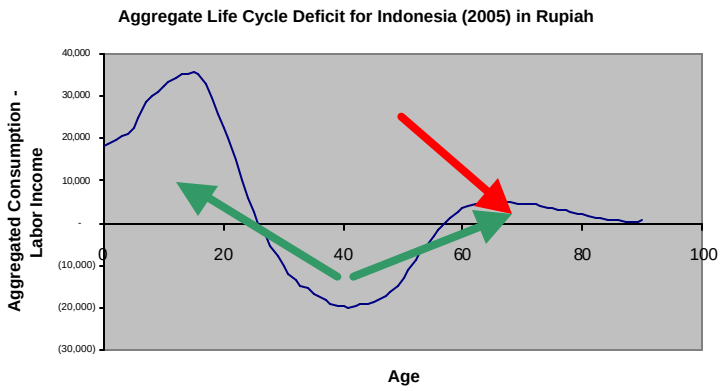


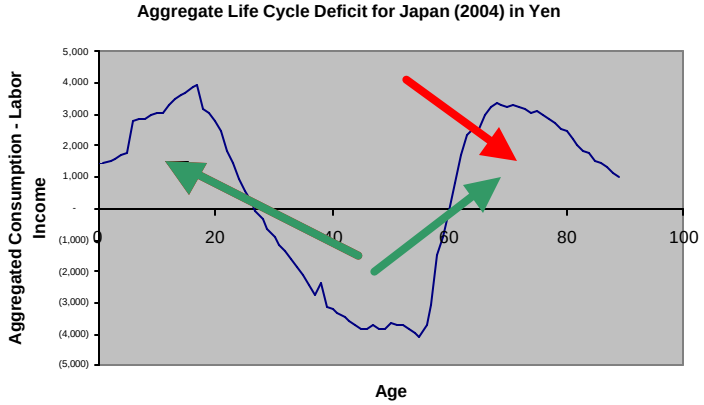




- Green arrows show transfers from surplus of prime working years.
- Red arrows show asset income consumed by elderly out of earlier savings.

Data from Maliki (Indonesia) and
H. Ogawa (Japan)

# Aggregate flows



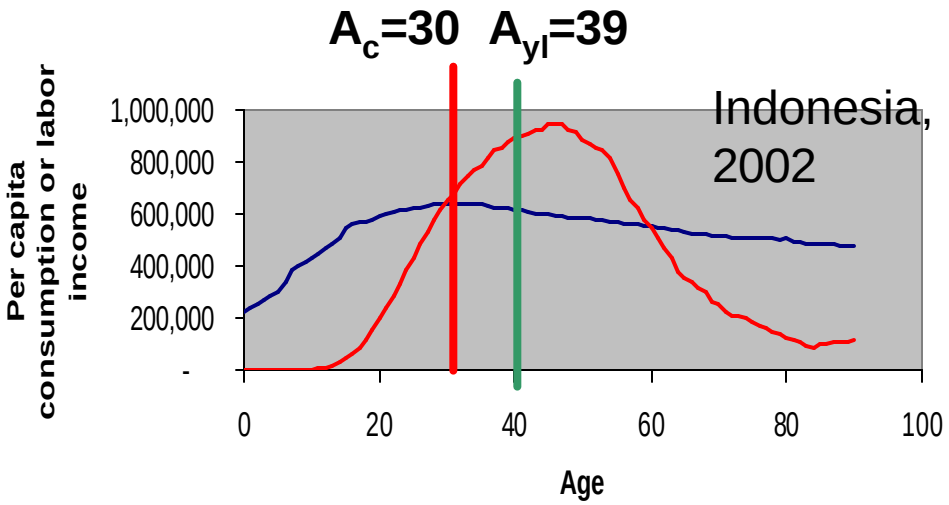



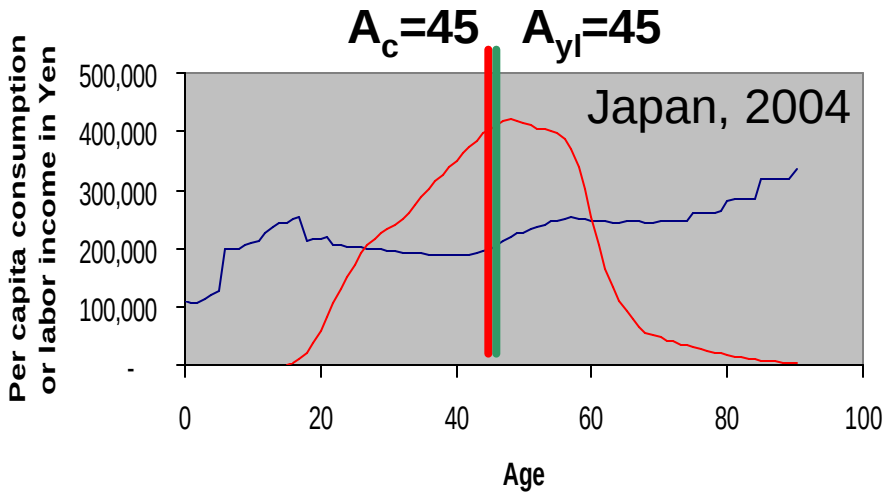

- Suppose the same proportion of old age consumption is funded by assets.
- Then assets per capita will be much higher in Japan
- If held in domestic investment, then capital labor ratio will be higher too.

Data from Maliki (Indonesia) and
H. Ogawa (Japan)

Population weighted average age

$$A_c = \frac{\sum_0^{100} xPop(x)c(x)}{\sum_0^{100} Pop(x)c(x)}$$

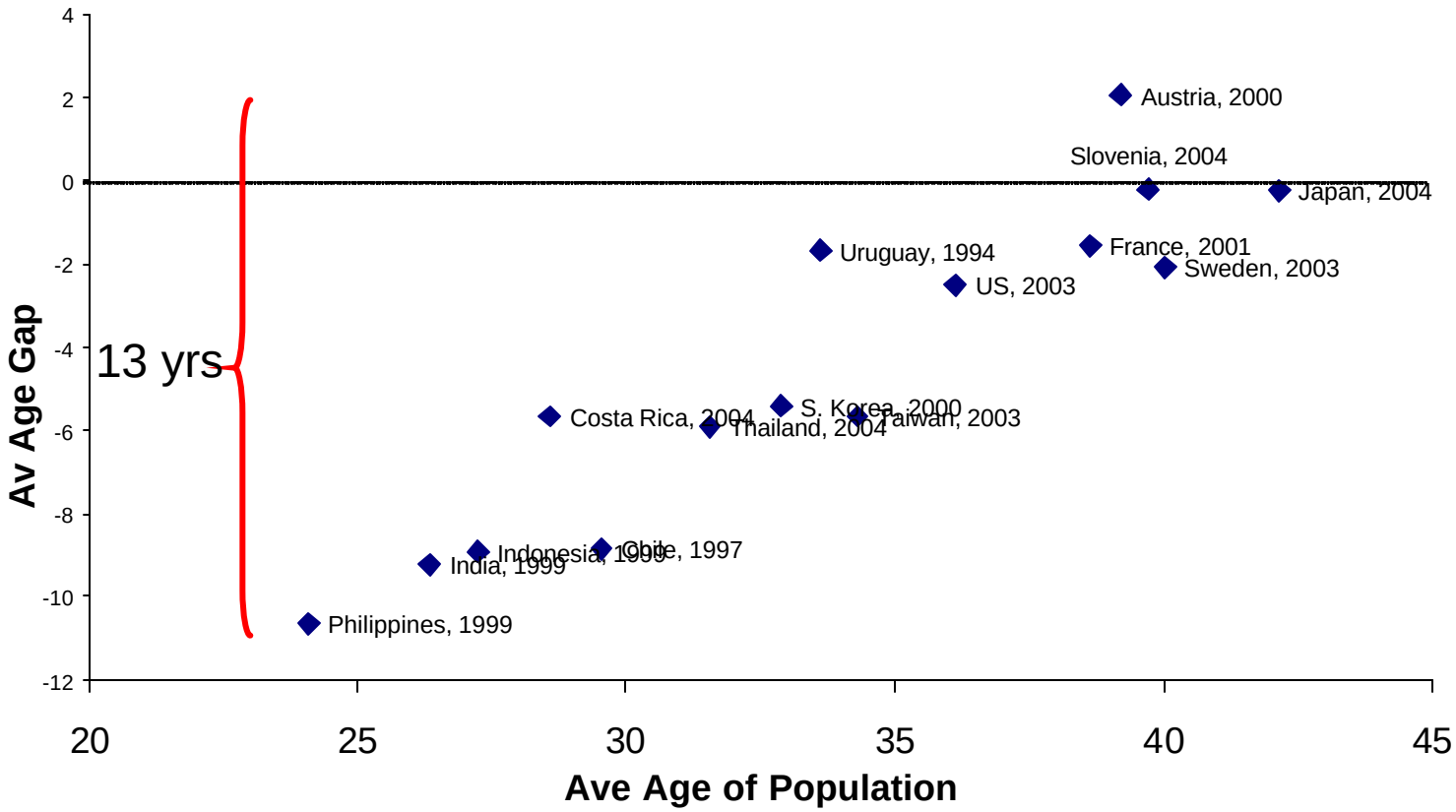



- In Indonesia, average unit of income is earned at 39 and consumed at 30
- Travels 9 years down the age scale.
- In Japan, it is earned and consumed at nearly the same age.

Data from Maliki (Indonesia) and H. Ogawa (Japan)

