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UNCTAD survey on the internationalization of R&D

Current patterns and prospects on the internationalization of R&D

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Executive Summary

UNCTAD's survey of the world largest R&D investors suggests that the pace of R&D internationalization may be accelerating. As many as 67 per cent of firms that responded to the survey stated that the share of foreign R&D is set to increase, while only 2 per cent indicated the opposite. In addition, the survey shows the significant differences in the degree of internationalization of R&D between different countries of origin. While the average firm in the survey spent 28 per cent of its R&D budget abroad in 2003, European TNCs had above average levels of R&D internationalization (41 per cent on average). United States TNCs were below the overall average (24 per cent) and Japanese and Korean TNCs displayed the lowest share of foreign R&D (15 and 2 per cent, respectively). However, according to the survey, the intention of TNCs in Japan and the Republic of Korea to increase the share of foreign R&D in the future appears to be particularly strong compared with TNCs in other parts of the world.

The survey predicts that developing countries as R&D locations are set to grow in importance in the next 5 years. More than half (57 per cent) of surveyed TNCs already have an R&D presence in China, India or Singapore. Developing Asia is the most often mentioned location for further R&D expansion by firms in all parts of the Triad (North America, Japan and Western Europe) and in the six main R&D investing industries (automotive, IT hardware, pharmaceuticals & biotechnology, electronic & electrical, software & computer services and chemicals). However, to date, the majority of developing countries remain excluded from this phenomenon. Whether R&D activities will spread to a growing number of developing countries will to a great extent depend on the ability of these locations to strengthen their innovation systems. For a broader analysis of the implications of the internationalization of R&D by TNCs, see the *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D.*

1. Introduction

Transnational corporations (TNCs) account for a major part of global R&D. With US$310 billion spent in 2002 (United Kingdom, Department of Trade and Industry (DTI) 2004), the 700 largest R&D spending firms of the world – of which at least 98 per cent are

TNCs[1] – accounted for close to half of the world's total R&D expenditure and more than two-thirds of the world's business R&D (Table 1).[2] Moreover, a growing share of the R&D carried out by these firms takes place outside their home countries. In order to gain a better understanding of the extent to which R&D is expanding abroad, UNCTAD undertook a survey of the world's largest R&D spenders between November 2004 and March 2005. As most of these firms are also some of the largest TNCs on earth, the survey also provides a good picture of current trends in the internationalization of R&D by large TNCs in general.

Table 1. Global R&D spending, 2002
(in billions of US Dollars and percentage)

Gross domestic expenditures on R&D (GERD)	677
Business expenditures on R&D (BERD)	450
R&D expenditures by the top 700 R&D spenders	310
Share of GERD (in per cent)	*46*
Share of BERD (in per cent)	*69*

Source: UNCTAD (2005).

2. Survey methodology and the sample characteristics

The population basis for the survey was the R&D scoreboard published by the United Kingdom's Department of Trade and Industry (DTI). Of the 700 top R&D spenders, UNCTAD contacted the first 300 firms, who combined accounted for more than 85 per cent of the total R&D expenditures. In addition, all companies in the DTI scoreboard who were based in developing, South-East European and CIS countries or economies were invited to participate in the survey, even if they fell outside the top 300. This brought the number of questionnaires sent out to 316.

[1] Some pharmaceutical firms with no foreign affiliates identified pursue their internationalization through strategic alliances with TNCs. For example, Cell Genesys, one of these pharmaceutical firms, is in a technology alliance with Novartis (Switzerland). The latter is also a 5 per cent shareholder of the former. As for Human Genome Sciences (United States), it has strategic alliances with GlaxoSmithKline (United States), Takeda (Japan), Schering-Plough (United States), Sanofi-Synthelabo (France), Merck (Germany) and the Pharmaceutical Division of the Kirin Brewery (China). In another case, ICOS (United States) is a 50 per cent owner of the Lilly ICOS joint venture formed with Eli Lilly (United States) for the global distribution of the drug Cialis.

[2] In 2003, the R&D expenditure of the 700 largest spenders rose further by more than 5 per cent, to $327 billion.

A total of 69 companies responded to the questionnaire, representing a response rate of 22 per cent.[3] The relatively low response rates are not uncommon for R&D-related surveys as many firms consider information concerning their R&D activities as too sensitive to be disclosed. The 69 participating firms accounted for 34 per cent of total R&D expenditure by the 316 firms in the overall population. Thus, there is a fairly good representation of some of the very largest R&D spenders. However, some potential shortcomings should be borne in mind: the reporting of R&D may not always be done in the same way due to different notions of what R&D entails, and some respondents may have omitted smaller R&D activities.

