# Growth Model Basics

## Lecture 13

# Growth Model Basics



- **Core Growth Theory: review**
  - **Labor and Capital Inputs**
  - **Determinants of Labor Productivity**
  - **Supply Effects of Investment**
  - **The Need for National Savings**
- **Growth theory is "Macro Macro"**
  - **it attempts to explain differences in economic performance over decades and centuries, rather than months, quarters, or years**
- **What allows an economy to produce more goods in one decade than another?**
- **What allows one country to produce more?**
- **What creates convergence?**

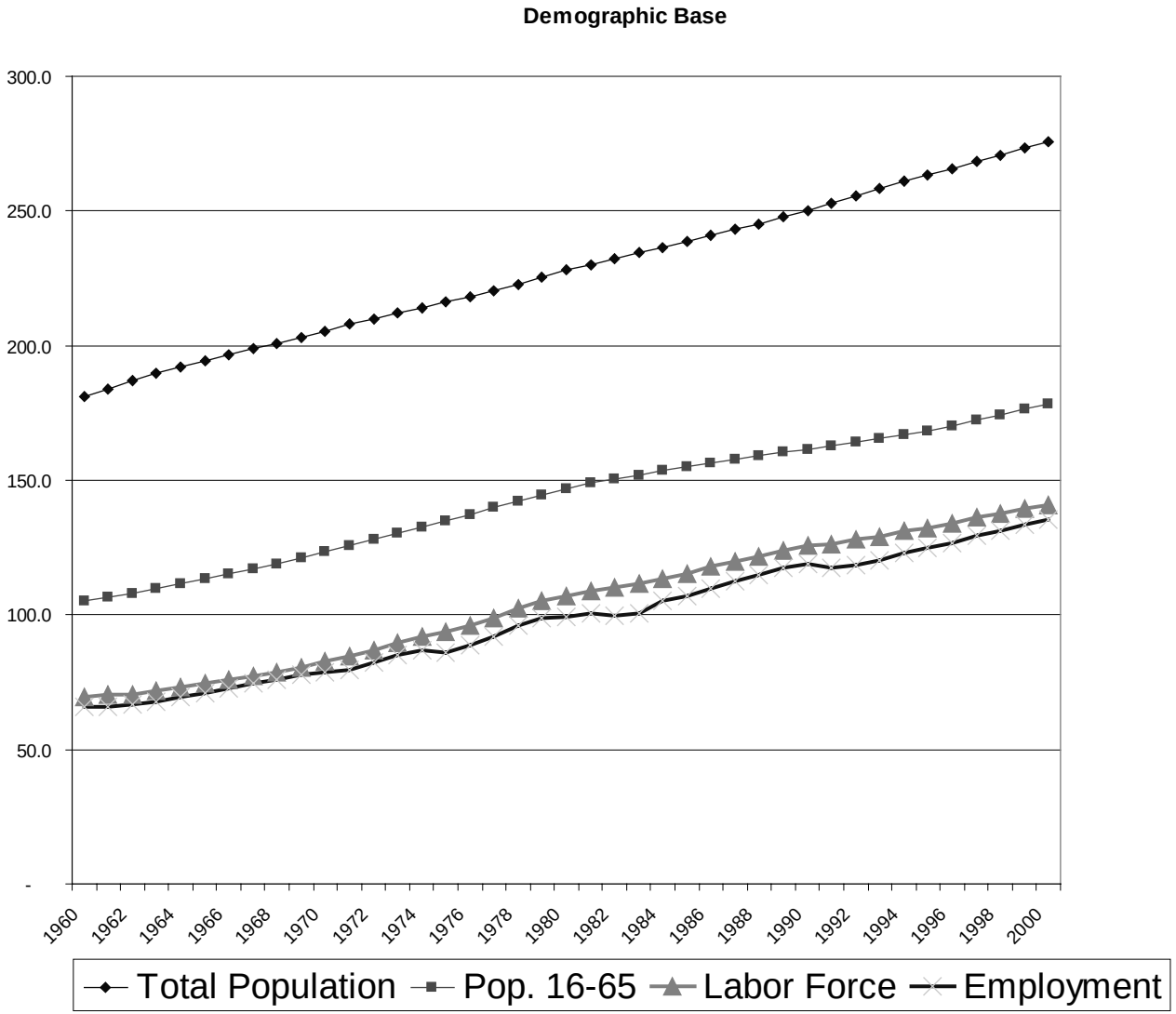
# The Structure of U.S. Growth from the Perspective of Labor Inputs