# Average Consumption-Earning Gap by Average Age of Population

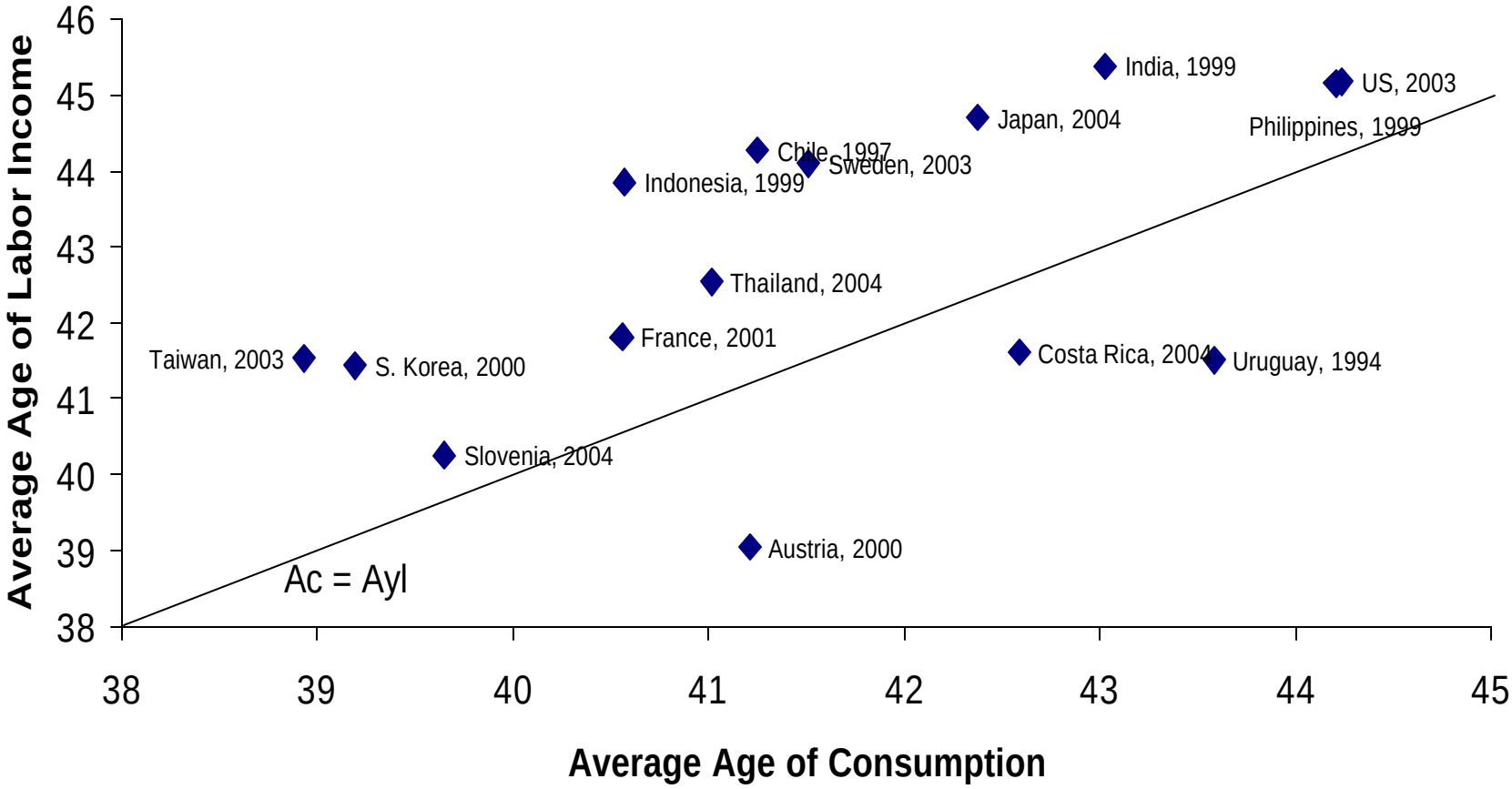



Data from NTA Country Teams

# How much of the difference in age gaps is due to the shapes of the age profiles?

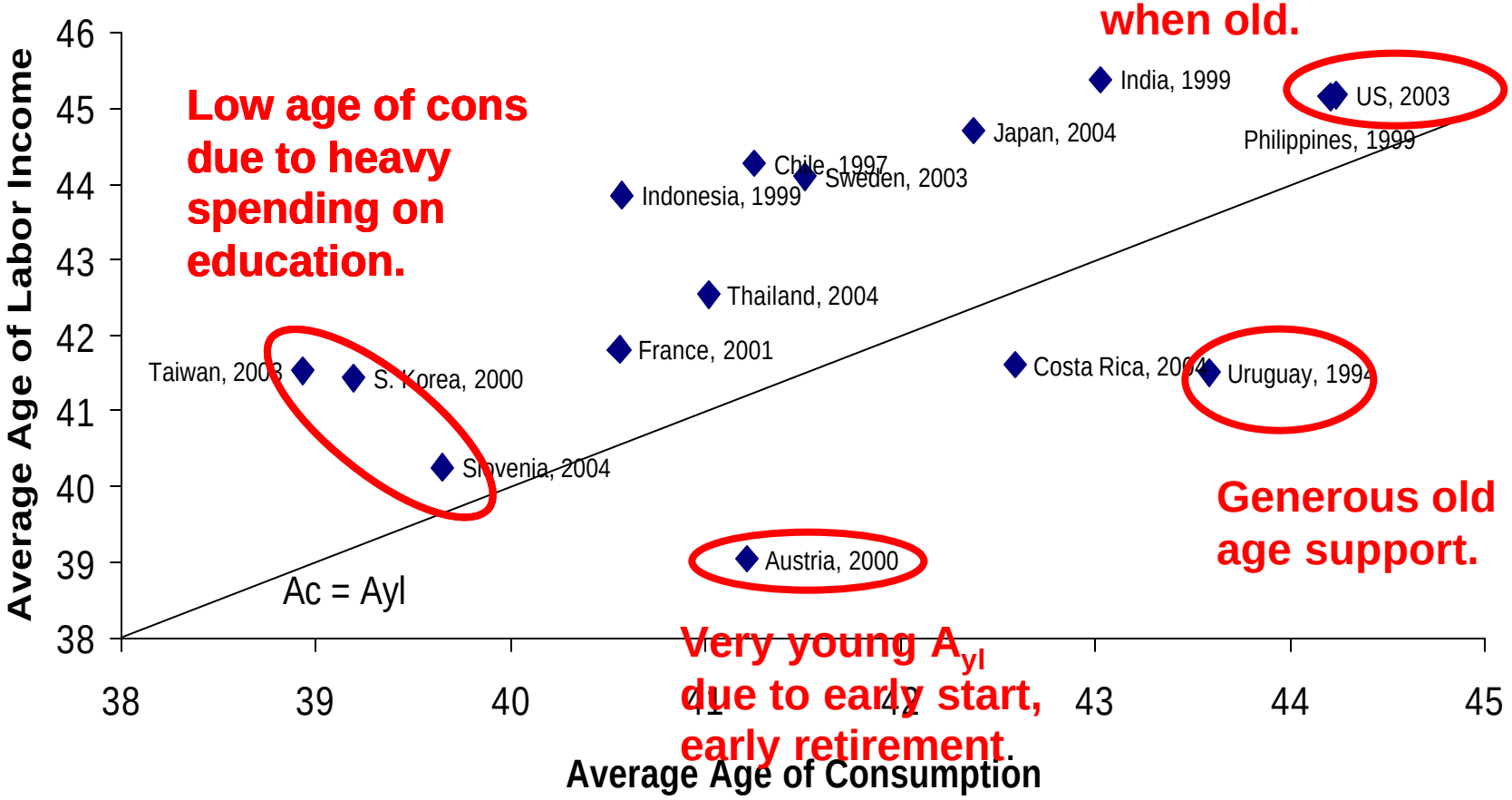
Data from NTA Country Teams

# Average Age of Labor Income and Consumption with Population Held Constant (stationary, e0=75)




Data from NTA Country Teams

# Average Age of Labor Income and Consumption with Population Age Distr. Constant (stationary, e0=75)




Data from NTA Country Teams

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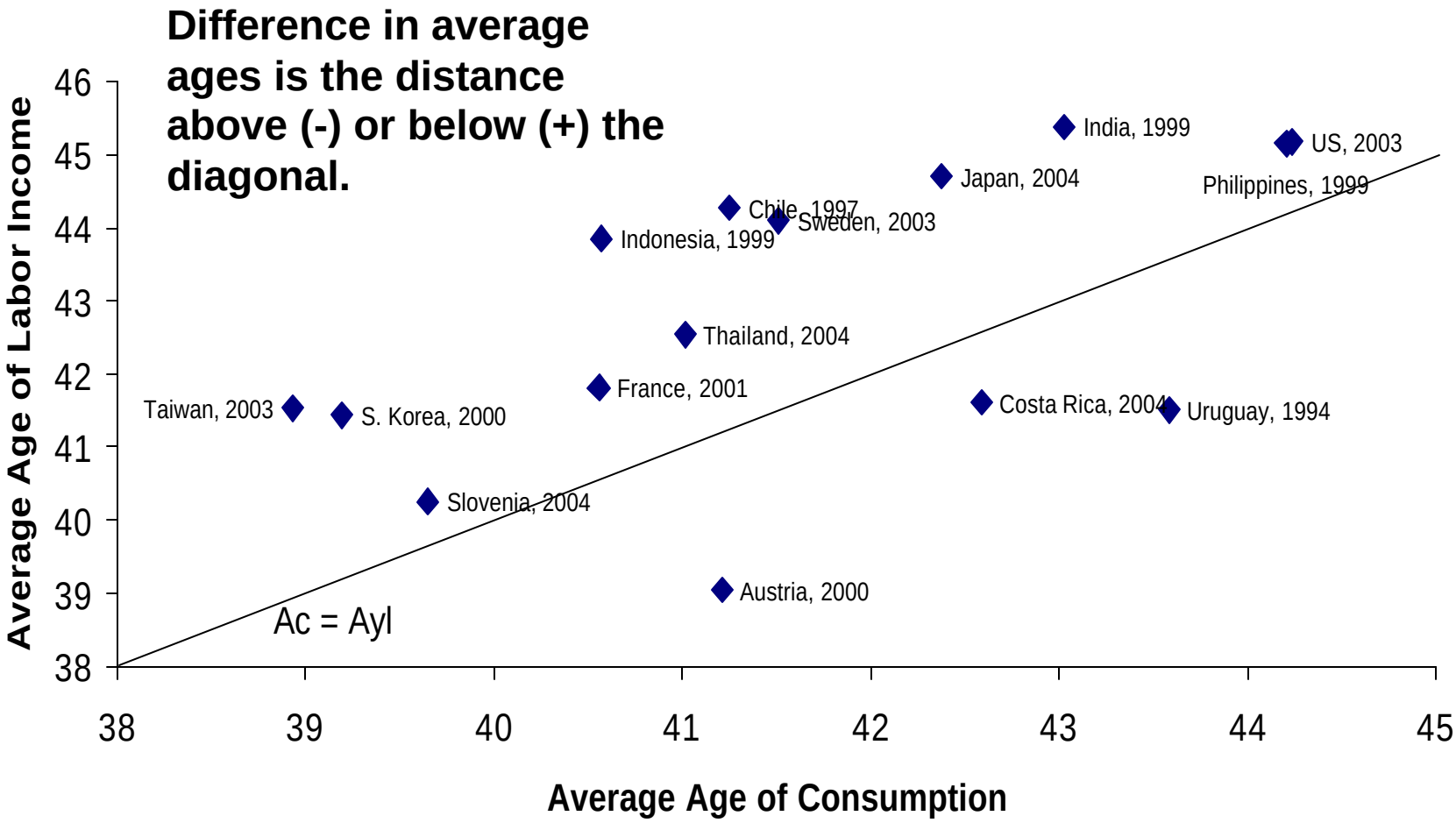


