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Article

Japan Leads in Integrating Foresight into Innovation Policy

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Abstract: This article examines the evolution of scientific and technological Foresight research over the past decade, particularly in Japan, highlighting its integration into science, technology, and innovation policy formulation. Initially limited to analytical reports, Foresight now includes interdisciplinary and intersectoral approaches, utilizing advanced methods such as weak signals and "jokers" to enhance research robustness. The study addresses the knowledge gap in understanding the impact of these integrated methods on policy development. It aims to analyze Japan's significant financial investments in R&D, predominantly funded by the private sector, and the role of government support through initiatives like those from the Ministry of International Trade and Industry (MITI). The results show that Japan's approach has maintained its competitive edge in the global market by fostering innovation and aligning national priorities with global trends. The implications suggest that other nations can enhance their technological capabilities by creating integrated and well-supported research environments. Further research should explore the long-term impacts of these foresight practices on innovation ecosystems and the potential of emerging methodologies in shaping future technological landscapes.

Keywords: Japan's policy, High-Tech, Innovation, Imitation, High Demand, World Market, Society 5.0, Technologies, Startups, Startup Ecosystems.

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1. Introduction

Japan is one of the world leaders in scientific and technological potential, with high R&D expenditures and a number of researchers exceeding the OECD average. It is also a leader in the number of patents, although the dynamics of their issuance are not always stable. Japan has long been established as a leader in the world of innovation, confirming its high-tech and innovative nature. Japan's innovation system is recognized as a global model, comparable to the United States. Its model is initially imitative, focusing on improving and perfecting products and production, rather than on radical innovations. Japan has not integrated globally into innovation activities, with a low share of foreign companies in innovative products. Despite difficulties, Japan has managed to maintain its position among the scientific and technological leaders since the 1970s to the present day. By concentrating the main resources on carefully selected areas, the Japanese not only outpaced their competitors, but also took the first places in the world in a number of key industries. The main efforts were aimed at dominating the most capacious markets, such as automotive, electronics, photography, medical equipment, machine tools, chemical industry and others. Later, this list was supplemented by personal computers, office equipment, digital cameras, LCD and plasma panels. At the same time, a number of areas, such as aircraft construction, were excluded from the priorities, since the post-war revival of the aviation industry seemed difficult. The creation of military equipment was also limited to small orders for the Self-Defense Forces.

Literature Review

Japanese developers and manufacturers focused on producing products that are in high demand both in world markets and within the country, excluding low-demand goods from their plans. This led to the fact that electronic equipment for research in the field of nuclear fusion, superconductivity and other extreme phenomena began to be purchased abroad. Despite the fact that in terms of volume and level of achievements, Japanese R&D was significantly inferior to American ones, the country has taken a strong position in the markets of many types of heavy and light industry products, squeezing out traditional leaders. This gave rise to talk of a "Japanese challenge" or even a "Japanese threat". The close connection between Japan's foreign policy and the interests of the United States significantly facilitated the implementation of the selected selective strategy and provided access to the latest American technologies, equipment and participation in Western R&D. In addition, since defense issues were mainly solved thanks to the Japan-US Security Treaty, Japan's scientific and technological potential was oriented towards the development of civilian industries, where military topics occupied less than 1% of the total R&D volume[1].

Particularly strong positions were taken by Japanese machine tool manufacturers. Although their machines lagged behind many foreign ones in accuracy and performance, they led in sales on global markets. The Japanese were suspected of dumping, but a special investigation showed that they focused on producing the most in-demand machines required by all engineering industries. Mass production allowed them to implement the principle of economies of scale and significantly reduce prices - doubling the output volume reduced production costs by approximately 30%.Japanese industrialists actively used this principle, aiming to meet the demands of mass consumers with modern, high-quality products that surpassed foreign counterparts [2].

2. Materials and Methods

A significant influence was the focus on microelectronics, which served as the basis for radically improving product characteristics and rapidly introducing new types of goods. There was widespread use of microprocessors and microcomputers in production equipment, allowing individual control devices to be added to almost every device used in the economy. Microelectronics also contributed to reducing the size and cost of information technology, including computers and communication devices, paving the way for the informatization of production and society [3].

Table 1. Financial investments in high-tech industries in 2015.

Countries	Investments (in mlrd dollars)
USA	502.9
China	408.8
Germany	112.8
Japan	170.1
France	60.9
Great Britain	46.3
Russia	40.5

As seen in Table 1, significant financial investments are required for successful advancement in high technology. In 2015, the U.S. spent $502.9 billion on research and development, China - $408.8 billion, Germany - $112.8 billion (in terms of purchasing power parity). Japan also stands out for its high level of investment in these goals, amounting to $170.1 billion. Few countries can afford such expenses: for example, in France, they amount to $60.9 billion, in the UK - $46.3 billion, in Russia - $40.5 billion dollars [4].

