

**RESEARCH AND DEVELOPMENT
IN INFORMATION AND COMMUNICATION TECHNOLOGIES
IN THE MAJOR INDUSTRIAL COUNTRIES**

STATISTICAL ANALYSIS OF INVESTMENT

SUMMARY

**Canada, South Korea, United States, Japan, European Union
(including Germany, Finland, France, United Kingdom, and Sweden)
and main non-OECD countries**

February 2007

Study prepared for the
**French Ministry for Education, Higher Education and Research (Ministère de
l'Éducation Nationale, de l'Enseignement Supérieur et de la Recherche)**

by the

French Association of Electronic Information Industry
(Groupement Français de l'Industrie de l'Information: GFII)

in partnership with

M.V. Études et Conseil

Update of study prepared in 2003 and 2005 for the
Strategic Advisory Board on Information Technologies
(Conseil Stratégique des Technologies de l'Information: CSTI)
with the assistance of the
French Minister Delegate for Higher Education and Research
(Ministre délégué à l'Enseignement Supérieur et à la Recherche)

Methodological principles:

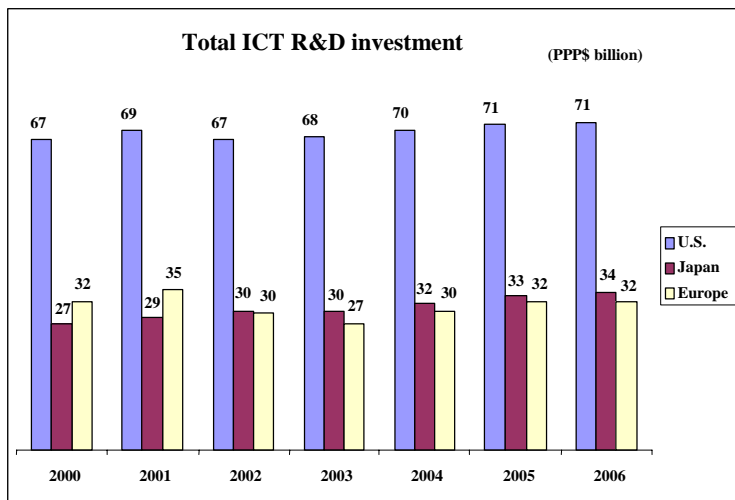
- The statistics on the nine OECD member countries (United States, Canada, Japan, South Korea, Germany, France, United Kingdom, Finland, and Sweden) are compiled from the OECD's general R&D statistics. The latest release (September 2006) corroborates the quantitative data up to the 2004 series. **As a result, the data provided for 2005 and 2006 are only estimates.** *Whenever we were unable to make assumptions about trends in either year, we simply applied the previous year's figure. Thus what may appear to be a "stagnant" indicator actually reflects this methodological bias.*

- Whenever we have had to use these data to build a structural indicator (such as ICT R&D spending per capita), we have taken the 2004 figures since they are the latest reliable data validated by OECD.

- Monetary values are expressed in U.S. dollars on a Purchasing Power Parity basis (PPP\$). The reason is that international comparisons need to be expressed not in terms of nominal currency units (\$ or €) but in PPP terms, which reflect a currency's real strength. OECD prepares annual tables for converting local currencies into PPP\$.

- Unless otherwise indicated, "Europe" or "European Union" refers to the 25-member Union (EU25).

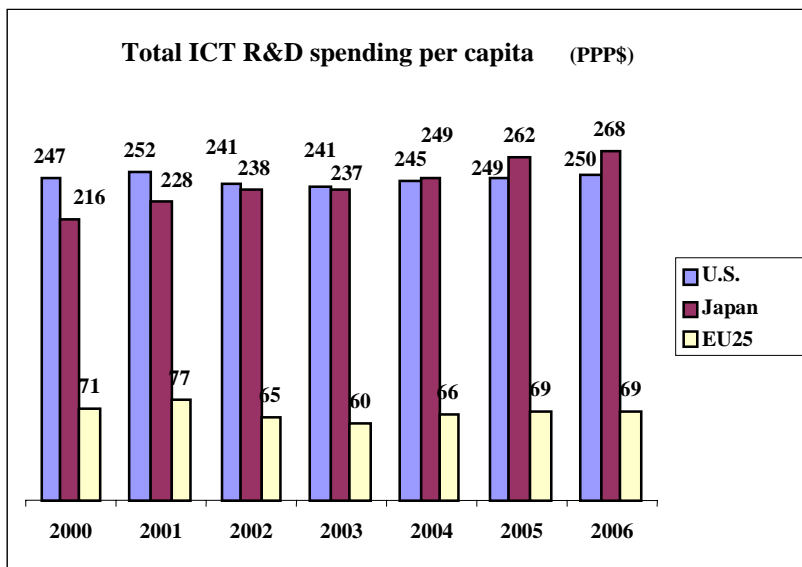
1 – In absolute-value terms, U.S. investment in ICT R&D is more than double that of Europe and Japan



→ In absolute-value terms, total **ICT R&D investment in the U.S.** (\$67 billion in 2000, \$71 billion in 2006) is consistently **more than double that of the EU25** (ca. \$32 billion).

Between 2000 and 2005, the **U.S./Europe gap has widened by 11.4%**. Europe now also lags Japan, which was not the case in 2000.

