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PAWEŁ PASIERBIAK

The Technological Leadership of the Japanese Economy?

Abstract

The author focuses on the technological development of Japan and assesses the country's international position in that field. He argues that Japan could achieve a position as a global technological leader thanks to the adroit and supportive policy of the state and the dedication of enterprises to technological development. But in the current, more complicated domestic and external economic circumstances, the country's leading position is coming under threat. Because of growing competition from new, mainly Asian rivals, the old leaders need to adjust to the new situation. This means that in some fields of technology Japan will lose its advantages as well.

1. Introduction

Technical and technological progress is one of the most decisive factors for the current and future economic position of the Japanese economy. Progress in this area generally determines the opportunities for the country's economic growth, and those economies that are developing on the basis of technology record the highest long-term dynamics of growth. This is considered in many theories of economic growth, where aspects of technological progress are often very important.[1] Therefore, those countries which thanks to technology are able to use their resources in not only intensive but also extensive ways, and whose governments pursue an active policy of promoting technological development and innovation, are the only ones which can attain a leading global position.

Japan's post-war economic development is an interesting example of the idea that through adroit technology development (among other factors), the country has been able to succeed in transitioning from the position of a backward country into a world leader. Confirmation of this can be found both in the number of indicators describing the technological development of the country[2] and the general perception of Japanese products as well as the whole economy as thoroughly modern and highly technologically advanced. The 1970s was a period when the technological gap between Japan and the most advanced economies closed, and the country entered a phase of technology creation, and the acquisition and consolidation of its position of global technology leadership. In the second

[1] Technology is not, of course, the only factor of economic growth. In the classical approach there are three factors of production: land, labor and capital. In more recent concepts, both technology and entrepreneurship can be perceived as such factors.

[2] This will be developed in more detail in section 2.

half of the 1980s the Japanese economy offered products which were model examples of the progress that can be achieved through skillful technological development.

This position of leadership should not, however, be taken for granted. In the early 1990s a difficult period of economic slowdown for the Japanese economy began. At the same time, some dynamic changes occurred in the global economy and started influencing the balance of power within the global economy. It also posed challenges for Japan in the ??technical and technological areas; these changes are the focus of this study.

The analysis will cover the technological position of Japan related to other countries and the factors determining this position. In particular, the aim is to show the evolution of the development of Japan's technological level by the end of the 190s, and to compare the country's current position with such economies as that of the United States, Germany, South Korea and China. The analysis will cover the most important areas of technology. As the country's foreign trade also reflects the level of technological development, this sphere of economic activity will also be evaluated in detail.

The main analysis carried out in this study will include the most recent years (since 2000), but for a synthetic presentation of the evolution of Japan's technological level we will include the years immediately after World War II. The large amount of statistical data needed to achieve this goal influenced the research methods used in the paper. These include an analytical method (analysis of primary sources in the form of statistical data collected by the OECD and the World Bank) and a descriptive method.

2. The technological progress of the Japanese economy after World War II

After World War II Japan had to make a decision about the foundations of its future development. With a choice of two alternative routes, the government decided that economic development would be based on extensive economic ties with the rest of the world.[3] Active participation in the international economy was to be an effective way to upgrade the structure of the national economy. Both the government and the whole of Japanese society was convinced that the production and export of modern goods would quickly lead to economic and social advancement. In order for this to be possible, it was necessary to focus on improving the technological level of business enterprises and the entire economy.

Technical and technological progress serves as an incentive for improving the efficiency of the manufacturing process, but it also influences the prices and the non-price competitiveness of export supply.[4] Improved efficiency through technological progress leads to a decrease in the cost of production, but also helps to improve the utility of goods and the introduction of new products and models. An increasingly favorable relationship between price and product quality makes consumers more willing to purchase such goods.

All postwar Japanese governments were aware of this link. Therefore, deliberate state policy led to technological development. When private companies increased their position and technological progress was based on their commitment, governments were able to conduct a useful supporting policy.

[3] The first was development based on Japan's own resources for production, and the second was development in co-operation with the outside world.

[4] Jan Bossak, Elżbieta Kawecka-Wyrzykowska, Mieczysław Tomala, *Stany Zjednoczone, EWG, Japonia – współpraca i rywalizacja* [The United States, EEC, Japan – Co-operation and Rivalry], Warszawa: Polskie Wydawnictwo Ekonomiczne, 1988, p. 57.

After World War II, Japan pursued a policy of technological development similar to that of the Meiji period, that of importing technology from abroad. Along the same lines, directly after the war Japan was eager to take advantage of the technical expertise from more developed countries such as the United States, the United Kingdom, France and Germany. Initially, the main channel of technology transfer was imports of machinery and equipment[5], but in subsequent periods, the most desirable method of acquiring of technical knowledge became licensing. This was used in those industries that were the subject of industrial policy implemented by the state, especially in such industries as electrical and non-electrical machinery, chemicals, transportation and electronics. [6] Importing licenses was the most important way of obtaining technology in the early 1960s, when the technological level of the country still remained at a relatively low level. However, in later years, when the scientific base of the country began to develop intensively, Japan improved its ability to adapt foreign licenses. Japan began to close the technological gap dividing it from the developed countries.[7] Under such conditions, it became increasingly important to create its own technology and specific solutions. Bringing Japan's technological level up to that of the developed countries also meant that the licenses were less willingly sold to Japan, and in new areas of research, restrictive regulations on the import of technology were employed.[8] The strategy of 'catching up', as Japan's technology policy after World War II was described, was replaced in the 1980s by a strategy of seeking innovative technologies.[9]

The high level of technological development achieved by Japan was clearly reflected in foreign trade. Comparisons with the United States and countries of the European Economic Community were much in Japan's favor. Detailed data which illustrate this issue are presented in Table 1.

