# Productivity growth in UK industries, 1970-2000: structural change and the role of ICT

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**This presentation is based on**

Oulton and Srinivasan (2004). "Productivity growth in UK industries, 1970-2000: structural change and the role of ICT". Mimeo.

Basu, Fernald, Oulton and Srinivasan [BFOS] (2004). "The case of the missing productivity growth: or, does information technology explain why productivity accelerated in the United States but not the United Kingdom?" NBER Working Paper no. 10010 and *NBER Macroeconomics Annual 2003* (Gertler and Rogoff, eds).

Oulton (2002). "ICT and productivity growth in the UK". Bank of England Working Paper no. 140 and *Oxford Review of Economic Policy*, 18, No. 3, 363-379.

# ROADMAP (1)

- Where does the UK stand vis-à-vis the US?
- The role of ICT capital in the UK:  lessons from growth accounting
- Testing the growth accounting assumptions econometrically
- Beyond growth accounting:  complementary investment

# ROADMAP (2)

- In the UK, serious measurement problems hinder a proper assessment. But the UK still appears to lag behind the US, particularly in software and telecoms.
- No productivity *improvement* in the UK, but productivity *growth* in the 1990s more rapid than in the US.
- ICT investment has played a major role in productivity growth in the 1990s, according to both growth accounting and econometrics.
- Some evidence that underlying UK performance is *better* that it seems, due to the "masking effect" of complementary investment

# Bank of England Industry Dataset

- KLEMS framework
- 34 industries, covering whole economy (31 in market sector)
- For each industry,
- gross output
- value added
- intermediate input
- labour services
- capital services
- 3 types of ICT capital (computers, software, and telecoms)
- 4 types of non-ICT capital (equipment, buildings, vehicles and intangibles)
- Labour services: hours worked

# UK measurement issues

1. UK computer price index is unreliable. Solution: use US price index

2. The *level* of UK software investment (in current prices) is implausibly low

   *Suggested corrections*

   | | |
   |---|---|
   | Multiply by 3 | Oulton (BoE WP, 2001) |
   | Multiply by up to 10! | Ahmad *et al* (OECD WP 2003/5, 2003) |

3. There is **no** UK price index for software (and the US index leaves a lot to be desired)

# Consistency with national accounts

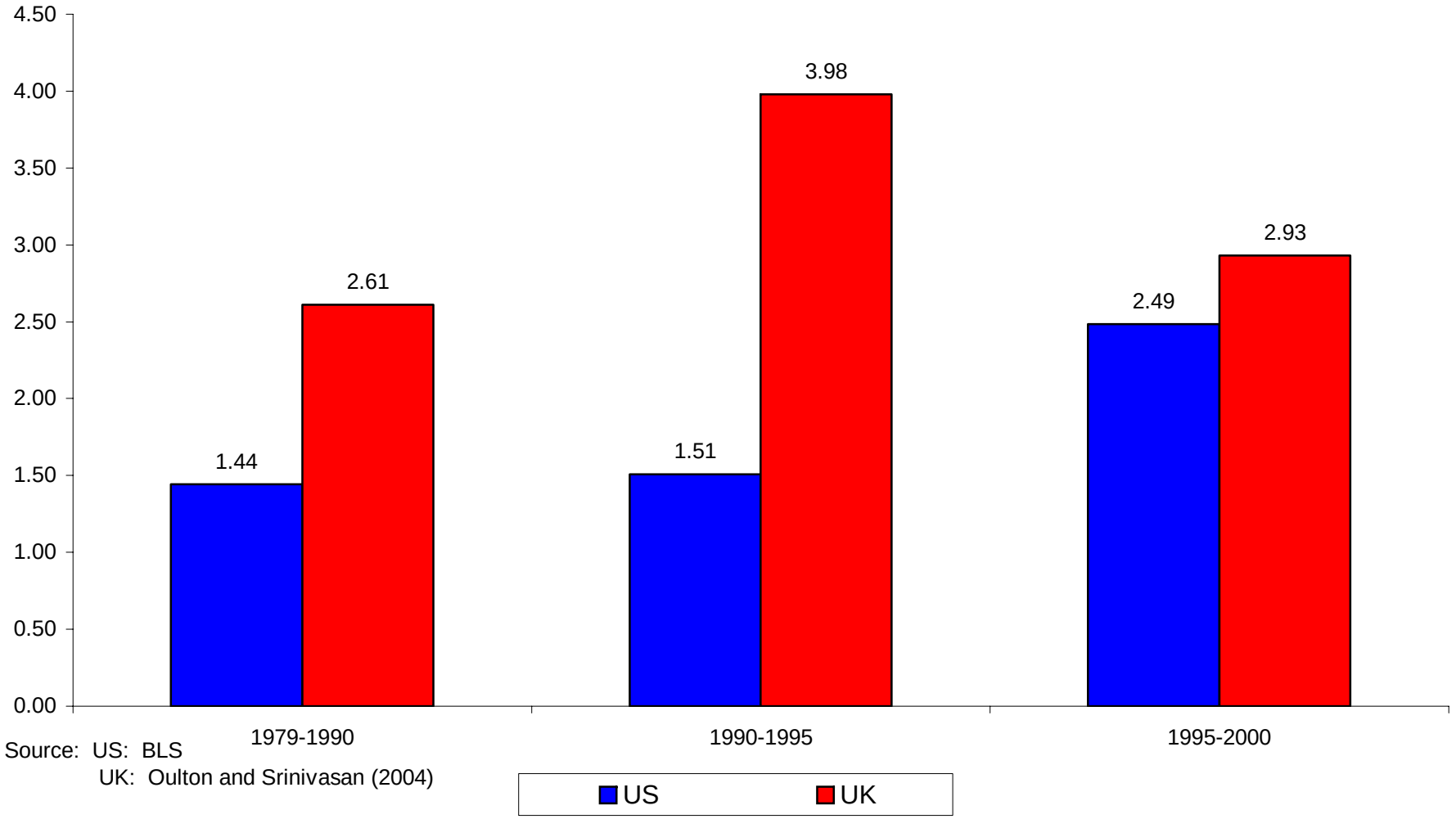
- *Prior to adjustments*, the dataset is consistent with the 2002 national accounts in both *nominal* and *real* terms

- Adjustments:

  (1) Using US price indices for computers and software increases output growth in ICT-producing industries