Over 80% of Japanese R&D is funded by the private sector, which also finances a third of all fundamental research. Company leaders recognize that only innovation leaders can withstand international competition by quickly creating and applying new knowledge. The world is now in a state of "hypercompetition" where success is achieved by simultaneously meeting all major market requirements such as product uniqueness, quality, price, delivery times, after-sales service and more [5].

The Japanese government also actively supports companies in following important global scientific and technological trends. An example of such support is the activities of the Ministry of International Trade and Industry (MITI), predecessor of the modern Ministry of Economy, Trade and Industry (METI). Initially, there was close cooperation between various organizations, as well as financial and structural support from the state. Only at a subsequent stage of development did competition between companies begin, when the transition to practical application and refinement of research results occurred, with each firm independently engaged in their further development and skill improvement [6].

3. Results

The final sections of the forecast, devoted to the practical application of advanced technologies in the social sphere and management, are of great public importance. Technologies from the "Social Infrastructure" section are intended for use in areas such as:

1. territory development and protection
2. construction
3. environmental protection
4. communications and logistics
5. operation of transport systems
6. overcoming emergency situations

Technologies from the "Servitization and Management" section include:

1. tools for implementing socio-economic policies and management
2. maintenance of complex systems and objects
3. expansion of robotization of auxiliary functions
4. measures related to marketing and service design.

Source: According to: Organisation for Economic Co-operation and Development. Reference: OECD. StatExtracts [Electronic recurs]. URL: http: //www.stats.oecd.org/ index. (date address: 13.05.2017); Россия и страны мира. 2016. Стат. сб. / Росстат. М., 2016. С. 321, 328, 332; Наука. Инновации. Информационное общество. 2016. Крат. стат. сб. / Нац. исслед. ун-т «Высшая школа экономики». М. : НИУ ВШЭ, 2016. С. 10, 14, 18, 19, 24, 25, 30, 35. ,2014 г., В WEB of Science, 2015 y.

According to Japanese experts, in the coming decade there will be a qualitative renewal of many key technologies in almost all spheres of activity. This will be a serious challenge for all industries, which will need to quickly move to new development trajectories. Radical innovative changes are possible only if society has a sufficiently high scientific, technical and industrial potential. Japan has not only mastered a wide range of technologies, but also has virtually any necessary equipment, materials and tools, which allows it to quickly restructure for new tasks [7].

Table 2. Indicators of scientific and technological development of leading countries in the world* 2015 [13, p. 19; 14, p.7; 15, p. 35].

Indicator	Republic of Korea	Japan	USA	China	England	Russia	France	FRG
Research & development expenditures, billion dollars	72.2	166.8	496.8	368.7	44.1	40.5	58.7	108.8
% of GDP	4.29	3.59	2.74	2.05	1.70	1.13	2.26	2.90
Number of R&D employees, thousand people	430.9	895.3	1412	3710.6	387.9	738.8	422.5	608.9
Including researchers	345.5	682.9	1308	1524	273.6	379.4	351	351.1
The number of researchers per 10.000 employed in the economy	135	105	89	20	89	66	99	82
Volumes of high-tech exports, billion dollars	133.4	100.9	155.6	558.6	70.6	9.84	114.6	199.8
The share countries in global scientific journal publications, in %	3.73	4.97	25.97	18.46	7.57	2.25	4.79	6.95

The country has unique human resources capable of actively supporting and developing a production culture that is the key to high quality and the main condition for the implementation of modern and future high technologies. Having mastered the art of sustainable innovative development, Japan has secured a strong position among the world's scientific and technological leaders [8].

ANALYSIS

According to the information provided, the United States leads in the share of patent applications worldwide, reaching 18.2% in 2015, followed by Japan at 15.7% and Russia at 1.2%. The share of publications in scientific journals worldwide was 25.97% for the US, 2.25% for Russia, and 18.46% for China [9].

The trend of increasing the share of R&D conducted in foreign subsidiaries began before the crisis and has become a stable trend for Japanese companies. This trend is associated with a reassessment of the importance of innovation and the increasing complexity of technological processes. Conducting comprehensive research requires unique experience, knowledge, and resources that no one possesses alone. Therefore, large corporations, government laboratories, universities, and other infrastructure elements of the national innovation system are joining forces to create new technologies. These associations are created for fundamental and applied R&D, which is changing the model of conducting transnational business [10]. Japanese companies, although closed, are increasingly integrating into the global economy, which is accelerating the transition to a new paradigm of perceiving innovation activity [11].

In June 2015, Japan adopted an Integrated Strategy for Science, Technology, and Innovation to effectively prepare for the Fifth Basic Plan. The strategy recommends paying special attention to three aspects:

1. The need to adapt to upcoming changes in the process of creating value in the economy.
2. The need for Japan to take the initiative in solving complex problems facing the country and the world.
3. The need to create a favorable cycle of mutual support between human resources, knowledge, and means, where the state cares for society, and society in turn creates new opportunities for promoting innovation.