- **population**
- **x ( 1 -dependency rate )**
- **= working age population**
- **x labor force participation rate**
- **= labor force**
- **x 1 - unemployment rate**
- **= employment**
- **x hours per employee**
- **=hours worked**
- **x output per hour ( “labor productivity” )**
- **=output**

# The Structure of U.S. Growth





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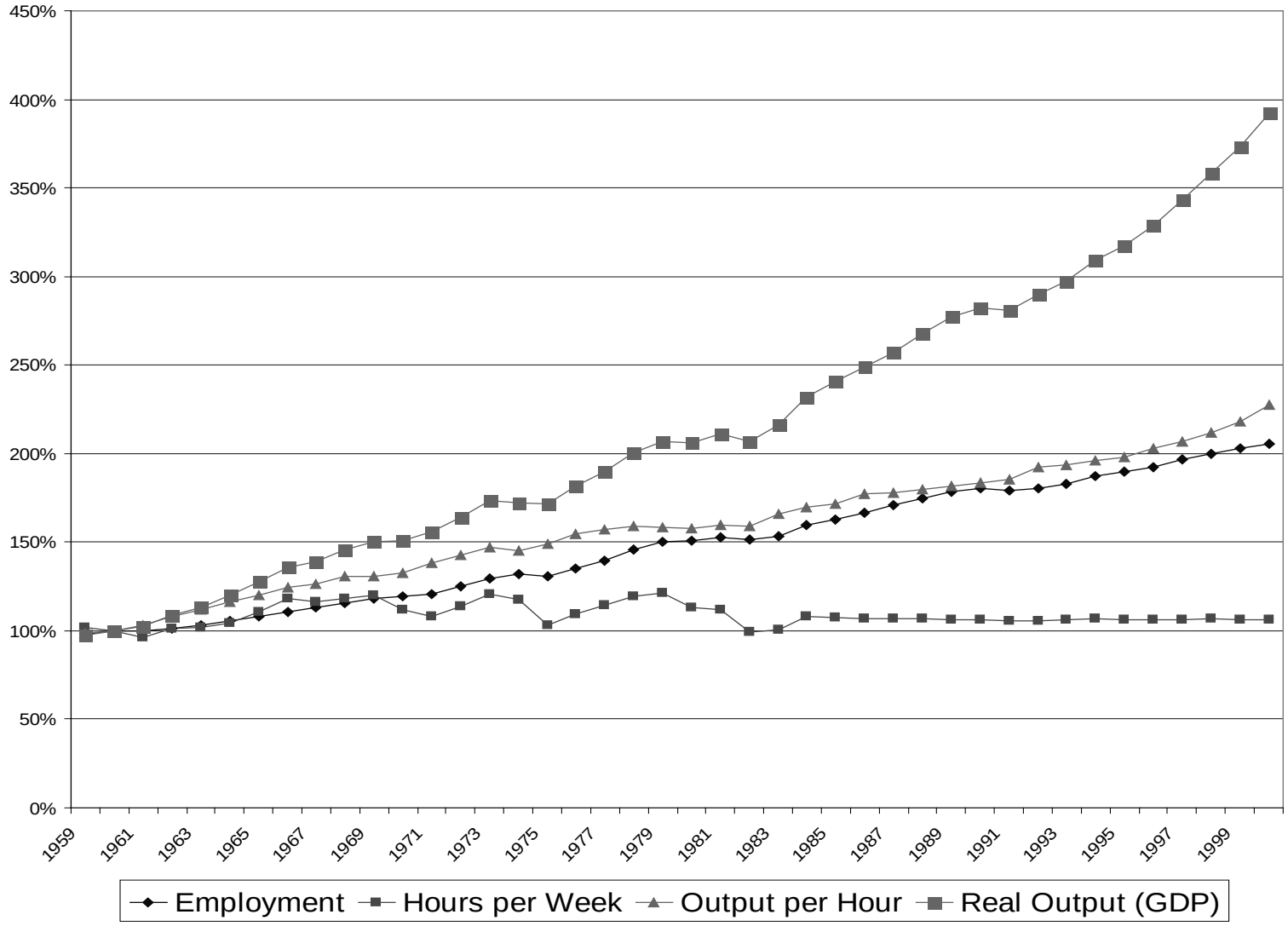

