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CHANGES IN GLOBAL RESEARCH AND DEVELOPMENT: DECENTRALISATION OR A NEW CONCENTRATION?²

Abstract

Since the 1990s, the highly concentrated field of global research and development (R&D) has been undergoing a series of changes, which many scholars interpret as a shift toward increased decentralization. A dynamic rise in R&D spending has been accompanied by greater contributions from countries outside the Triad, also via the activity of transnational corporations (TNCs), which boost their R&D expenditure on the one hand, and serve as the driving force behind R&D internationalisation on the other. While it once seemed that decentralisation would continue, a closer analysis of global R&D suggests that its concentration has actually increased since the middle of the second decade of the 21st century. The decentralization of R&D has led to a dynamic rise in the global importance of China and South Korea, which in turn triggered a new concentration process and a shift of global R&D toward a new centre in East Asia. The process of decentralisation, which causes a diffusion of R&D across a large number of actors, including developing countries, affects global R&D to a lesser extent than the new process of concentration, which now seems to be gathering momentum.

JEL Classification Code: **F23, O30, O39.**

Keywords: Global R&D, transnational corporations, concentration ratio, new global R&D structure, R&D decentralisation, R&D global leaders, China, South Asia.

Introduction

For decades, research and development in the world economy has been highly concentrated within a small group of countries. However, decentralising changes

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have already been underway in global R&D since the 1990s; an ever greater role today is played by economies outside the Triad. The investment behaviour of transnational corporations, a key entity in global R&D, likewise seems to proceed toward decentralisation.

The purpose of this article is to determine whether observed changes in global R&D indeed have led to decentralisation, i.e. the diffusion of R&D activity in the world economy. Major trends in global R&D are outlined to enable an analysis of the concentration level in the 1981–2013 period based on two indicators: the Cr_k concentration ratio and the Herfindahl-Hirschman Index (HHI). The analysis is focused on R&D investment in individual economies, as well as a group of one thousand transnational corporations with the highest R&D activity. Results are used to define the current model of global R&D.

Global R&D: evolution and trends

Global R&D investment has seen dynamic growth since the 1980s, owing to the process of globalisation and the associated rapid technological progress, fuelled by greater R&D expenditures aimed at generating new knowledge and technology. Globalisation gave rise to the new concept of the knowledge-based economy, where knowledge represents an essential factor of production, the resources of which determine the standing of a given country in the world. This has increased the importance of knowledge; its dynamic development is now promoted by a boost in research and development investment on an unprecedented scale. The greatest growth has been observed since the middle of the 1990s. In 1981, global R&D amounted to c. 163 billion USD; by 1989, the had figure doubled. In 1995, the value approached 473 billion and reached c. 678 billion in 2000, 1.3 trillion in 2010, and 1.6 trillion in 2015 (fig. 1). To sum up, global R&D investment saw a nearly tenfold increase between 1981 and 2013 and more than trebled in the 1995–2013 period alone. It is also worth noting that global R&D continued to increase even in periods of economic downturn and the global economic crisis. The immunity of R&D investment to recession can be attributed to continuing strong pressure to generate knowledge and technology.

As shown in fig. 1, global R&D investment has always shown a high degree of concentration. Until the end of the 1980s, it was almost the exclusive province of five countries: the USA, Japan, Germany, France, and Great Britain. These five economies accounted for 85% of global R&D, with the US markedly in the lead: the American contribution exceeded the total investment made by the other four countries put together. In the second half of the 1990s, two Asian countries joined the fray: South Korea (in 1995) and China (in 1997). The importance of China, in particular, has been growing ever since. In 2004, it ranked third in terms of R&D investment size (following the US and Japan), and, from 2009 onwards, has been steadily strengthening its position as the world's runner-up. South Korea, on the other hand, has been ranked

fifth worldwide ever since 2010. China and South Korea have thus joined the group of five traditional leaders for the long run. Currently, these seven countries account for nearly 80% of global R&D investment; this new system remains highly concentrated.