According to Table 1, the largest increases in exports by Japan were recorded in the field of high-demand growth goods that are also high-tech products. In this group Japan showed the highest growth of share among OECD countries. In the group of medium-demand growth goods Japan also showed an increase, but less than in the previous group. Smaller but still positive changes occurred in the group of low-demand growth goods. The analysis confirms the changes that took place in the Japanese comparative advantage – specialization in labor-intensive products was replaced by specialization in capital- and later in knowledge-intensive products. At the same time, the perception of Japanese products on international markets was changing. They became known for having the highest level of technological advancement, a high degree of reliability and relatively low prices.

Japan's rapid postwar technical and technological progress was achieved mainly by conducting a deliberate policy in that field of the national economy. This was reflected

[5] J. Monkiewicz, 'Importowana technika w rozwoju technicznym gospodarki japońskiej' [Imported Technology in the Technical Development of the Japanese Economy], *Kapitalizm*, No. 1/ 1979, p. 121.

[6] Ibid., p. 123.

[7] See among others: Hugh Patrick, *The Phoenix Risen from the Ashes: Postwar Japan*, Center Paper No. 151, New Haven: Yale University, 1970, pp. 314–317.

[8] *Economic Survey of Japan 1981/1982*, Tokyo: Economic Planning Agency, 1984, p. 230.

[9] Yuko Harayama, 'Japanese Technology Policy: History and a New Perspective', *RIETI Discussion Paper Series*, 01–E–001, August 2001, p. 8.

Table 1. Changes of shares in total exports of OECD in the years 1968–1985, in percentage points

Specification	Percentage changes in years:		
	1973/68	1979/73	1985/79
Industrial goods in total			
Europe-10	–1.83	+0.24	–1.44
United States	–3.63	–0.17	+0.73
Japan	+1.61	+0.85	+5.37
Goods of high demand growth			
Europe-10	–3.43	–0.56	–2.54
United States	–4.96	+0.57	+1.24
Japan	+2.21	+0.70	+7.14
Goods of medium demand growth			
Europe-10	–1.19	–0.29	–2.42
United States	–4.61	–0.99	+0.21
Japan	+2.85	+1.64	+5.66
Goods of low demand growth			
Europe-10	–1.67	+1.70	+1.93
United States	–1.55	–0.09	–1.05
Japan	–0.71	–0.40	+1.85

Europe-10 – without Greece and Portugal, and discounting intra-EEC trade.
Goods of high demand growth – modern goods. Goods of low demand growth – traditional (not modern) goods.

Source: John A. Quelch, Robert D. Buzzell, Eric R. Salama, *The Marketing Challange of Europa 1992*, Addison-Wesley Publishing Company 1991, p. 5. Citation after Bogumiła Mucha-Leszko, *Rozwój powiązań w gospodarce światowej – etapy globalizacji i regionalizacja procesów gospodarczych* [Development of Links in the World Economy – Phases of Globalization and Regionalization of Economic Processes] in Bogumiła Mucha-Leszko (ed.), *Współczesna gospodarka światowa. Główne centra gospodarcze* [Contemporary World Economy. Main Economic Centers], Lublin: Wydawnictwo UMCS, 2005, p. 59.

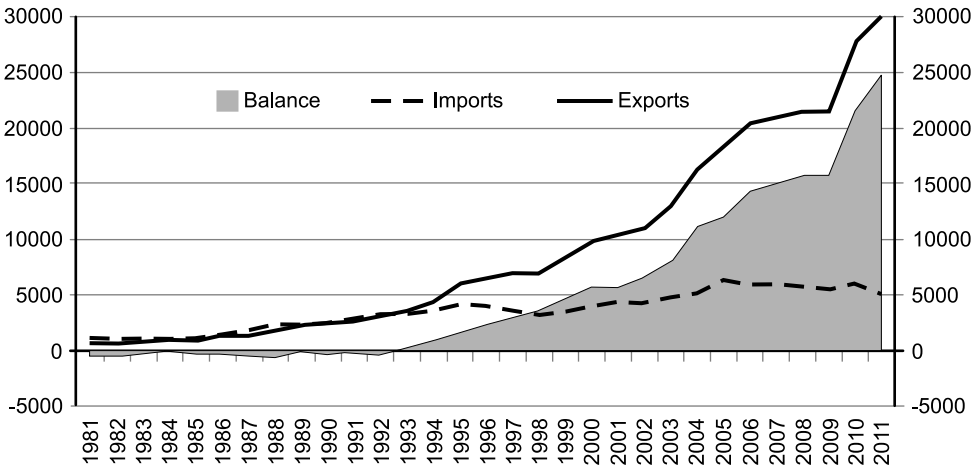
inter alia by the amount of funding allocated to research and development. From the beginning of the 1950s Japan extensively increased not only the absolute level of spending but, more importantly, its share of expenditure on R&D in relation to GDP. In 1953, the share was 0.5% and has constantly increased since then.[10] Comparison of Japan to other countries confirms the much greater involvement in the financing of research and development. In

[10] Dirk Pilat, *The Economics of Rapid Growth: the Experience of Japan and Korea*, Aldershot: Edward Elgar Press, 1994, p. 69.

1990, the ratio of expenditure on R&D to GDP was 2.91% in Japan, while in the United States it was 2.65%, and in Germany 2.61%.[11] In 2000, the shares were 3.00%, 2.71% and 2.47% respectively.[12] In subsequent years, Japan's share has even increased, and the country technological development has reached higher and higher levels.

However, this did not mean that along with achieving a better position Japan was losing interest in acquiring foreign technical expertise. On the contrary, in parallel with the development of their own scientific research facilities and exporting the results of their technology, Japan was still interested in importing technology from abroad. An illustration of this process, and at the same time a synthetic measure of the level of technological development, is the technology balance of payment, as measured by the difference of inflows and outflows arising from the selling and purchasing of the licenses. The following statistical evidence (Chart 1) shows the tendencies.

Chart 1. Technology balance of payments: Payments and receipts, in US$ million



Source: OECD, 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

The information from Chart 1 clearly shows the changes which Japan has experienced in the balance of technology since the early 1980s. Yet by 1993, revenues were almost equal to expenditures, resulting in a relatively stable technological balance. Since then, however, we can observe a stabilization of expenditures at an average amount of about US$5 billion, while at the same there has been a very dynamic growth in revenues from export licenses.