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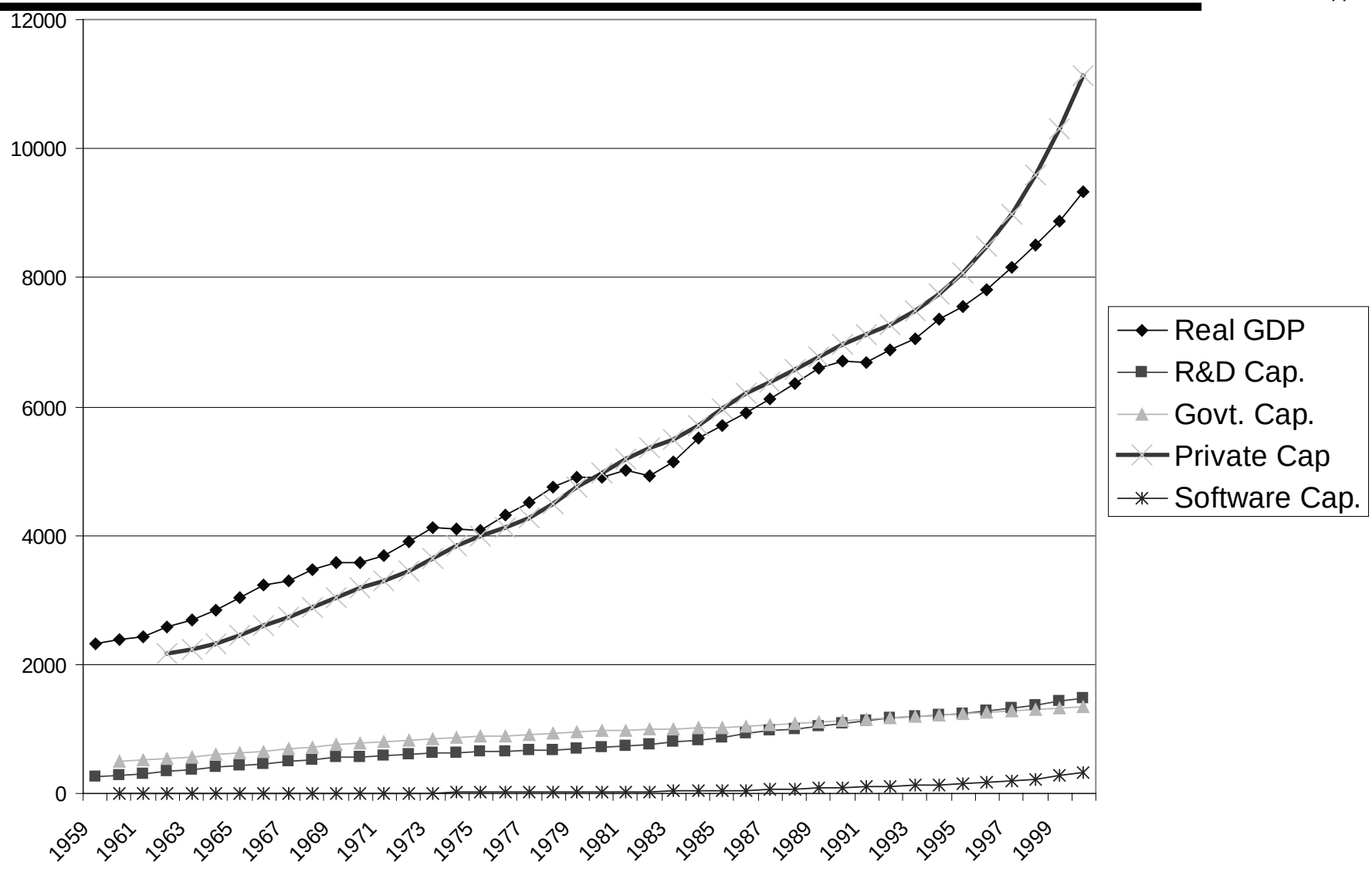


# The Structure of U.S. Growth



| CAGR's | Real Output ( GDP ) | Output per Hour | Output per Hour (Mfgr only) | Labor Force | Capital-Private | Capital-Government | Capital - R&D |
|---|---|---|---|---|---|---|---|
| 60-73 | 4.3% | 3.0% | 3.0% | 1.9% | 3.8% | 3.1% | 6.1% |
| 73-92 | 2.7% | 1.4% | 2.6% | 1.9% | 2.8% | 1.9% | 3.4% |
| 92-2000 | 3.9% | 2.1% | 4.4% | 1.2% | 2.8% | 1.6% | 3.1% |
| | | | | | | | |
| 60-2000 | 3.5% | 2.1% | 3.1% | 1.8% | 3.1% | 2.2% | 4.2% |
| | | | | | | | |
| 50-73 | 4.0% | 2.4% | 2.6% | #N/A | 3.6% | 3.5% | #N/A |