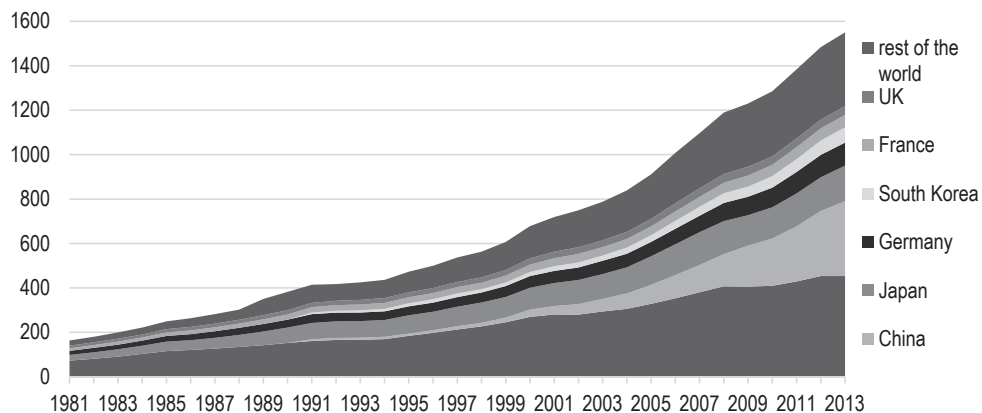


Figure 1. Global R&D investment (billions USD, PPP)

Source: analysed by the author based on OECD (2015).

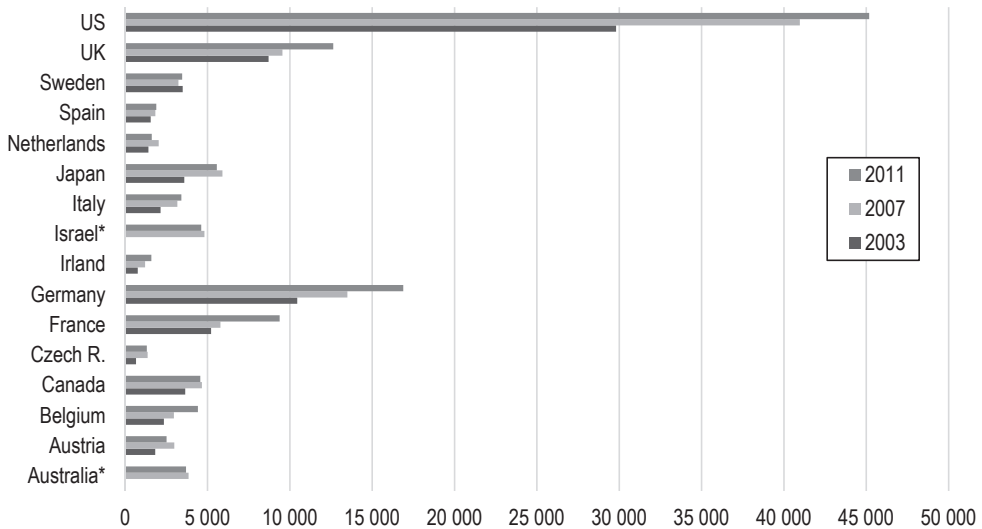
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Despite the high concentration of global R&D, a decentralising process has been underway since the 1990s, and R&D is now on the rise in centres other than the traditional Triad (OECD, 2011; Kehal & Singh, 2006, pp. 432-446). An important surge in R&D investment can be observed in the developing world (Borras & Hakonsson, 2012): in 2013, countries from outside the top seven invested c. 332 billion USD in research and development, as compared to 336 billion in China and approx. 453 billion in the US. Decentralisation has accelerated since 2000, further increasing the

role of other developed and developing countries, primarily Russia, India and Brazil (UNCTAD, 2005a, pp. 3-4; 2005c, pp. 7-10; OECD, 2010, pp. 118-121). Of course, R&D decentralisation is mainly reflected in the success story of China and South Korea, which have now joined the traditional global leaders (Hiratuka, 2011; Lu & Chen, 2012). This issue has been addressed in many publications, including several OECD and UNCTAD reports, which hail it as an opportunity for developing countries to participate in the global mechanism of generating knowledge through increased R&D (UNCTAD 2005b, pp. 97-103; UNCTAD 2009, pp. 29-30; OCDE, 2007). R&D decentralisation is also linked to a process of internationalisation spear-headed by transnational corporations.