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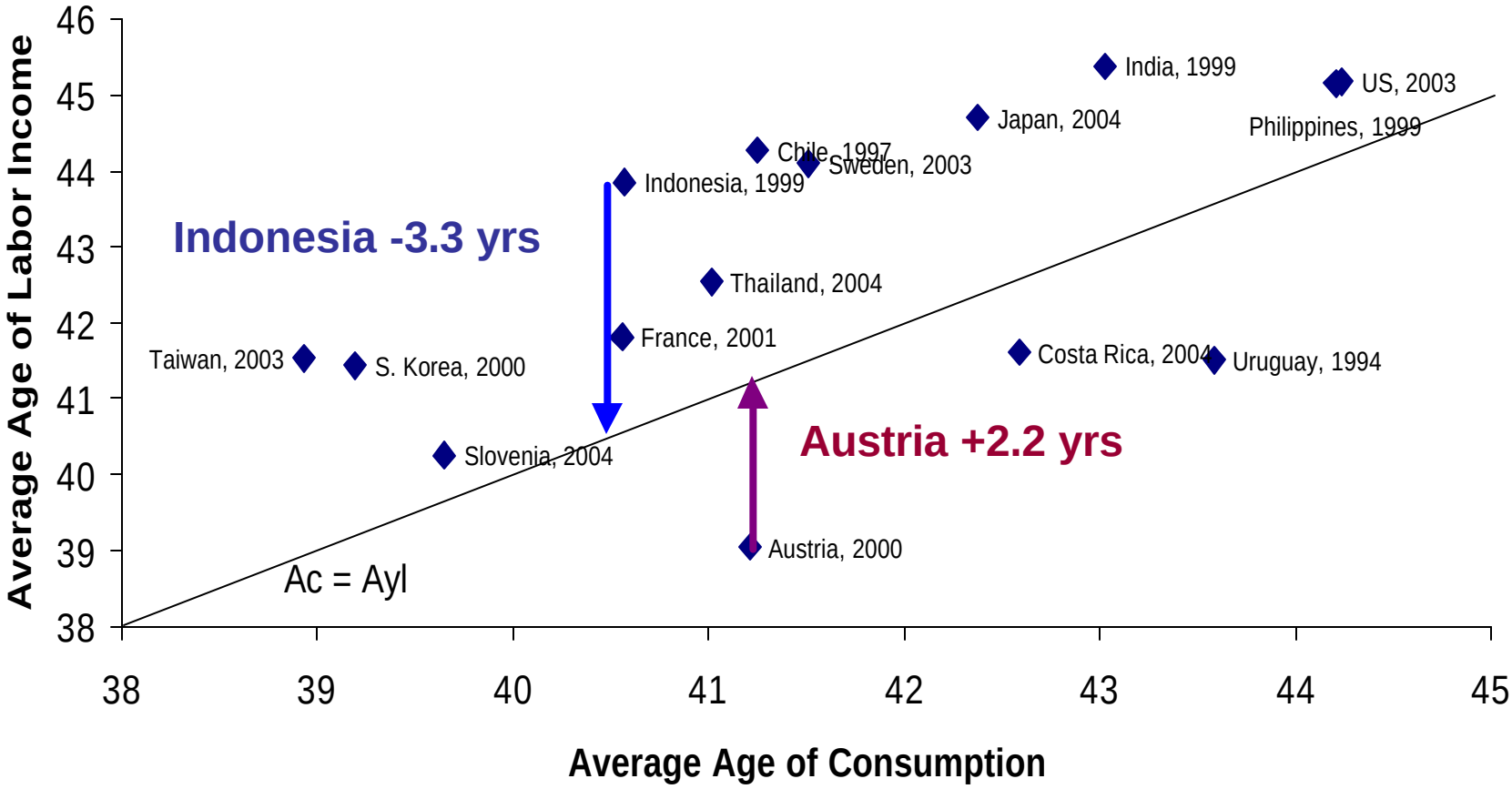



Data from NTA Country Teams

- total range in age gap was 13 years
- range due to differences in profiles is 5.5 years.
- So both population age distribution and shapes of age profiles help determine gap.

# V. Wealth and the age gap: the golden rule case

- Demographic and economic steady state
- Saving and capital such as to maximize per capita consumption.
- r=n+g

# Now suppose babies had to go into debt to feed themselves….

- At the start of life, $c(x)>y_l(x)$; dependency.
- Suppose we keep a notional account of debt and credit over the life cycle, discounted to age 0.
- Credit gained (or lost) at age x is:

  $e^{-rx}\, l(x)\, [y_l(x)-c(x)]$

  where r is interest rate, l(x) is survival from 0 to age x.
- Cumulated up to age x, we get W(x):

$$W(x)=\int_0^x e^{-rx} l(x)\left[y_l(x)-c(x)\right]dx$$

- Now find the average level of per capita in the whole population, call it W
- W = pop(x)*W(x)/totpop

$$W = \frac{\int_0^w e^{-rx} l(x) W(x)\, dx}{\int_0^w e^{-rx} l(x) dx}$$

The average wealth per capita in the population may be pos or neg

# The Willis result

$W = c(A_c - A_y)$ , where c = per capita cons

- If $A_c > A_y$ then indivs need to hold onto some output for later consumption, so wealth, W, is on average positive in the population.
- If $A_c < A_y$ then indivs consume before they produce, and must go into debt on average, so W is negative.

- Alternatively: $W/c = A_c - A_{yl}$
- So wealth relative to consumption is roughly proportional to $A_c - A_{yl}$

# The demand for wealth rises over the demographic transition.

- Why?
  - Older people hold more wealth; in old population, there are more of them.
- Also:
  - Longer life means workers need to accumulate more wealth for longer old age.
  - Lower fertility means adults consume more and need to save more to maintain in old age.

# VI. The role of intergenerational transfers

- We just considered the wealth needed to achieve consumption targets.
- Wealth can be held in two forms:
  - Transfer wealth (expected future transfers received minus expected future transfers made)
  - Assets or Capital

# NTA data on shares of old age support from different sources

- Asset income (land, equities, interest, etc.)
- Family transfers (not including bequests at death)
- Public transfers (Pay As You Go pensions, health care, and long term care)
- Triangle graph shows shares, not levels, so must add to 100%.
- Bequests not included; just old age cons.

