AMERICAN
ECONOMIC
ASSOCIATION

INFORMATION TECHNOLOGY AND U.S. ECONOMIC GROWTH

By

Dale W. Jorgenson

Harvard University

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INFORMATION TECHNOLOGY AND U.S. ECONOMIC GROWTH

INTRODUCTION:

Prices of Information Technology

THE INFORMATION AGE:

Faster, Better, Cheaper!

ROLE OF INFORMATION TECHNOLOGY:

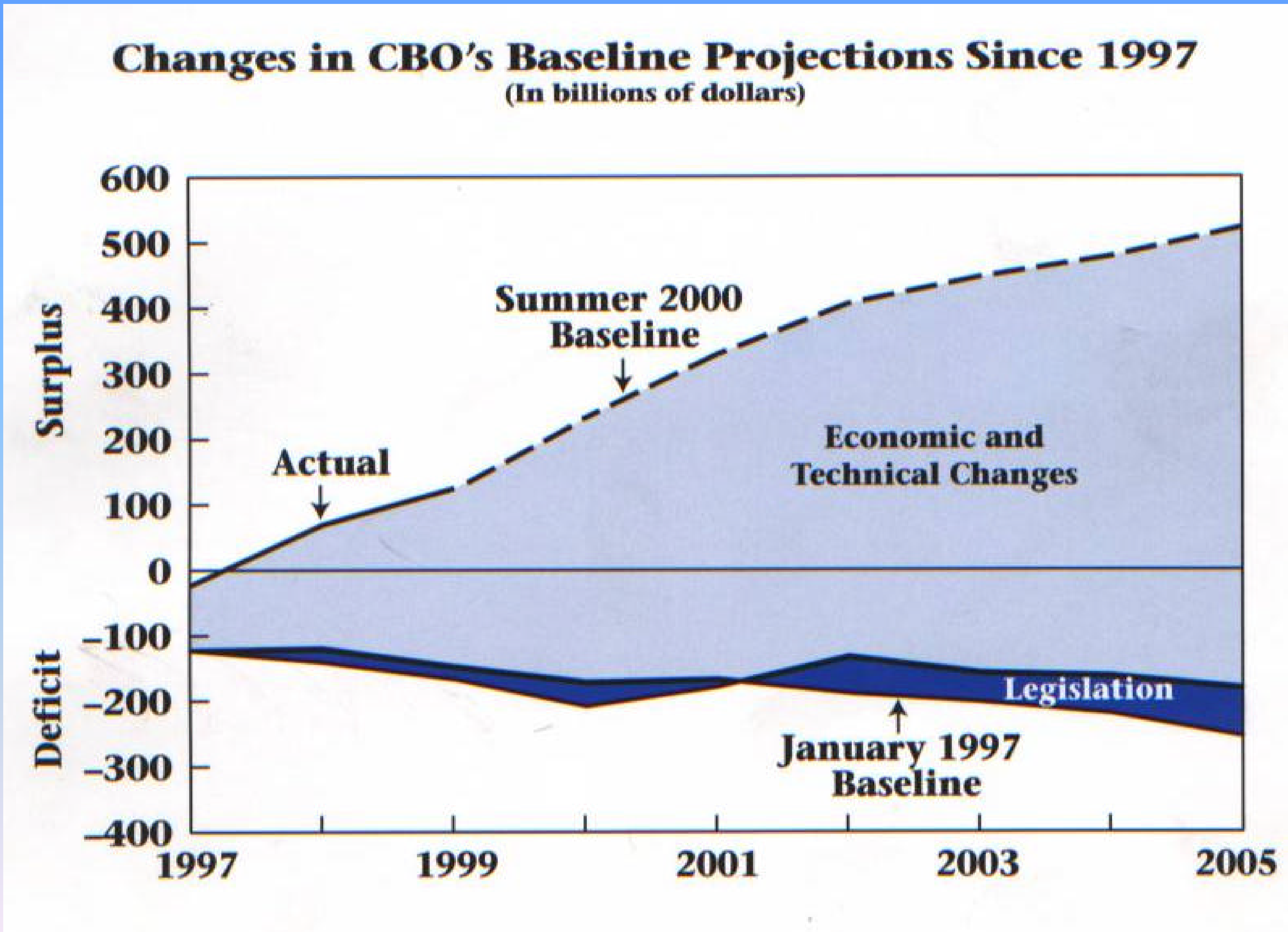
IT Prices and the Cost of Capital

AMERICAN GROWTH RESURGENCE:

IT Investment and Productivity Growth

ECONOMICS ON INTERNET TIME:

The New Research Agenda


Changes in CBO's Baseline Projections Since 1997
(In billions of dollars)
600
500
400
300
200
100
0
-100
-200
-300
-400
Surplus
Deficit
1997
1999
2001
2003
2005
Summer 2000
Baseline
Actual
Economic and
Technical Changes
Legislation
January 1997
Baseline

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:

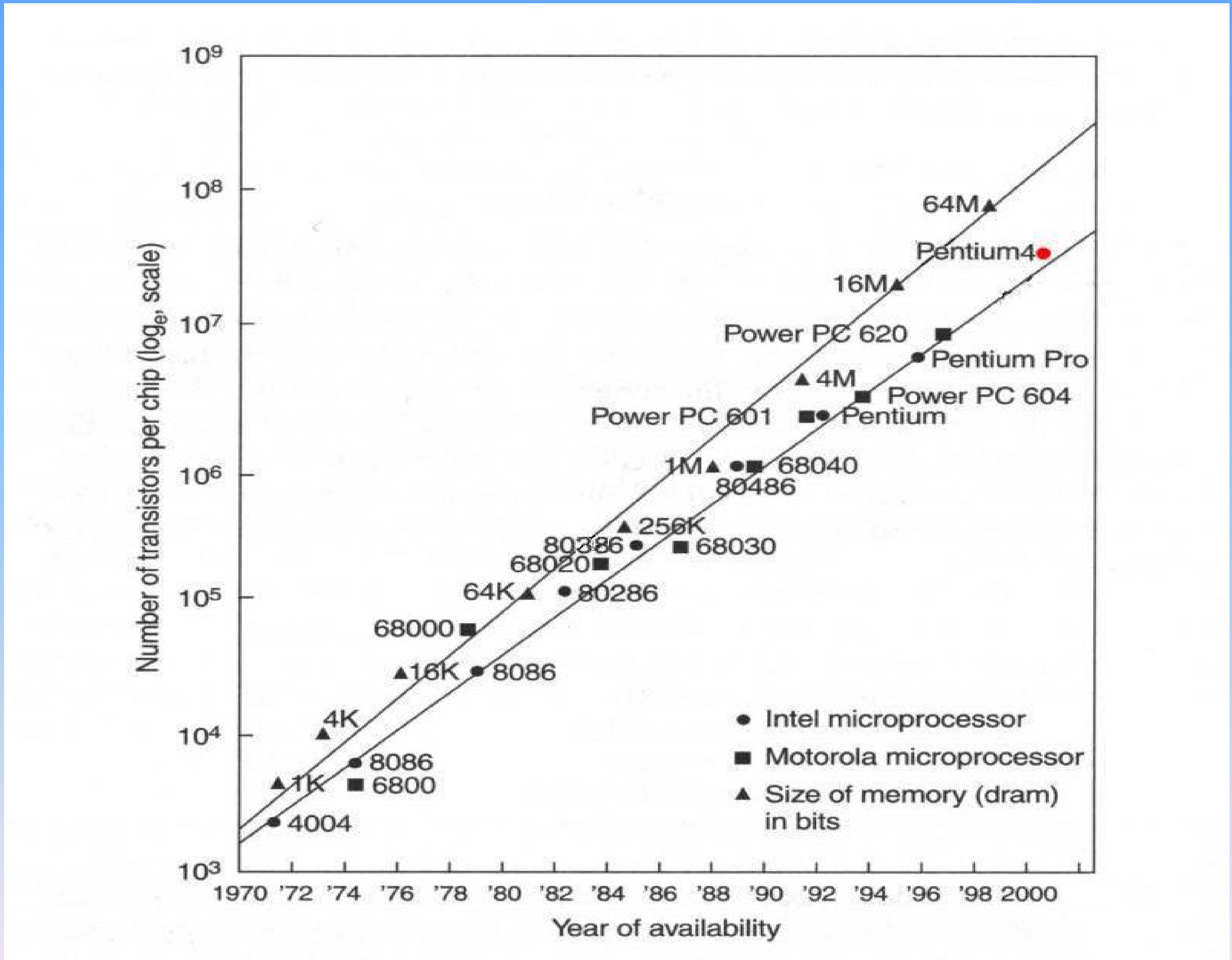
Development of Semiconductor Technology.