Table 2 shows the distribution of home economies in the total population and among the 69 respondents. Over 80 per cent of the total population came from only five countries: the United States, Japan, Germany, the United Kingdom and France. In the UNCTAD survey, with a similar pattern to the DTI Scoreboard, about 88 per cent of the 69 respondents came from the United States, Western Europe and Japan. The respondents from developing economies were based in the Republic of Korea (5), Hong Kong (China) (1), South Africa (1) and Taiwan Province of China (1).[4]

Table 2. Home economies of the 316 R&D spenders and the respondents in the UNCTAD survey
(in per cent)

Economy	Total population (316 firms)	UNCTAD sample (69 firms)
United States	36.4	17.4
Western Europe	30.4	52.2
(Germany)	(8.2)	(23.2)
Japan	24.0	18.8
Rest of World	9.2	11.6
(Republic of Korea)	(2.9)	(7.3)
Total	100.0	100.0

Source: United Kingdom, DTI 2004, UNCTAD survey.

Companies in the United States were the most cautious in sharing R&D-related information and are consequently somewhat underrepresented in the sample. Still, some of the largest United States R&D investors did participate. Meanwhile, Germany and the Republic of Korea were overrepresented in the survey (Table 2).

[3] It should be noted that the results in this note diverge somewhat from those reported in the World Investment Report 2005 (WIR05). This is because the note includes a response that arrived too late to be included in the WIR05.

[4] The 69 respondents in the survey were based in the following 14 countries: Denmark, France, Germany, Hong Kong (China), Italy, Japan, Republic of Korea, South Africa, Sweden, Switzerland, Taiwan Province of China, The Netherlands, United Kingdom and the United States.

The 316 R&D spenders in the total population are concentrated in a relatively few industries. The top three industries (automotive, IT hardware and pharmaceuticals/biotechnology) accounted for about 60 per cent of the 316 R&D spenders in 2003 in terms of R&D expenditure, and the top six industries accounted for 81 per cent (table 3). The industrial composition of the UNCTAD survey sample is broadly similar to that of the DTI's R&D scoreboard: IT hardware, automotive, pharmaceuticals, electronic and electrical, and chemicals are 5 of the 6 main R&D investing industries. The software and computer services industry was somewhat under-represented in terms of number of participating firms mainly due to a low response rate by the United States companies, but quite representative in terms of R&D expenditure.

Table 3. Industry breakdown of total population and the UNCTAD sample
(in per cent)

Industry	R&D expenditure		Number of firms	
	Percentage of 316 companies	Percentage of 69 respondents	Percentage of 316 companies	Percentage of 69 respondents
Automotive	20.6	25.9	10.1	10.2
IT hardware	20.2	16.7	19.3	13.0
Pharmaceuticals/biotechnology	19.1	23.0	13.9	15.9
Electronic and electrical	11.6	14.6	9.8	11.6
Software/computer services	5.3	5.6	5.7	4.3
Chemicals	4.6	6.4	7.6	10.2
Others	18.6	7.8	33.6	34.8
Total	100.0	100.0	100.0	100.0

Source: United Kingdom, DTI 2004, UNCTAD survey.

3. Current patterns in the internationalization of R&D

a. Western European TNCs show the highest levels of R&D internationalization

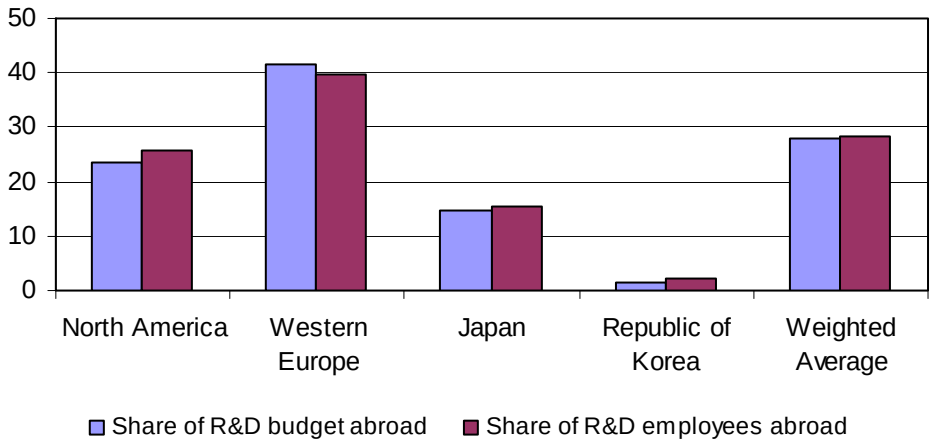
The average firm in the UNCTAD survey spent 28 per cent of its R&D budget abroad in 2003,[5] including in-house expenditure by foreign affiliates and extramural spending on

[5] In order to eliminate the distortions caused by under- and overrepresentation, this has been calculated as a weighted average of responses, using the regional distribution of the 316 questionnaires for weighting. Due to the overrepresentation of Western Europe in the responses, the unweighted average would have been 34 per cent .