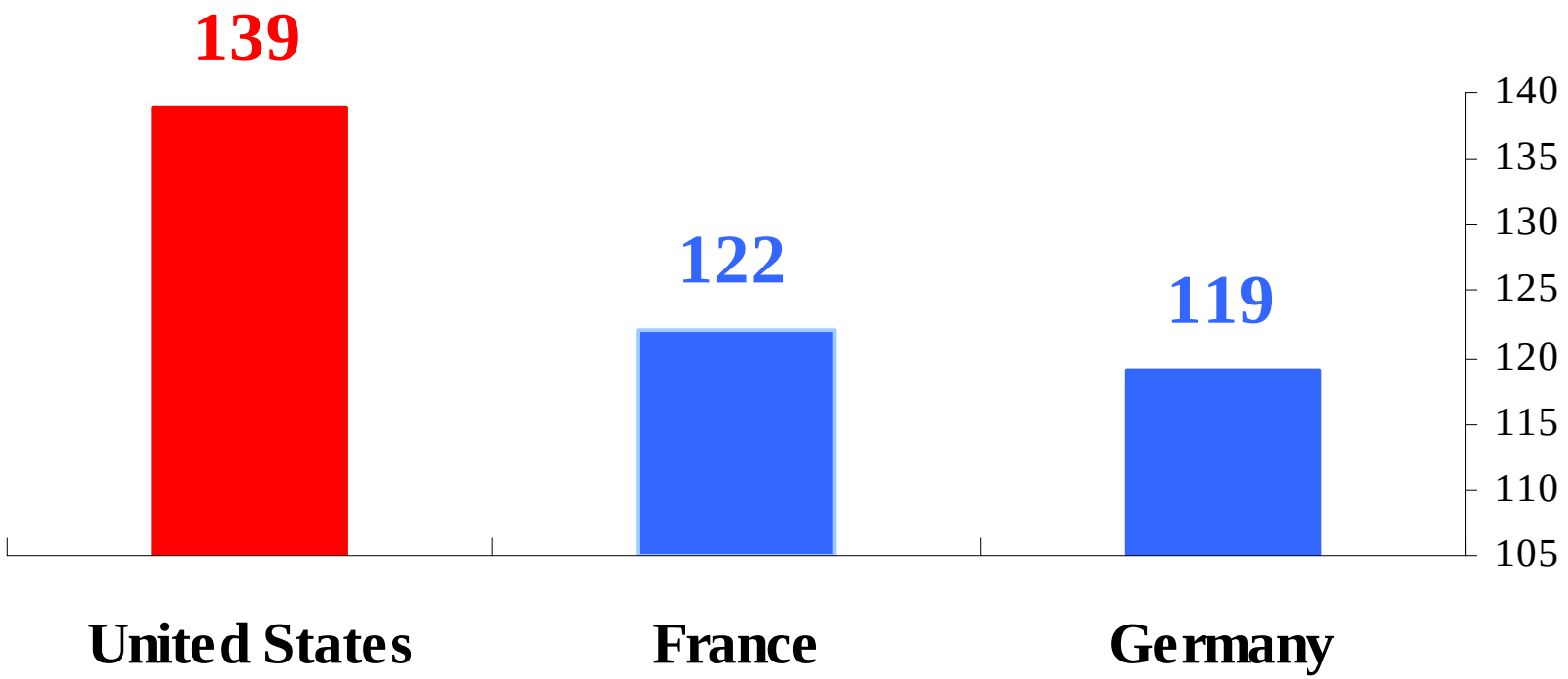
  (2) "Times 3" adjustment to software investment changes profits and value added in all industries, so changes weights in calculating aggregate TFP. Also, it raises level and growth rate of GDP

# Growth of output per hour, % pa
# (US: nonfarm business sector UK: market sector)




Source: US: BLS
UK: Oulton and Srinivasan (2004)

## Labour Productivity in the Market Sector, 1999
## (U.K.=100)
**(Source: O'Mahony and de Boer (2002))**



# Labour productivity growth and its components in the UK market sector: average annual growth rates, per cent per annum

| | Output per hour worked | Physical capital deepening | Human capital deepening | Solow residual |
|---|---|---|---|---|
| *Period* | (1) | (2) | (3) | (4) |
| 1979-1990 | 2.61 | 1.59 | 0.41 | 0.61 |
| 1990-2000 | 3.45 | 1.93 | 0.65 | 0.88 |
| | | | | |
| 1990-1995 | 3.98 | 1.72 | 0.83 | 1.42 |
| 1995-2000 | 2.93 | 2.13 | 0.47 | 0.33 |
| *Change* | *-1.04* | *0.41* | *-0.36* | *-1.09* |

Source: Oulton & Srinivasan (2004)
Note: (1) = (2) +(3) + (4)

# Contributions to growth of labour productivity, UK market sector, % of total

| *Period* | **ICT capital** | Non-ICT capital | Human capital | Solow residual | Total |
|---|---|---|---|---|---|
| 1979-1990 | **26.5** | 34.5 | 15.6 | 23.4 | 100.0 |
| 1990-2000 | **28.2** | 27.7 | 18.8 | 25.3 | 100.0 |
| | | | | | |
| 1990-1995 | **15.0** | 28.4 | 20.9 | 35.7 | 100.0 |
| 1995-2000 | **46.1** | 26.7 | 16.0 | 11.3 | 100.0 |
| | | | | | |
| *Change* | **+31.1** | *-1.7* | *-4.9* | *-24.5* | |