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:

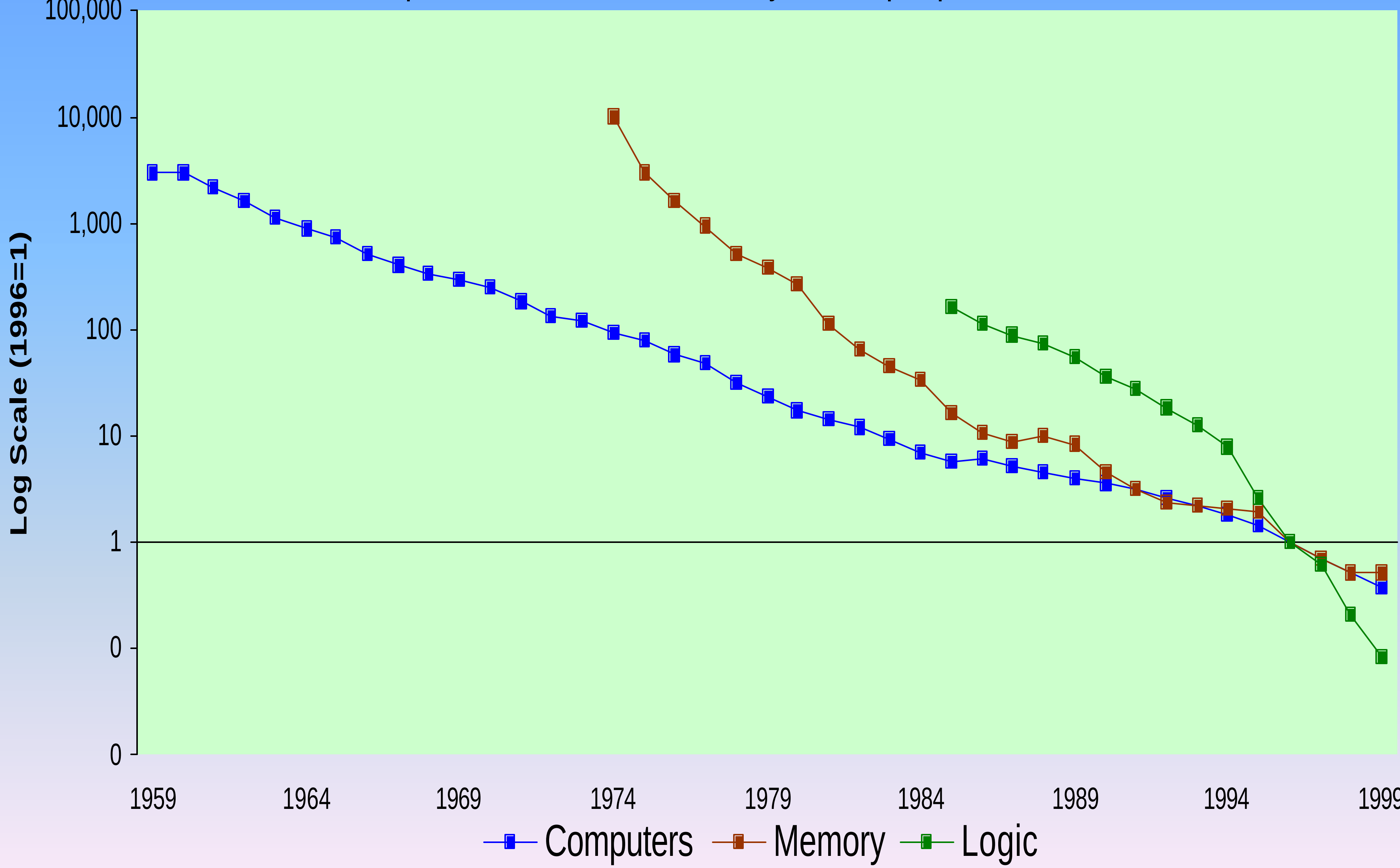
Terminal, Switching, and Transmission.

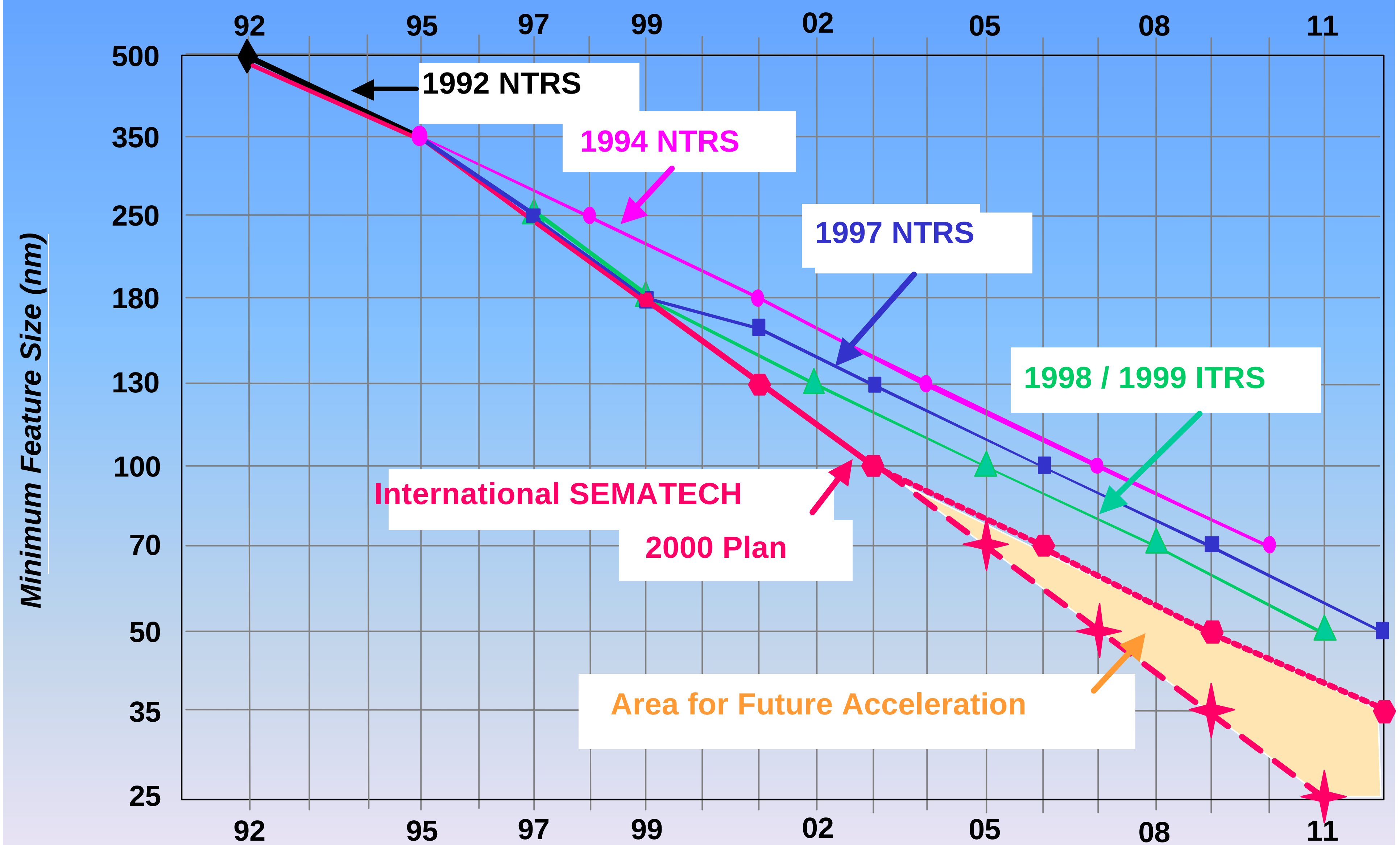
SOFTWARE:

Prepackaged, Custom, and Own-Account.