R&D contracted out to other countries (Figure 1). The share of R&D workers abroad in total R&D employees was similar (Figure 1).[6]

Within this global picture, significant differences existed in the degree of internationalization of R&D based on the share of foreign to total R&D expenditure between different countries of origin (Figure 1).[7] Japanese and Korean TNCs displayed the lowest share of foreign R&D (15 per cent and 2 per cent, respectively). United States TNCs were also below the average (24 per cent). Conversely, Western European TNCs reported the highest levels of R&D internationalization (41 per cent on average).[8] Within Western Europe, companies from the United Kingdom (66 per cent) and Switzerland (61 per cent) had the most internationalized R&D activities.

Figure 1. Share of foreign to total R&D by home region or country in the UNCTAD survey
(Per cent)



Source: UNCTAD.

The average number of countries in which foreign R&D is carried out by the responding companies in the survey was 6.3, with a range between 0 and 29 locations. Again, Japanese and Korean TNCs showed the lowest spread in terms of number of foreign countries

[6] Not all firms answered both questions.

[7] Foreign is defined as the investment in countries outside home country, thus German investment in the UK is considered foreign even if both of them are within the category of Western Europe.

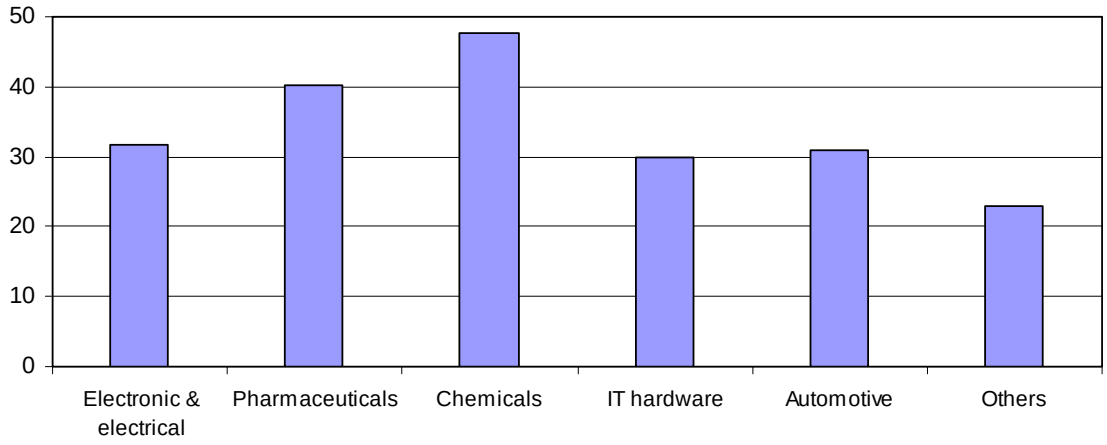
[8] Previous studies (Roberts 2001, Edler *et al*. 2002, von Zedtwitz and Gassmann 2002), while finding that the Western European firms were the most internationalized, also noted that their lead over the United States TNCs was small. In the Edler *et al*. 2002 survey (p. 158), the European firms were estimated to spend one third of their R&D budget abroad in 2001, followed closely by the North American firms (32 per cent) and only very distantly by the Japanese firms (11 per cent). In Roberts' (2001) survey, Western European firms were estimated to spend 35 per cent of their R&D budget abroad, followed by the North American firms (33 per cent) and the Japanese firms (10 per cent). The discrepancy with the UNCTAD survey is due to the fact that the survey by Roberts treated intra-European and intra-North American R&D flows as domestic.

in which R&D is performed (4.6 and 2.2 respectively). United States TNCs were similar to the global average (6.0). Conversely, western European TNCs had high levels of dispersion (7.9).

b. Chemical and pharmaceutical industries are the most internationalized

Due to the limited sample size of the UNCTAD survey, only tentative conclusions can be drawn concerning industry-wide variations. Chemical and pharmaceutical industries are the most internationalized in terms of R&D (Figure 2). The relatively low level of internationalization in the electronic and electrical industry partly reflects the strong presence of Japanese firms in that industry. Interestingly, the IT hardware industry's level of R&D internationalization was more pronounced in terms of R&D employees abroad than in terms of expenditure – possibly indicating that R&D abroad is undertaken with a view to reducing labour costs (Table 4). The opposite appeared to be the case for the automotive industry – possibly suggesting the greater importance in that industry of market-seeking motives for foreign R&D.

Figure 2. Foreign R&D to total R&D expenditure by industry in the UNCTAD survey
(Per cent)



Source: UNCTAD.