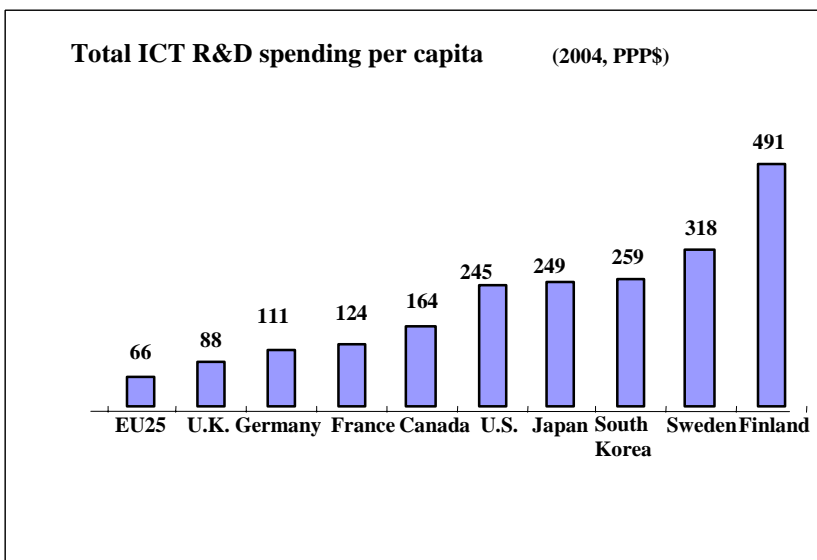
2 – ICT R&D intensity in Europe is almost four times weaker than in the United States and Japan, in terms of spending per capita



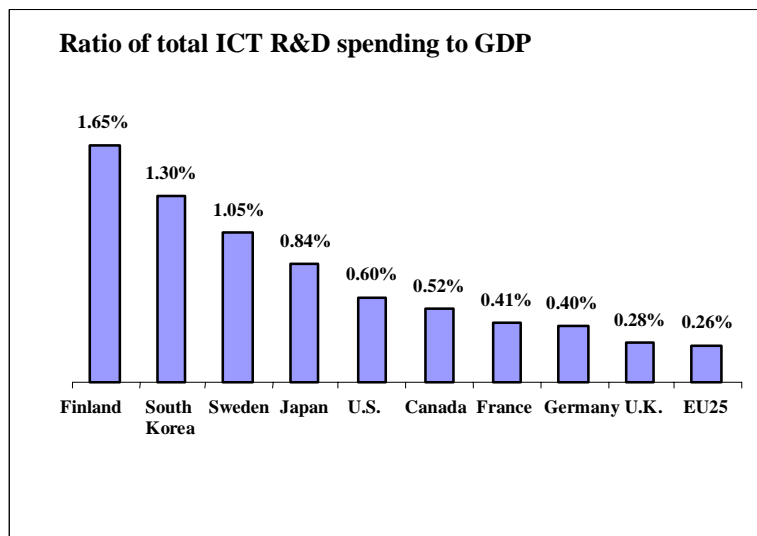
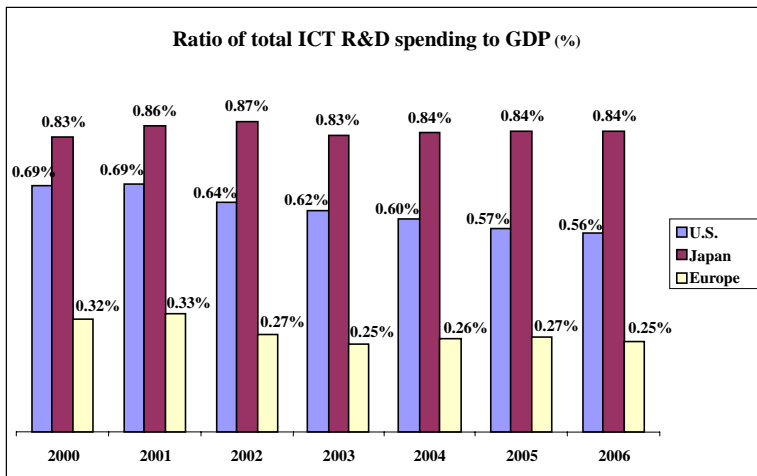
→ **Japan and the United States spend between PPP\$250 and PPP\$268 per capita on ICT R&D, versus Europe's PPP\$69** (2006 values). While this per-capita figure is fairly stable in the U.S., it rose 24% in Japan between 2000 and 2006. In the EU25, it declined 2.8% between 2001 and 2006.

→ **ICT R&D spending per capita is highly variable:** we find a 1:7.4 ratio between the lowest value (EU25 average) and the very high value observed in Finland. On this criterion, Europe displays strong heterogeneity.

The major EU economies (France, Germany, United Kingdom) register values above the EU25 average; however, these amounts are less than half those of the United States, Japan, and South Korea.



ICT R&D intensity measured by the ratio of ICT R&D to GDP is more than 2-3 times lower in Europe than in the United States and Japan



2004 data

→ The same findings are true of the ratio of ICT R&D to GDP, but here the EU25/U.S. ratio exceeds 1:2, and the EU25/Japan ratio exceeds 1:3.