It should be noted that TNCs play a particularly important role in global R&D, accounting for nearly half of total R&D investment in the world, and serve as the main-spring of R&D internationalisation through foreign direct investment in research and development activity (OECD, 2008; European Commission, 2012a). TNCs locate their R&D centres in various countries around the world and often create R&D departments as part of their production and services base (UNCTAD, 2011, pp. 6-13; Farrell, 2006, pp. 89-94). They contribute to the internationalisation of research and development, creating global innovation networks that generate knowledge and technology in different countries across the world (Contractor et al, 2011, pp. 168-190). It is precisely the strategy of transnational corporations that propels the diffusion of R&D activity in the global economy; even developing countries can benefit from the process if a TNC selects them as a location for a new R&D centre. The R&D potential of TNCs is substantial; R&D expenditures of individual corporations often exceed those of many countries. For this reason, TNC behaviour will largely determine the shape of global R&D.

As mentioned before, TNCs play a decisive role in the process of R&D internationalisation by moving their R&D centres outside their country of origin (Morcos, 2003). In practice, they often pick locations in developing countries (Shackelford, 2012), but the major R&D investment flows still continue to occur between traditional centres, i.e. the US and Western Europe, as shown in fig. 2. The highest values can be observed in the US-based branches of transnational corporations (c. 45 billion USD in 2011), originating mainly in Europe and Japan. In Europe, on the other hand, investment is attracted primarily by Germany, Great Britain, and France, with the highest activity shown by American companies. It should be noted that foreign TNC investment in these main centres grew between 2003 and 2011, which means that foreign R&D locations also became more concentrated over that period. The principal centres attract the most foreign R&D investment flows. Indeed, TNCs also choose locations in developing countries, but their involvement there is significantly lower (UNCTAD 2005a, p. 12; Contractor et al, 2011, pp. 48-72; UNCTAD 2011, pp. 12-13). On the other hand, for these „new” economies, investment by TNCs has meant a sharp rise in their standing in global R&D.



*no data available for 2003.

Figure 2. R&D of branches of foreign TNCs (millions USD PPP)

Source: as in fig. 1.

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Analysis of global R&D concentration levels

In order to determine the concentration level of global R&D investment, two indicators will be used:

- the concentration ratio, Cr_k ,
- the Herfindahl-Hirschman index (HHI).

The concentration ratio, Cr_k , represents the share (k) of the largest actors in the total market for a given group. It is predominantly used to investigate the concentration level of a product in the market; in the current analysis, global R&D investment will be treated as the market and individual markets assumed as its actors. To arrive at a full picture of global R&D concentration, four indicators will be calculated: Cr_1 , Cr_3 , Cr_5 , and Cr_7 , representing, respectively, the share of the global R&D leader, and the total share of the top three, five, and seven R&D highest-investing countries in the global market. The analysis will cover the 1981-2013 period, allowing us to determine whether global research and development has been subject to a decentralisation process through decreasing the share of top R&D-economies.

The Herfindahl-Hirschman Index, on the other hand, represents the sum of squares of the market shares of all actors in the market and can take on values between 0 and 1. In contrast to Cr_k ratios, the HHI takes stock of all the actors, but attributes a greater weight to those with the largest share in the market. An increase in the index signals a rise in market concentration; a decrease represents a more even distribution among the actors and an increase in their number. A market is defined as diffuse when the HHI is lower than 0.1, and values between 0.1 and 0.18 indicate a concentrated market; when the HHI exceeds 0.18, the market is defined as highly concentrated (Department of Justice, 2015).