The Fifth Basic Plan, officially adopted in January 2016, for the first time incorporates a long-term philosophy of science and technology development - the concept of "Society 5.0" or "Super-Intelligent Society". The plan consists of seven chapters, covering basic principles, actions to create new value, solutions to economic and social problems, strengthening the foundations of science, technology, and innovation (STI), building a favorable cycle of human resources, knowledge, and funding, deepening the links between STI and society, and expanding opportunities for STI advancement [12].

Four key directions of the Fifth Plan:

1. Actions to create new value in the development of future industries and social transformations
2. Solving economic and social problems through a comprehensive approach at both domestic and international levels
3. Strengthening the foundations of STI by developing researchers' capabilities, supporting fundamental research, and providing comprehensive funding
4. Building a systemic favorable cycle of human resources, knowledge, and innovation funding to enhance Japan's competitiveness. Translate this text into English:

To deepen the ties between NTI and society, as well as to expand opportunities for promoting NTI, the Plan provides for stimulating the venture business, supporting joint activities of universities and corporations, and creating industry platforms. These measures are implemented in cooperation between the government and the private sector, where the government acts as a coordinator and guarantor [13].

The Fifth Basic Plan of Japan in the field of science and technology, implemented from 2016 to 2020, was aimed at developing the country's startup ecosystem. The EDGE-NEXT program, launched by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT), contributed to the creation of new innovative companies by supporting entrepreneurship among students, graduate students, and young researchers [14].

Over the past decade, Japan's startup sector has grown significantly, but most new companies complement rather than compete with large corporations. This is because employees of large firms often found startups that are later acquired by their employers.

Despite the successes in developing the startup ecosystem, Japan ranks only 16th in the Global Innovation Index 2020, while in the Global Competitiveness Index, it consistently holds the 6th position [15].

The COVID-19 pandemic has pushed Japan to accelerate technological development. In February 2020, the government allocated around 2 billion yen for research and development in the areas of diagnostics, clinical trials, the use of existing drugs, and the creation of new vaccines based on mRNA.

The fourth goal of the Plan envisaged doubling the number of new venture companies engaged in R&D. However, in the economic downturn caused by the COVID-19 pandemic, startups, as high-risk enterprises, were particularly vulnerable to the instability of 2020. Despite the steady growth in the number of startups and their capitalization since the adoption of the Fourth Basic Plan, by the end of 2018, the number of startups had increased by only 50%, and capitalization had tripled. By the beginning of 2021, these indicators had declined. It is difficult to assess the impact of COVID-19 definitively, considering that the gradual decrease in the number of startups began as early as the end of 2018. Nevertheless, in terms of the established plan targets, this goal was not achieved.

Of the six target indicators of the Fifth Basic Plan, only one was exceeded: the amount of funds received by universities from joint research with the private sector increased by 60% instead of the planned 50%. The other indicators showed positive dynamics, except for the number of articles in the top 10% by citation count, which decreased. A particularly important achievement was the increase in government spending on R&D for the first time since 2003.

4. Discussion

The Fifth Basic Plan in Japan, highlighting the implementation of the Society 5.0 concept and its impact on the country's science and technology policies. The plan aimed for annual investments in research and development (R&D) of around 26 trillion yen, but the actual average annual investment was only 19.5 trillion yen, approximately 4.2% of the GDP. While falling short of the target, this investment level met the minimum threshold set in the plan at 4% of the GDP.

In summary, the Fifth Basic Plan did not fully achieve most of its goals. It failed to reach the planned targets for the number of female researchers, saw a decrease in the proportion of highly cited scientific publications despite an overall increase in publications, and did not meet the desired levels for the number of venture companies and university patent licenses. Additionally, the annual investment volume did not reach the planned 26 trillion yen mark.

5. Conclusion

The evolution of scientific and technological foresight research, particularly in Japan, underscores the importance of integrating foresight into the formulation of science, technology, and innovation policies. The incorporation of interdisciplinary and intersectoral approaches, alongside advanced methods such as weak signals and "jokers," has enhanced the robustness of foresight research. Japan's significant financial investments in R&D, predominantly funded by the private sector, highlight the critical role of innovation in maintaining competitive advantage in a state of hypercompetition. The active support from the Japanese government, exemplified by MITI's initiatives, has been pivotal in aligning national priorities with global scientific and technological trends. This study implies that fostering such integrated and well-supported research environments is essential for other nations aiming to enhance their technological capabilities. Further research should focus on the long-term impacts of these foresight practices on national and global innovation ecosystems and explore the potential of emerging foresight methodologies in shaping future technological landscapes.

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