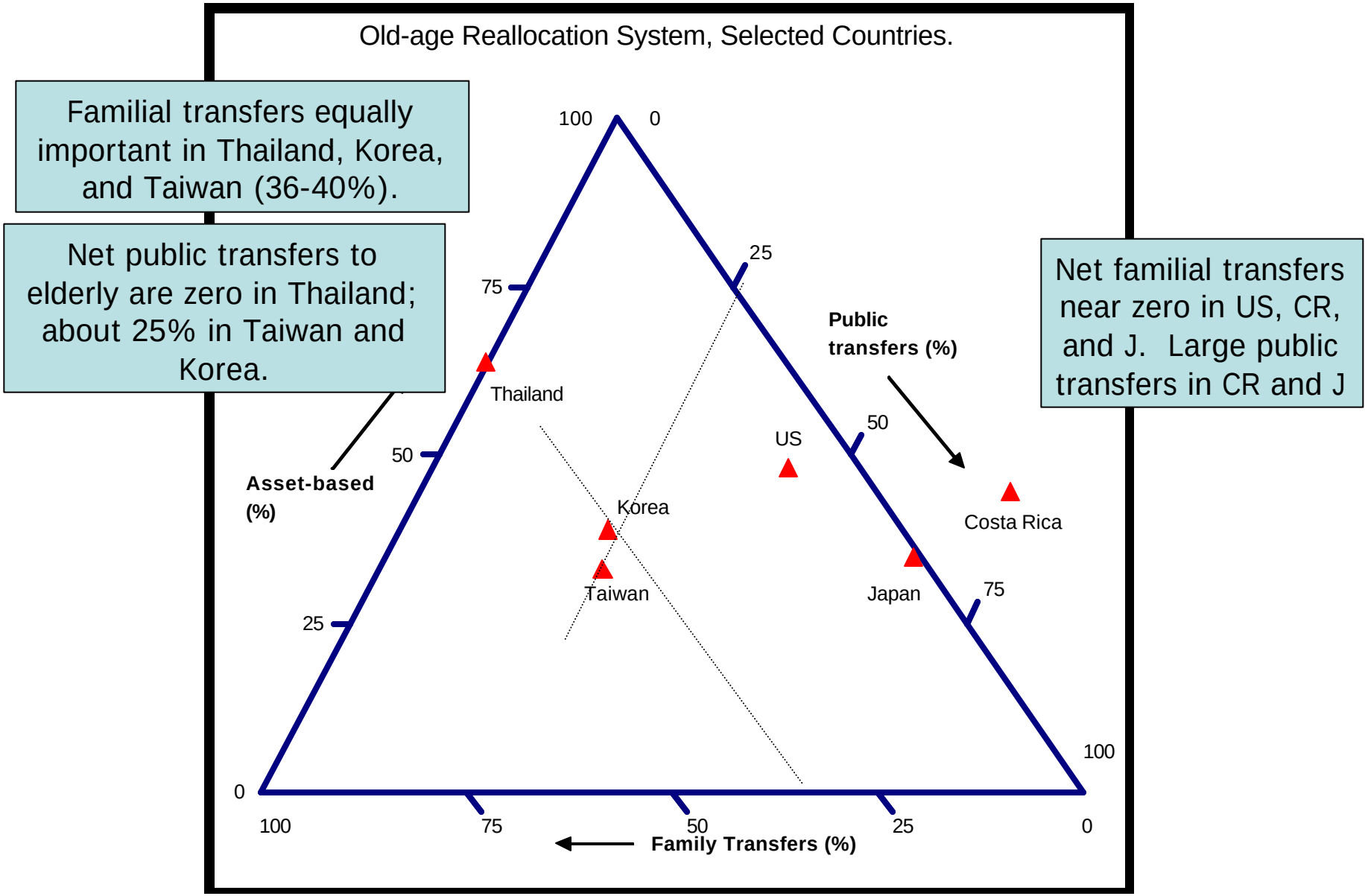



Diagram from Andy Mason

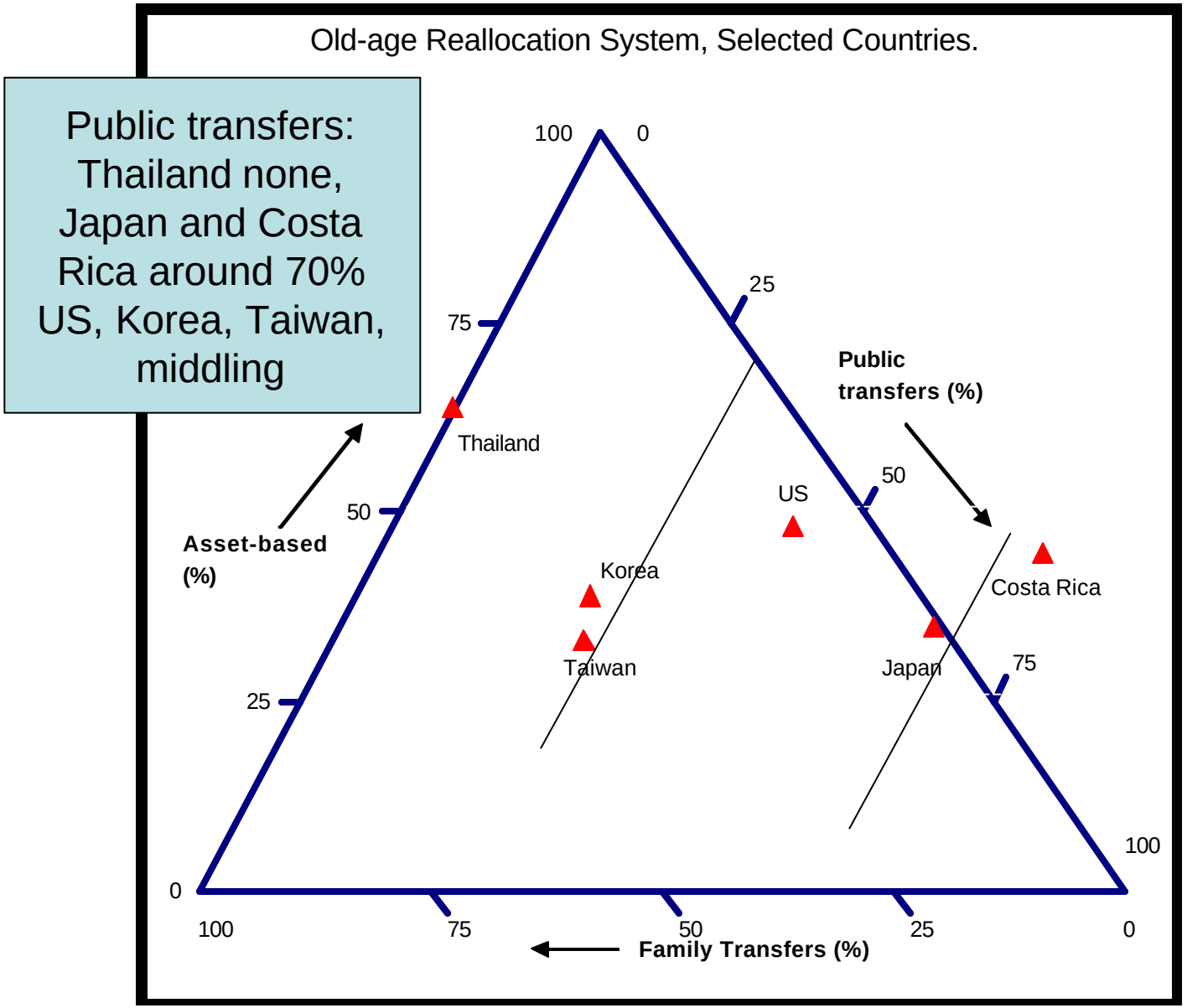



Diagram from Andy Mason

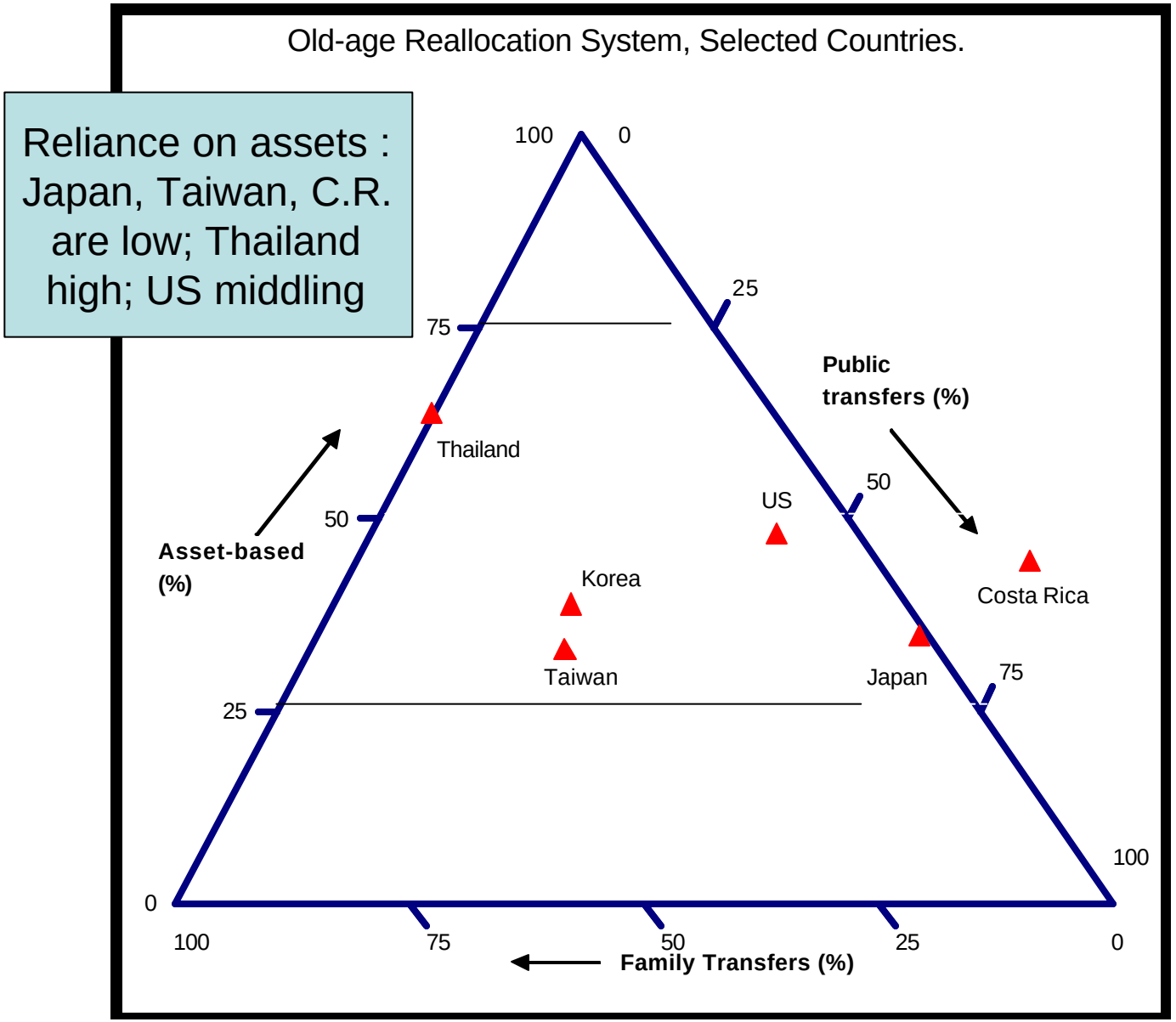



Diagram from Andy Mason

# VII. Demographic Transition and Capital Accumulation

- Changing dependency gets most attention for ec dev and pop aging.
- Changes in capital accumulation may be more important.

# Calculating the demand for wealth and capital over the demographic transition

- Based on different theoretical models, approaches.
- Model with Social Planner maximizing discounted social welfare function with full foresight.
- Model with individuals saving and consuming over their life cycles to maximize their life time utility.

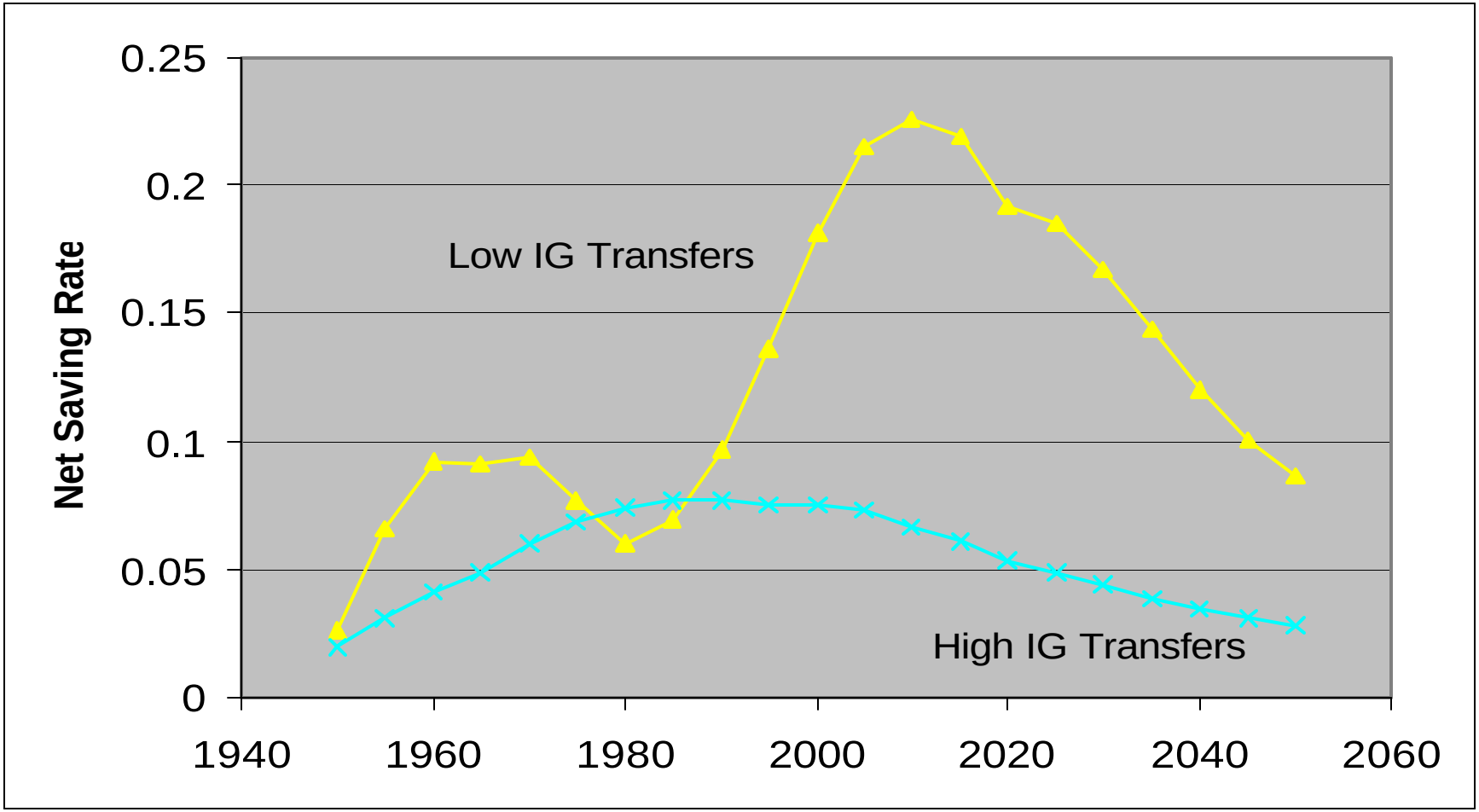
# Here take a different approach – no optimization--emphasizes institutional setting

- Assume
  - share of old age consumption supported by asset income stays constant over time.
  - altruistic sharing maintains the shape of the cross sectional consumption age profile.
  - Demography is known in advance.
- Can solve recursively for unique growth path and asset holdings.