As mentioned before, over the long term, global research and development activity has been highly concentrated in a relatively small group of countries. This is shown in fig. 3. All four indicators suggest a high concentration of global R&D in the 1981-2013 period, but the values can be observed to decrease, which indicates that a process of decentralisation has begun. In practice, the greatest drop was observed for the Cr_1 indicator, i.e. for the R&D market share of the United States. In the 1980s, the Cr_1 ranged from c. 44 to 47%; it fell to 40% over the next decade and continued to drop even further (down to c. 30%) after 2000. However, the dominance of the American economy remains significant even today. It is worth noting that the market is defined as highly concentrated when the top four actors jointly account for 40% of the market; in the case of global R&D, this level is achieved by the leader alone.

In turn, the Cr_3 ratio, representing the added shares of the top three global R&D countries, exceeded 70% in the 1980s, and steadily decreased over the 1990s. However, beginning in 2004 (58.7), it began to grow again due to the dynamic activity of China, which replaced Germany in the top three. In 2009, China permanently pushed Japan from second position. In 2013, the Cr_3 equalled 61.3.

Cr_5 steadily decreased, going down from c. 85% in the 1980s to c. 70% in the first decade of the 21st century. China joined the top five in 2000, followed by South Korea in 2010. As a consequence, in 2010, the market share of the top five highest-investing countries began to grow and the Cr_5 rose to 72.4% by 2013. At the moment, the indicator includes the shares of the US, China, Japan, Germany, and South Korea.

Cr_7 levels showed a similar trend over the studied period; in the 1980s, the ratio exceeded 90%, only to drop to 76.7% in 2008. Beginning in 2009, it began to grow and rose to 78.6% by 2013. The Cr_7 group now includes South Korea (from 1995) and China (from 1997).

To sum up, concentration ratios attest to a steady decrease in the share of world leaders in global R&D; this could be interpreted as a sign of R&D decentralisation. However, the rise of China and South Korea to the top of the fray reversed earlier trends and triggered the new tendency of R&D concentration, which was observable over the last couple of years. Considering the dynamic growth of R&D expenditure in China, the trend is likely to be reinforced even further. At the same time, it should be emphasised that the market share of the global R&D leader showed a consistent decrease over the studied period.

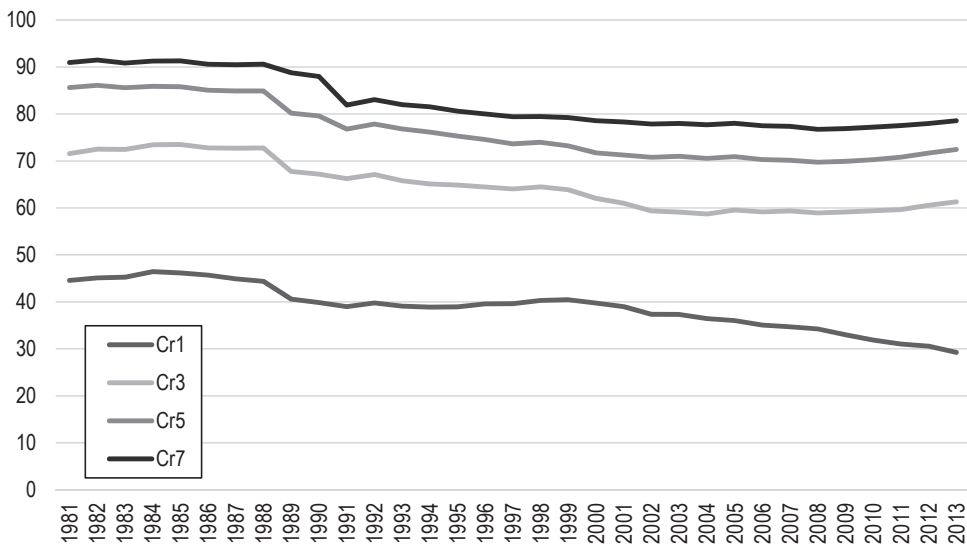


Figure 3. Global R&D concentration indicators

Source: calculated and analysed by the author.