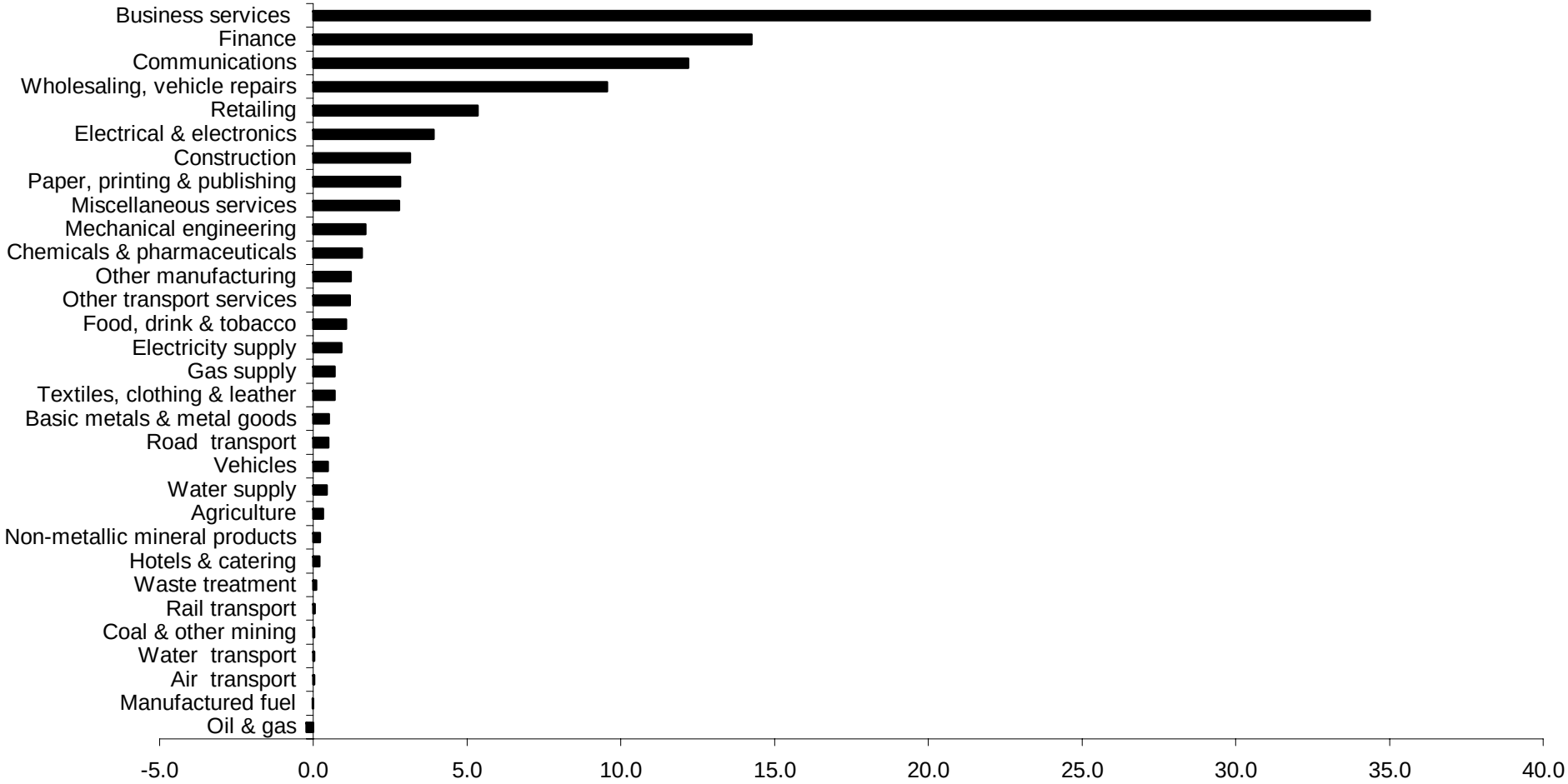
Source: Oulton and Srinivasan (2004)

# Proportion of physical capital deepening accounted for by ICT (per cent)

| ***Period*** | |
|---|---|
| **1970-1979** | **25.0** |
| **1979-1990** | **43.4** |
| **1990-2000** | **50.5** |
| | |
| **1990-1995** | **34.5** |
| **1995-2000** | **63.3** |
| ***Change*** | ***28.8*** |

Source: Oulton & Srinivasan (2004)

## Contributions to ICT capital deepening, 1990-2000: per cent of total




Source: Oulton and Srinivasan (2004)

# Assuming the conclusion?

# Objections to growth accounting

- Dotcom bust?
- Long lags?
- Externalities?

**Our approach**

- Test growth accounting econometrically
- Complementary investment and capital

## Testing the growth accounting assumptions

Panel model:

$$\textit{Growth of value added per hour worked}_{it} =$$

$$\textit{gamma}*\textit{Capital deepening}_{it} + \textit{Error}_{it}$$

According to growth accounting, ***gamma* = 1**

[NB: Capital deepening = capital income share *times* growth of capital services per hour]

**Panel regression test of growth accounting assumptions: dependent variable is growth of real value added per hour**

*Hours growth, time dummies and fixed effects also included; N = 30, T=10 (1990-2000)*

| | *Length of period (years)* | | | | |
|---|---|---|---|---|---|
| *Independent variable* | One | Two | Three | Four | Five |
| ICT capital deepening | 0.850* | 1.374** | 1.521** | 1.618** | 1.646** |
| | (0.406) | (0.320) | (0.290) | (0.290) | (0.304) |
| | | | | | |
| Non-ICT capital deepening | 0.573** | 0.655** | 0.730** | 0.745** | 0.659** |
| | (0.139) | (0.120) | (0.117) | (0.120) | (0.126) |

# What is complementary investment?

- Expenditure incurred in getting ICT projects to work, eg
  - retraining the workforce
  - consultancy services
  - managerial time devoted to restructuring the organisation
- The national accounts treat this as intermediate consumption, like office stationery (and software prior to ESA95)
- 3 to 4 times the cost of computers and software
- If it improves the ability to absorb new ICT, it's investment

# Complementary investment and capital: theory

Measured TFP growth =

Complementary capital deepening

*minus*

Complementary investment deepening

*plus*

True TFP growth

# Complementary investment and capital: intuition

*Assume that both complementary capital and complementary investment are growing faster than other inputs*

Then

1. Omitting complementary *capital* **raises** the measured TFP growth rate

2. Omitting complementary *investment* **lowers** the measured TFP growth rate

# How large is the bias in conventional TFP?

- The bias may be positive or negative

- BUT in a boom, the bias ***falls,*** ie if it was zero before it becomes ***negative*** now, so

  **TFP appears to fall**

- Reason: in a boom, ***investment grows more rapidly than capital***

**Change in bias in conventional TFP measure, following on change in desired growth rate of complementary capital: simulation**

Assumptions:
(1) complementary investment is 4 times ICT investment
(2) depreciation rate of complementary capital is 13%

# Change in TFP bias

| *Increase in desired growth rate of complementary capital* | |
|---|---|
| From 3% to 5% p.a. | **-0.23 % pa** |
| From 10 to 20% p.a. | **-0.72 % pa** |

# Test of complementary investment hypothesis: dependent variable is *change* in TFP growth, 1995-2000 over 1990-1995

| *Independent variables* | (1) |
|---|---|
| Change in ICT capital deepening | 2.110** |
| | (0.890) |
| Change in ICT investment deepening | — |
| Constant | -1.239** |
| | (0.350) |
| $R^2$ | 0.197 |
| *N* | 29 |

# Test of complementary investment hypothesis: dependent variable is *change* in TFP growth, 1995-2000 over 1990-1995

| *Independent variables* | (1) | (2) |
|---|---|---|
| Change in ICT capital deepening | 2.110** | 4.827** |
| | (0.890) | (1.093) |
| Change in ICT investment deepening | — | -1.769** |
| | | (0.422) |
| Constant | -1.239** | -1.303** |
| | (0.350) | (0.299) |
| $R^2$ | 0.197 | 0.423 |
| *N* | 29 | 29 |

# Conclusions

- In a growth accounting sense, ICT capital deepening accounts for **28**% of the growth of labour productivity in the 1990s, and for **46**% of growth over 1995-2000.