Table 4. Degree of R&D internationalization[a] by industry in the UNCTAD survey
(in per cent)

Industry[b]	Share of foreign in total R&D expenditure	Share of R&D employees abroad as percentage of total
IT hardware	29.8	37.5
Automotive	31.0	23.2
Pharmaceuticals/biotechnology	40.3	39.5
Chemicals	47.7	45.4
Others	23.1	26.7

Source: UNCTAD.
[a] Based on foreign R&D expenditure and R&D employees abroad.
[b] It is not possible to compare the shares of foreign R&D expenditure and R&D employees abroad as some respondents only answered only one of the two questions.

c. Growing importance of developing economies in foreign R&D locations

According to the UNCTAD survey, although the majority of the R&D conducted abroad takes place in other developed countries (the United States and the United Kingdom are the top two destinations), a large share of the responding companies also carry out R&D in developing countries.[9] The subsequent analysis depicts where foreign R&D activities are located; It should, however, be noted that the data only indicate where companies are performing R&D, but not how much R&D is being carried out.

Current locations in the developing world hosting overseas R&D of the world's top R&D spenders include China (3rd global destination in terms of number of times mentioned), India (6th), Singapore (9th) and Brazil (12th) (Figure 3). More than half (57 per cent) of the responding firms have at least one R&D facility in China, India or Singapore. Also notably, a large number of other developing R&D locations (15 economies) were indicated by at least one of the respondents. In South-East Europe and the CIS, the Russian Federation and Bulgaria were the only R&D locations mentioned.[10]

The distribution of R&D locations varies somewhat by home economy. Western Europe was mentioned most often as a host region for R&D by firms from all parts of the Triad. However, Japanese TNCs were more likely to have R&D bases in Asia than in the United States. For western European TNCs the opposite was true. In terms of industry variation, firms in software & computer services, electronic & electrical and IT hardware industries mentioned developing Asia relatively more often than other firms. Conversely, firms in pharmaceuticals, chemicals and automotive industries more seldom reported having an R&D presence in developing Asia: the share of Western Europe and North America figured particularly prominently in the responses by pharmaceuticals and chemicals firms.

[9] An earlier survey (Edler *et al.* 2002) also concluded that North America and Western Europe were the most attractive target regions for foreign R&D, while Japan's attractiveness for R&D carried out by TNCs from abroad was well below the country's science and technology potential. Among the developing regions and South-East Europe and the CIS, the "Asian Tigers" were mentioned by 23 per cent of the firms surveyed. "Eastern Europe" (12 per cent) and Latin America (10 per cent) were far less important, while Africa was hardly mentioned at all.

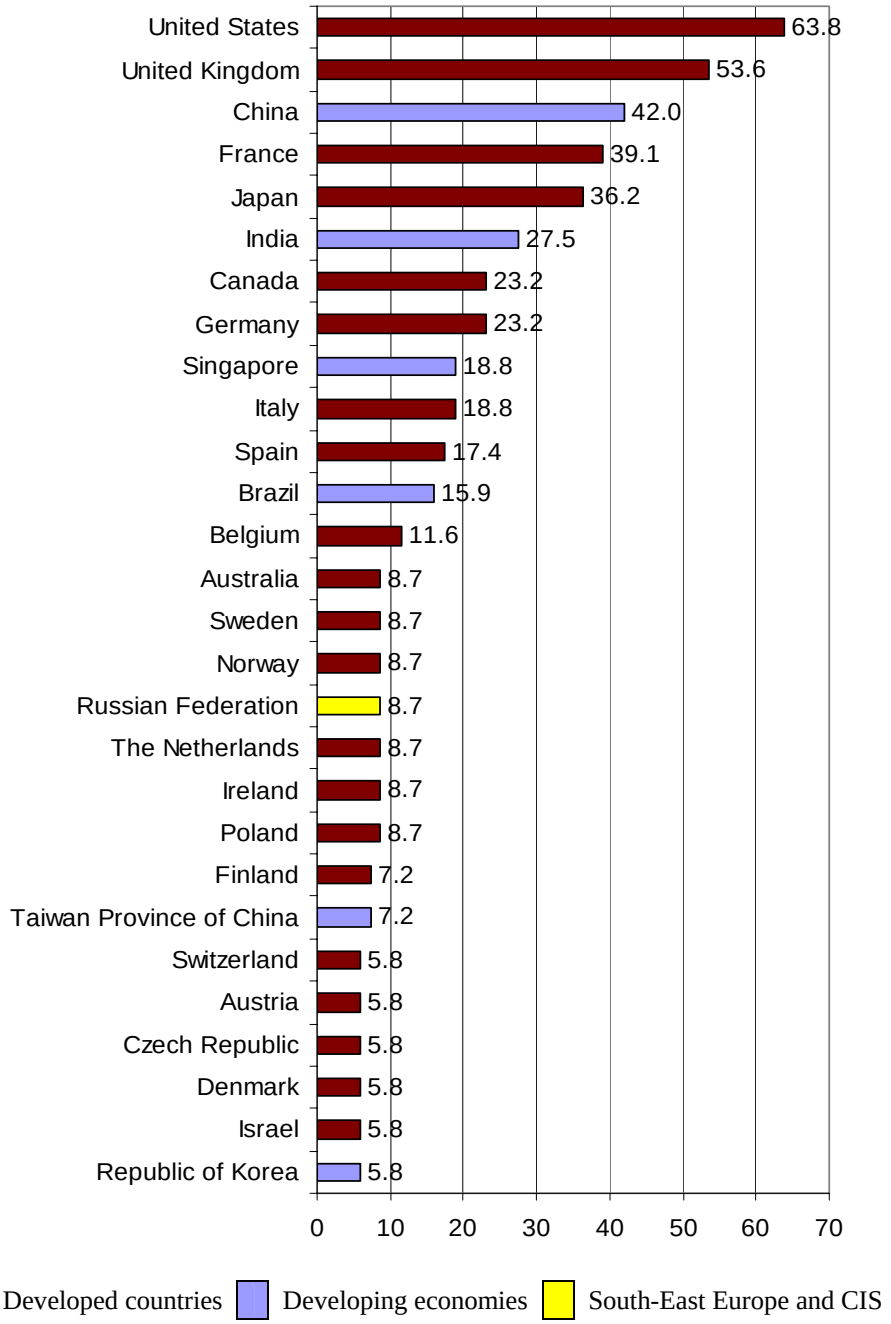
[10] Bulgaria was mentioned by only one respondent.