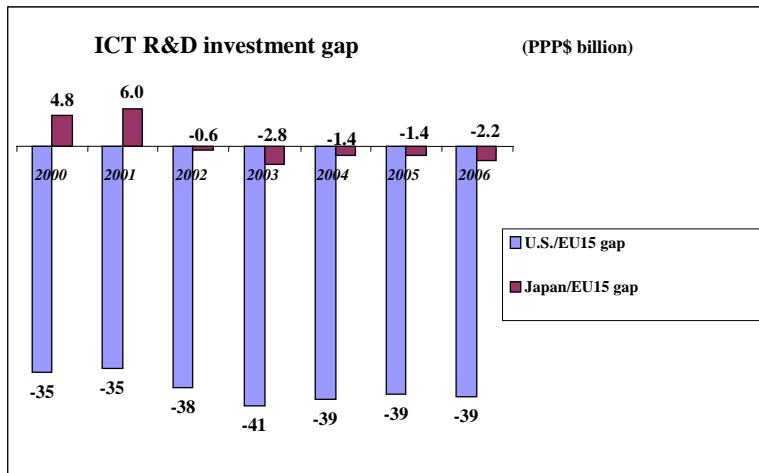
We also note that the ratio is declining both in the U.S. and Europe: in 2000-2006, the intensity measured by the ratio fell 18.8% in the U.S. and 21.8% in Europe. Only Japan is maintaining a high level at 0.84%.

Here as well, we find an extreme variability for the ICT R&D/GDP ratio among the nine countries studied, including in the EU25. The EU25 average is a weak 0.26%, whereas Finland (1.65%) and Sweden (1.05%) are among the three countries scoring above 1%.

3 – The ICT R&D intensity gap in Europe’s disfavour is wider than the gap in total R&D

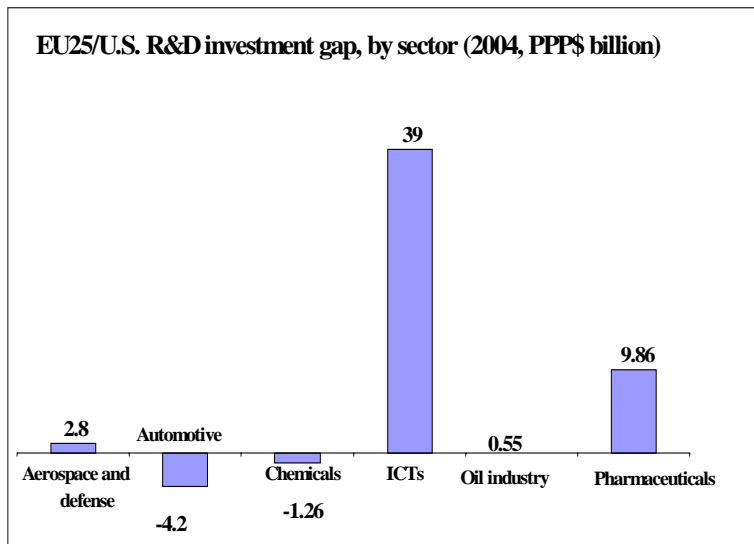
→ The gap between the U.S., Europe, and Japan is distinctly wider for ICT R&D than for total R&D. The intensity gap (measured by spending per capita) for total R&D is 1:2 in favour of the U.S., but 1:3.7 specifically for ICT R&D. The gap between Europe and Japan is similar, albeit slightly narrower.

4 – The “European lag” in ICT R&D is increasing



→ The gap between U.S. and European ICT R&D investment is widening. In absolute-value terms, it has grown from **-\$35 billion** to **-\$39 billion**. The absolute-value gap with Japan, which was still positive in Europe’s favour at PPP\$6 billion in 2001, turned negative in 2002 and is estimated at -PPP\$2.2 billion for 2006.

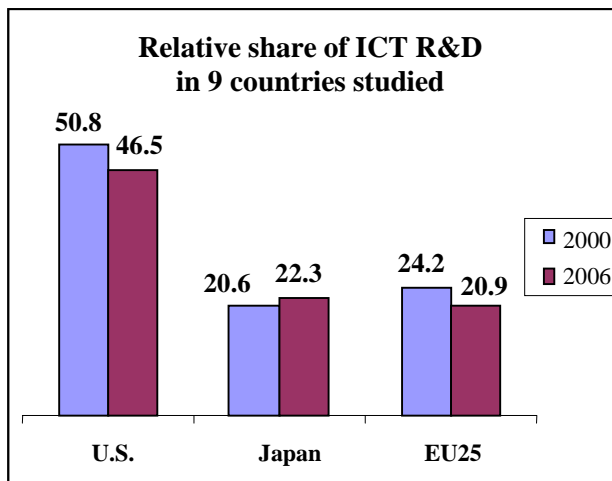
5 – ICTs are the only R&D sector in which Europe displays such a negative gap with the other major economies



→ In no other technology-oriented R&D sector is the gap so negative, despite the fact that ICTs are “empowering technologies” that determine performance in all economic sectors.

Interestingly, apart from aerospace, this ranking of the “R&D balance” is a rather accurate reflection of the EU25/U.S. trade balance.