- Econometric analysis does not contradict this assessment.

- TFP growth apparently fell, comparing 1995-2000 with 1990-1995.

- But econometric analysis suggests that conventionally measured TFP growth was biased downwards in 1995-2000, due to failure to account properly for complementary investment. So underlying performance may have been better than measured.

# THE END

# How does the UK stand vis-à-vis the US?

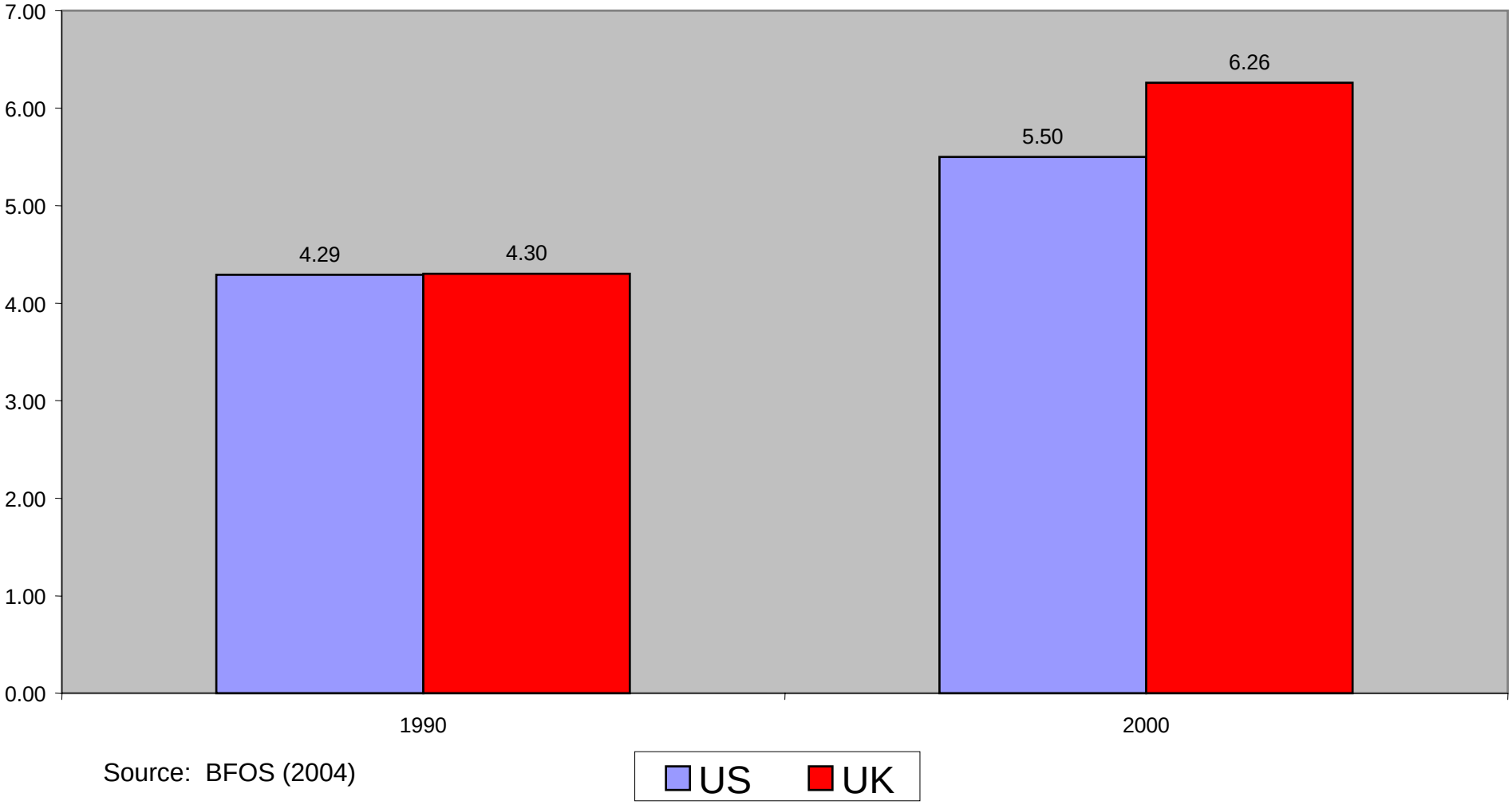
Two measures are important:

1. Income share of ICT capital

   [profit generated by ICT capital as % of nominal GDP]

2. ICT stocks per capita

## Income shares of ICT capital in private nonfarm GDP (per cent)




Source: BFOS (2004)