The above analysis provides a basis for assuming that in the second half or the 1980s Japan became a highly technologically developed country whose products could compete successfully not only on international markets but also on the highly demanding markets

[11] OECD, 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

[12] Ibidem.

of such developed countries as the United States and some Western European countries.[13] In the 1980s products of Japanese origin became synonymous with the highest quality. Growing demand for Japanese products around the world confirmed the effectiveness of the industrial and technological restructuring of the economy.

3. The technological maturity of Japan in the 21st century

Forty years after the end of World War II, Japan had established a strong position of technology leadership in the global economy. A well-managed policy of industrial development and the technological involvement of private companies in a constant drive to improve efficiency through the implementation of innovation were the main reasons for this success, but public confidence about the benefits of technology development was also important. However, when symptoms of stagnation in the economy appeared in the early 1990s, the technology and innovation field also displayed some disturbing phenomena. What is more, these were also perceived as attributing to the negative impact on the overall economy. According to Marcus Noland, in the second half of the 1990s Japan failed to meet virtually any of the criteria that should have been maintained for the national innovation system to be defined as effective.[14] In his view, Japan did not have strong ties to industry and science, there was a lack of strong foreign trade and investment connections, and the scientific background was weak. In addition, business was not supported by favorable risk-taking institutions, and the existing conditions did not facilitate the creation and dissemination of innovation. Japan started to be perceived as a country that had lost not only its position in international trade and investment, but also its position of a technology leader.

Analyzing the changes that have taken place in the new century in Japan in the fields of science, technology and innovation, and applying them to the country's biggest competitors in that field, the picture that emerges is not stable, and is certainly complex and multi-dimensional.[15] In many areas Japan is still a leader which does not need to feel threatened, but there are also some spheres where its position is endangered, mainly from the quickly developing emerging economies.

Considering R&D expenditures, which are one of the key indicators,, we can say that Japan still spends a great deal in relation to GDP. In Table 2, data is collected for Japan and other selected countries.

In 1990, Japan's spending totaled US$68.8 billion, or 2.91% of the GDP. In 2011, expenditures reached US$146.5 billion, an increase of 113%, and its share of the GDP was 3.39%.[16] Among the countries listed in Table 2, only South Korea (4.03%) spent more than

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[13] Andrzej H. Jasiński [ed.], *Innowacje i transfer techniki w gospodarce polskiej* [Innovations and Technology Transfer in the Polish Economy], Białystok: Wydawnictwo Uniwersytetu w Białymstoku, 2000, p. 142.

[14] Marcus Noland, *Industrial Policy, Innovation Policy, and Japanese Competitiveness,* Washington: Peterson Institute for International Economics, WP 07–4, May 2007, p. 14.

[15] A comparative analysis of Japan will be made in respect of economies such as the United States, Germany, South Korea and China. These are two groups of countries, the first of which consists of the so-called traditional leaders (including the US and Germany), while the second includes those countries that aspire to that role (such as China and South Korea).

[16] OECD, 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

Table 2. GERD as a percentage of gross domestic product, 1990–2011

Specification	1990	1995	2000	2005	2010	2011
Germany	2.61	2.19	2.47	2.51	2.80	2.88
Japan	**2.91**	**2.87**	**3.00**	**3.31**	**3.25**	**3.39**
Korea	–	2.30	2.30	2.79	3.74	4.03
USA	2.65	2.50	2.71	2.59	2.83	2.77
EU-28	–	1.65	1.74	1.73	1.91	1.94
China	–	0.57	0.90	1.32	1.76	1.84

EU-28 covers the former EU27 members plus Croatia, which is to join the EU on July 1, 2013.

Source: OECD, 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

Japan. The United States and the EU countries spent much less on the sphere of R&D in relation to GDP.

This phenomenon is confirmed by the analysis of expenditure on R&D in terms of its growth. Countries such as South Korea and China have a significant advantage over the more developed countries such as the United States and Japan. In 2010–2011, the growth rate in Korea exceeded 11%, and reached 14% in China.[17] Japan showed an increase of 1.43% (2010) and 3.53% (2011), while in the same period expenditure in the US decreased by 0.45% (2010) and 0.52% (2011). This is not a result of lower volume in absolute terms, but above all of the base effect, which states that the size of the increase is related to a lower base, as in the case of Korea and China.

Forecasts for 2013 predict a further increase in expenditures for R&D (see Chart 2), but the largest increase will be in Brazil (31%), India (12%) and China (12%).[18] This means that transformations are also taking place in this area of the world economy. With all the importance of research and development, Japan has developed some specific characteristics in its scientific and research sphere[19]: it is mainly of civilian nature, it is primarily funded by the private sector, and in addition Japanese companies attach great importance to the effectiveness of these expenditures. This means that resources are focused in industry, and furthermore, the best specialists are working in industry. The analysis of the structure of expenditure on R&D leads to the conclusion that the main source of funds for R&D is indeed industry. Figure 3 shows the sources of funds for R&D in Japan.