Latin America was mentioned on a number of occasions by companies in the auto industry, but Western Europe held the top spot in the numbers of mentions by this particular industry.

Further information on the industry breakdown can be gauged from Figure 4, which depicts the industry breakdown of those companies that reported having R&D activities in six of the most frequently mentioned host locations. In terms of the number of respondents by industry that are performing R&D in each host country, pharmaceuticals and electronic & electrical industries account for a relatively large share of the foreign R&D presence in the United States and the United Kingdom. The pharmaceutical industry accounts for the largest number of firms with a foreign R&D presence in France and Japan. In China, electronic & electrical and IT hardware industries are among the two most important industries among firms with an R&D presence. Software and computer industry TNCs are relatively more important in India than in other locations.

Figure 3. Current foreign locations of R&D in the UNCTAD survey

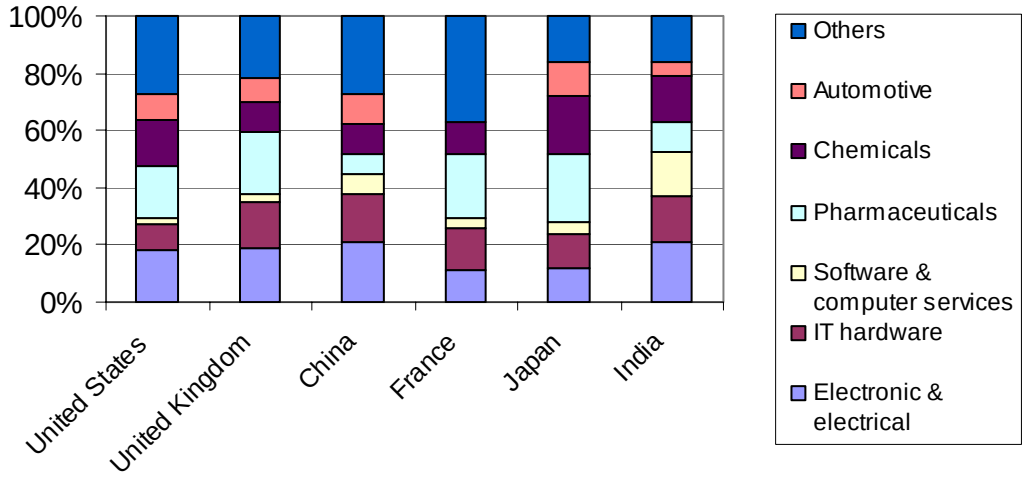
(Per cent of responses)



Source: UNCTAD.

Note: Economies mentioned by three respondents include: Hungary, Mexico, Portugal and Thailand. Economies mentioned by two respondents include: Indonesia, Malaysia, the Philippines, South Africa and Turkey. Economies mentioned by one respondent include: Argentina, Bulgaria, Costa Rica, Estonia, Greece, Hong Kong (China), Morocco, Saudi Arabia, Slovakia and Viet Nam.