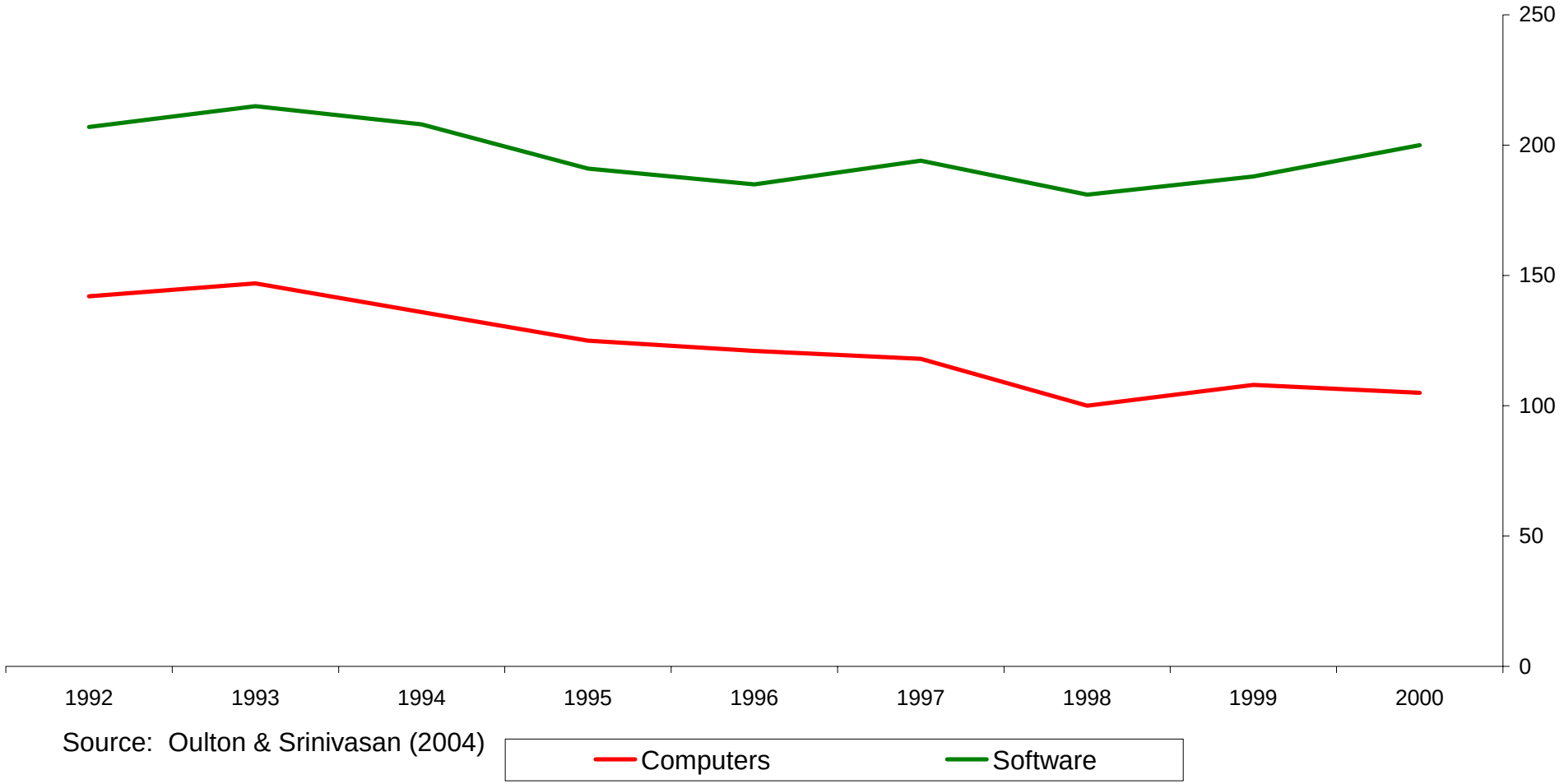
UK software investment multiplied by 3!

# Income shares of ICT capital services, UK market sector, per cent

| | |
|---|---|
| **1970-1979** | **1.80** |
| **1979-1990** | **3.05** |
| **1990-2000** | **5.16** |
| | |
| **1990-1995** | **4.33** |
| **1995-2000** | **6.03** |
| ***Change*** | ***+1.70*** |

UK software investment multiplied by 3!

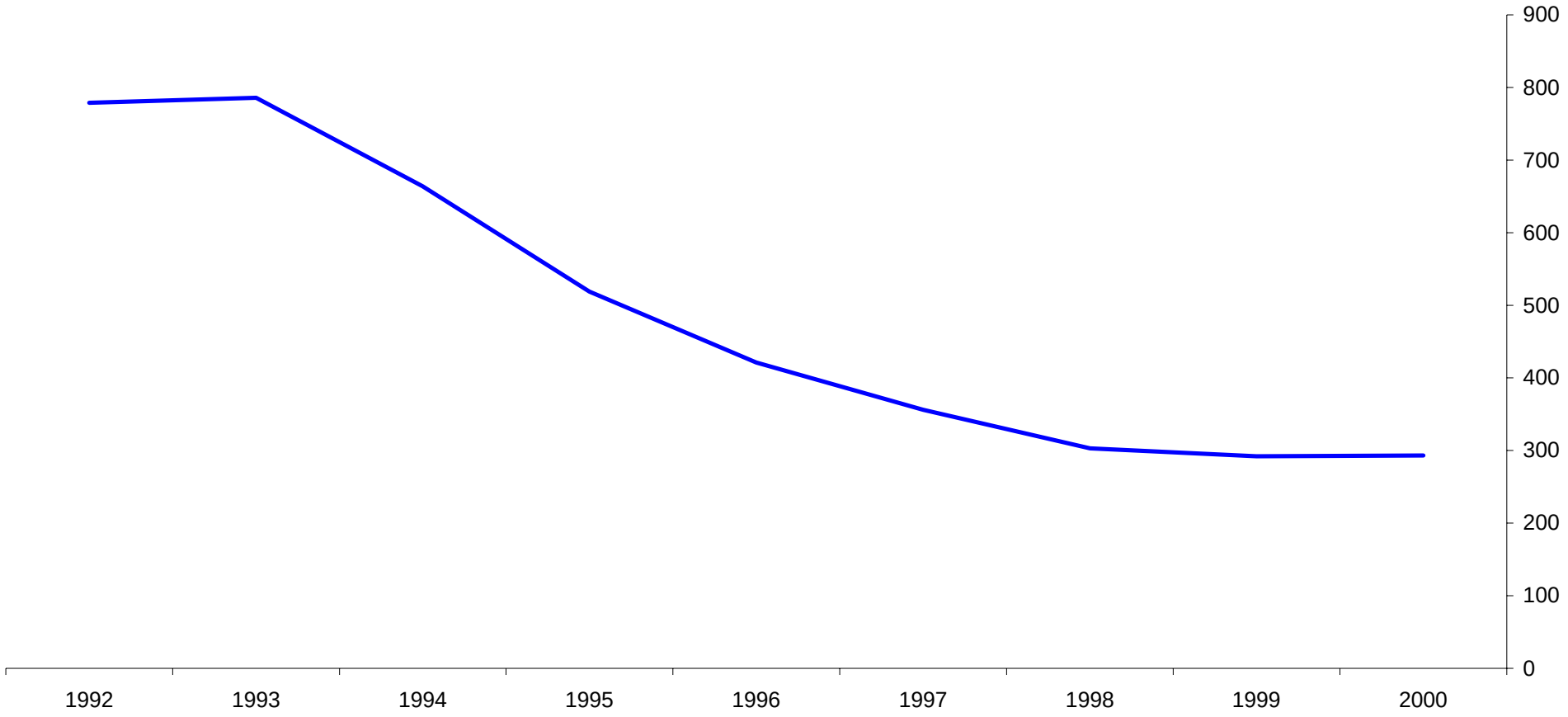
## Ratio of US ICT stocks per capita to UK ICT stocks per capita (UK=100)




Source: Oulton & Srinivasan (2004)