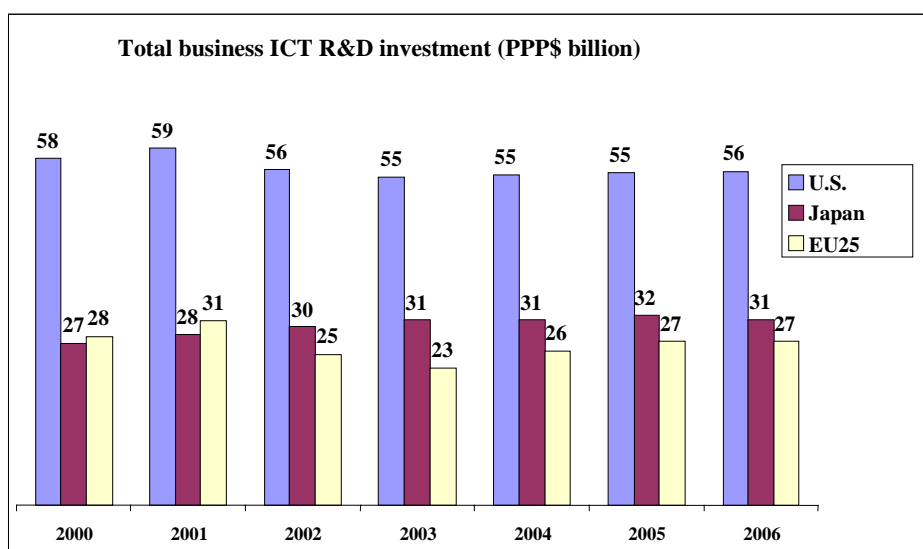
6 – The erosion of EU25 and U.S. relative shares of total ICT R&D investment is benefiting Japan and non-OECD countries



→ The EU25 and U.S. relative shares of total ICT R&D investment fell 1.3 points and 4.3 points respectively. On this criterion, Japan registered a mild increase. This concerns only the relative share among the nine OECD countries studied. The decline would be much steeper if measured against global ICT R&D investment, as India and China are benefiting from the erosion in the developed countries’ relative positions.

7 – European firms self-finance less ICT R&D than their U.S. and Japanese counterparts

In the three economic subsets of the “triad,” self-financing by ICT firms still accounts for more than 80% of total ICT R&D investment (in 2003: 78.7% in the U.S., 84.7% in the EU25, and 90.7% in Japan). *Because of its share in total funding, private financing of ICT R&D is the chief determinant of total ICT R&D in absolute-value and annual-growth terms.*



As with total ICT R&D funding, these absolute values encompass high disparities in the relative intensity of firms’ ICT R&D spending, whether measured against GDP or against the country’s population. There is a wide intensity gap between spending by EU25 firms and by their Japanese and U.S. counterparts. *As a share of GDP, European firms spend less than half on ICT R&D than their Japanese and U.S. rivals. On a per-capita basis, they spend about three times less.*

Relative intensity of business ICT R&D

U.S.

Ratio of business ICT R&D to GDP

Business ICT R&D per capita (PPP\$)

2000	2001	2002	2003	2004	2005	2006
0.69%	0.69%	0.64%	0.62%	0.60%	0.57%	0.56%
212	215	200	194	193	194	195

Japan

Ratio of business ICT R&D to GDP

Business ICT R&D per capita (PPP\$)

2000	2001	2002	2003	2004	2005	2006
0.64%	0.67%	0.71%	0.74%	0.76%	0.73%	0.68%
199	208	218	216	225	238	243

EU25

Ratio of business ICT R&D to GDP

Business ICT R&D per capita (PPP\$)

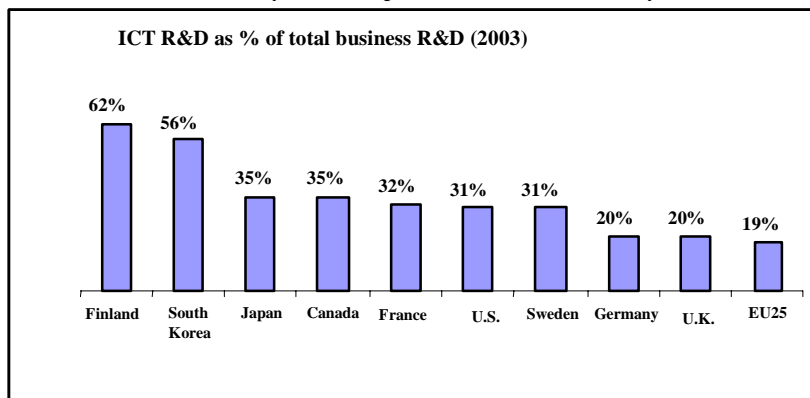
2000	2001	2002	2003	2004	2005	2006
0.24%	0.24%	0.26%	0.26%	0.26%	0.25%	0.22%
75	81	66	60	67	72	72

8 – Measuring the ICT share of developed countries' industrial structures

2003 data	(A) ICT R&D share of total business R&D	(B) ICT-sector value added as % of total business value added
Finland	62%	14.9%
S. Korea	56%	13.2%
Japan	35%	7.58%
Canada	35%	7.61%
France	32%	8.5%
U.S.	31%	10.47%
Sweden	31%	9.0%
Germany	20%	6.93%
U.K.	20%	10.8%
EU25	19%	8.0%