# The Determinants of Labor Productivity



- **What enables an employee to produce more or less per hour?**
  - **The "state of the art" potentially available (the production possibility frontier").**
  - **His/ Her own education and training to absorb the state of the art.**
  - **The quantity and quality of available, complementary "tools" such as computers, assembly machines.**
- **What "infrastructure" can the nation provide to influence:**
  - **the level of output in a workplace?**
    - » education, health, attitudes toward work, regulation, taxation
  - **the efficiency of "connections" between workplaces?**
    - » communication, transportation, common language, anti-monopoly regulation, global access

# Alternative Types of Capital



- **Economists can refer to almost all of these factors as simply different types of "capital"**
  - **Types of Capital**
  - **Tangible equipment and structures**
  - **Human, from brains through brawn**
  - **Technological, e.g. accumulated R&D**
  - **Infrastructure, i.e. tangible goods not owned by one enterprise**
- **"Capital" in this context simply means something that is long-lasting and not used up by the process of production**
- **More narrowly, "capital" sometimes only means tangible goods such as equipment, buildings, highways**
- **What nuances should be considered when differentiating among types of capital--equipment & buildings, human, technology, infrastructure?**
  - **Causes of Decay or Obsolescence**
  - **Potential for Multiple Simultaneous Users= "Public Good"**
  - **Ability to own or control once created/ put in use**

# A Basic Model of Production



- **Output=Q=A $K^b L^{1-b}$**
- **Output per Worker = Q/L**

  = q (lower case letter to denote "per worker")

  =A $K^b L^{1-b}$ / L ("A" = technology-driven productivity)

  = A $K^b L^{-b}$

  = A $(K/L)^b$

**and using lower case again to denote "per worker"**

$q = A\ k^b$

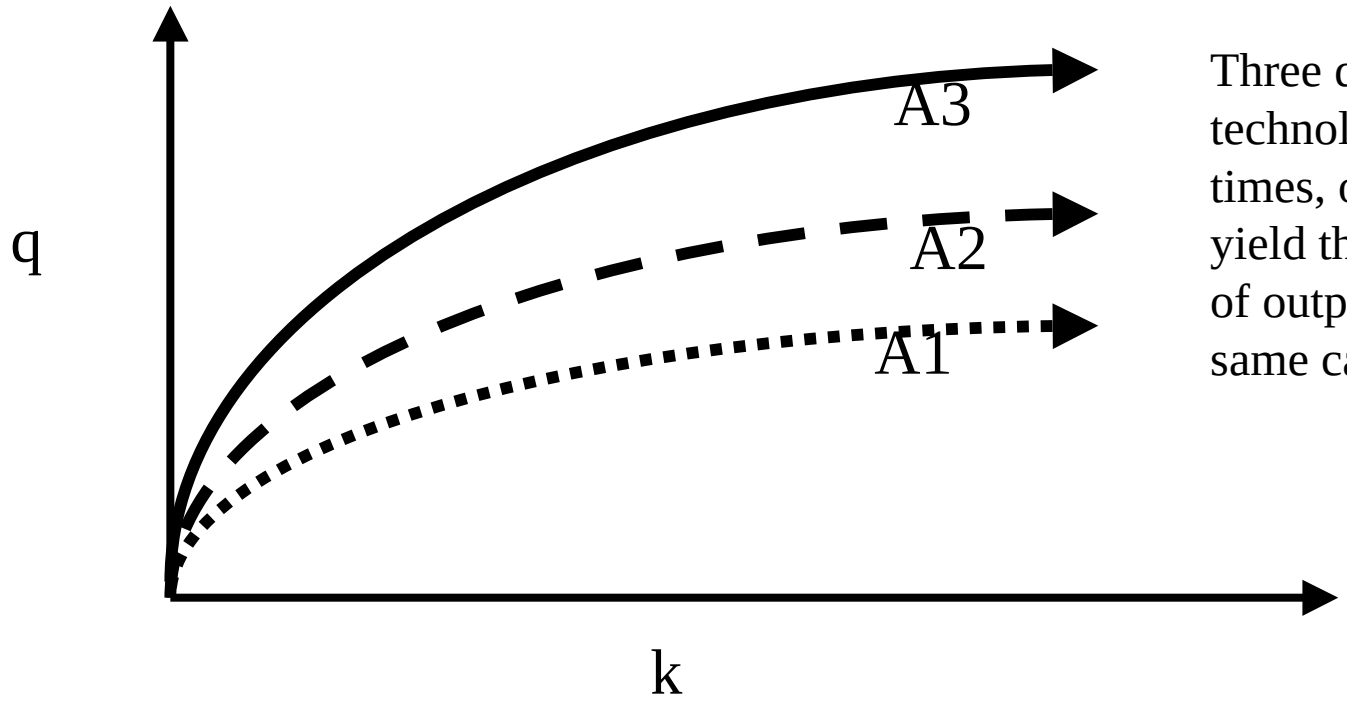
**So the "standard of living" = output per worker = product of 2 key factors**