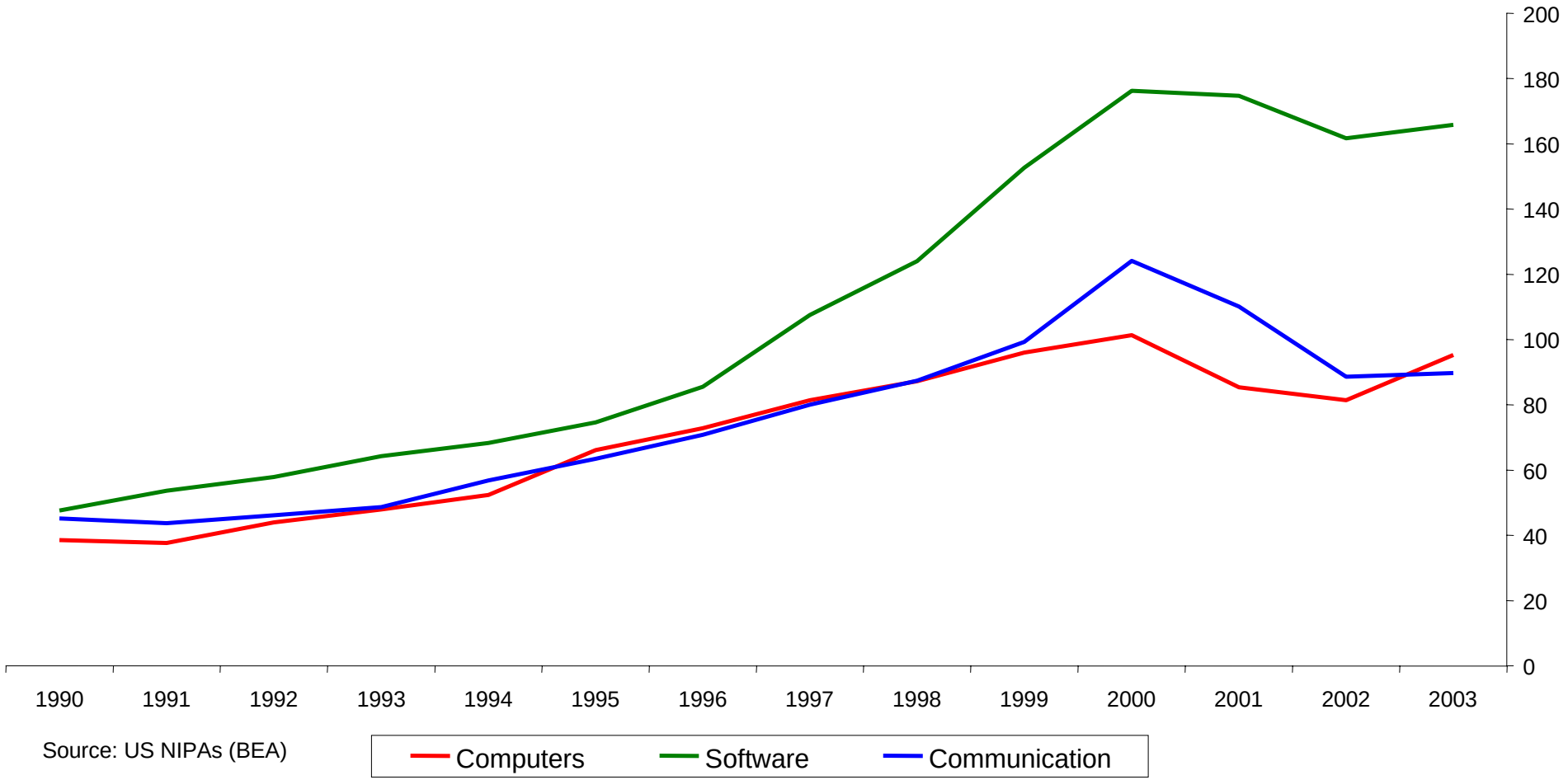
UK software investment multiplied by 3!