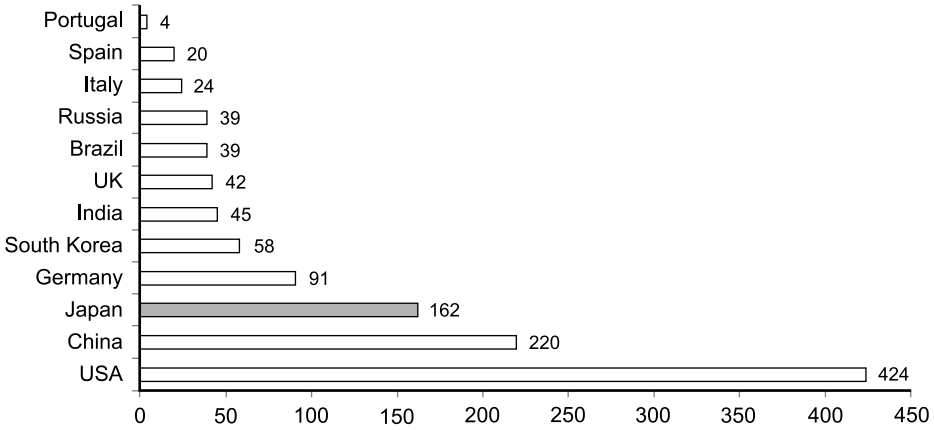
In 2011 industry financed over 75% of total R&D spending. At the same time, there is a tendency to government's decreasing involvement in financing this sector of the economy. What differentiates Japan from other countries is a clear lack of participation of foreign

[17] OECD, 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

[18] *Financial Times*, Thursday, May 30, 2013, p. 15.

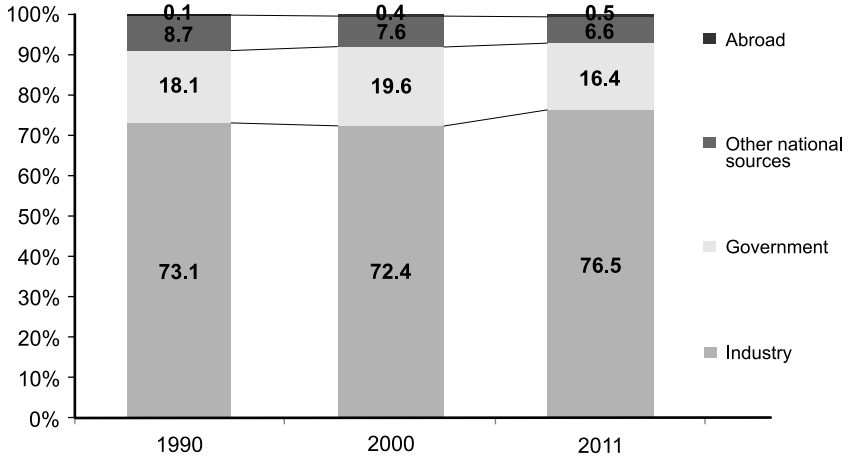
[19] For more details see Paweł Pasierbiak, *Miejsce Unii Europejskiej w zagranicznej ekspansji gospodarczej Japonii* [The Position of the European Union in The Foreign Economic Expansion of Japan], Lublin: Wydawnictwo UMCS, 2008, pp. 103–104.

Chart 2. Estimates of GERD in 2013 for selected countries, in US$ million



Source: *Financial Times*, Thursday, May 30, 2013, p. 15.

Chart 3. Sources of Japanese GERD financing, in %



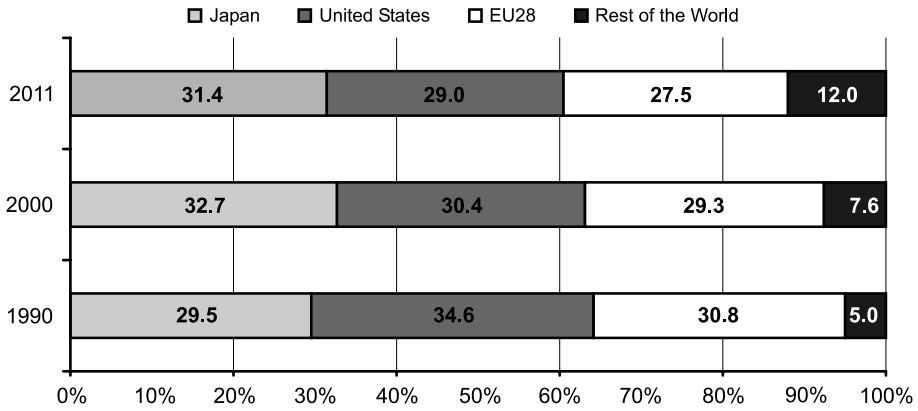
Source: OECD, 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

capital in financing R&D. This is primarily due to low openness to foreign capital, resulting in a lack of strong investor interest in the functioning of the Japanese market.[20] Japan's commitment to efficiency caused it to develop its industrial innovation capabilities. This is

[20] According to UNCTAD data, in 2012 Japan's share of in world's total inward FDI stock was 0.9%, while Germany's was 3.1% and China's 3.7%. UNCTAD, *World Investment Report 2013. Global Value Chains: Investment and Trade for Development*, New York and Geneva: UN, 2013, pp. 217–218.

confirmed by the high number of patents submitted by Japan and the country's participation in the number of patents obtained abroad. In 2011, the Japanese ICT sector alone reported more than 17,000 patents; this result was higher than that of the USA (16,548) and the EU28 (12,513).[21] Japan is also a leader in terms of participation in the triadic patent families.[22] Graph 4 contains data for Japan, the US and the EU.

Chart 4. Share of countries in triadic patent families, in %



Source: Author's calculations based on OECD, 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

The position of the United States, which in 1990 was the strongest, has weakened over time to 2011. Similarly, the role of the European Union has also been reduced, and the only member of the international economic relations' 'triad' which enhanced its importance in this respect was Japan.