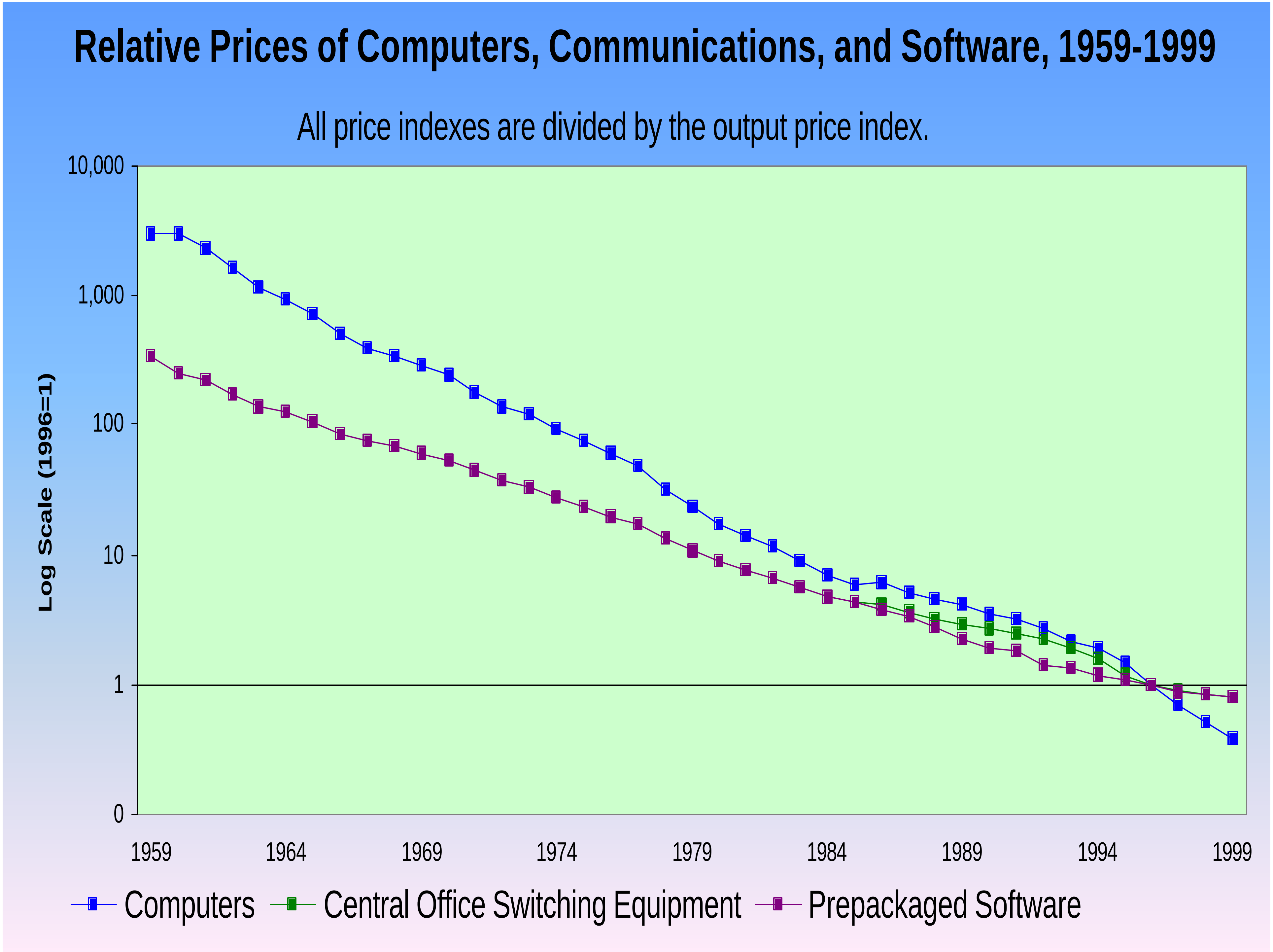
Relative Prices of Computers and Semiconductors, 1959-1999

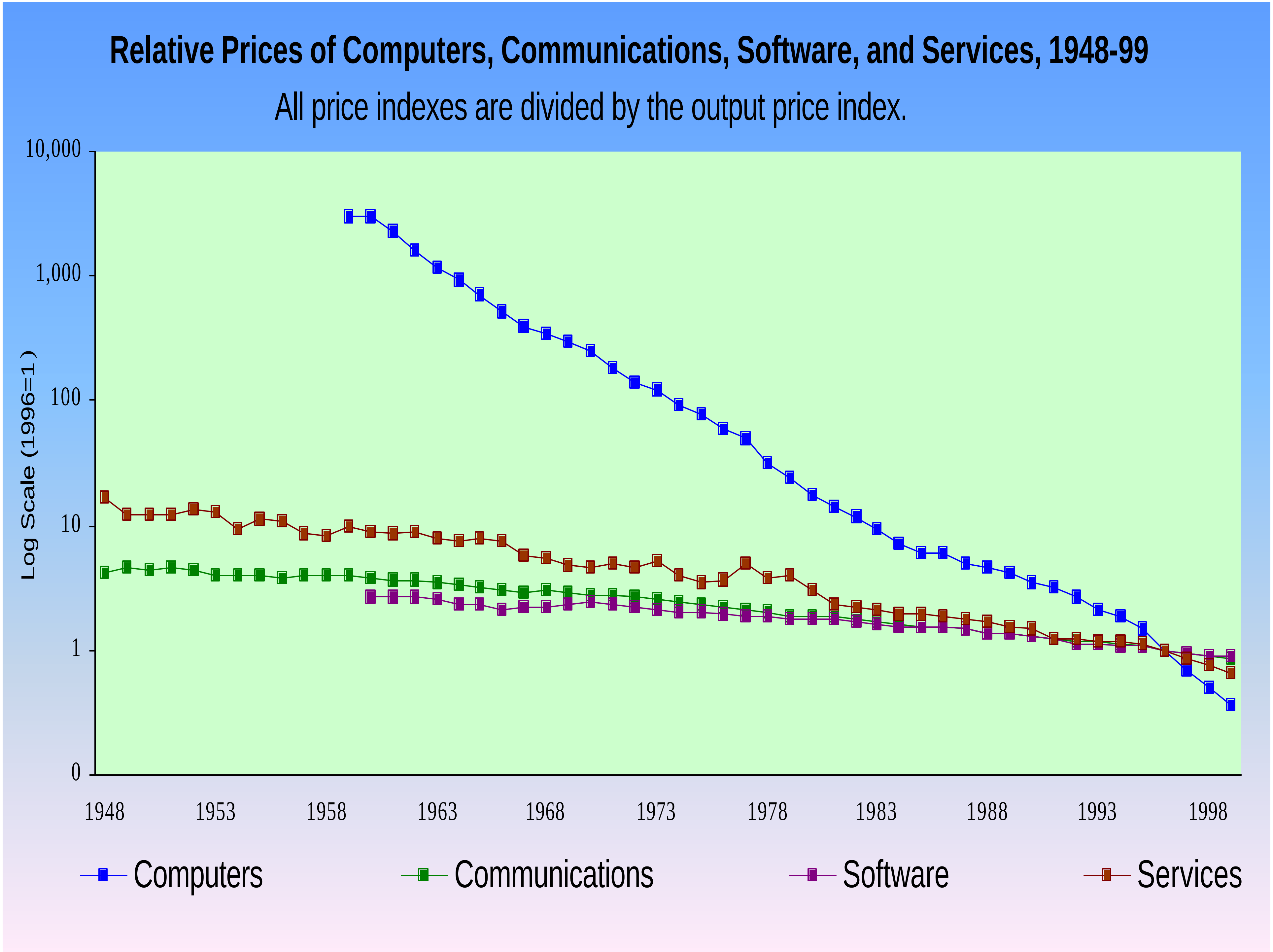
All price indexes are divided by the output price index.





Semiconductor Roadmap Acceleration


Relative Prices of Computers, Communications, and Software, 1959-1999
All price indexes are divided by the output price index.
Log Scale (1996=1)
10,000
1,000
100
10
1
0
1959
1964
1969
1974
1979
1984
1989
1994
1999
Computers
Central Office Switching Equipment
Prepackaged Software


Relative Prices of Computers, Communications, Software, and Services, 1948-99
All price indexes are divided by the output price index.
10,000
1,000
100
10
1
0
Log Scale (1996=1)
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
Computers
Communications
Software
Services

MODEL OF PRODUCTION: Production Possibility Frontier.