Note: for parameter B, the latest OECD data

cover 2003, which is why the comparison concerns that year

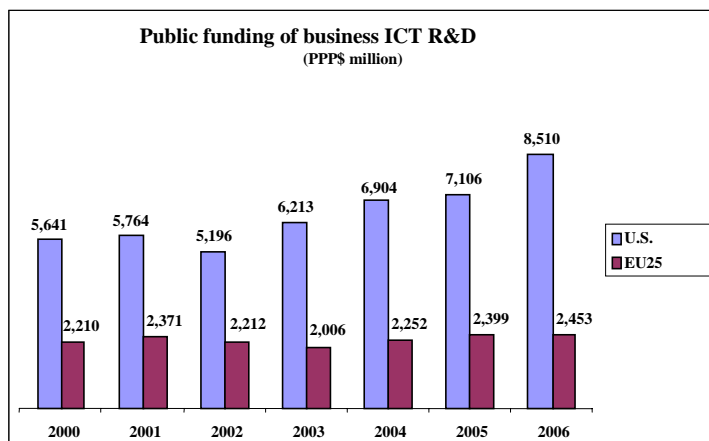


→ The table opposite shows the ICT share of the developed countries' industrial structures.

The ratio of ICT firms' R&D to total business R&D in all sectors accordingly varies within a range of about 3:1 between countries that are very heavily ICT-oriented (Finland, South Korea) and regions and countries (such as the EU25 and Germany) in which the parameter is smaller than or equal to 20%.

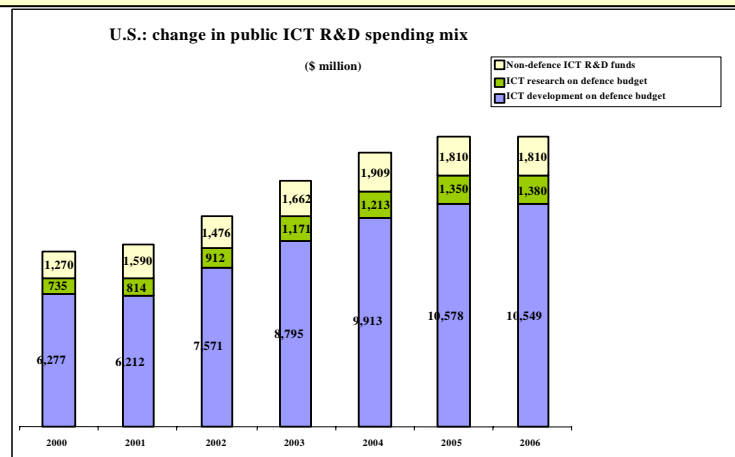
Note that this ranking is only partly reflected in parameter B, "ICT-sector value added as % of total business value added."

9 – Public funding of business ICT R&D is four times greater in the United States than in Europe

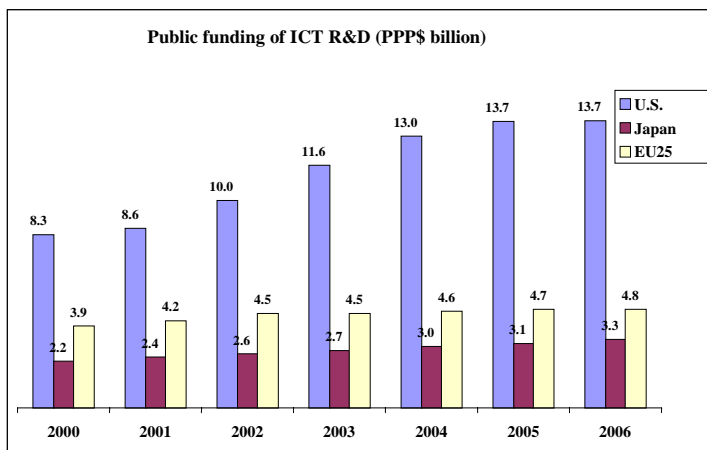


→ One of the main determinants of the U.S./EU25 gap is the size of public funding of business ICT R&D, a large share of which is included in defence spending. The Defence R&D budget has always been a key contributor to the U.S. R&D effort, particularly in ICTs. But the phenomenon has sharply intensified in recent years.

→ However, the fact that Japan holds strong positions without massive public funding of private-sector R&D shows that the “American model” is only one of several possible scenarios for private/public interaction, shaped by the country’s military-power requirements.



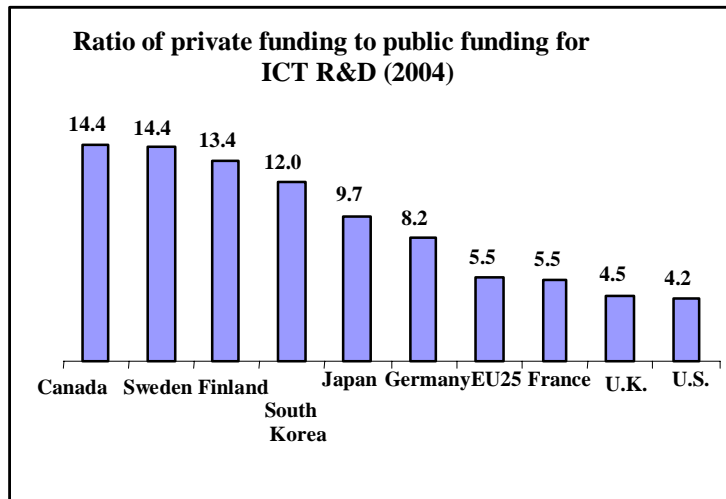
10 – Public funding of ICT R&D: Europe’s better performance does not alter the basic findings