## Ratio of US communication equipment stock per capita to UK stock per capita (UK=100)



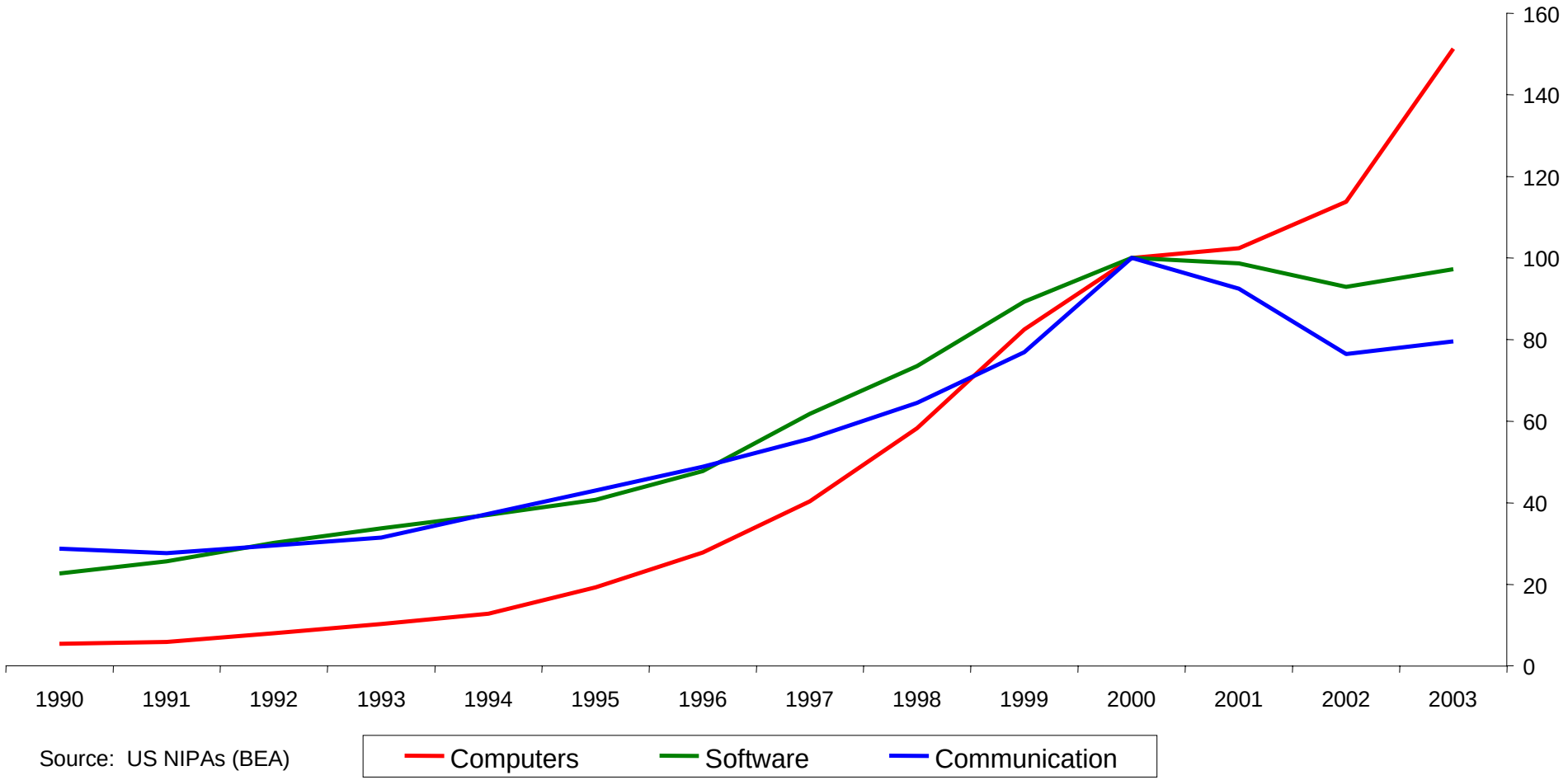

Source: Oulton & Srinivasan (2004)

# Private investment in ICT in the US: $billion, current prices



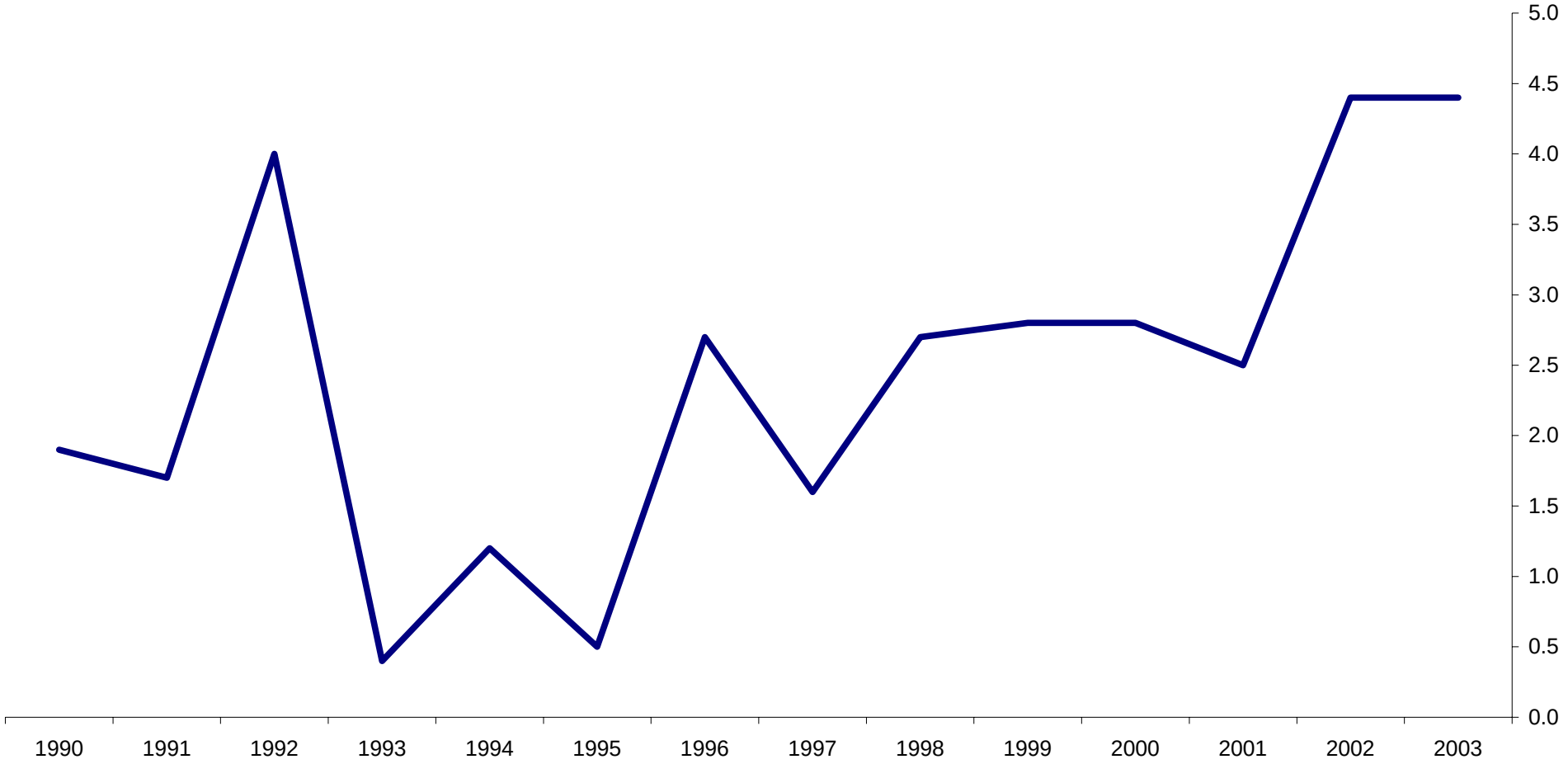

Source: US NIPAs (BEA)