**<u>productivity</u> x <u>capital per worker</u>**

# A Basic Model of Production



- **Output=Q=A $K^{b}L^{1-b}$**
- **Output per Worker = q = A $k^{b}$**




Three different technologies (for 3 different times, or nations, etc) yield three different levels of output per worker for the same capital per worker

# An Extended Model of Production



- **Define the roles of three types of capital: P&E, Infrastructure, and R&D (the latter raises the productivity of all factors)**
- **Output=**

  **total factor inputs * total factor productivity**
- **thus log(output) = log( inputs) + log ("TFP")**
- **log (Total factor inputs) =**

  **.62 * log (Hours)**

  **+.35 * log (Private Plant & Equipment & Housing Capital)**

  **+.03 * log (Public Infrastructure)**
- **log( Total factor productivity) =**

  **unexplained time trend**

  **+.05 * log (R&D capital stock)**

# An Extended Model of Production



- **log (Total factor inputs) =**

  **.62 * log (Hours)**

  **+.35 * log (Private Plant & Equipment & Housing Capital)**

  **+.03 * log (Public Infrastructure Capital)**
- **The inputs are substitutes for one another, with constant returns to scale (sum of elasticities/coefficients = 1).**
- **A 10% increase in private capital will boost output by only 3.5% unless all other inputs are also raised 10%.**
- **Basic Magnitudes today**
  - **Real GDP= $7 Trillion; less housing & govt employ=$5 T**
  - **Real Private Capital= $ 5 Trillion**
  - **Real Infrastructure= $ 1 Trillion**
  - **Real R&D Stock = $ 0.6 Trillion**

# Returns to Capital in this Extended Model of Production



- **log (Total factor inputs) =**

  **.62 * log (Hours)**

  **+.35 * log (Private Plant & Equipment & Housing Capital)**

  **+.03 * log (Public Infrastructure Capital)**

- **Basic Magnitudes today: Real GDP less housing= $5 Trillion,Real Private Capital= $ 5Trillion,Real Infrastructure= $ 1 Trillion**

- **The gross rates of return to capital are the derivatives of output with respect to capital=dQ/dK=dQ/dlogQ *( dlogQ/dlogK) * (dlogK/dK)**

  **= Q * .35 * (1/K private) = .35 * Q/K private = .35 for private**

  **and = Q * .03 * (1/K infra) =.12 * (Q/K infra) = .12 for public infra**

- **The net rates of return =the gross rates minus depreciation**

  **depreciation of capital lasting 10 years is 10%, 50 years is 2%, thus**

  **=.35-.10=.25 for private and .12-.02=.10 for public**

- **In other words, if these estimates are accurate, the real rate of return to private investment is perhaps 2.5 times as great as the real rate of return**

# The Special Role of Technology and Science in Boosting the Value of All Other Inputs



- **log( Total factor productivity) =**

  **unexplained time trend**

  **+.06 * log (R&D capital stock)**
- **the gross rate of return is**

  **.06 * (Q / K r&d ) = .06 * (4 / .6) = .40**
- **the net rate of return, if R&D lasts for 25 years, is**

  **.40 - .04 = .36**
- **R&D "works" by boosting the value of any other input by increasing the "knowledge" applied in he use/application of that input (labor, machines, or infrastructure).**
- **R&D is assumed to be different than other capital because a 10% increase of this stock add 10% to output, regardless of whether all other inputs are increased 10%. Science, genius, technology, etc. are not exhausted by applying them repeatedly or spreading them over more of other inputs, such as would be the case if only hours or the number of machines were increased.**

# Lessons to be Drawn from the Production Model



- **Labor productivity can be enhanced by boosting capital formation, but this does not raise total factor productivity hence the nation may not be ahead in a broader sense.**
- **This brings us back to a basic linkage: the investment required to boost capital formation mandates saving. Saving is foregone consumption. So we can trade not consuming today for more capital and more labor productivity and more consuming tomorrow. Whether we are ahead or not depends on our valuation of the return to this saving.**
- **If the real cost of funds is only 5%, then the economy is seriously under-investing in all types of capital, since the net rates of return**
  - **--- 36% for R&D, 25% for business capital, and 10% for infra.-- all exceed the cost**
  - **---consider why these differences might exist across types of assets and between asset returns and costs**