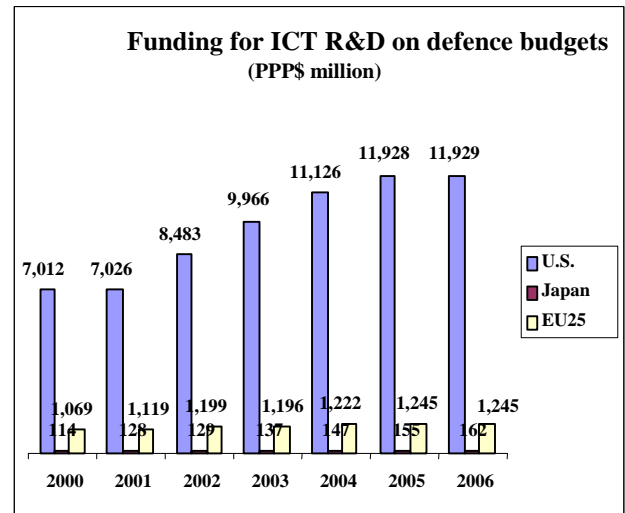
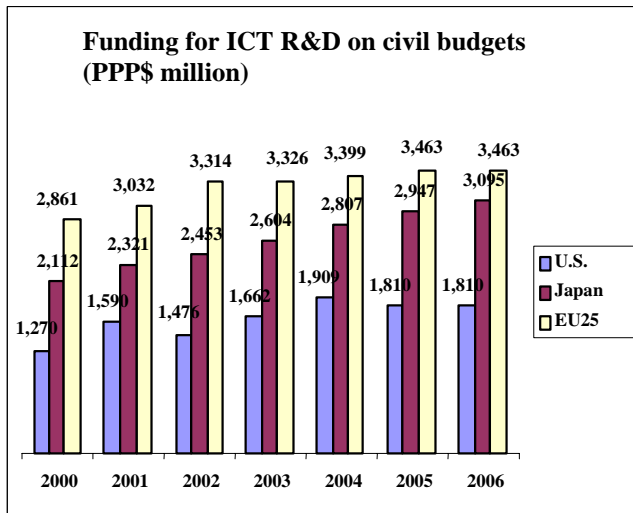
→ The shifts in public funding of ICT R&D alter the ranking by total ICT R&D investment. Because of the small volume of public research spending on industry-oriented technologies (excluding space), Japan has clearly slipped to third place here. But Europe has been largely outpaced, its gap with the U.S. widening by 104% between 2000 and 2006 despite the comparable size of the two economies.

11 – The leverage effect of public ICT R&D funding on private funding in Europe is comparatively inadequate, except in Finland and Sweden

→ The gap in public ICT R&D funding is smaller than the gap in private-sector investment. However, if we view public spending as a lever that stimulates private investment, we find that \$1 of public funding is matched by \$9.70 of private investment in Japan, \$4.20 in the United States, and \$5.50 in France and the EU25. But the last two values, despite their closeness, reflect contrasting situations. Japan’s performance is due to its substantial private R&D, whereas its public ICT R&D funding is relatively modest, on the same order of magnitude as that of the EU25. The U.S. value is low because of the high volume of public ICT R&D funding. By contrast, the \$5.50 figure for the EU25 and France is due not so much to heavy public funding as to the relative weakness of private-sector R&D.

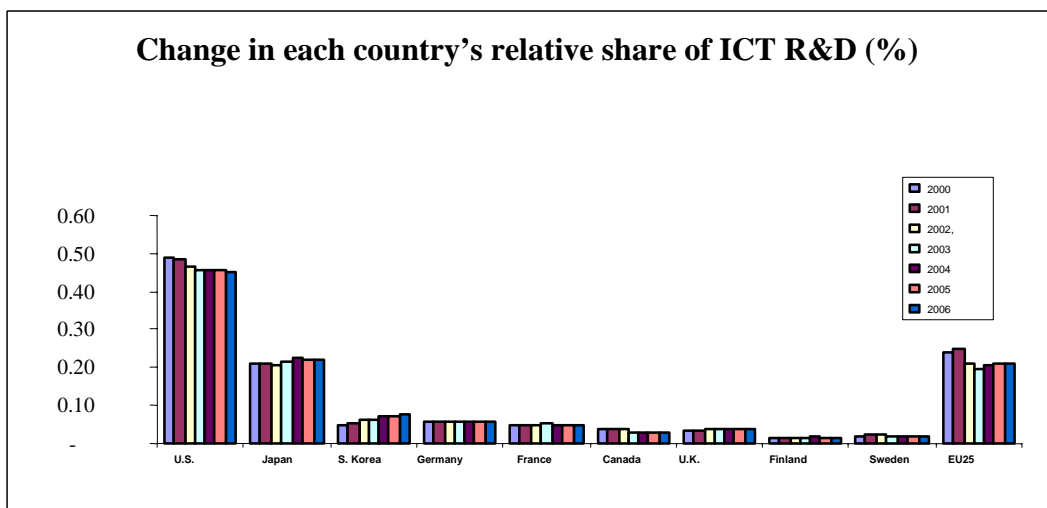


12 – ICT R&D funding on civil budgets is twice as high in Europe as in the United States, but ICT R&D funding on defence budgets is ten times greater in the United States than in Europe



13 – A wide variety of ICT R&D profiles among the nine countries studied

➔ **Absolute leaders:** these are, of course, Japan and the United States. The latter accounts for about 45% of total ICT R&D investment by the nine countries studied, a decrease of nearly 4.3 points in the period. *In contrast, Japan's relative share has remained nearly stable.* Europe's share has been declining as well.