An analysis of HHI trends supports similar conclusions (fig. 4). A very high level of global R&D concentration was observed throughout the 1981-2001 period, with the HHI consistently above the 0.18 mark. However, the figure steadily decreased. In

the 1980s, it was greater than 0.25, which means that R&D was very concentrated in a narrow group of countries and most economies showed no R&D activity at all. In the 1990s, it oscillated around 0.2, signalling an incipient decentralisation of global R&D. The index continued to drop even further, going down to 0.15 in 2011; this figure, however, still indicated a high degree of market concentration. Beginning in 2012, the HHI increased again, signalling a new process of concentration, attributable to the fact that R&D investment grew faster among world leaders than among other countries.

To sum up, even though market concentration markedly decreased, i.e., the decentralisation process began, an analysis of HHI trends suggests that a return to greater concentration is already underway.

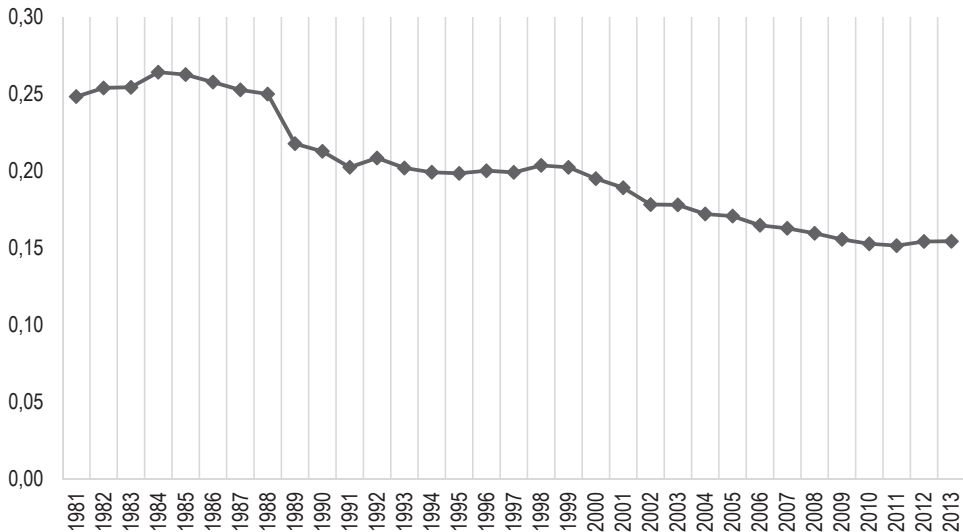


Figure 4. The HHI of global R&D

Source: calculated and analysed by the author.

Since TNCs are the driving force behind global R&D and account for the transformations observed in its structure, an analysis of R&D concentration was performed covering the 1000 highest-spending TNCs. Companies were classified by country of origin; R&D spending was then added for individual countries. In the next step, concentration levels were analysed by calculating Cr_1 , Cr_3 , Cr_5 , Cr_7 ratios and the HHI value. Statistical data came from EU rankings that covered the 2003-2013 period (European Commission, 2004a, 2004b, 2005a, 2005b, 2006a, 2006b, 2007a, 2007b, 2008a, 2008b, 2009a, 2009b, 2010a, 2010b, 2011a, 2011b, 2012b, 2013, 2014a, 2014b).