4. The technological intensity of Japanese trade

After World War II, international trade became one of Japan's major sources of economic success. Japan actively and peacefully began to participate in the international economy. However, in order to succeed on international markets it had to offer products which were not only reasonably priced, but would also have a high utility value. These competitive advantages could only be provided under the rapid technological advancement of the country. Progress was reflected not only in the country's economic and production structure, but also in its increasingly attractive export offer. Japanese products were increasingly finding buyers on international markets. In the second half of the 1980s, Japan achieved very high status as an

[21] OECD, 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

[22] Patent families refer to triadic families: i.e. a patent is a member of the patent families if and only if it is filed at the European Patent Office (EPO), the Japan Patent Office (JPO) and is granted by the US Patent and Trademark Office (USPTO). OECD, *Main Science and Technology Indicators Volume 2012 Issue 2*, OECD Publishing. http://dx.doi.org/10.1787/msti-v2012-2-en, 2013, p. 102.

exporter of technologically advanced goods.[23] In the early 1990s, the Japanese economy started to feel the economic slowdown, which was reflected in a deterioration of the economy's macroeconomic condition as well as changes in the field of foreign trade (among other factors). Opinions were formulated that the Japanese economy was too heavily dependent on the current situation in the global economy. The demand on the international market, which by nature is independent of any policy undertaken by the governments of individual countries, created a certain burden for Japan. A growing external demand had a positive effect on the condition of the internal economy and a low level of demand negatively affected the dynamics of economic development. Attempts to become independent from the negative impact of the external environment by stimulating domestic demand have not yet succeeded.[24] In such circumstances it was more important for the products sold on international markets to maintain their technological leadership. The high level of technological advancement is conducive to the achievement of higher margins, and thus has a positive effect on the condition of businesses, foreign trade and the state of the economy. However it is worth noting that the contemporary conditions for exporters are radically different from those observed in the 1990s. The ever greater degree of the globalization of economic processes leads businesses increasingly to move their production processes abroad. This also results in changes to the foreign trade of each country. Existing leaders need to make adjustments caused by the pressure of rapidly developing new actors in the global economy.

Table 3 shows data on the exports of high technology products for selected countries from the beginning of this century. It can be concluded that, apart from 2009, the value of exports of such goods has steadily increased.

In 2009, many national economies experienced a collapse in global trade, including in the area of high technology. However, as illustrated by the data, in 2010–2011 there was a rebound in the value of exports and a resumption of growth. The growth rate of exports of high technology goods varied between countries; the highest growth was demonstrated by countries such as China and South Korea. To the same extent this is the result of the technological progress which has taken place in these countries, but it should be also treated as a result of the globalization of economic activities. For both China and Korea, a major role in their foreign trade is played by the import of components and sub-assemblies to be installed in the country of final stage of production. Therefore, according to the traditional approach to trade statistics, the final product is recognized as highly valued. In reality, much of the value added to the final good is added in other countries.[25] However, data showing changes in the share of economies (in the traditional approach) indicate that all the previous leaders are less important in the world economy in this respect. An illustration of this process can be found in Chart 5.

Analysis of the data clearly shows a decrease in Japan's position in world exports of high technology goods. Between 2000 and 2010, the country's share fell from 11.1% to just 6.8%. This brings Japan to the level of South Korea, while the latter country is experiencing a growing trend. Japan was not the only country whose share fell (the United States

[23] Bogumiła Mucha-Leszko (ed.), *Współczesna gospodarka światowa. Główne centra gospodarcze* [Contemporary World Economy. Main Economic Centers], Lublin: Wydawnictwo UMCS, 2005, pp. 59–60.

[24] OECD, *OECD Economic Surveys: Japan 2009*, OECD Publishing, Paris 2009, pp. 22–23.

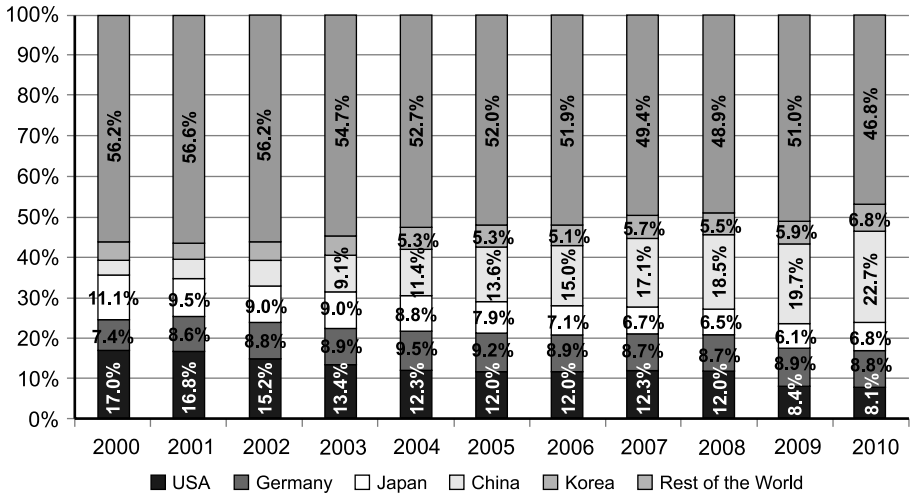
[25] This problem will also be considered in next paragraph of this article.

Table 3. High-technology exports of selected countries in the years 2000–2011, in % and US$ million

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
World	*1159*	*1051*	*1068*	*1192*	*1431*	*1589*	*1825*	*1767*	*1841*	*1572*	*1792*	–
EU	390.3	386.2	385.3	421.4	499.9	552	624.6	554.3	581.9	511.1	574.1	622.4
	33.7%	36.7%	36.1%	35.4%	34.9%	34.7%	34.2%	31.4%	31.6%	32.5%	32.0%	–
USA	197.5	176.2	162.1	160.3	176.3	190.7	219	218.1	220.9	132.4	145.5	145.3
	17.0%	16.8%	15.2%	13.5%	12.3%	12.0%	12.0%	12.3%	12.0%	8.4%	8.1%	–
China	41.7	49.4	69.2	108.7	163	215.9	273.1	302.8	340.1	309.6	406.1	457.1
	3.6%	4.7%	6.5%	9.1%	11.4%	13.6%	15.0%	17.1%	18.5%	19.7%	22.7%	–
Korea	54.3	40.4	46.9	57.5	76.1	83.9	93.4	101	100.9	92.9	121.5	122
	4.7%	3.8%	4.4%	4.8%	5.3%	5.3%	5.1%	5.7%	5.5%	5.9%	6.8%	–
Japan	128.9	99.5	95.9	107.1	126.2	125.4	129.2	117.9	119.9	95.2	122	126.5
	11.1%	9.5%	9.0%	9.0%	8.8%	7.9%	7.1%	6.7%	6.5%	6.1%	6.8%	–

Source: Author's calculations based on World Bank Database. http://data.worldbank.org/indicator/TX.VAL.TECH.CD/countries. 2013 (accessed 23.04.2013).