Figure 4. Share of industries in foreign R&D presence in major host countries



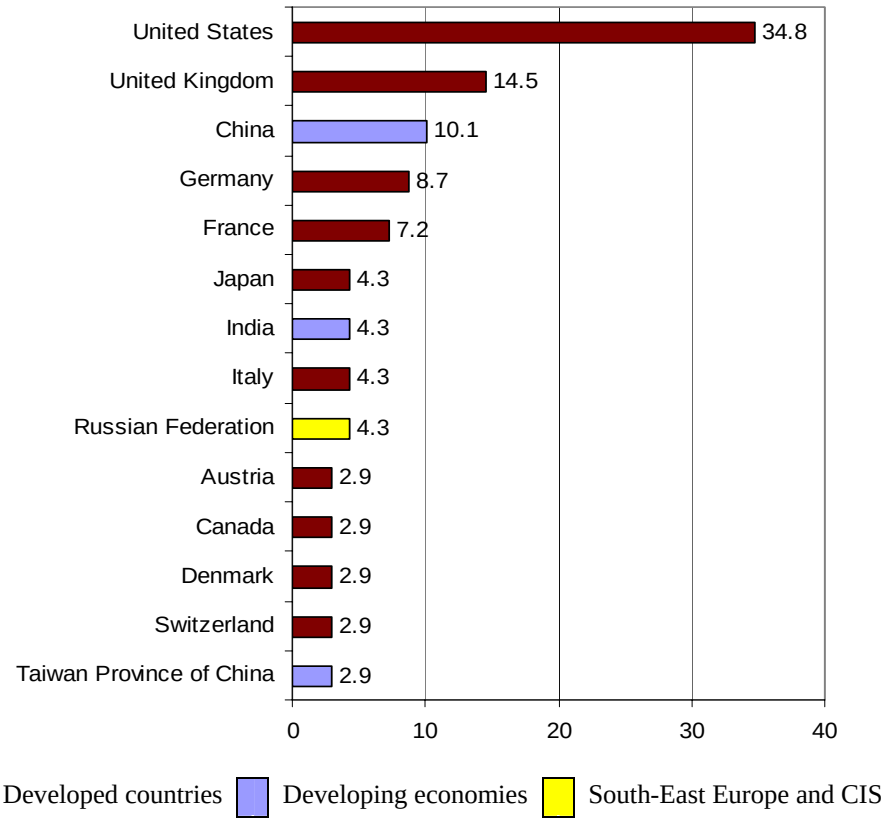
Source: UNCTAD.

d. TNCs involve developing countries in their collaboration on R&D

The companies responding to the UNCTAD survey also answered questions related to international non-equity collaboration in the area of R&D. The most frequently mentioned location for such arrangements was again the United States followed by the United Kingdom. China was in third place, ahead of Germany and France (Figure 5). Next to France, an equal share of the responding companies had R&D collaboration with counterparts in Japan, Italy, the Russian Federation and India. Other developing and South-East European and CIS economies mentioned included: Argentina, Brazil, Mexico, Morocco, Singapore, Taiwan Province of China and Tunisia.

Western Europe was the most often mentioned region for R&D collaboration, followed by North America. In terms of the importance of the current locations of R&D collaboration by industry, firms in software & computer services, IT hardware and electronic & electrical industries had relatively high international R&D collaboration with counterparts in developing Asia. On the other hand, firms in pharmaceuticals industry had particularly high international R&D collaboration with counterparts in western Europe and firms in chemicals industry had relatively high international R&D collaboration with counterparts in Western Europe and North America.

Figure 5. Current locations of international non-equity R&D collaboration in the UNCTAD survey
(Per cent of responses)



Source: UNCTAD.
Note: Countries mentioned by one respondent include: Argentina, Belgium, Brazil, the Czech Republic, Hungary, Mexico, Morocco, the Netherlands, Poland, Singapore, Sweden and Tunisia.

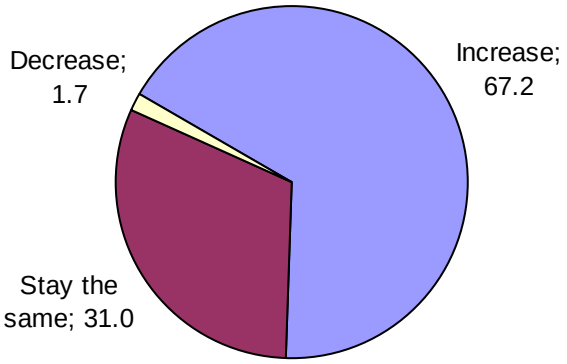
4. Future outlook on R&D internationalization

a. The pace of R&D internationalization will be accelerating

As many as 67 per cent of the responding firms stated that the share of foreign R&D is set to increase; only 2 per cent indicated the opposite, while the remaining 31 per cent expected the level of internationalization to remain unchanged (Figure 6). The momentum appears to be particularly strong among companies in Japan and the Republic of Korea, which have so far been less aggressive in terms of R&D internationalization. Ten out of eleven Japanese companies in the sample and 80 per cent of the Korean firms planned to increase their foreign R&D, while 67 per cent of the United States' firms and 58 per cent of European firms indicated such intentions.

There were some differences by industry regarding the prospects of TNCs expanding foreign R&D. Firms in electronic & electrical and automotive industries showed the strongest intentions (80 per cent and 75 per cent respectively) to increase their foreign R&D, while a somewhat smaller proportion of firms in pharmaceuticals and IT hardware industries indicated similar intentions.

Figure 6. Prospects of TNCs locating R&D abroad in the UNCTAD survey, 2005-2009
(Per cent of responses)



Source: UNCTAD.