# Two scenarios: high level of transfers to elderly (65%); or low level (35%)

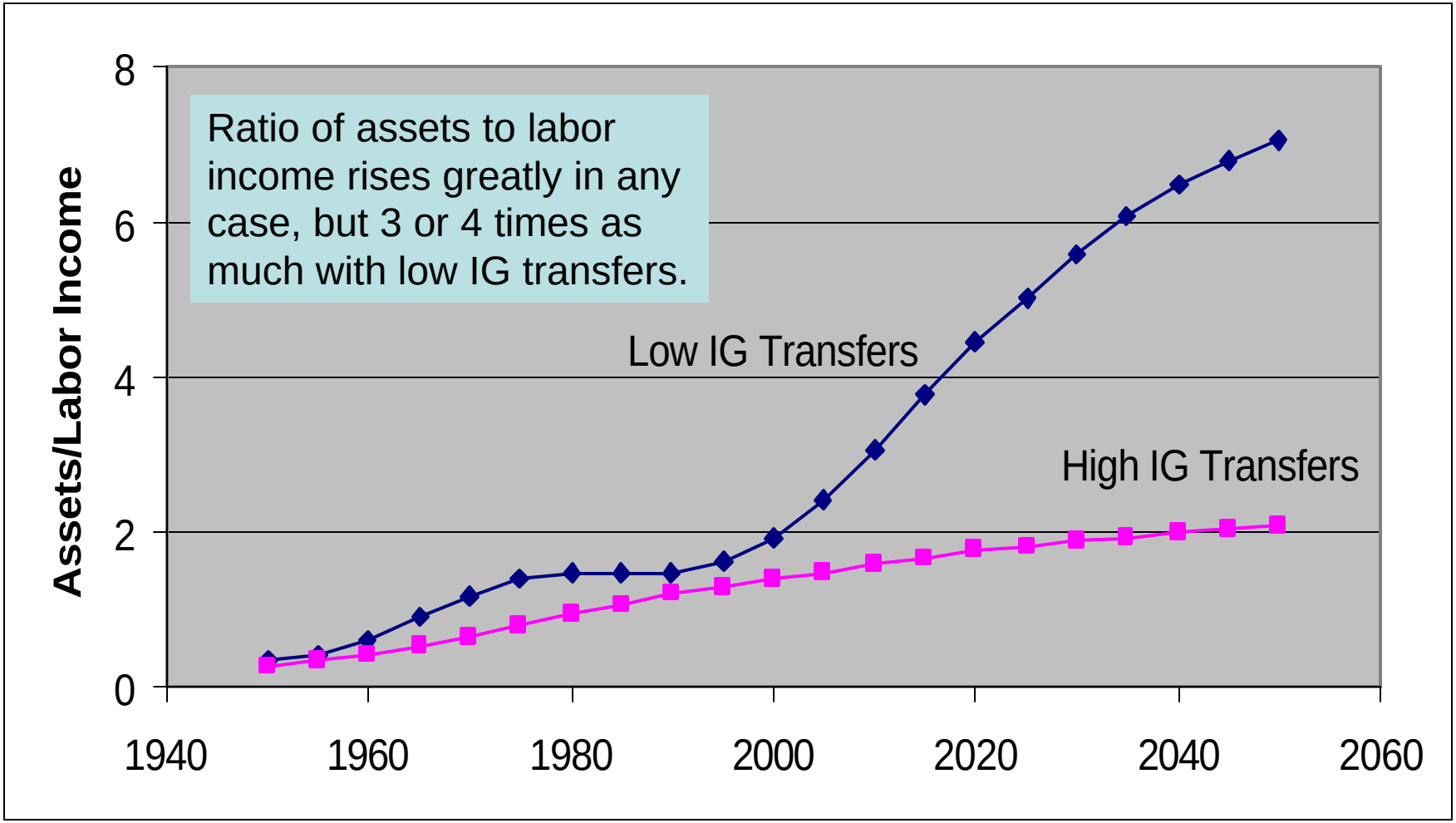
- Other assumptions
  - Productivity growth raises income age profile by 2% per year.
  - Open economy; rate of return on assets is 3%.
- Aggregate saving is calculated to maintain asset share of old age consumption support.
- Results will be shown relative to a 2% growth trajectory from prod gr.

# Simulated Saving Rate, ASEAN (S.E. Asian countries), 1950-2050



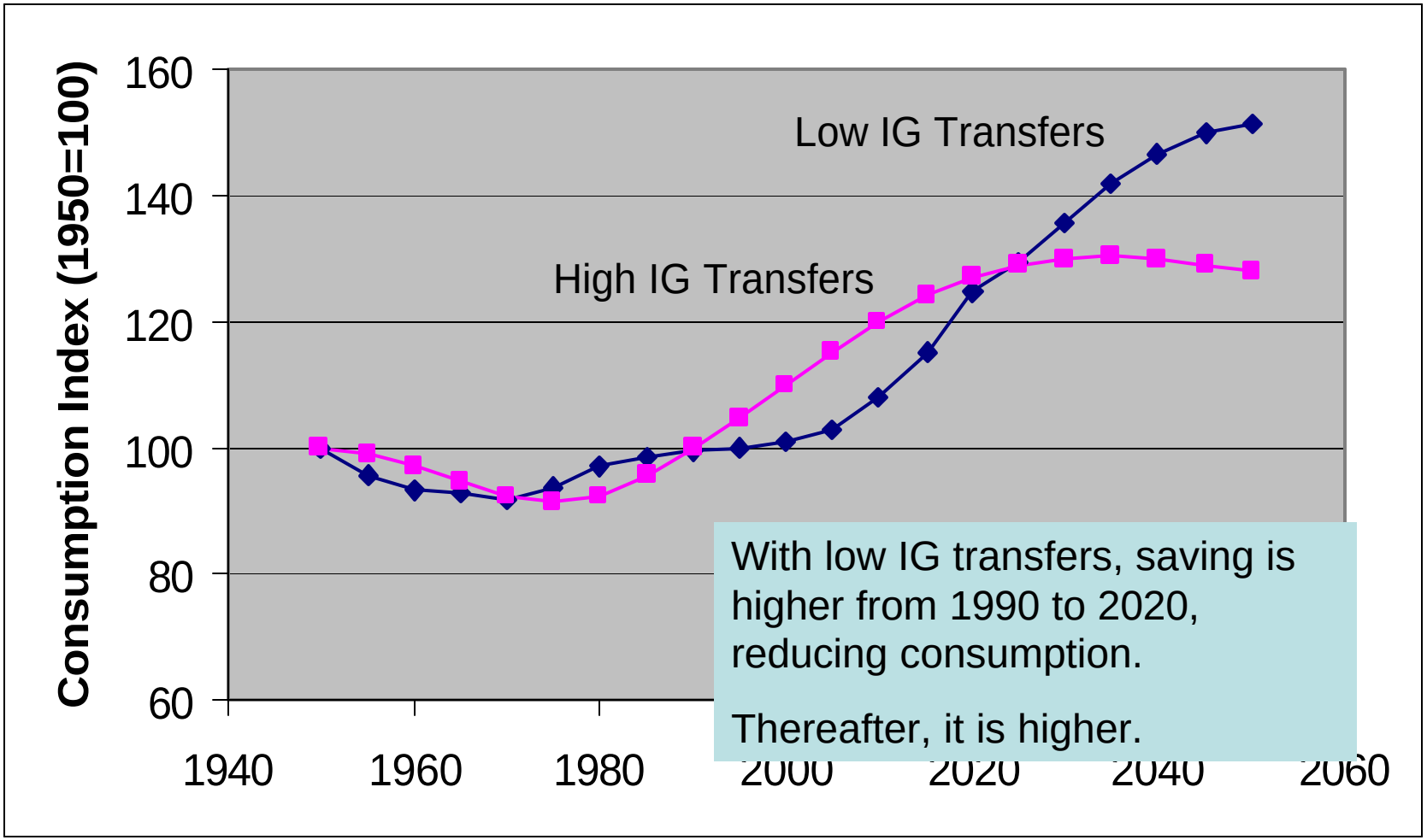

From Mason, Lee and Lee (2008)

# Simulated Assets/Labor Income, ASEAN




From Mason, Lee and Lee (2008)

# Simulated Consumption, ASEAN




From Mason, Lee and Lee (2008)

# These sorts of results are qualitatively like those from optimization approaches

- Timing of swings differs
- Level of savings rates differs
- Capital/labor income ratios differ

**Big picture is the same:**

1. The demographic transition leads to a major increase in capital per worker.
2. The greater the role of transfers to the elderly, the smaller is the increase in capital intensity.
3. Eventually consumption rises with lower transfers, but initially it is lower.
4. **Population aging leads to a decline in savings rates but an increase in capital intensity.**

# VIII. Human capital and the demographic transition

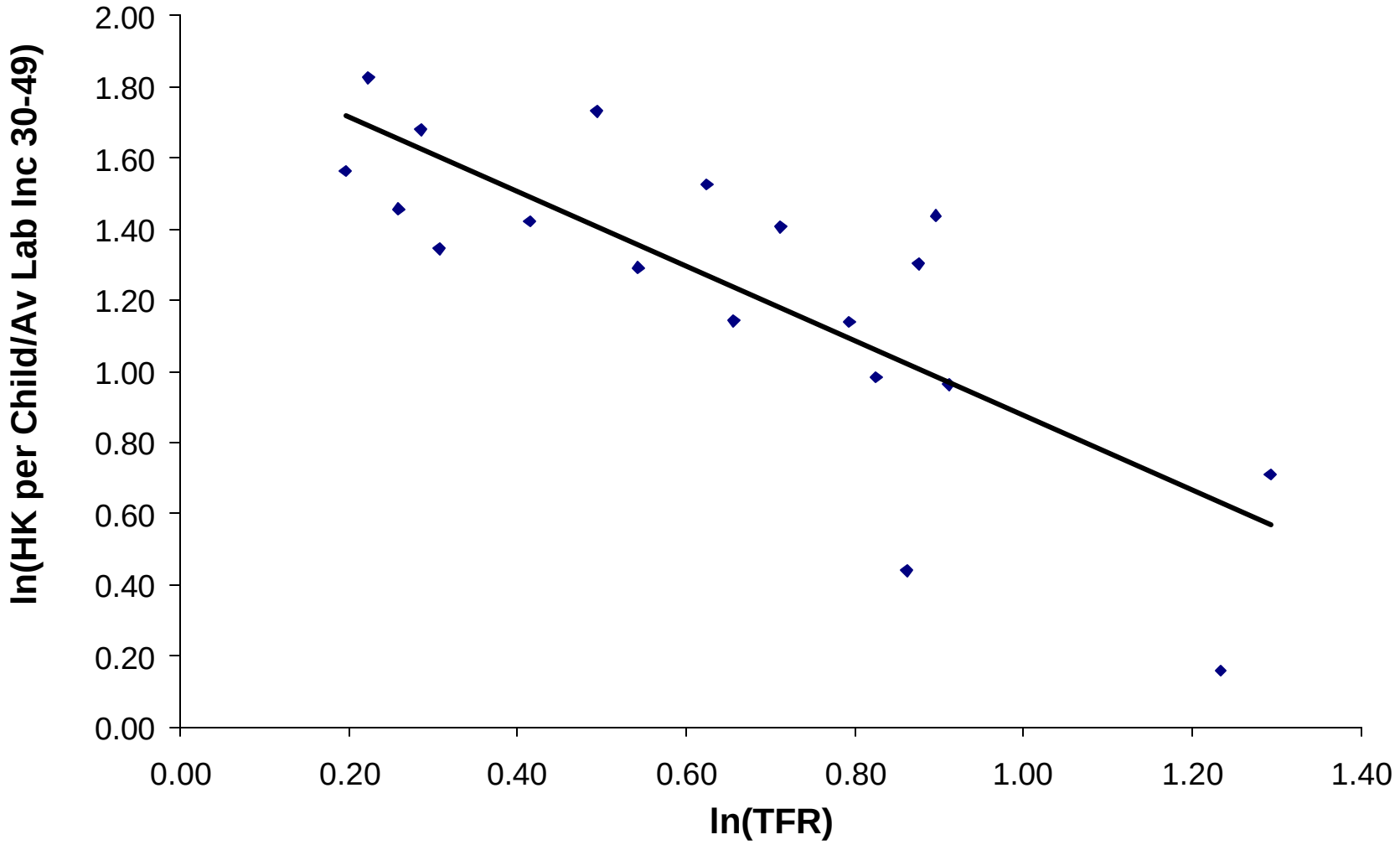
- Measure public and private expenditures on health and education at each age.
  - Sum these for health ages 0-18
  - Sum for education ages 0-26
  - Gives synthetic cohort HK investment per child
- Construct ratio of HK to average $y_l(x)=$ , ages 30-49.
- Plot log of HK/$\hat{y}_l$ against log of TFR.