Chart 5. Share in world's high-technology exports of selected economies, in %



High-technology exports are products with high R&D intensity, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

Source: Author's calculations based on World Bank Database. http://data.worldbank.org/indicator/TX.VAL.TECH.CD/countries. 2013 (accessed 23.04.2013).

showed an even greater reduction of the share, by 8.9%), but if we take into account the position of Germany, which to some extent has been strengthened, the situation of Japan is not that good. In particular, comparisons with China give negative results. In the period analyzed (2000–2010), China increased its share in exports of high technology goods from 3.6% to 22.7%. Here again the hypothesis about the falling position of developed countries and the rising position of developing countries can be confirmed.

The analysis of more detailed data on Japanese exports and imports of high technology goods confirms the country's deteriorating competitiveness. In almost all areas of analysis (electronic industry, the office machinery and computer industry and the pharmaceutical industry), the deterioration in Japan's trade balance with other countries is easily seen.

One area that has shown little improvement was the *instrument industry*, where there was an increase in surplus, and the *aerospace industry*, where the previously recorded deficit decreased. The changes described are illustrated in Table 4. This data also shows the

Table 4. Japanese high-technology trade balance and share in world's exports, in US$ million and %

Industry	Trade balance [US$ mln]			Export market share [%]		
	1990	2000	2011	1990	2000	2011
Aerospace industry	–3549.2	–2468.8	–1488.5	0.7	1.5	1.8
Electronic industry	38100.2	47568.8	13872.1	37.4	12.8	5.8
Office machinery and computer industry	19498.7	7658.7	–7141.2	24.3	9.3	3.3
Pharmaceutical industry	–1784.0	–2419.9	–18173.3	3.9	2.9	1.0
Instrument industry	8603.3	13743.1	20348.2	17.5	14.2	8.2

Source: Author's calculations based on OECD 'Main Science and Technology Indicators', *OECD Science, Technology and R&D Statistics* (database). Doi: 10.1787/data-00182-en. 2012 (accessed 22.06.2013).

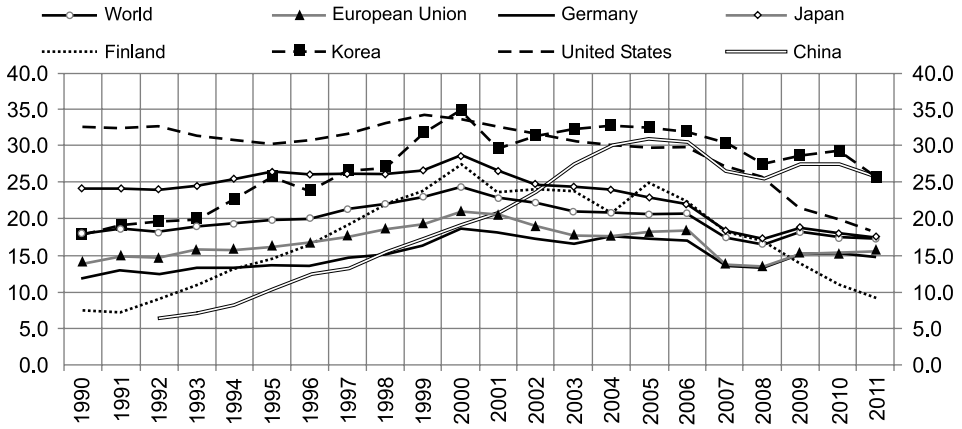
dramatically declining participation rates of Japan in world exports in selected groups of high-tech products. The biggest decline in the share between 1990 and 2011 showed an *electronic industry* (from 37.4% to 5.8%) and *office machinery and computer industry* (from 24.3% to 3.3%). The highest share in world exports of high technology goods was found in the *instrument industry*, but here too there was a decrease from 17.5% (1990) to 8.2% (2011).

This is also the consequence of internal transformations in each country. In the developed countries there is a noticeable reduction in the share of high technology products exports in the total exports of manufactured products. This trend is also apparent throughout the world as a whole (see Chart 6).

However, in developing countries (Korea, China) the trend is clearly reversed – the share of high-tech goods in total exports of manufactured goods has increased. In the case of China in 2004–2006 the level even reached 30%, with the global average little more than 20%. This reflects the positive changes in the structure of production and exports of developing countries.

In the case of Japan, data on the share of exports of high technology goods in the manufacturing export are similar to that for the global average. However, the declining

Chart 6. High-technology exports (% of manufactured exports) of selected economies, in %



High-technology exports are products with high R&D intensity, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.

Source: Author's calculations based on World Bank Database. http://data.worldbank.org/indicator/TX.VAL.TECH.CD/countries. 2013 (accessed 23.04.2013).

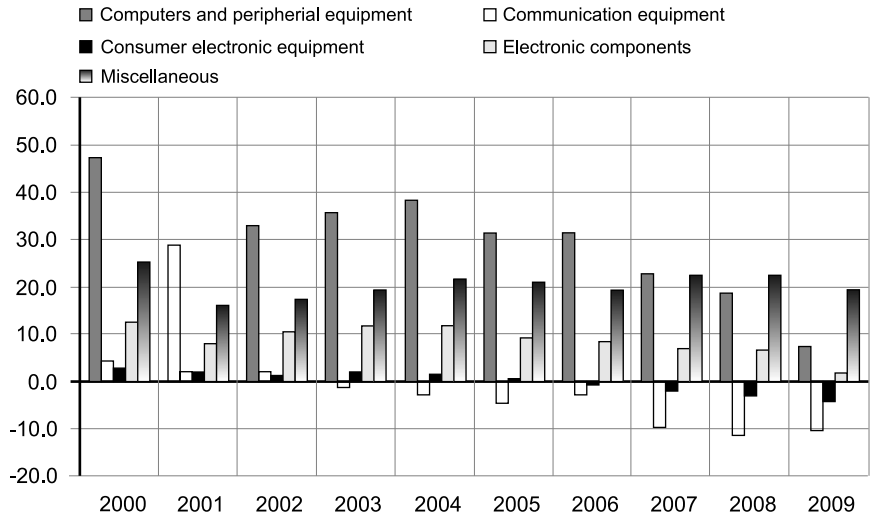
share of the above-mentioned products in Japanese exports can be perceived as a negative phenomenon. Another symptom of adverse changes is Japan's trade balance with the rest of the world in the field of ICT products. In the years 2000–2009, this balance deteriorated drastically; the surplus fell from US$47.3 billion to US$7.4 billion (see Table 5).