→ **The rest of the pack** includes all the countries with relative shares of less than 10% among the nine countries studied. Their profiles, however, are not uniform. France, Sweden, the United Kingdom, and Canada are experiencing a decline in their relative shares of total ICT R&D. Finland's share is stable at 1.55%, a level that exceeds the country's weight in the global economy. Germany's share has edged up 0.03%, apparently thanks to R&D in "embedded IT"—an area of German excellence.

14 – Contrasting public policies for ICT R&D

→ Public ICT R&D funding rose an average 56% in the period 2000-2006 in the nine countries studied, but only 24% in the EU25.

In some of these countries (including France, the United States, the United Kingdom, and the EU25 collectively) there was a discrepancy between the increase in State-funded R&D and that of private financing of R&D.

→ **Countries within the average:** Apart from the "proactives" (see below), only **France, the United Kingdom, and Japan converge toward the nine-country average** (56% growth) with a deviation of less than 10 points.

→ **Lagging group:** The other countries—including Germany (11% growth) but also the EU25 in the aggregate—lag behind this average growth in public ICT R&D spending.

Index for public funding of ICT R&D

	2000	2001	2002	2003	2004	2005	2006
U.S.	100	104	120	140	157	164	167
Japan	100	110	116	123	133	139	146
Germany	100	101	105	107	109	110	111
France	100	112	120	127	130	139	145
U.K.	100	113	130	131	129	149	152
S. Korea	100	114	128	136	147	167	184
Canada	100	100	104	109	113	121	124
Finland	100	103	109	111	119	126	133
Sweden	100	101	129	155	154	162	169
<i>Total</i>	<i>100</i>	<i>106</i>	<i>119</i>	<i>133</i>	<i>145</i>	<i>153</i>	<i>156</i>
EU25	100	106	115	115	118	120	124

→ **Proactive group:** these countries post above-average growth in public ICT R&D funding. This small group includes South Korea (84% growth), Sweden (69% growth), and the United States (64% growth).

15 - European public policies in ICT R&D are less directed toward firms

→ The varying intensity of public policies for ICT R&D funding is also measured by State support for corporate R&D. In absolute-value terms, the United States ranks at the top, far ahead of South Korea, France, and Germany. But there is a radical divergence in the index profiles of the United States, South Korea, Finland and Sweden—whose public ICT R&D funding of firms grew more than 20% during the period—and all the other countries (including France), whose support for private-sector R&D remained more or less stable. While in some countries, such as France and Canada, public funding broadly reflects a proactive policy, the main beneficiaries have been public research agencies.

Public funding of business ICT R&D*PPP\$ million*

	2000	2001	2002	2003	2004	2005	2006
U.S.	5,641	5,764	5,196	6,213	6,904	7,106	8,510
Japan	434	374	420	389	378	399	407
Germany	487	544	497	480	499	518	533
South Korea	499	717	589	542	566	581	603
France	623	686	736	673	679	673	680
Canada	125	155	137	127	131	132	142
U.K.	404	441	349	554	475	474	479
Sweden	101	103	113	117	125	127	129
Finland	69	71	73	77	81	82	84
Total	8,382	8,855	8,109	9,172	9,838	10,092	11,567
EU25	2,210	2,371	2,212	2,006	2,252	2,399	2,453

Index for public funding of business ICT R&D

	2000	2001	2002	2003	2004	2005	2006
U.S.	100	102	92	110	122	126	151
Japan	100	86	97	90	87	92	94
Germany	100	112	102	99	102	106	109
S. Korea	100	144	118	109	113	117	121
France	100	110	118	108	109	108	109
Canada	100	124	110	102	105	106	114
U.K.	100	109	86	137	118	117	119
Sweden	100	102	112	116	124	126	128
Finland	100	103	105	112	118	119	122
Total	100	106	97	109	117	120	138
EU25	100	107	100	91	102	109	111

16 – New trends since earlier studies

By consolidating the 2000-2004 figures and extending the series through more reliable estimates for 2005-2006, we can draw the following conclusions:

→ Countries such as *South Korea, Finland, and Sweden* are consistently pursuing highly proactive policies, as regards both public and private funding, to specialise their R&D in ICTs. Driven by this decade-long momentum, South Korea, during the period studied, became the third largest contributor to total ICT R&D among the nine countries examined—behind the United States and Japan. However, ICT R&D spending by South Korean firms, while very robust, is growing more slowly than all-industry corporate R&D spending. ICT R&D is no longer the single driver of the country's overall R&D growth.

→ In 2003, some leading developed economies with a historical ICT R&D tradition (*France, United Kingdom, and Japan*) seemed to slip far below the average ICT R&D growth recorded for all the other countries. Now, they appear to be *rebounding* back to the average growth rate since 2003. *But this positive trend is chiefly fuelled by public funding, whereas the intensity of private-sector ICT R&D has remained persistently low.* The United Kingdom—largely thanks to a targeted public policy—has moved from the “lagging” group to the “proactive” group.