# A different measure than usual

- Includes both public and private spending
- Synthetic cohort measure
- Does not include opportunity cost of students' time

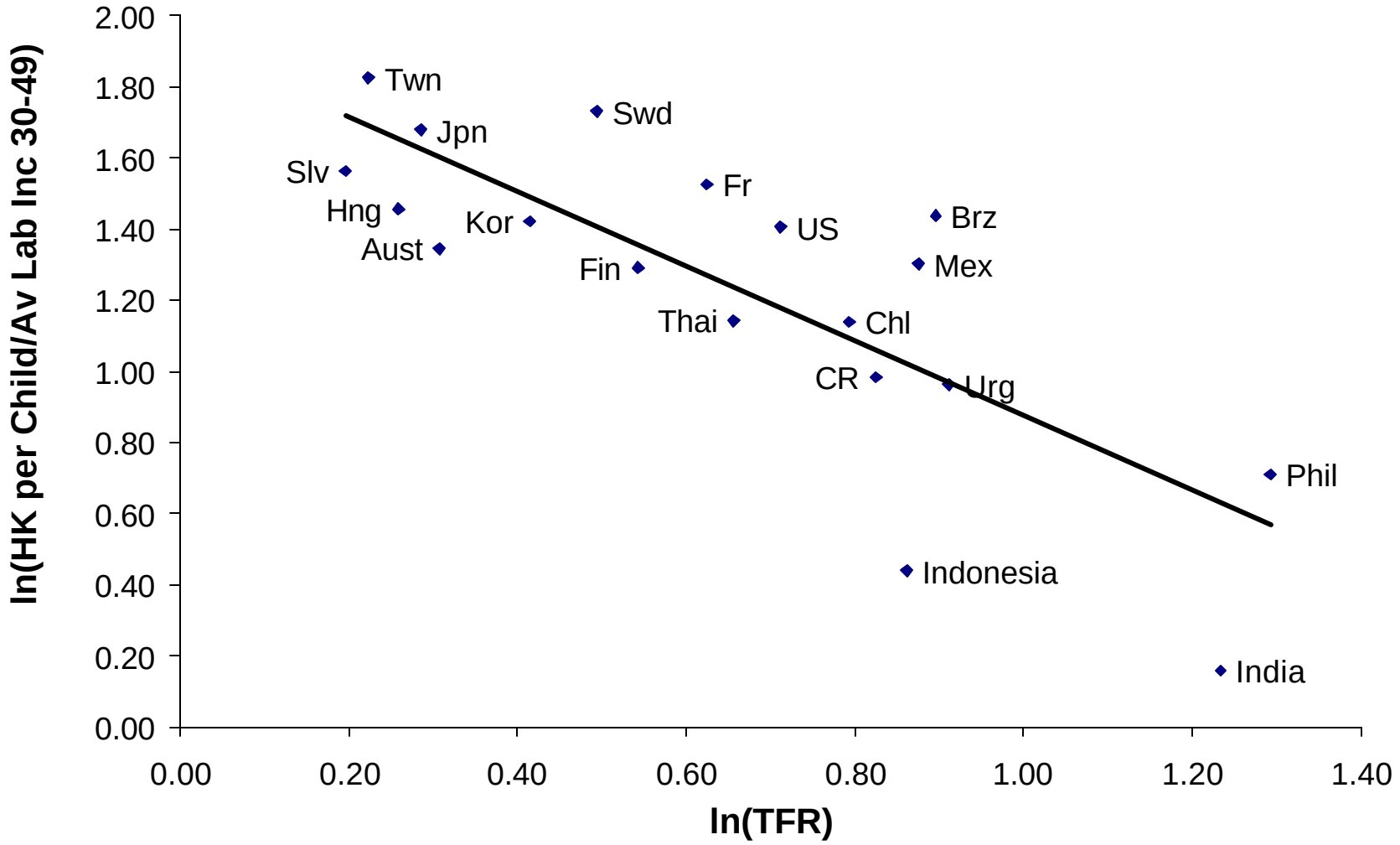
- Look at it in relation to the period TFR – a synthetic cohort measure of fertility.

**Figure 1. Per Child HK Spending (Public and Private) vs. Fertility**



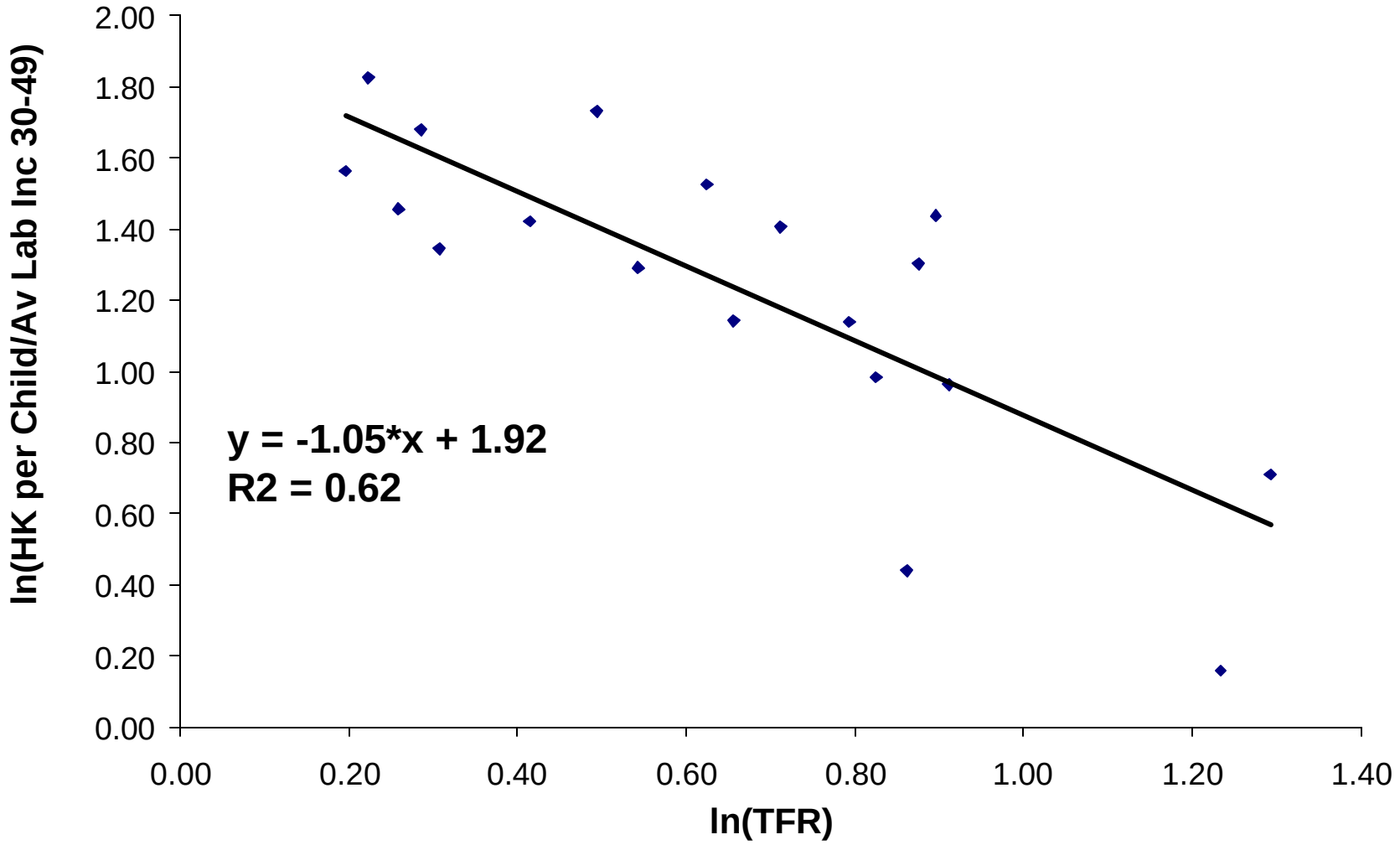

Data from NTA country teams

**Figure 1. Per Child HK Spending (Public and Private) vs. Fertility**




Data from NTA country teams

**Figure 1. Per Child HK Spending (Public and Private) vs. Fertility**

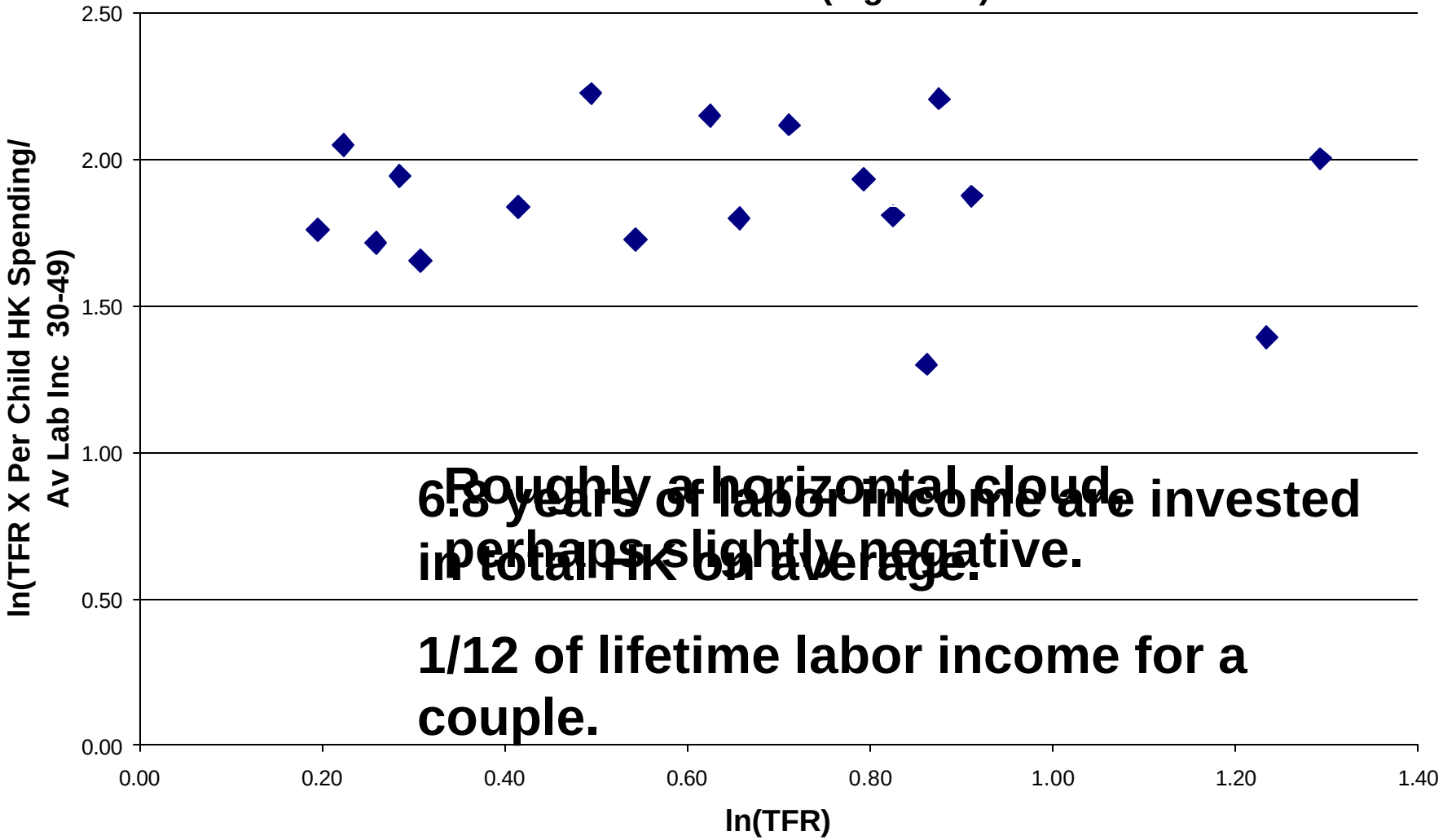



Data from NTA country teams

# Now calculate total HK spending on all children

- Multiply TFR times HK per child, and plot its log against log(TFR).