# Private investment in ICT in the US: index numbers, 2000=100



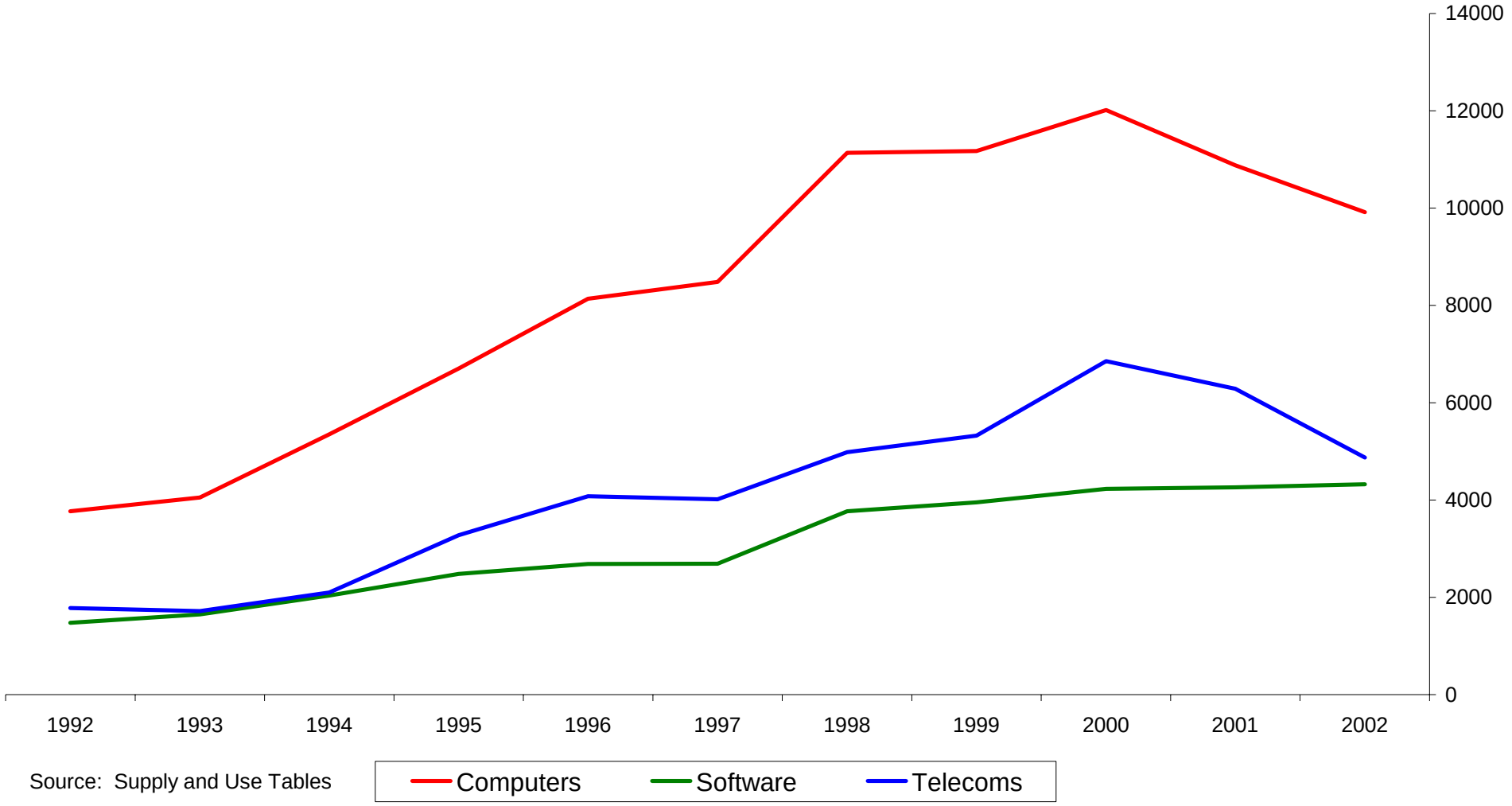

Source: US NIPAs (BEA)

## Growth of output per hour, US nonfarm business sector, % pa



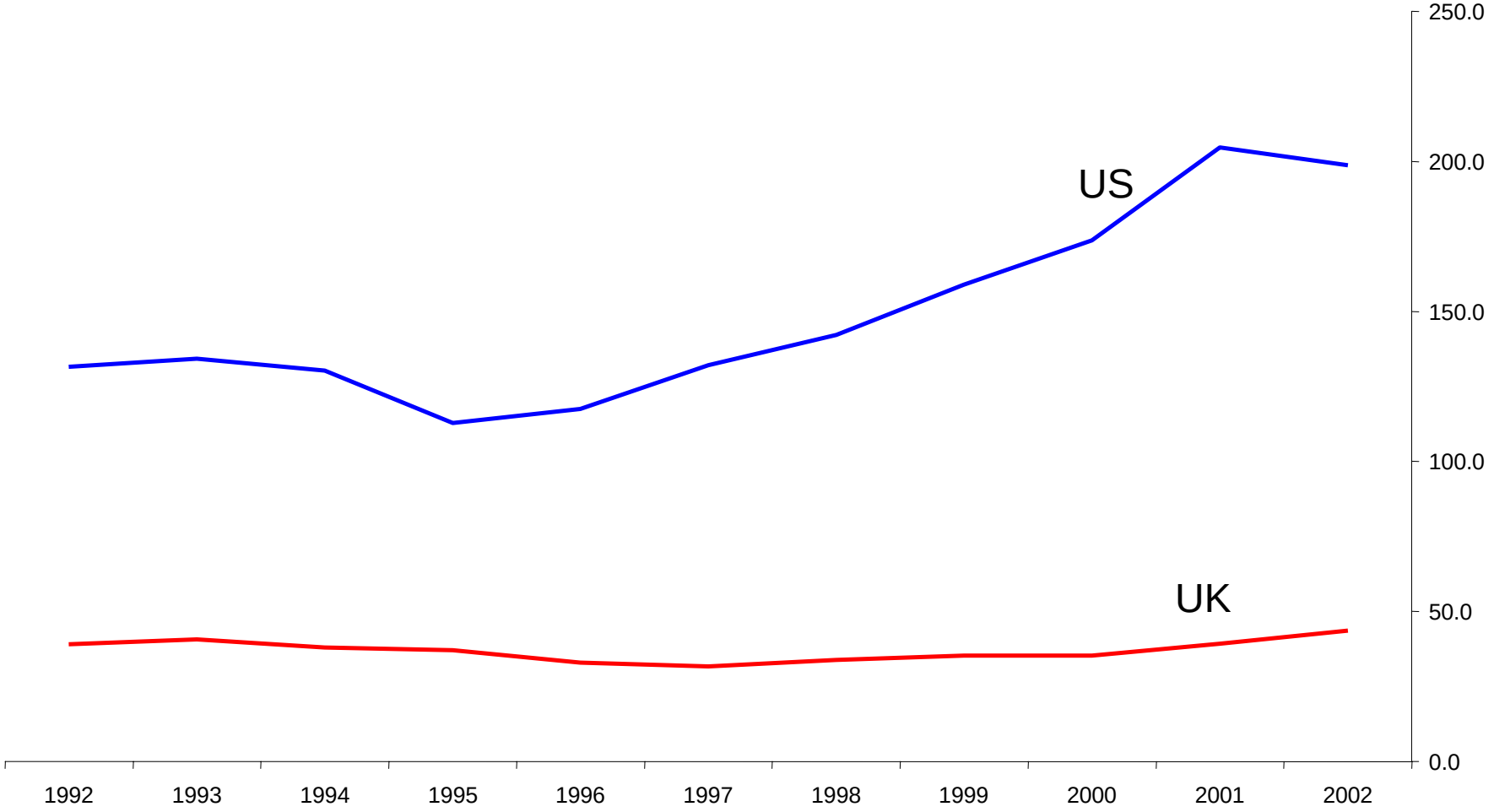

Source: BLS

# ICT investment in the UK market sector
## £m, current prices




Source: Supply and Use Tables

# Software investment as a percentage of computer investment
# (US: private sector  UK: market sector)




Source:  US NIPAs and UK SUTs