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

where:

I - Investment

C – Consumption

$$w_I, w_C - Shares\ of\ Investment, Consumption$$

K – Capital

L – Labor

$$v_K, v_L - Shares\ of\ Capital, Labor$$

A - Total Factor Productivity (TFP)

ROLE OF INFORMATION TECHNOLOGY: IT Prices and the Growth of Output.

OUTPUT SHARES OF IT:

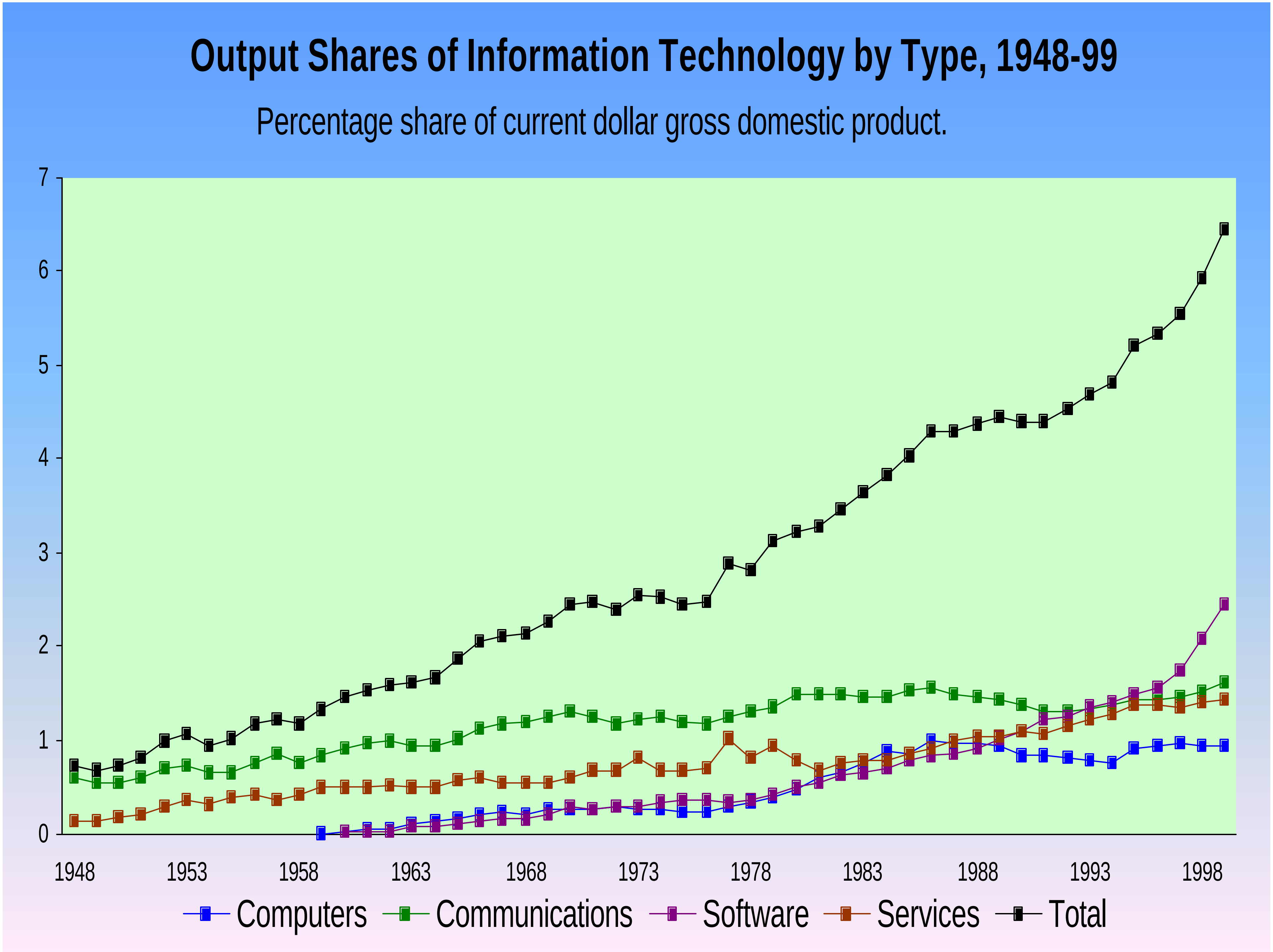
Computers, Communications Equipment, Software, and IT Services.

OUTPUT CONTRIBUTION OF IT:

Investment and Consumption Goods Output.

OUTPUT CONTRIBUTION BY TYPE:

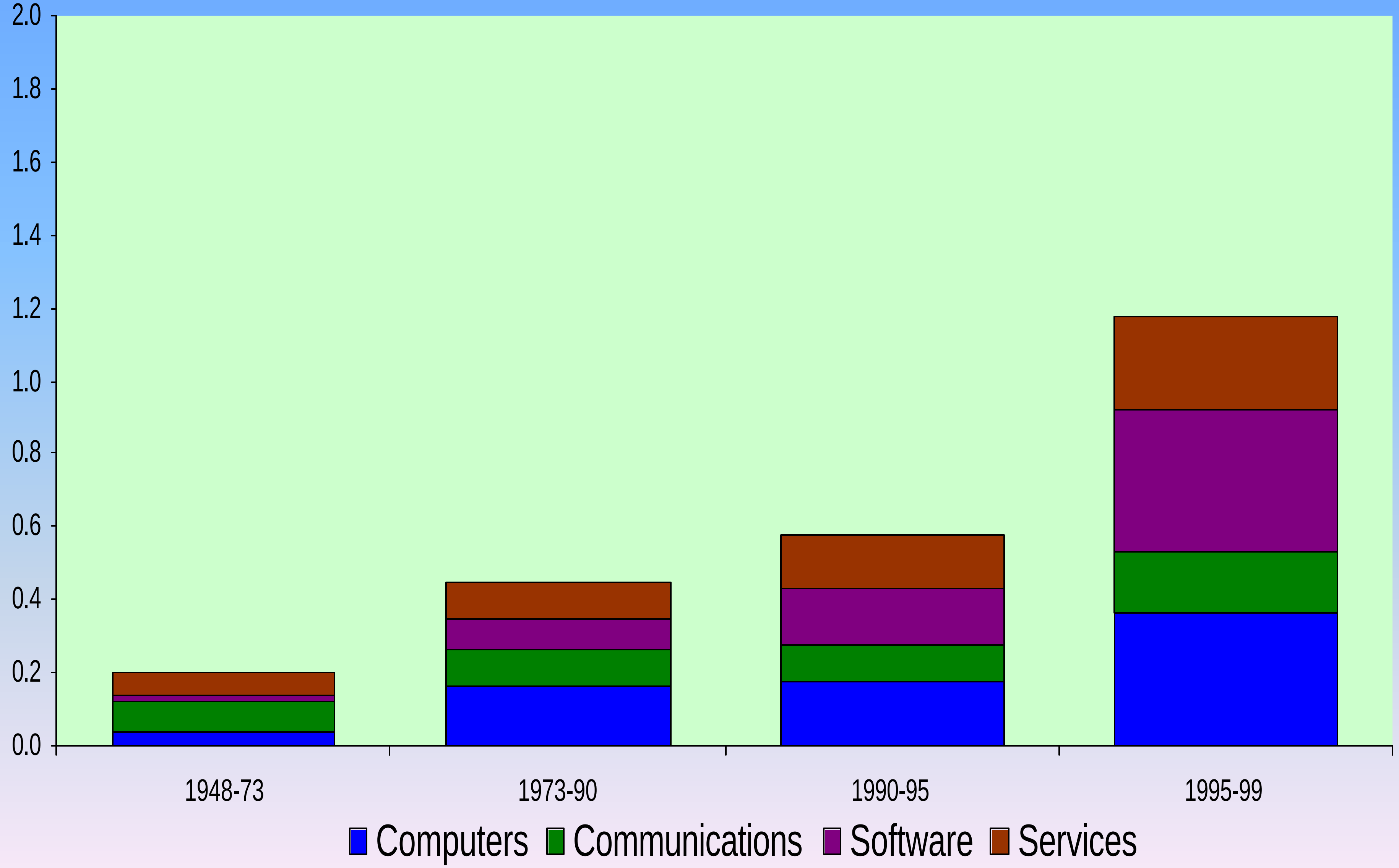
Computers, Communications Equipment, Software, and IT Services.