**Figure 5. Total Expenditures Per Woman for All Children's HK vs. Fertility**
**for 18 NTA countries (log scale)**




Roughly a horizontal cloud, perhaps slightly negative.

**6.8 years of labor income are invested in total HK on average.**

**1/12 of lifetime labor income for a couple.**

Data from NTA country teams

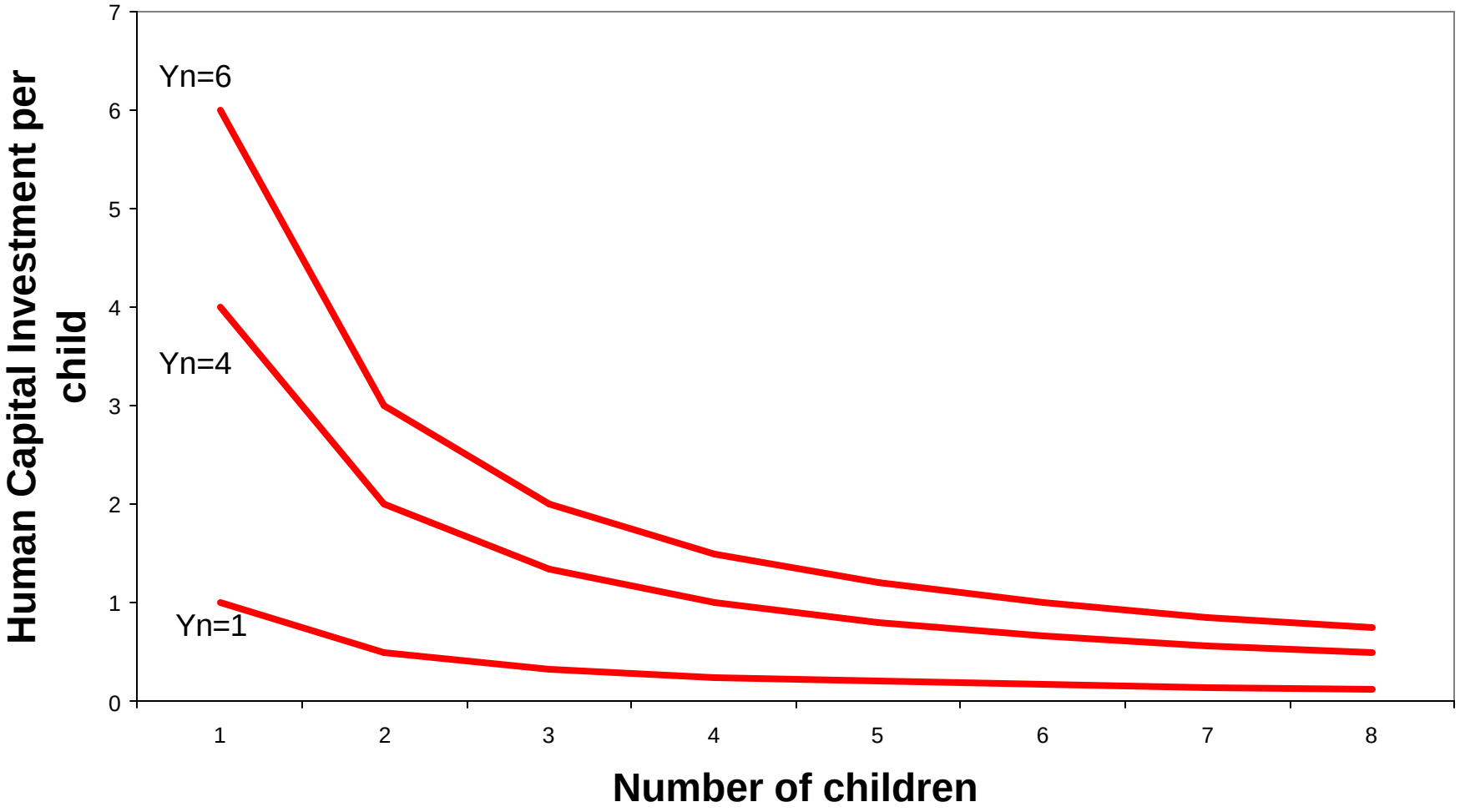
# Association is non-causal

- We don’t know whether fertility decline causes rising HK investments per child.
- Desire to make bigger HK investments causes fertility decline.
- Some other factor like rising income causes both fertility and HK changes.
- Here is one theory about a causal path from income growth to other changes. In some models the HK growth causes income growth.

# The standard Quantity-Quality model

- Assume that the share of total labor income spent on HK is fixed, consistent with scatter plot.
- Draw budget constraints for differing levels of income.
- Quantity and quality interact multiplicatively in the budget constraint, both with positive income elasticities for constant price.

## The Standard Model: Rising Income Leads to Choice of Lower Fertility and Higher HK Investment per Child



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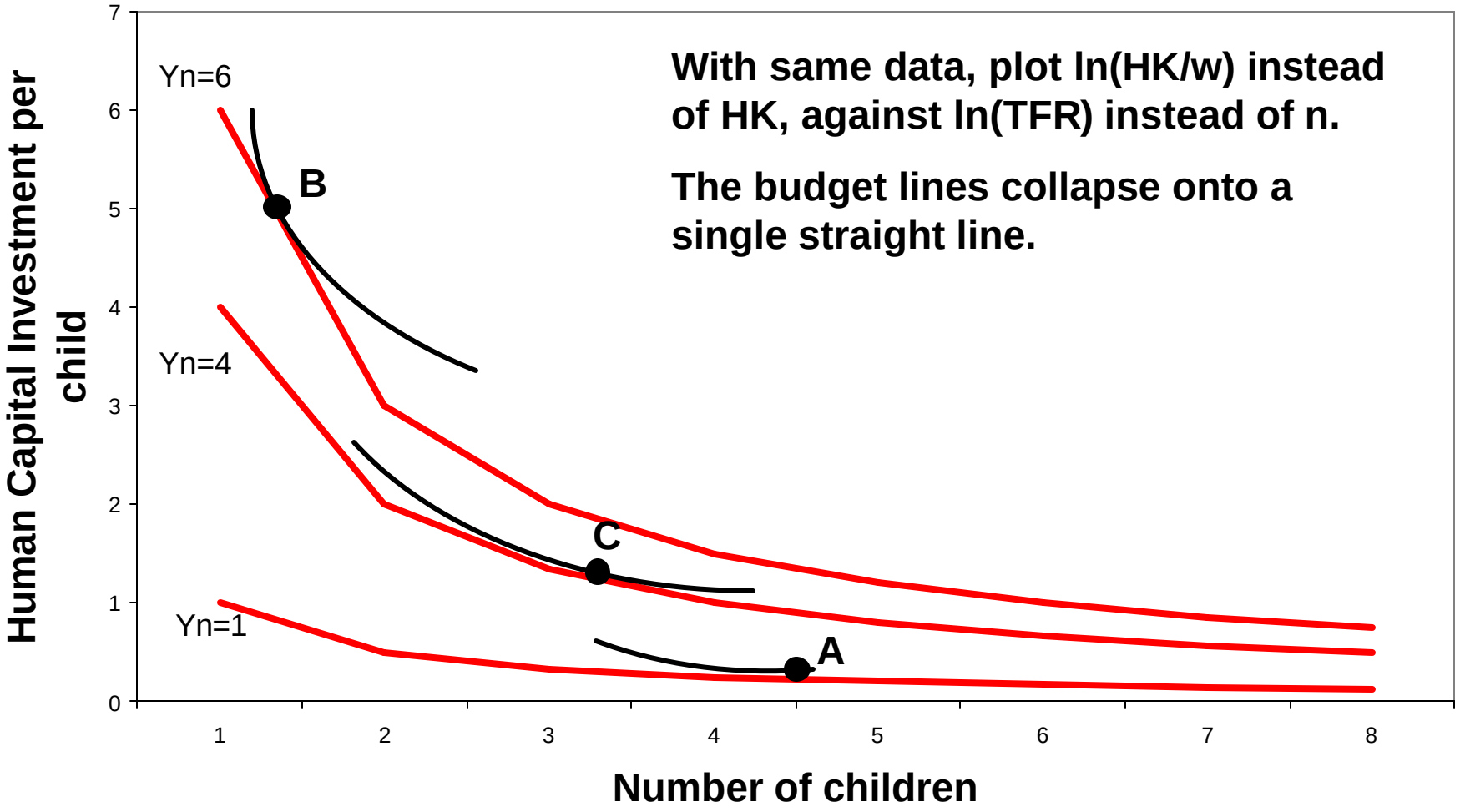
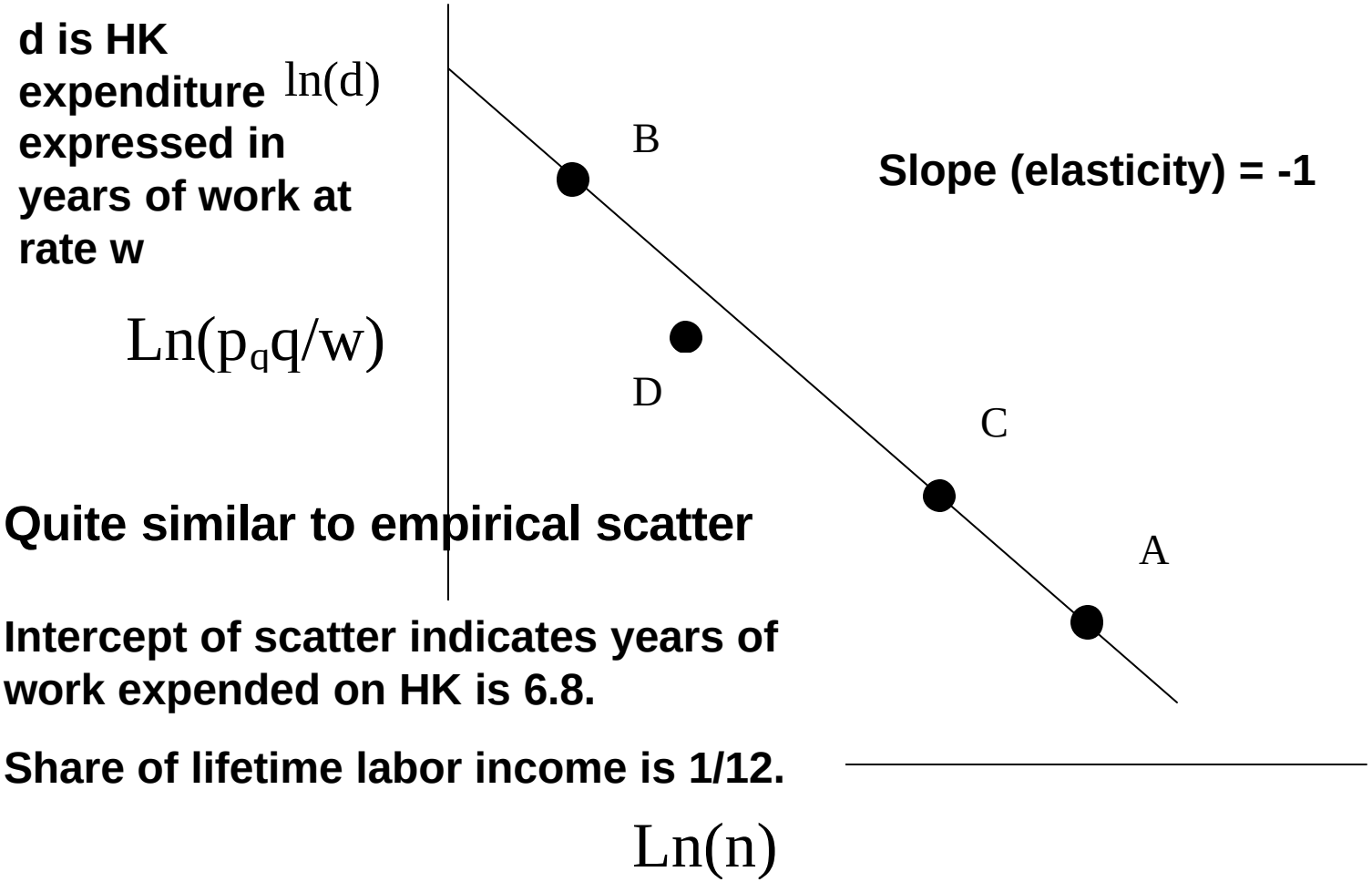


The transformed budget constraint showing different quantity-quality choices.



