INFORMATION TECHNOLOGY AND U.S. ECONOMIC GROWTH

By

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Presidential Address to the American Economic Association
New Orleans, Louisiana, January 6, 2001
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INTRODUCTION:
Prices of Information Technology

THE INFORMATION AGE:
Faster, Better, Cheaper!

ROLE OF INFORMATION TECHNOLOGY:
IT Prices and the Cost of Capital

AMERICAN GROWTH RESURGENCE:
IT Investment and Productivity Growth

ECONOMICS ON INTERNET TIME:
The New Research Agenda
THE INFORMATION AGE: Faster, Better, Cheaper!

MOORE (1998): "If the automobile industry advanced as rapidly as the semiconductor industry, a Rolls Royce would get half a million miles per gallon, and it would be cheaper to throw it away than to park it."

INVENTION OF THE TRANSISTOR:
Development of Semiconductor Technology.

THE INTEGRATED CIRCUIT:
Memory Chips; Logic Chips.

MOORE'S LAW: The number of transistors on a chip doubles every 18-24 months (Pentium 4, released November 20, 2000, has 42 million transistors).
Transistor Density on Micro Processors and Memory Chips
HOLDING QUALITY CONSTANT: Matched Models and Hedonics.

SEMICONDUCTOR PRICE INDEXES:
Memory and Logic Chips.

COMPUTER PRICE INDEXES:
The BEA-IBM Collaboration.

COMMUNICATIONS EQUIPMENT:
Terminal, Switching, and Transmission.

SOFTWARE:
Prepackaged, Custom, and Own-Account.
Relative Prices of Computers and Semiconductors, 1959-1999

All price indexes are divided by the output price index.

All price indexes are divided by the output price index.
Relative Prices of Computers, Communications, Software, and Services, 1948-99

All price indexes are divided by the output price index.

Computers
Communications
Software
Services
MODEL OF PRODUCTION:
Production Possibility Frontier.

\[ w_{I,t} \Delta \ln I_t + w_{C,t} \Delta \ln C_t = v_{K,t} \Delta \ln K_t + v_{L,t} \Delta \ln L_t + \Delta \ln A_t \]

where:

I - Investment
C – Consumption
K – Capital
L – Labor

\[ w_{I}, w_{C} \] – Shares of Investment, Consumption

\[ v_{K}, v_{L} \] – Shares of Capital, Labor

A - Total Factor Productivity (TFP)
ROLE OF INFORMATION TECHNOLOGY: IT Prices and the Growth of Output.

OUTPUT SHARES OF IT:
Computers, Communications Equipment, Software, and IT Services.

OUTPUT CONTRIBUTION OF IT:
Investment and Consumption Goods Output.

OUTPUT CONTRIBUTION BY TYPE:
Computers, Communications Equipment, Software, and IT Services.
Output Shares of Information Technology by Type, 1948-99

Percentage share of current dollar gross domestic product.

Computers
Communications
Software
Services
Total

Output Shares of Information Technology by Type, 1948-99

Percentage share of current dollar gross domestic product.
Output Contribution of Information Technology by Type

Average annual percentage growth rates, weighted by the output shares.
Output Contribution of Information Technology

Average annual percentage growth rates, weighted by the output shares.
ROLE OF INFORMATION TECHNOLOGY: IT Prices, Investment, and Productivity.

INPUT SHARES OF IT:
Computers, Communications Equipment, and Software.

CAPITAL CONTRIBUTION:
IT versus Non-IT Capital Services.

CAPITAL CONTRIBUTION BY TYPE:
Computers, Communications Equipment, and Software.
CAPITAL INPUT AND THE COST OF CAPITAL

PERPETUAL INVENTORY METHOD

\[ K_{i,t} = (1-\delta_t)K_{i,t-1} + I_{i,t} \]

where:

- \( K \) - capital stock
- \( I \) – investment
- \( \delta \) - depreciation rate

RENTAL PRICE OF CAPITAL INPUT

\[ c_{i,t} = [r_i - \pi_{i,t} + (1+\pi_{i,t})\delta_i]P_{i,t-1} \]

where:

- \( c \) - price of capital input
- \( P \) - price of investment
- \( r \) - rate of return
- \( \pi \) - asset-specific inflation rate
Input Shares of Information Technology by Type, 1948-99

Percent share of current dollar gross domestic income.

<table>
<thead>
<tr>
<th>Year</th>
<th>Computers</th>
<th>Communications Equipment</th>
<th>Software</th>
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Capital Input Contribution of Information Technology by Type

Average annual percentage growth rates, weighted by the income shares.
Capital Input Contribution of Information Technology

Average annual percentage growth rates, weighted by the income shares.

Non-IT Capital Services • IT Capital Services
AMERICAN GROWTH RESURGENCE: IT Investment and Productivity Growth.

TOTAL FACTOR PRODUCTIVITY:
IT-Production versus Non-IT Production.

 SOURCES OF U.S. ECONOMIC GROWTH:
Capital Input, Labor Input, and TFP.

AVERAGE LABOR PRODUCTIVITY GROWTH:
Capital Deepening, Labor Quality, TFP.
Contributions of Information Technology to Total Factor Productivity Growth

Average annual percentage change in relative prices, weighted by average nominal output shares.
Sources of Gross Domestic Product Growth

Average annual percentage rates of growth, weighted by average nominal income shares.

- 1948-73
- 1973-90
- 1990-95
- 1995-99

Legend:
- Labor Input
- Non-IT Capital Input
- IT Capital Input
- Non-IT Production
- IT Production
SOURCES OF AVERAGE LABOR PRODUCTIVITY GROWTH

\[ \Delta \ln y_t = v_{K,t} \Delta \ln k_t + v_{L,t} (\Delta \ln L_t - \Delta \ln H_t) + \Delta \ln A_t \]

where:

\[ y = \frac{Y}{H} - \text{Output per Hour Worked (ALP).} \]

\[ k = \frac{K}{H} - \text{Capital Input per Hour Worked.} \]

• CAPITAL DEEPENING: growth of capital input per hour worked, weighted by the share of capital.

• LABOR QUALITY GROWTH: growth of labor input per hour worked, weighted by the share of labor.

• TOTAL FACTOR PRODUCTIVITY.
Sources of Average Labor Productivity Growth

Average annual percentage rates of growth, weighted by average nominal income

- Labor Quality
- Non-IT Capital Deepening
- IT Capital Deepening
- Non-IT Production
- IT Production
ECONOMICS ON INTERNET TIME: The New Research Agenda.

• The Solow Paradox -- we see computers everywhere but in the productivity statistics -- versus the Information Age.

• Equity Valuations and Growth Prospects: accumulation of intangible assets versus irrational exuberance.

• Widening Wage Inequality: capital-skill complementarity versus skill-biased technical change.

• Modeling IT and the semiconductor industry: permanent versus transitory contributions to economic growth.
Minimum Feature Size (nm)

Semiconductor Roadmap Acceleration