→ In the two previous editions of our study, **Germany** registered a decline in its relative share of total ICT R&D volume. Today, on the basis of the 2006 revision, it appears to be recovering. We may assume that this is probably due to the ramp-up of R&D on “embedded” ICTs, i.e., incorporated into non-ICT manufactured products such as automobiles, aircraft, and machine-tools.

→ The highlight of the period studied is, however, the very *clear trend reversal in the funding of in-house ICT R&D by U.S. firms: in the past three years, their funding has been trending down by an annual 2% in real terms*, i.e., a near-stagnation in current \$. By contrast, U.S. public funding of ICT R&D, primarily out of defence budgets (85%), remains on a robust growth path.

→ This *new divergence between the growth paths of public funding and private funding* has significantly altered the structure of total U.S. funding for ICT domestic R&D expenditures, with an increase in the public-funding share from 12.3% to 19.3%. The U.S. is the only country studied to experience such a shift. The U.S. also recorded an abrupt slump in the ratio of in-house ICT R&D to GDP. This intensity indicator declined from 0.69% to 0.56% during the period. The intensity of all-industry R&D did not follow the same pattern. *Today, ICT R&D is no longer the main engine of all-industry R&D spending in the U.S.*

→ A new development is the *significant erosion of the U.S. and EU25 relative shares of private-sector ICT R&D funding in the nine countries studied.* This is especially true of the United States, which lost 4.3 points of relative share between 2000 and 2006. The decline in the U.S. and EU25 relative shares would probably be even steeper if the reference universe—including countries such as India and China—were more closely adjusted to the actual profile of the global economy (see below).

→ Meanwhile, *public ICT R&D funding of U.S. firms* rose 104%. The figures may capture a *dual pattern in U.S. firms' ICT R&D budgets: on the one hand, “regular,” non-strategic R&D that can be easily outsourced or relocated; on the other hand, strategic, long-term R&D (massively parallel architectures, signal processing, bioinformatics, optronics, etc.) largely financed through public procurement and defence contracts.*

→ However *OECD data and other sources examined provide no evidence that the R&D ramp-up in non-OECD countries* (see below) *is paralleled by a “loss of substance” for the developed economies' R&D potential*—quite the contrary. The growth in R&D among the main non-OECD countries is therefore only one facet of the internationalisation of R&D activities. The OECD report emphasises that:

"Current R&D internationalisation has three distinguishing characteristics: it is taking place at a much faster pace, it is spreading to an increasing number of countries, including developing countries, and it involves R&D that extends beyond adapting technology to local conditions. The last of these phenomena may represent a distinctive new trend in the internationalisation of R&D. In the past, the evidence suggested that major global firms kept their key technology creation activities – as evidenced by R&D and patenting – close to their home bases. Now, however, they seem not only to seek to exploit knowledge generated at home in other countries, but also to tap into worldwide centers of knowledge. This implies genuinely international sourcing of knowledge."

→ It is therefore inappropriate, when discussing ICT R&D, to use the term “relocation” in its ordinary sense: the brisk growth of R&D activities in the non-OECD countries reflects the following:

- 1) more than a transfer of resources and activities, a determination by firms to redefine the “global distribution” of their R&D programmes (by, among other things, entering markets that offer high potential);
- 2) the determination to tap an abundant intellectual workforce that is cheap, perfectly trained, and available in the country, even as human resources available in the developed countries have become scarcer and more expensive.

Rather than a relocation, we are witnessing a globalisation of R&D activities in general—and ICT R&D activities in particular—aimed at tapping the strong competencies and resources of science workers in countries such as India and China (but the spectrum of countries concerned is not confined to these two).

A test estimate of ICT R&D *by firms* in the main non-OECD countries yields the figures reported in the table below (2005 data):

Series 1	Current \$ billion	Series 2	PPP\$ billion	Current \$ billion
China	38.7	U.S.	54.9	54.9
India	10.7	Japan	28.6	34.1
Brazil	7.3	S. Korea	11.5	16
Russia	3.9	Germany	8.2	7.8
Taiwan	4.9	France	6.3	5.7
Israel	2.3	Canada	4.9	4.8
Singapore	1.3	U.K.	4.3	5.1
Total 1	69.1	Sweden	2.7	3.63
		Finland	2.4	2.31
		Total 2	123.8	132
		EU25	25.6	22.1

Source: Battelle Institute for non-OECD countries (series 1), OECD for the others (series 2); OECD data for country-by-country conversion of PPP\$ billion into current \$ billion

From these figures, we can deduce—with a small margin of error—that:

- ICT R&D by the seven non-OECD countries in series 1 accounts for over one-half of the in-house ICT R&D in the nine countries in series 2, which represent over 90% of the developed countries' R&D;
- a country such as China has an ICT R&D sector that already exceeds its Japanese counterpart and would promote the country to the second world rank;
- a country such as India, with ICT R&D of about \$10 billion, is already ahead of all the European countries and posts a figure equal to half of total EU25 spending;
- a country such as Taiwan weighs as much as Canada;
- a country such as Israel weighs as much as Finland, despite the latter's exceptionally high ICT R&D spending.