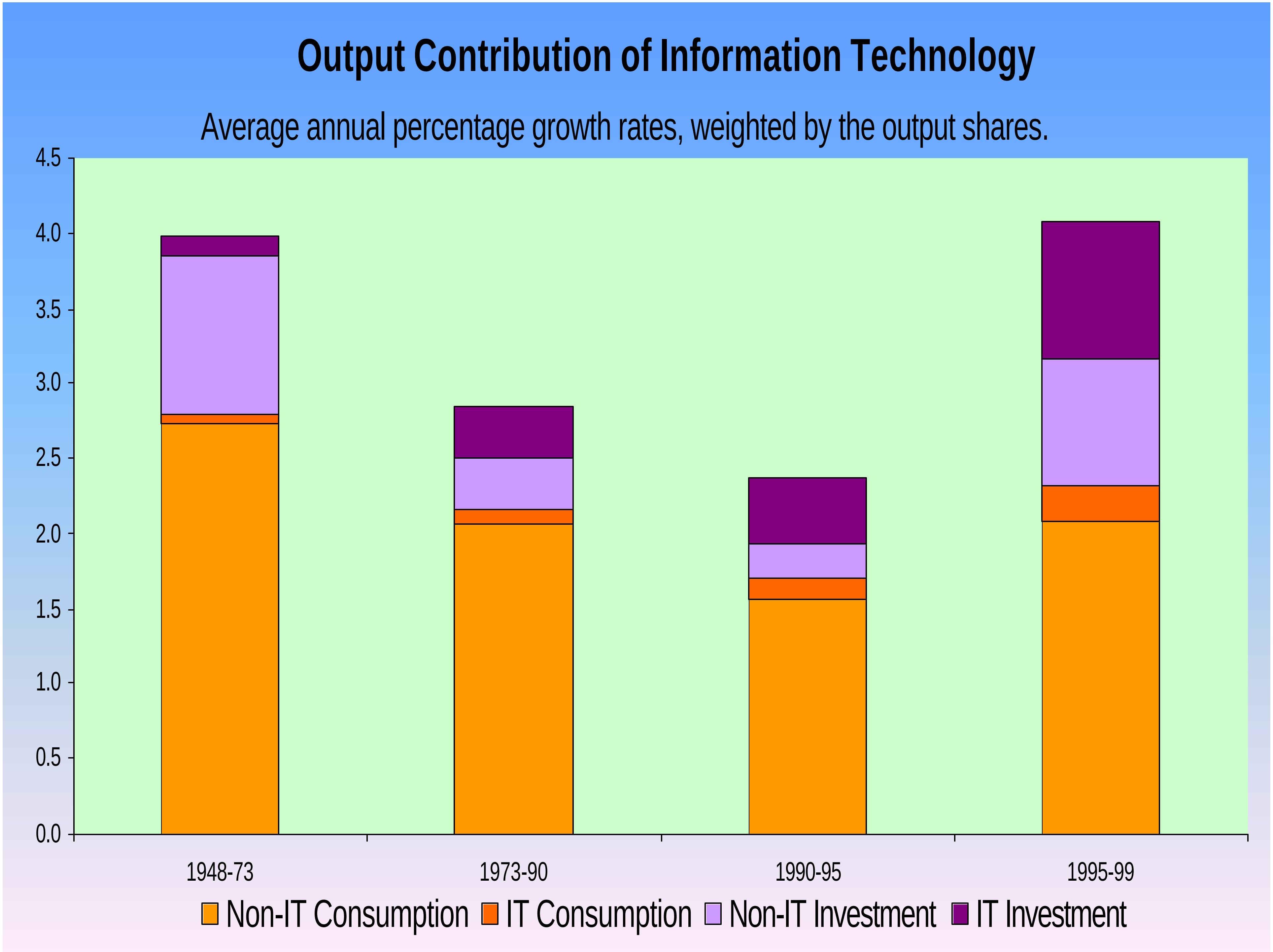


Output Shares of Information Technology by Type, 1948-99
Percentage share of current dollar gross domestic product.
0
1
2
3
4
5
6
7
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
Computers
Communications
Software
Services
Total

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.
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1948-73
1973-90
1990-95
1995-99
Non-IT Consumption
IT Consumption
Non-IT Investment
IT Investment

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

<u>PERPETUAL INVENTORY METHOD</u>

$$K_{i,t} = (1 - d_i) K_{i,t-1} + I_{i,t}$$

where:

K - capital stock

I – investment

δ - depreciation rate

<u>RENTAL PRICE OF CAPITAL INPUT</u>

$$c_{i,t} = [r_t - p_{i,t} + (1 + p_{i,t}) d_i] P_{i,t-1}$$

where:

c - price of capital input

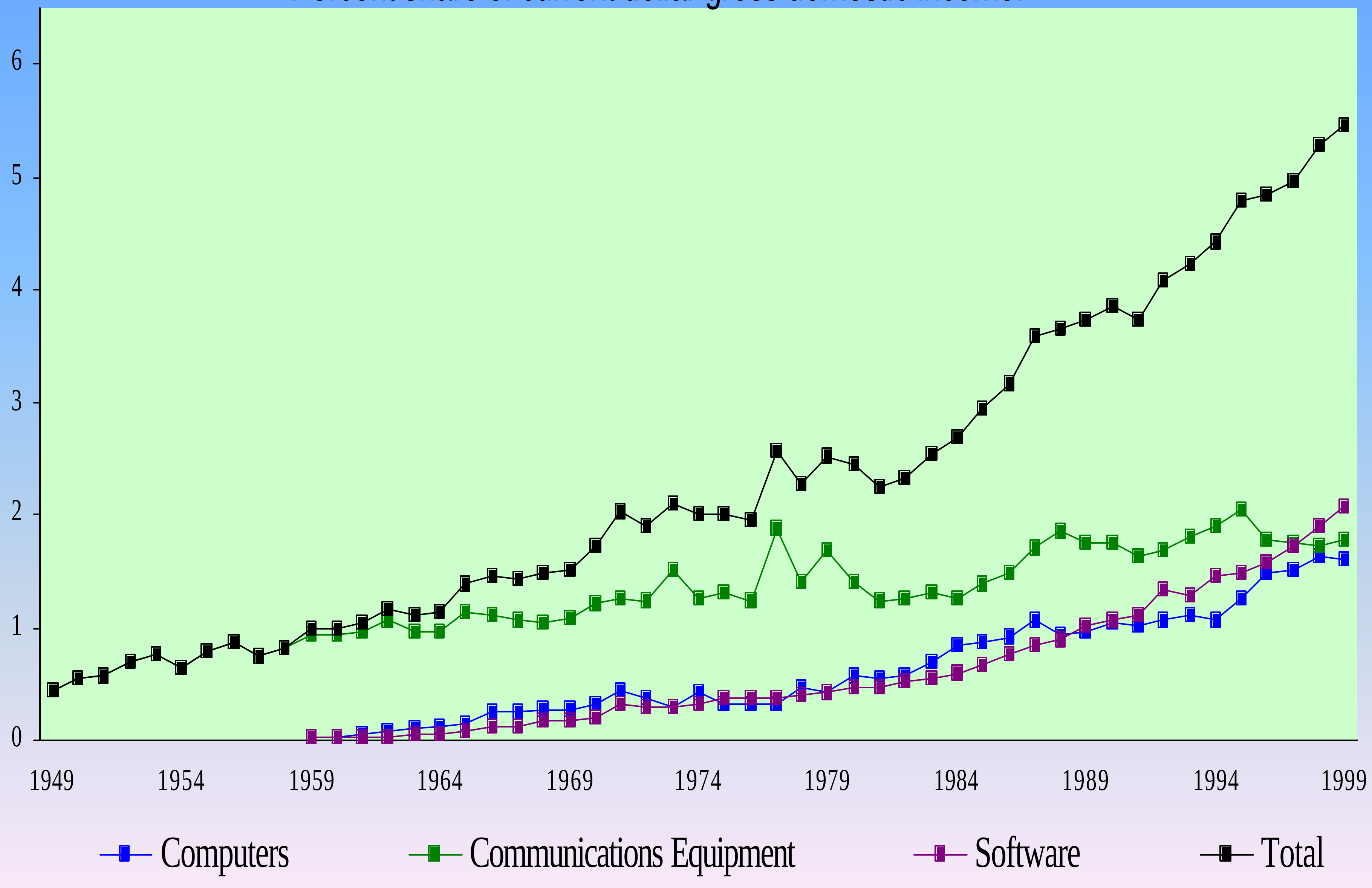
P - price of investment

r - rate of return

π - asset-specific inflation rate

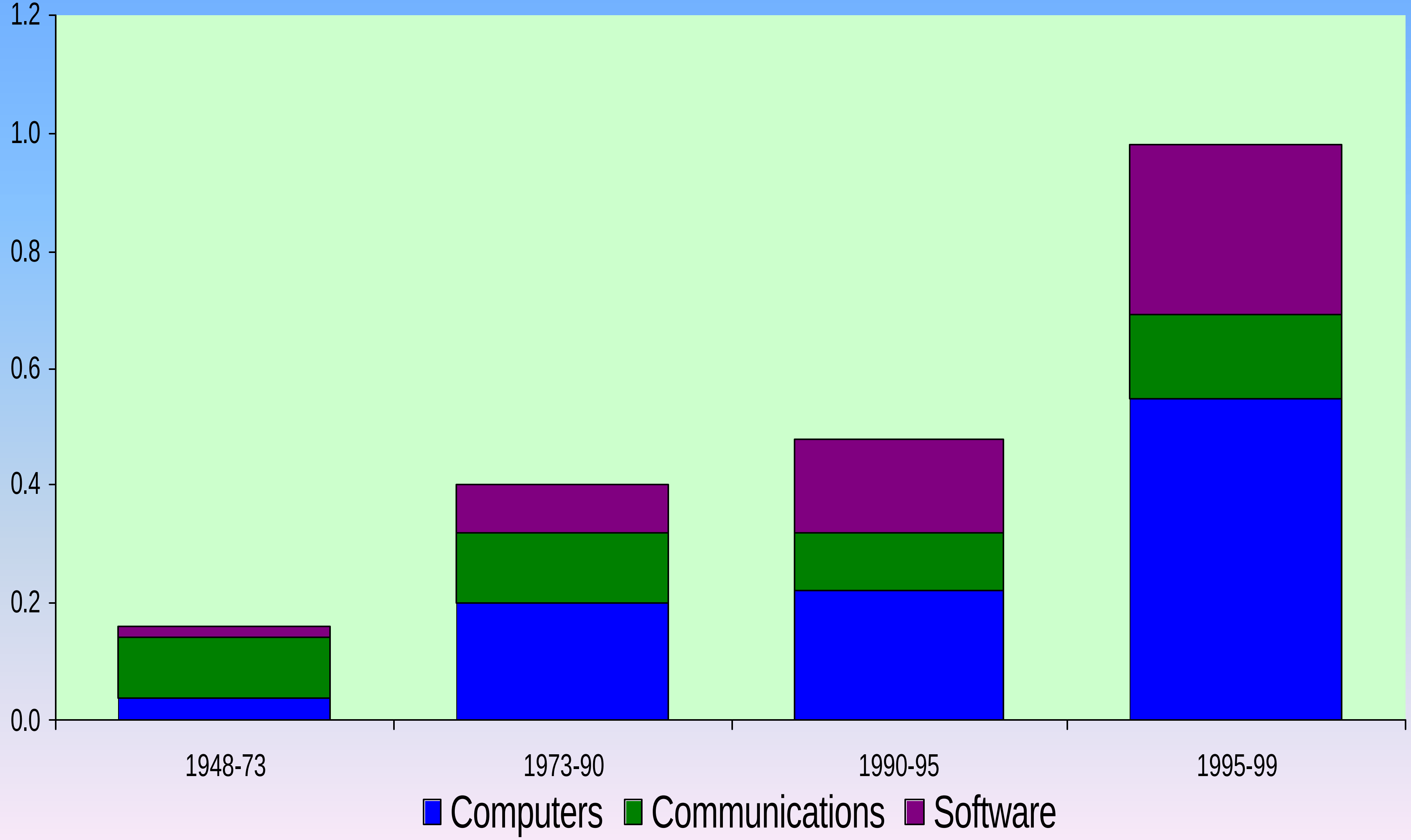
Input Shares of Information Technology by Type, 1948-99

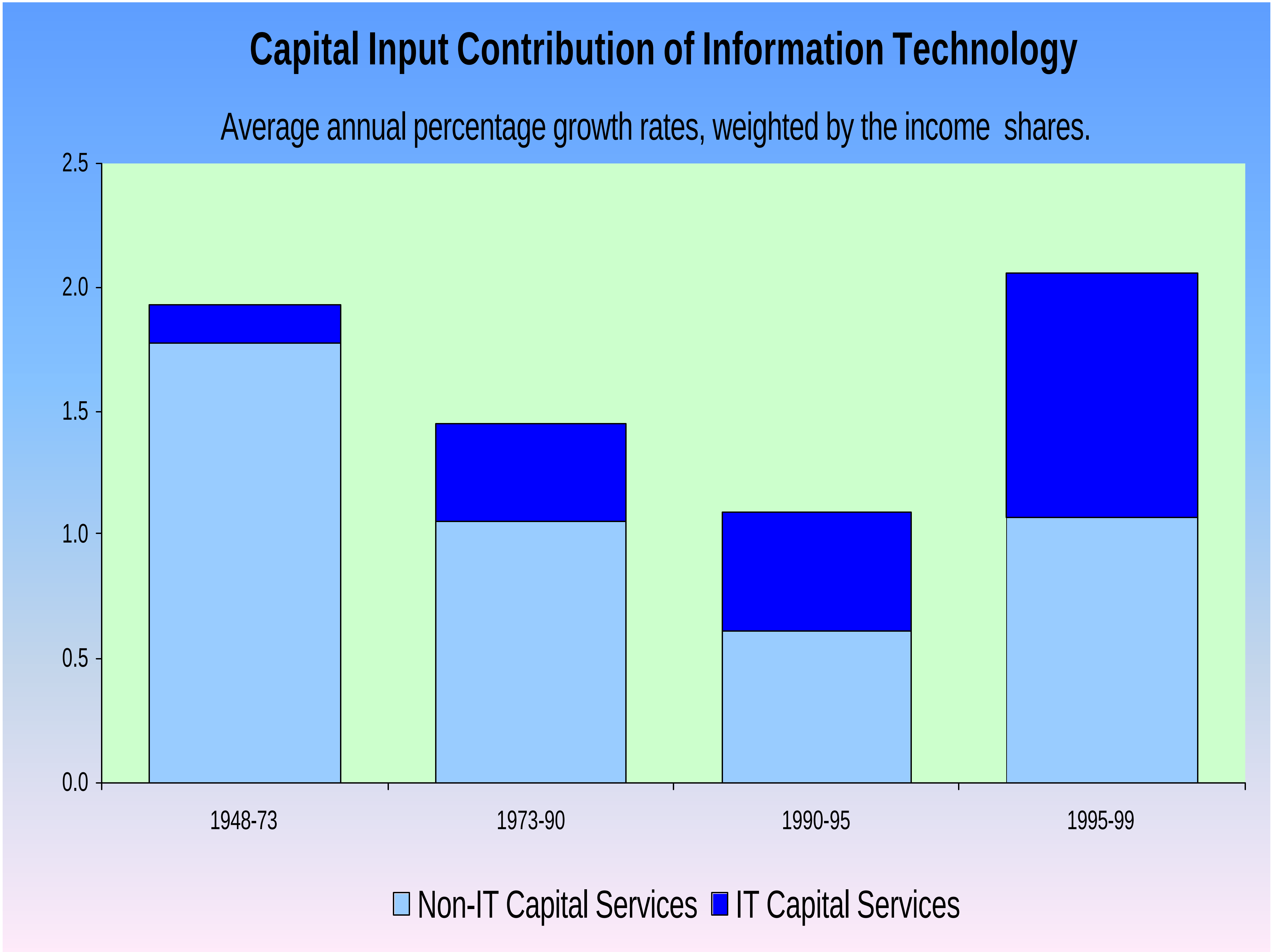
Percent share of current dollar gross domestic income.