The analysis of the 1000 highest-spending TNCs (fig. 5) showed a higher degree of R&D concentration than that for the global R&D market, by c. 10% across all four indicators, i.e. Cr_1 , Cr_3 , Cr_5 , and Cr_7 . This indicates the continuing dominance of transnational corporations from the US, Japan, Germany, France, Switzerland, and Great Britain. Since 2004, the top 7 has also included South Korean TNCs. Chinese companies, on the other hand, still have a relatively low standing, ranking eighth in 2013 (16 billion USD). Cr_i indicators for TNCs dropped slightly in the 2003-2013 period, i.e. the degree of concentration decreased. The exception to the rule was Cr_1 , i.e. the market share of the leader, the US economy, whose corporations continue to be the strongest actors in the R&D market. Beginning in 2010, American TNCs have increased their share in the top 1000.

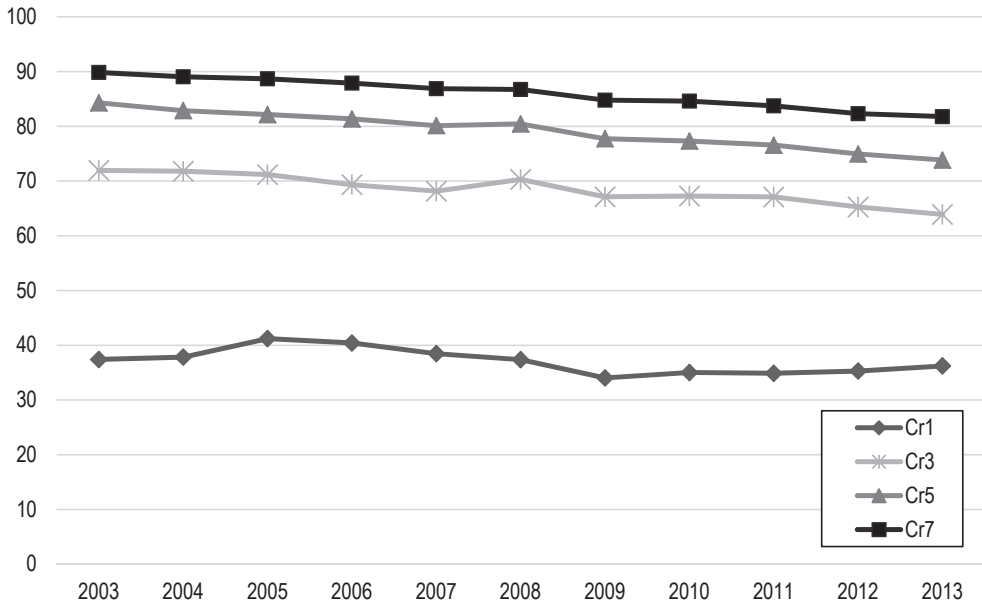


Figure 5. R&D Concentration indicators for the top 1000 R&D highest-spending TNCs
Source: calculated and analysed by the author.

An analysis of the HHI indicator also confirms a very high degree of concentration for transnational corporations (fig. 6). The HHI was greater than 0.2 throughout the 2003-2008 period (with the highest value, 0.23, observed in 2005). Between 2009 and 2013, the figure fell, dropping from 0.19 to 0.18, but the degree of concentration remained relatively high. This suggests that the top 1000 TNCs belonged to a small group of countries strongly dominated by a handful of leaders. In practice, the group only represents as few as 38 countries, most of which make negligible contributions

to the total. In 2013, total R&D investment equalled c. 491 billion USD; of this figure, American TNCs accounted for 178 billion, Japanese TNCs for 79 billion, German TNCs for 57 billion, French TNCs for 27 billion, Swiss TNCs for 22 billion, British TNCs for 21 billion, and South Korean TNCs for 18 billion.