- So our scatter plot shows a common transformed budget constraint with different fertility-HK choices.
- Differing incomes is one possible cause.
- Many others.

# Production and Human capital

- Human capital (HK)
  - Portion of wage, W(t), workers invest in their children is inversely related to their fertility, F(t)
  - Human capital of workers one period later is
  - HK(t+1) = h(F(t)) W(t)
- Wage (W)
  - Wage is increasing in human capital
  - W(t) = g(HK(t))

Baseline Specifications

$$HK(t+1) = \frac{W(t)}{12F(t)}$$

$$W(t) = g\,HK(t)^{.33}$$

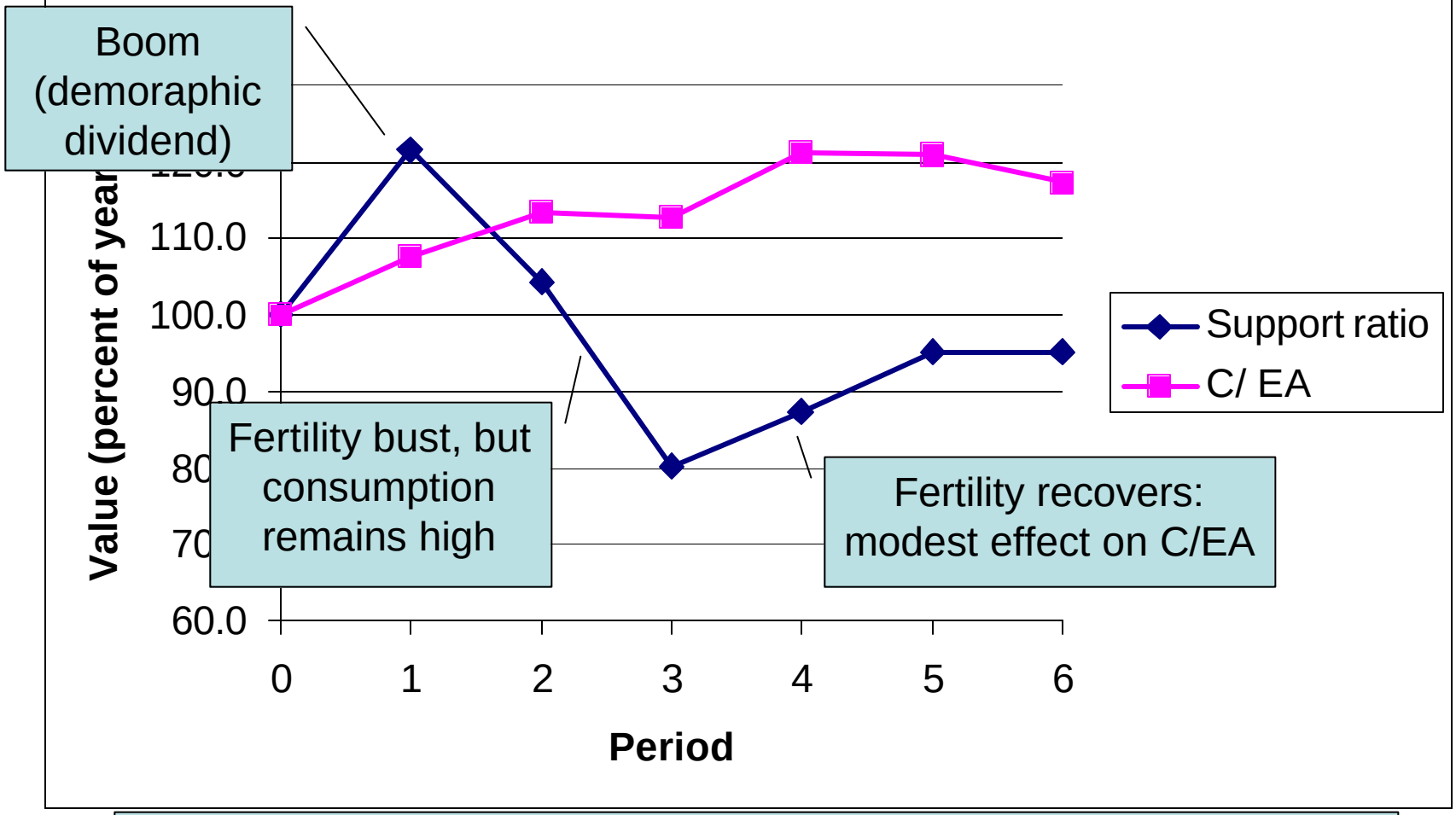
# Other sources of variation in fertility/HK choice

- **Pref for HK**: Rate of return to HK; survival rates; consumption value of HK.
- **Price of HK** due to medical technology, transportation improvements, etc.
- **Price of number**: family allowances, fines for second child, changing access to effective contraceptives
- **Cultural influences** on varying share of income allocated to total HK expenditures and on number.

# Model—basic structure

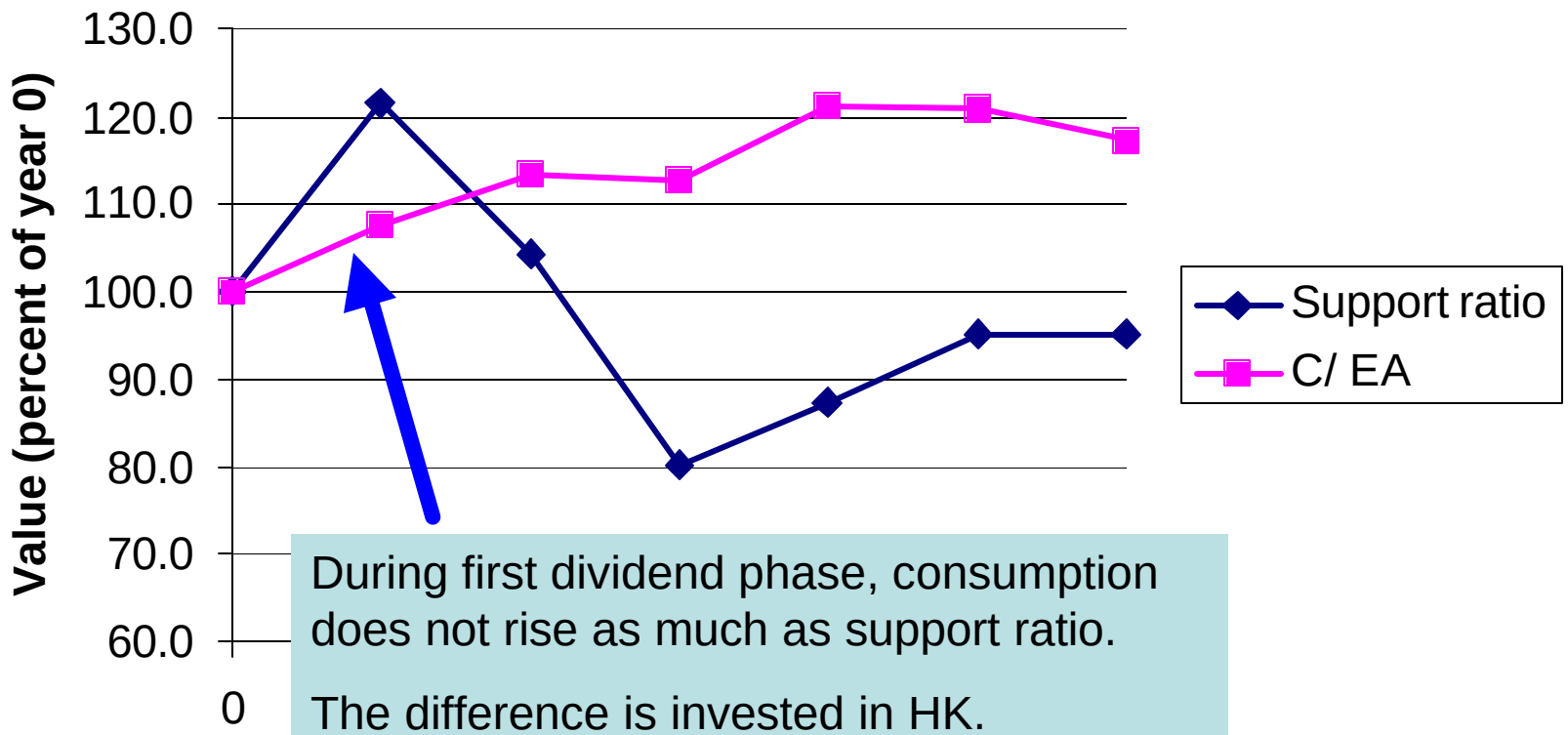
- Take fertility variations as given, trace out consequences for HK, wage, consumption.
- 3 generations:  children, workers, retirees; usual accounting identities.
- No saving or physical capital.
- HK drives wage growth; wage growth drives HK growth. (Lee and Mason 2008)

## Figure 6. Macro Indicators: Baseline Results




Bottom line: Low fertility leads to higher consumption.
Human capital investment has moderated
the impact of fertility swings on standards of living.

## Figure 6. Macro Indicators: Baseline Results




During first dividend phase, consumption does not rise as much as support ratio.

The difference is invested in HK.

That is why ih later periods, consumption is proportionately higher than the support ratio.

From Lee and Mason (2008)

# Conclusions for changes over the transition

- Support ratios change over demographic transition; ending where started, roughly.
  - Importance in long view may be exaggerated.
  - In shorter view, pop aging is a painful payback phase.
- Bigger effect is on capital intensity
  - Raises productivity per worker
  - Raises wealth and asset income
- However, increased demand for wealth can be met either by increased asset holdings or through increased transfer wealth.
- Major role for policy and institutions at every point; nothing inevitable.
- Increased human capital results from low fertility—so closely related to aging: same cause for both.
  - Raises productivity.

# END

Data from