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.
2.5
2.0
1.5
1.0
0.5
0.0
1948-73
1973-90
1990-95
1995-99
Non-IT Capital Services
IT Capital Services

AMERICAN GROWTH RESURGENCE: IT Investment and Productivity Growth.

<u>TOTAL FACTOR PRODUCTIVITY:</u>

IT-Production versus Non-IT Production.

<u>SOURCES OF U.S. ECONOMIC GROWTH:</u>

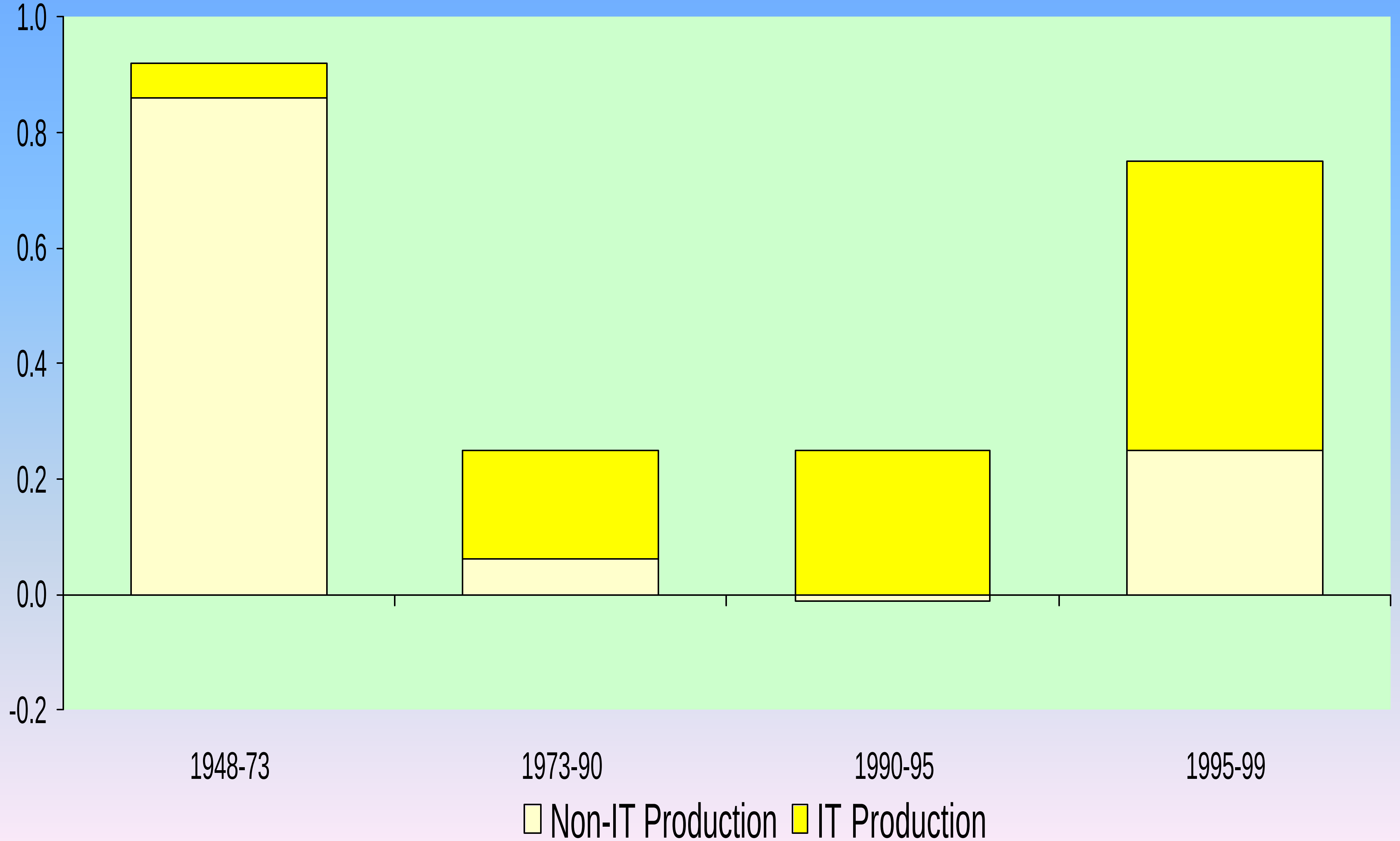
Capital Input, Labor Input, and TFP.

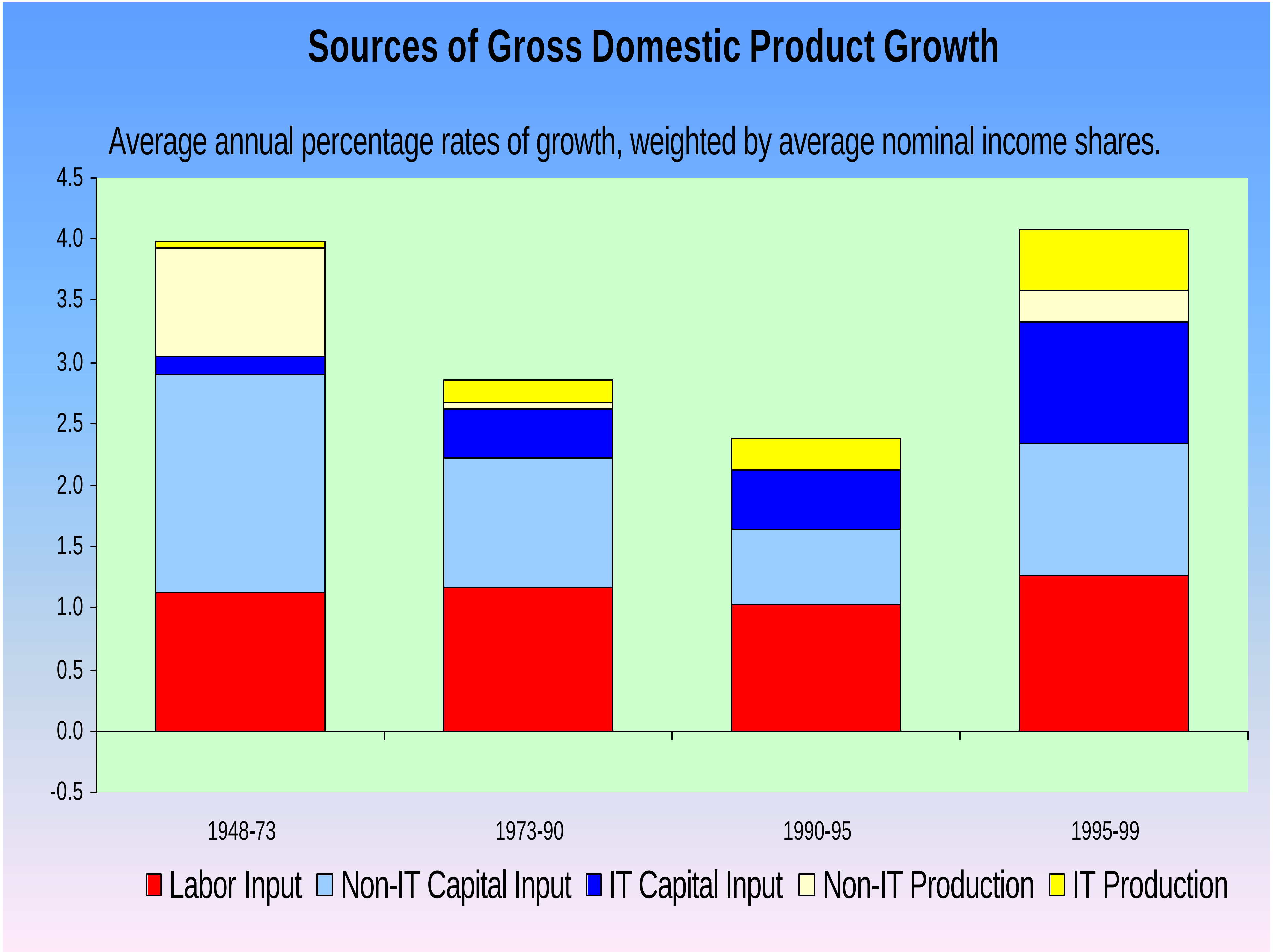
<u>AVERAGE LABOR PRODUCTIVITY GROWTH:</u>