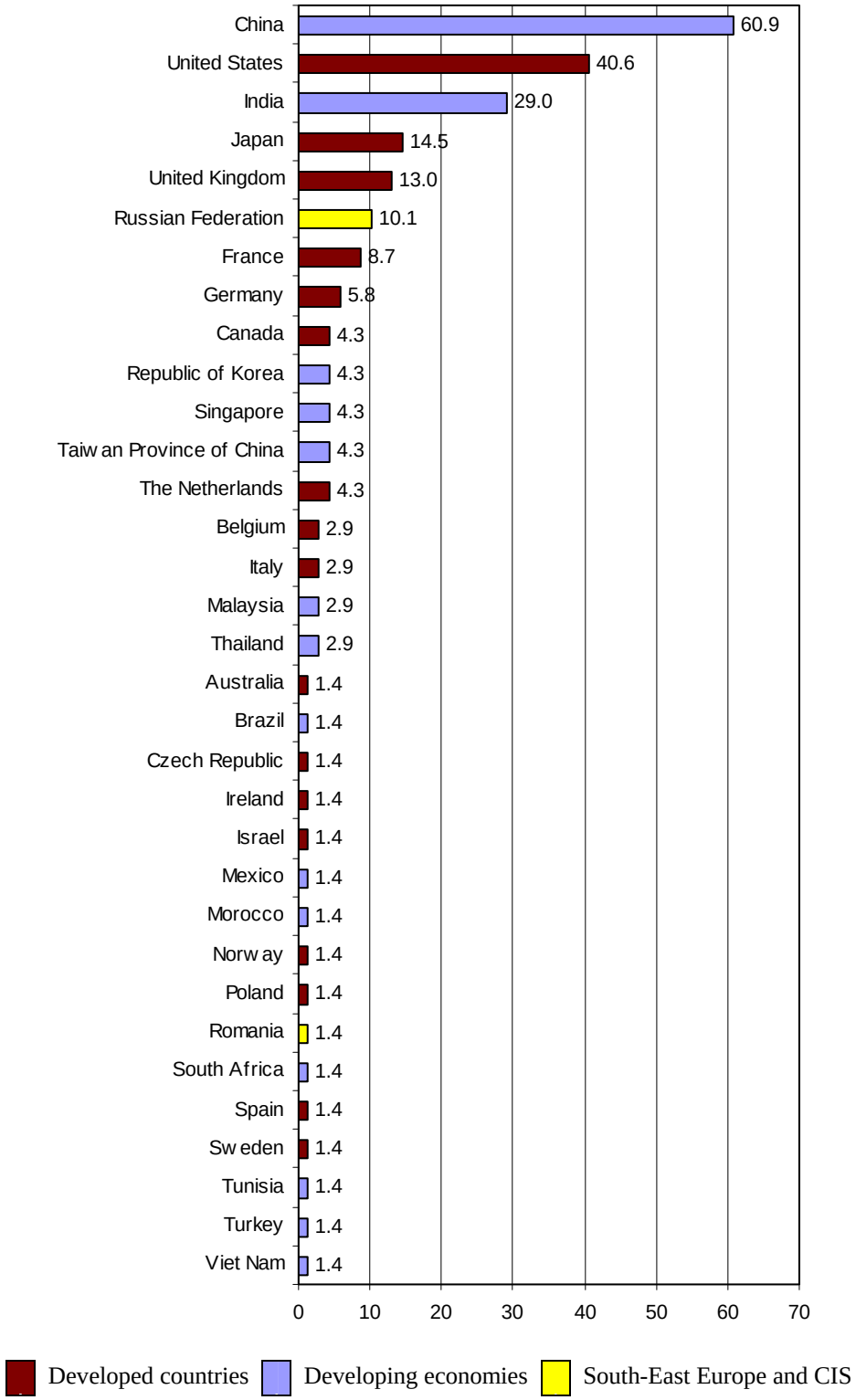
b. Further shift towards developing countries in global R&D of TNCs

In terms of preferred locations for new R&D projects abroad, the survey results suggest a further shift towards some specific developing and South-East European and CIS markets, although the United States, Japan and some European countries (e.g. United Kingdom, France and Germany) are still among the prime targets for new R&D in the next 5 years (Figure 7). China was the R&D destination mentioned most often, followed by the United States. In third place was India, another significant newcomer location for R&D. The Russian Federation was in sixth place. Other developing economies that were mentioned as candidates for further R&D by at least 2 per cent of the companies were the Republic of Korea, Singapore, Taiwan Province of China, Malaysia and Thailand. Very few respondents indicated any plans for expanding R&D in Latin America and Africa.

Developing Asia was the most often mentioned region for further R&D expansion for firms in all parts of the Triad. North America was the second most often mentioned target for further R&D for firms from Western Europe and Japan, while Western Europe was the

second most often mentioned R&D destination for firms from the United States. In terms of the importance of future R&D locations by industry, firms in all six main industries indicated developing Asia most often. This was most pronounced for R&D spenders in chemicals, software & computer services and IT hardware industries.