# The Links Among Saving, Investing and Productivity



- **WE MUST HAVING SAVINGS TO INVEST.**
- **WE MUST HAVE INVESTMENT TO BUILD CAPITAL TO RAISE LABOR PRODUCTIVITY.**
- **HOW WELL IS THE U.S. SETTING ITSELF UP FOR GROWTH BY SAVING?**
- **HOW WELL ARE OTHER NATIONS DOING?**

# The New Economic Order: Open Borders for Goods, Technology and Finance

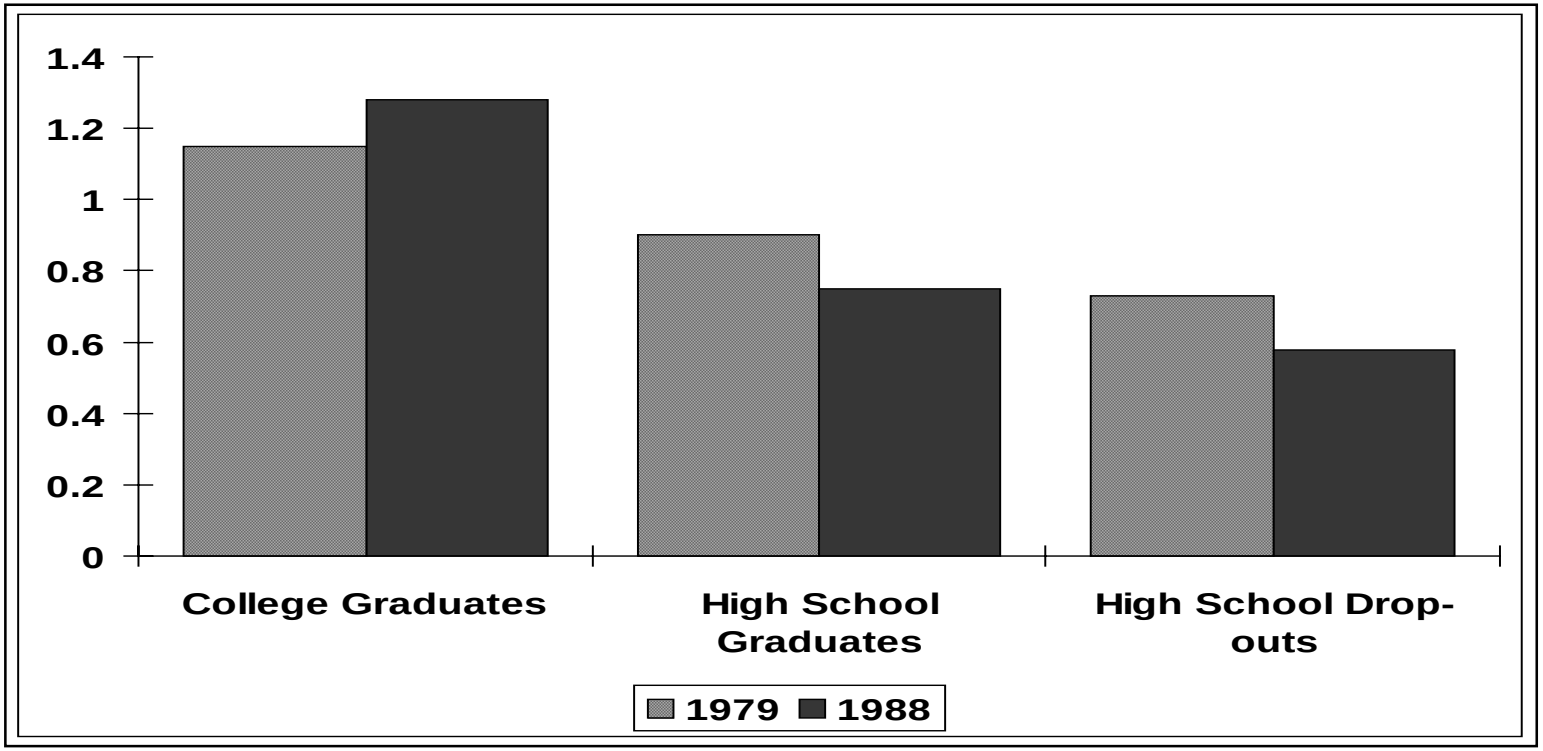


- **Increasingly *free trade with the developing world creates tremendous stress in the mature industrial economies:* the opportunity to move production and assembly technologies abroad removes a previously captive privilege from the workers of the United States, Japan, and Europe. The NAFTA and EC expansions point to extended trends in this direction.**
  - **Semi-skilled labor is now in gross over-supply worldwide.**
  - **Managers and entrepreneurs will benefit.**