Table 5. Product structure of Japanese ICT exports and imports in the years 2000–2009, in % and US$ million

Specification	2000	2005	2009	2000	2005	2009
	Exports			Imports		
Total (US$ billion)	108.80	100.81	70.16	61.48	69.50	62.73
Computers and peripheral equipment	29.0%	22.7%	10.1%	44.3%	39.6%	28.2%
Communication equipment	7.1%	3.4%	8.6%	7.9%	4.4%	16.5%
Consumer electronic equipment	17.5%	18.3%	16.3%	10.9%	13.3%	15.3%
Electronic components	42.1%	43.0%	55.8%	33.4%	32.5%	31.9%
Miscellaneous	4.3%	12.5%	9.2%	3.5%	10.1%	8.1%

Source: OECD, 'Harmonized System 1996: ICT Goods', *International Trade by Commodity Statistics* (database). Doi: 10.1787/data-00058-en. 2010 (accessed 27.06.2013).

Chart 7. Trade balances in Japanese ICT foreign trade, in billion USD



Source: OECD 'Harmonised System 1996: ICT Goods', *International Trade by Commodity Statistics* (database). Doi: 10.1787/data-00058-en. 2010 (accessed 27.06.2013).

A more detailed analysis of the structural changes leads to the conclusion that less and less importance in exports can be attributed to the group of *computers and peripheral equipment*. On the other hand, the *electronic components* group is growing in importance. This confirms the earlier statement about the rise of fragmentation of international production and its vertical integration, also in the case of Japan. In imports two groups have become less important: *computers and peripheral equipment* and *electronic components*, while the others have shown an increase. The worsening of Japan's general foreign trade in ICT goods was due to the deepening of unfavorable trends in all subsets of these goods. This is illustrated in Chart 7. In the first decade of this century the trade balance worsened in each commodity group. The surplus of US$47.3 billion in *computers and peripheral equipment* fell to only US$7.4 billion; in the case of *electronic components* it has decreased from US$12.4 billion to US$1.8 billion. The previously positive balance in *communication equipment* (US$4.3 billion) turned into a deficit (US$-10.6 billion). Similar trends were also seen in the *consumer electronic equipment* group (down from US$2.8 billion to US$–4.3 billion).

Besides these indicators for assessing the technological advancement of Japan's foreign trade and its international competitiveness, there are other measures which give a view on the country's position in the global economy. In the field of foreign trade, one of the most widely used measures is the index of revealed comparative advantage (RCA). This concept refers to the relative trade performance of individual countries in particular commodities.[26] When a country has achieved a revealed comparative advantage in the field of high-tech goods, it can form the basis for a positive assessment of the country's technological position.

[26] **RCAij = (xij/Xi)/ (xaj/Xa)**, where: *xij* : exports of product *j* from country *i*; *Xi*: total exports from country *i*; *xaj* total exports of product *j* from the reference area (e.g. the world); *Xa*: total exports from reference area. A country reveals comparative advantages in products for which the RCA indicator is higher than 1.

Table 6. Revealed Comparative Advantage (RCA) of selected economies in 1995 and 2009

Specification		Food products, beverages and tobacco	Textiles, textile products, leather and footwear	Wood, paper, paper products, printing and publishing	Chemicals and non-metallic mineral products	Basic metals and fabricated metal products	Machinery and equipment, n.e.c.	Electrical and optical equipment	Transport equipment	Manufacturing n.e.c.; recycling
2009										
Germany	GE	0.6389	0.1808	0.9437	0.9504	1.1523	1.8854	0.5955	0.5773	0.5773
	DVA	0.6168	0.1731	0.9410	0.9164	1.0438	1.9400	0.7037	0.6147	0.6147
Japan	GE	0.1022	0.1418	0.1552	0.6936	1.0915	1.2223	1.3848	0.9386	0.9386
	DVA	0.0963	0.1357	0.1487	0.6903	1.0427	1.2291	1.4954	0.9118	0.9118
Korea	GE	0.1915	0.5374	0.1884	0.8247	0.9143	0.7516	1.7160	0.1850	0.1850
	DVA	0.2144	0.6114	0.2283	0.6122	0.9204	0.8752	1.8091	0.2347	0.2347
United States	GE	0.9499	0.2116	1.5405	1.1634	0.6985	1.0374	0.9476	1.0779	1.0779
	DVA	0.8615	0.1902	1.4629	1.1471	0.7097	0.9988	1.0732	1.0751	1.0751
China	GE	0.3421	2.6121	0.5368	0.5082	0.8430	0.8392	1.8211	1.5906	1.5906
	DVA	0.3445	2.9657	0.4726	0.4874	0.8386	0.7762	1.7693	1.7631	1.7631
1995										
Germany	GE	0.6133	0.3899	0.7492	1.1301	1.1346	1.646	0.6258	0.5471	0.5471
	DVA	0.6072	0.3671	0.7402	1.1392	1.097	1.627	0.6695	0.5587	0.5587
Japan	GE	0.0679	0.2156	0.2695	0.5852	0.7101	1.347	1.8137	0.3916	0.3916
	DVA	0.0639	0.2147	0.2575	0.5858	0.6875	1.3033	1.8668	0.3821	0.3821
Korea	GE	0.2714	2.3087	0.1971	0.7799	0.9051	0.5635	1.608	0.6832	0.6832
	DVA	0.2782	2.3835	0.2027	0.7359	0.8604	0.5587	1.6563	0.7114	0.7114
United States	GE	0.9928	0.4041	1.1943	0.9241	0.6427	1.1933	1.3609	0.4261	0.4261
	DVA	0.9745	0.412	1.1574	0.9481	0.6411	1.14	1.3925	0.4246	0.4246
China	GE	0.8335	4.076	0.1889	0.6553	0.9065	0.6267	0.9074	3.5418	3.5418
	DVA	0.8353	4.0951	0.1793	0.6731	0.9182	0.5863	0.9328	3.4977	3.4977

GE – Revealed Comparative Advantage based on gross exports; DVA – Revealed Comparative Advantage based on domestic value added embodied in gross exports.

n.e.c. – not elsewhere classified.