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.
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
1948-73
1973-90
1990-95
1995-99
Labor Input
Non-IT Capital Input
IT Capital Input
Non-IT Production
IT Production

SOURCES OF AVERAGE LABOR PRODUCTIVITY GROWTH

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

where:

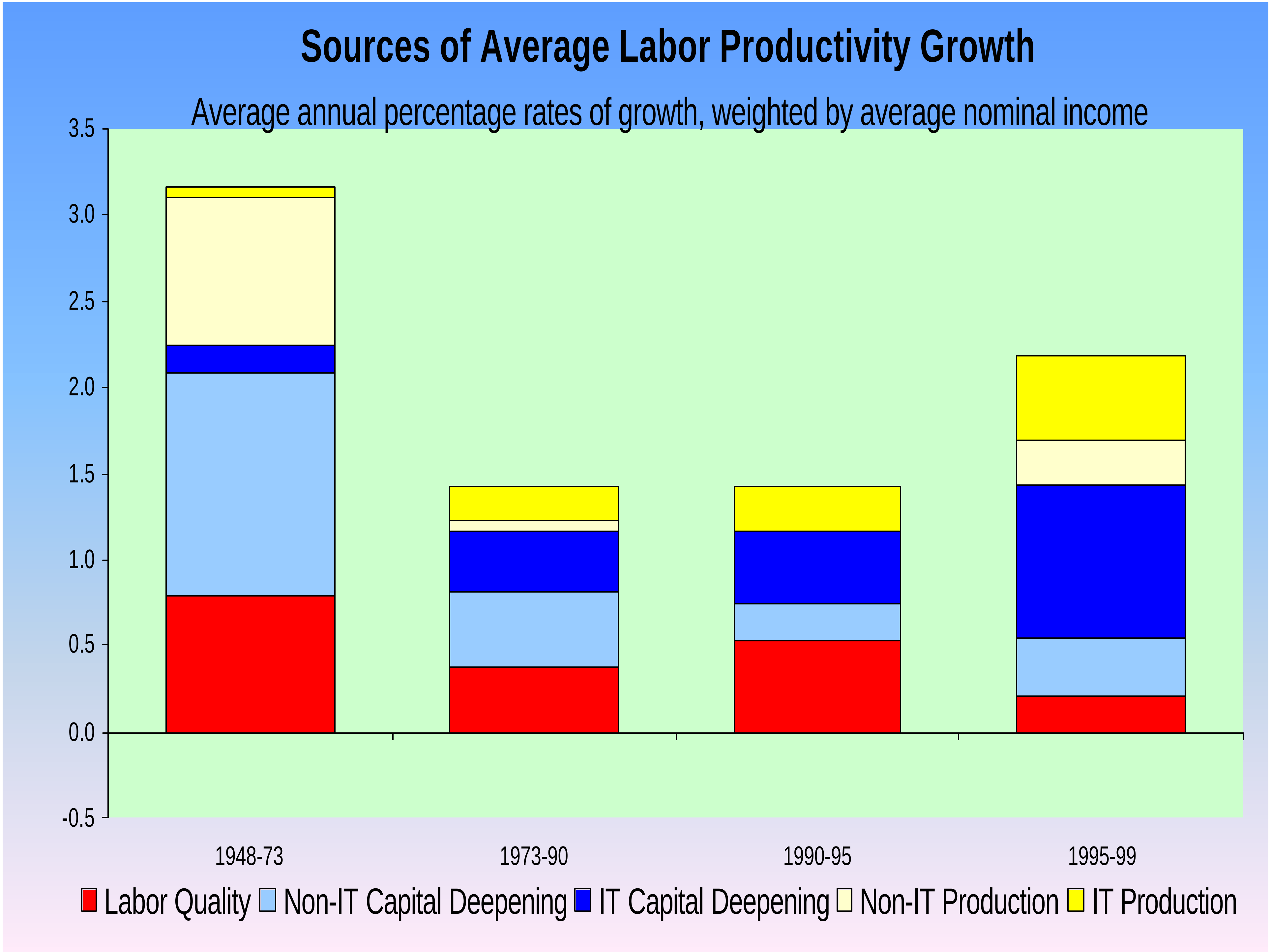
y = Y/H - Output per Hour Worked (ALP).

k = K/H - 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
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
1948-73
1973-90
1990-95
1995-99
Labor Quality
Non-IT Capital Deepening
IT Capital Deepening
Non-IT Production
IT Production

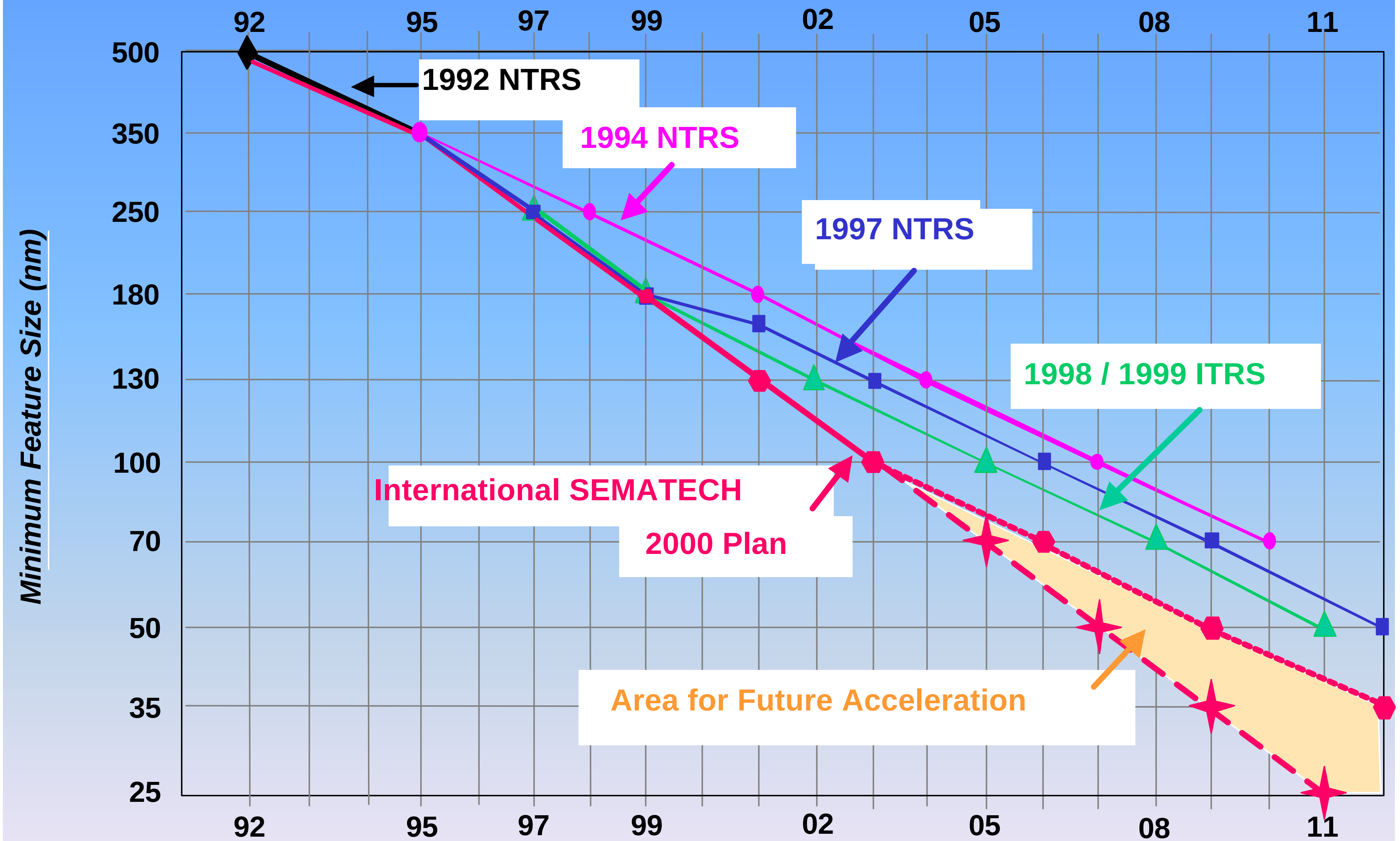
ECONOMICS ON INTERNET TIME:
The New Research Agenda.

•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.



Semiconductor Roadmap Acceleration

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