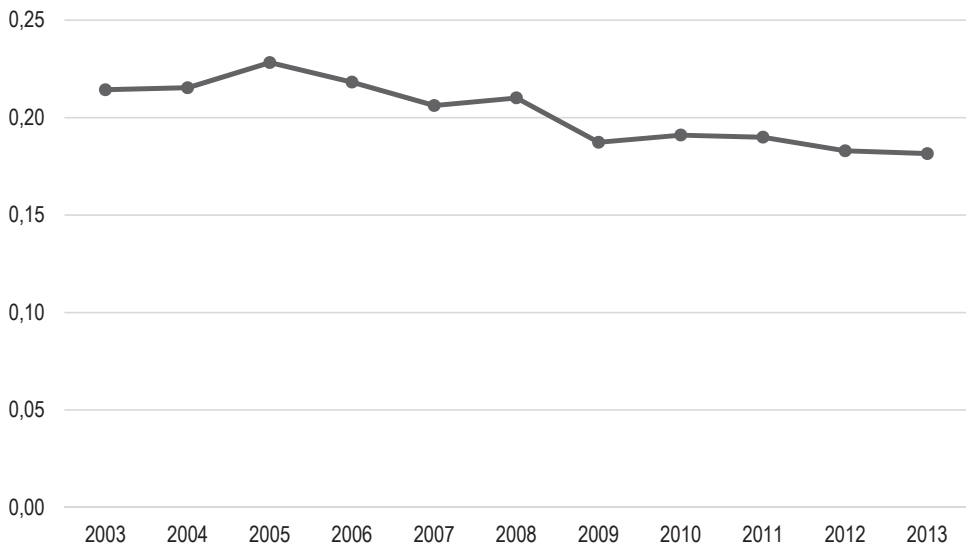


Figure 6. The HHI for the top 1000 R&D highest-spending TNCs

Source: calculated and analysed by the author.

To sum up, R&D in the top 1000 corporations shows a very high degree of concentration, with US corporations far ahead of the rest of the game. On the whole, a consistently high level of concentration can be observed, with the countries of origin of the Triad in the lead.

A new global R&D structure

Related to the processes of decentralisation and concentration, changes in global R&D activity have created a new balance in the world economy; beginning in 2009, the lead has increasingly shifted toward East Asia, including countries such as China, Japan, and South Korea (as well as Taiwan and Singapore). The Asian centre has consistently strengthened its position as a leader and now accounts for nearly 40% of total R&D investment worldwide (fig. 7). Of course, the most important position in the region belongs to China, whose involvement in R&D has shown particularly dynamic growth. It is worth noting that in 2000, the total share of these countries in global R&D amounted to less than 25%.

The second centre is located in the United States, the traditional leader, which accounts for 1/3 of global R&D expenditure today. Even though the US economy is still the strongest R&D actor, and American corporations continue to show the greatest R&D potential, the relative importance of the American centre has been on the wane. In the 1980s, the US accounted for 45% of global R&D spending; it still contributed 40% in the 1990s. However, beginning in 2000, the share steadily decreased and in 2009, the US surrendered its position as a leader to East Asia.