Figure 7. Most attractive locations for future foreign R&D in the UNCTAD survey, 2005-2009
(Per cent of responses)

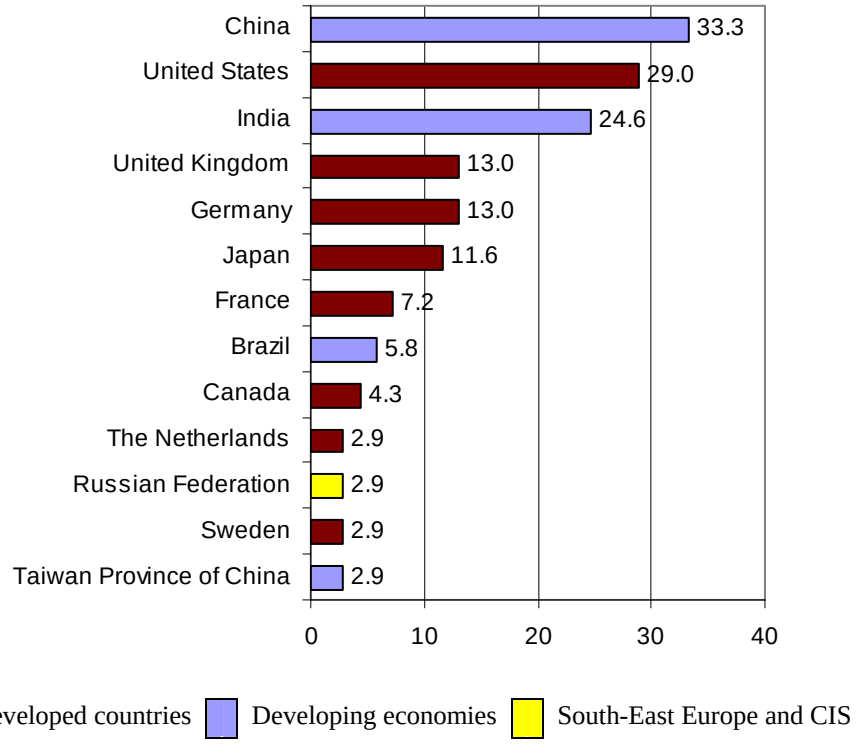


Source: UNCTAD.

c. TNCs also intend to expand R&D collaboration with developing country partners

Looking at the preferred locations for future non-equity R&D collaboration, the three top destinations were the same as for overall R&D: China, United States and India (Figure 8). The United Kingdom and Germany were in fourth and fifth place respectively, and Japan in sixth place. After China and India, Brazil was the third highest ranked developing economy location. Other developing, South-East European and CIS economies that were mentioned as candidates for future non-equity R&D collaboration were the Russian Federation, Taiwan Province of China, Malaysia, Mexico, Morocco, Singapore, South Africa, Tunisia and Turkey.

Figure 8. Most attractive destinations for non-equity R&D collaboration, 2005-2009
(Per cent of responses)



Source: UNCTAD.
Note: Countries mentioned by one respondent include: Australia, Austria, Belgium, Denmark, Italy, Malaysia, Mexico, Morocco, Norway, Poland, Singapore, South Africa, Spain, Switzerland, Tunisia and Turkey.

Developing Asia was the most often reported location for future R&D collaboration by firms in the United States and Western Europe, and Western Europe was the most often mentioned by Japanese firms. Industry-wise, developing Asia was the most often mentioned

destination by firms in all the six main R&D industries. Compared to other industries, software and computer services industry had clearly the highest share of respondents planning to expand R&D in Asian developing countries.

5. Concluding remarks

In conclusion, UNCTAD's survey of the largest R&D spenders shows that a number of Asian economies are among the prime targets for further R&D expansion. This marks a new stage in the globalization of economic activities. TNCs now view some developing economies not only as sources of cheap labour, but also of growth, skills and even new technologies.

As highlighted in the recently published *World Investment Report 2005* (UNCTAD, 2005), the expansion of R&D into selected developing countries, says UNCTAD, is a reaction to increased competition, which forces firms to innovate more at lower cost. TNCs are especially attracted to host countries that have the appealing combination of low wages and large pools of skilled workers.

The growing trend towards R&D internationalization is likely to continue. Underlying factors will provide compelling reasons for TNCs to seek out new locations for R&D activities. And as local enterprises and institutions in developing countries take part in those activities, they will progressively enhance their abilities and be in a better position to attract more business.

Foreign direct investment in research and development can help countries strengthen their innovation capabilities. But the requirements for entering the game are demanding, and most developing countries have not taken part in it. Whether developing countries host R&D activities by TNCs, and benefit from linking up with their global R&D networks depends on the quality of human resources and institutions as well as the capabilities of domestic firms.

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