# Returns to Education Have Risen



**(Multiple of average income)**



# The New Economic Order: Open Borders for Goods, Technology and Finance



**Unprecedented technology and capital transfers plus political *transformations signal high growth for selected developing nations*. The earliest and most rapid advancement will occur where:**

- **the work-force is the best educated and motivated;**
- **the indigenous entrepreneurial climate is most positive;**
- **equity investment and trade are encouraged;**
- **government fiscal and monetary policies are best balanced to keep inflation and exchange risks minimal; and**
- **the democratic heritage is strongest.**

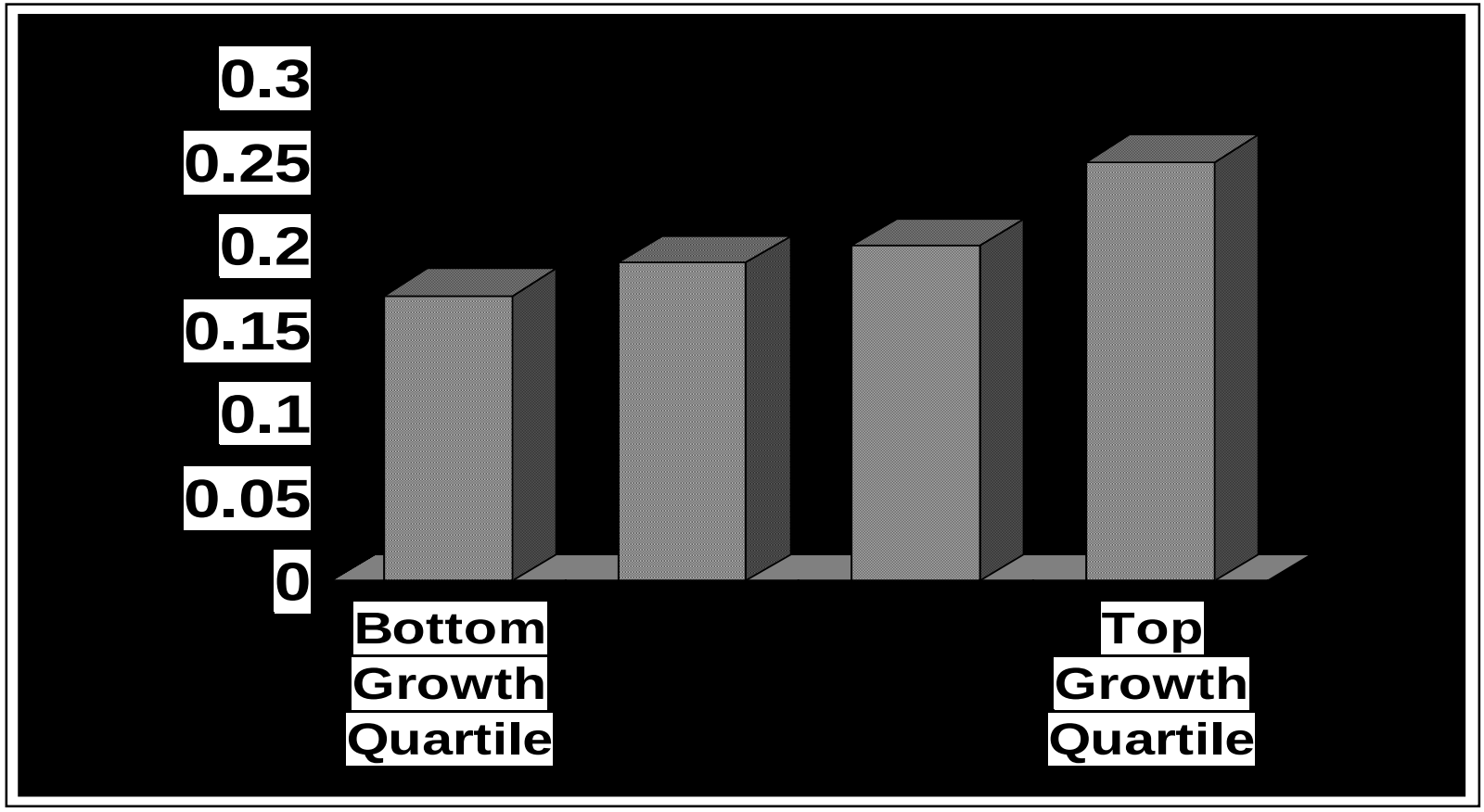
# The Most Rapid Growth

# in Developing Nations

# Has Occurred for those Having...

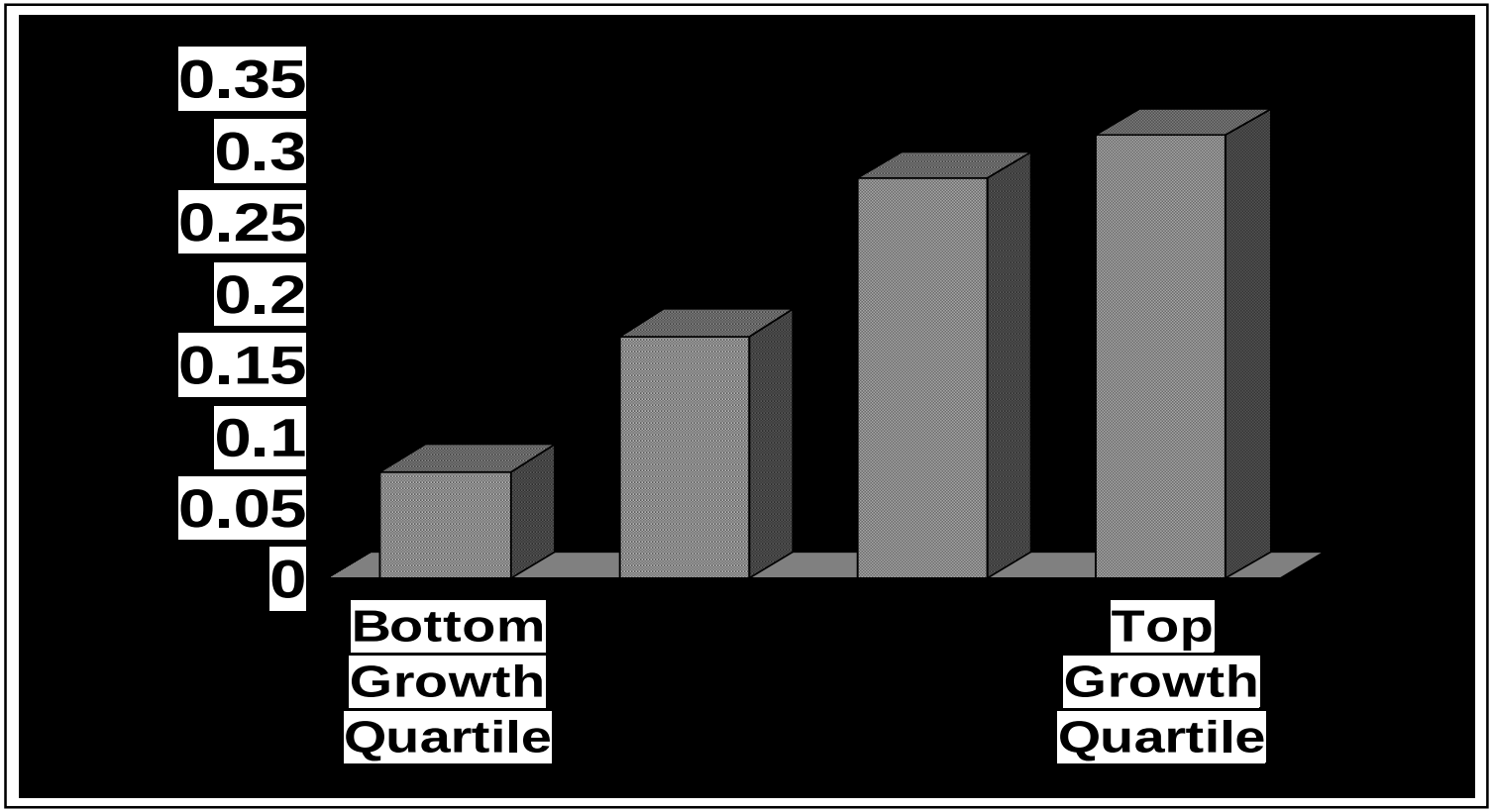
# ..High Investment Shares of GDP,





# ...High Secondary School Enrollment Rates,





# ...and High Trade Shares of GDP