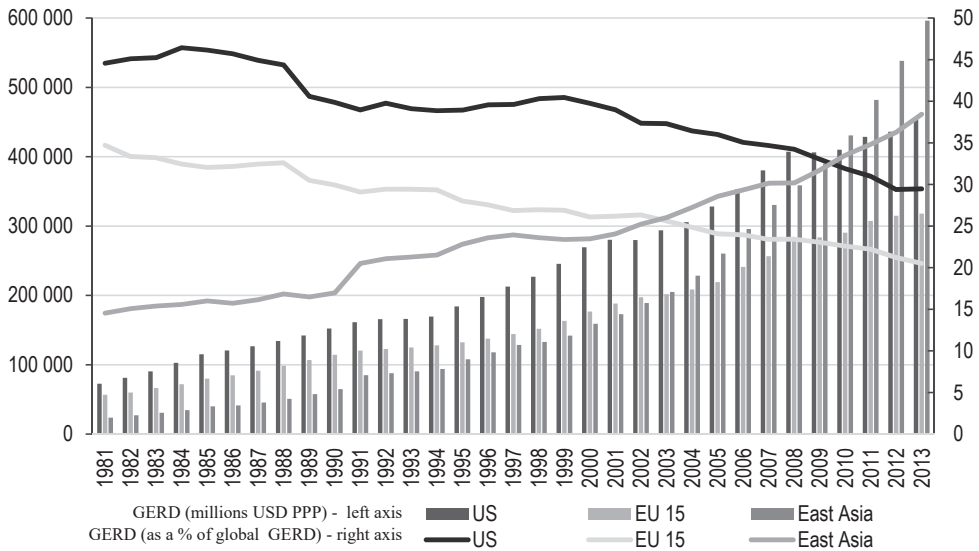


Figure 7. The three centres of global R&D

Source: calculated and analysed by the author based on OECD (2015).

The third R&D centre is focused in EU15, with Germany, France, and Great Britain leading the fray. Europe accounted for 20% of global R&D in 2013. Fig. 7 shows a steady drop in EU15’s importance (35% in 1981). Unfortunately, despite a noted growth of R&D investment in Europe over the studied period, the dynamic is too slow to keep up with the other two centres and the role of Europe in global R&D continues to decrease.

It is worth noting that the three major centres currently contribute to c. 89% of global R&D investment; the situation has not changed much since 1981, when the figure stood at 94%. The three centres have accounted for c. 89% of global R&D investment since 2000, even though in some years the share equalled c. 88%, and in 2012 even briefly fell to c. 87%. Nevertheless, there are no grounds to diagnose a real process of R&D decentralisation that would significantly incorporate individual

world economies into the main R&D development trend and considerably reduce the importance of the current leaders.

The paradox lies in the fact that while the decentralisation of R&D allowed China and South Korea to join the game as global R&D centres, the success of these two developing economies further increased R&D concentration worldwide. The new structure of global R&D, with East Asia in the lead, does not preclude R&D growth in countries outside the major centres, which has already been underway. The balance of the whole system, however, has shifted toward East Asia, which seems poised to further increase its R&D spending in the coming years. The growth of R&D investment in the Asian centre is simply impressive: beginning in 2009, expenditure increased by c. 11% per annum and reached a total of nearly 600 billion USD in 2013 (compared to c. 318 billion in the EU15 and c. 457 billion in the US).

The new structure is likely to be entrenched even further, with the Asian centre emerging as the most important actor in the new concentration process. Chances are slim regarding a change in the current system and the trends which can be observed. Concentration will probably remain the dominant trend, but a parallel decentralisation is also likely to occur, whereby an increasing number of countries will join the R&D market. In the coming years, however, these new actors will not have the clout to threaten the dominant position of the concentrated system of East Asia, the US, and the EU15, and reverse the increasing shift toward the Asian centre.

Conclusions

Global R&D activity today remains concentrated within a small group of countries. However, signs of decentralisation can be observed, with countries from outside the Triad increasingly joining the fray. In particular, decentralisation has manifested itself in the rise of two developing countries, China and South Korea, to leading positions in global R&D activity. However, since 2011, a parallel increase in global R&D concentration has also been observed, linked to the growing position of China.

Among the highest-spending transnational corporations, R&D concentration is even higher than in global R&D; the top 1000 continues to be overshadowed by companies from the US, Japan, Germany, France, and Switzerland. The position of China is still weak but South Korean companies are increasingly more visible. R&D internationalisation, significantly fuelled by TNCs, has occurred largely within the Triad, with only negligible R&D investment flow from the Triad to the outside.

To sum up, global R&D concentration has increased again, shaping a new system with East Asia as the leader and China, Japan, and South Korea leading the fray. The second global R&D leader is the United States; its importance, however, is marginally decreasing. The third centre is the EU15, specifically Germany, France, and Great Britain, but its position is seriously threatened. It seems that the decentralisation process that started in the 1990s, which introduced two new countries into the lead

and visibly diffused R&D activity across a larger group of countries, will affect the global R&D system to a lesser extent than the new process of concentration that began in the second half of the second decade of the 21st century.

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