Source: OECD/WTO, *OECD-WTO: Statistics on Trade in Value Added*, (database). Doi:10.1787/data-00648-en. 2013 (accessed 26.06.2013).

Table 6 contains data showing the RCA indices of Japan and other selected economies in the field of industrial products. The analysis covers the period 1995–2009, and also takes into account the non-traditional method of measuring flows of international trade – the value-added method.[27]

Analysis of the data demonstrates that in 2009 Japan showed an advantage in four areas: transportation equipment, electrical and optical equipment, machinery and equipment and basic metals and fabricated metal products. In 1995 Japan showed no superiority in the field of basic metals and fabricated metal products. Within each area, however, there have been some changes in the period 1995–2009: Japan has strengthened its position in transportation equipment, where the RCA indicator (according to the GE method) rose from 1.6774 to 1.8836. In other areas the relative advantage dropped slightly. If the non-traditional method for calculating the RCA is taken into account, in many cases the advantage of Japan was even greater.

A comparison of Japan's situation to that of other countries leads to the conclusion that Japan has an advantage in areas where the technology is used extensively. This means that foreign trade in terms of RCA does not show dynamic negative changes. However, in such an approach towards competitiveness, one can clearly notice modifications for increasing the relevance and competitiveness of developing countries. They occupy leading positions in more advanced product groups, which must result in processes of adjustment in developed countries.

Due to the deepening of the production fragmentation process, countries at lower levels of development are increasingly frequently producers of technologically advanced final goods. This inevitable process of geographical transformation, due to the increasing intensity of the globalization and growing freedom to relocate any element of the value-added chain, is reflected in the RCA indices in the traditional sense. However, measures describing this problem but using the concept of domestic value added show that the developed countries still have a greater advantage than would result from traditional measures. This is also the case for Japan.

5. Conclusions

On the basis of the analysis in this study, it can be concluded that the technological progress and innovation which took place in Japan in the postwar period was one of the most important factors contributing to the improvement of its international competitiveness. By the second half of the 1980s, Japan had ended the period of 'catching up' and had begun to create its own technology. At that time, it was rated as one of the world leaders in technology. Since the beginning of the 1990s, domestic and international factors greatly complicated the circumstances. Domestically, the Japanese economy began to experience long-term economic slowdown. Abroad, together with the increasing globalization of economic activities, Japan was obliged increasingly to compete not only with developed countries but also with emerging economies.

[27] In this work, we will not examine the method in any greater detail. For more, see R. Baldwin, 'WTO2.0: Global governance of supply-chain trade', *CEPR, Policy Insight No. 64*, December 2012; R. Stehrer, N. Foster, G. de Vries, 'Value Added and Factors in Trade: A Comprehensive Approach', The Vienna Institute for International Economic Studies, *Working Papers*, No. 80, June 2012.

Nowadays, the international competition has a slightly different character. If the global market is a place for conducting business, the technological advantage should be measured not only from a macro-level (national), but also from a micro- one (the level of individual enterprises). If a modern company freely locates elements of its value chain abroad, Japanese corporations can also do so. However, in the case of Japan, those aspects that are of the highest value added still remain within the country. These are elements which require high amounts of capital, knowledge, elevated expertise and a highly skilled workforce. This is supported by the amount of expenditure on research and development, which in Japan is principally provided by private companies. Japan is still a country that is extremely interested in the promotion of technological development, as is confirmed by the amount of expenditure on R&D. Japanese corporations are also interested in promoting innovative solutions, which is confirmed by one of the highest number of patent applications in the world and the participation in triadic patent families. As a disadvantage one can consider Japan's lack of interest in international cooperation in the field of technology. Expenditure on R&D financed by foreign affiliates is among the lowest in the world, which may adversely affect the overall productivity of production factors.

In the area of technological advancement, Japan's foreign trade situation is similar to that of other developed countries. The share of trade in high technology goods is falling, as this is mainly relocated to Asian countries (Korea and China). This means reducing Japan's leading role as an exporter of goods with a high degree of technological advancement. However, this is a macroeconomic view. From a microeconomic point of view, the situation is not as clear. Due to the fact that modern manufacturing processes are subject to fragmentation, it is difficult to determine the final contribution to the final products of particular companies. In the case of Japan, it is certainly high input, which can be confirmed by the increasing share of exports of electronic components (see Table 5). The continued importance of Japanese companies in the global economy and its technological leadership may be also proved by data on the participation of selected Japanese companies on the world market.[28] Around 75% of motors for hard-disk drives in computers come from Nidec, 90% of the micro-motors used to adjust the rear-view mirror in every car are made by Mabuchi; TEL makes 80% of the etchers used in making LCD panels; Covalent produces 60% of the containers that hold silicon wafers as they are turned into computer chips.

These and other examples indicate that the technological position of Japan, although changing, still remains strong thanks to the activities of individual companies. If we add to this a supportive national policy, we should refrain from making a clearly negative statement on the permanent decline in Japan's leadership role in the field of technology.

[28] *The Economist*, November 5th 2009, http://www.economist.com/node/14793432 (accessed 05.04.2013).

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