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R&D and Development Dilemma: Analysis of Japanese Electronics Industry

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Abstract: ***We study the factors which affect the Japanese economy stagnation. Using gross output data of Manufacturing from 1990 to 2015, we found among the top 10 industries, Machinery and equipment, Electrical, electronic and optical equipment, and Computer, electronic and optical products, these three industries which have negative growth are related to the GDP. We also find the R&D investment is related to the gross output in three industries. We argue that electronics industry's decay is the reason of Japanese economy stagnation. One important reason of the dilemma in electronics industry is the stagnation of R&D investment, which shows business enterprises' faith could be damaged for a long time.***

Keywords: Japanese economy stagnation; Electronics industry; Research and development investment; Economy sanction; Business enterprise confidence.

1. INTRODUCTION

There were financial crises during the 1990s in Japan, which lasted from 1992 to 2001. It was triggered by two crises: the bubble burst in February 1991 and the banking crisis that began in November 1997. However, the Japanese economy does not recover after the Lost Decade. The stagnation still continues. This paper focuses on the reason of economy stagnation and the reason behind.

The paper is related to the literature that studies the Japanese economy stagnation, the Japanese electronics industry, and the factors affecting business enterprise investment on R&D. Many researchers believe the Lost Decade is related to the financial reason. After signed the Plaza Accord agreement in 1985, Japan lost its export competitiveness (Mihut, 2014). The Central Bank of Japan also made some mistakes. The bank had large number of unrecognized losses. Management and regulators paid little attention to the losses (Sherman, 1995). After the financial crisis eruption, many Japanese bank still lent money to the insolvent companies which caused misallocation of funds. These inefficient companies have squeezed out potential profitable companies, exacerbating macroeconomic stagnation (Hoshi and Kashyap, 2004). Japan and some member countries of the European Monetary Union went through both stock and real estate market booms and busts, which led to the prolonged crisis (Fischer and Schnabl, 2018). About the decay of Japanese electronics industry, Koichi Hagiuda, Japanese minister of economy, trade, and industry, said that the decay of Japanese semiconductors was suppressed and counterattacked by opponents such as the United States, but more importantly, it was Japan's own strategic and tactical mistakes that led to the fading of electronics industry and the defeat of ambition. It is believed Japan does not catch up with the upgrade of technology and products. When personal computer which asked for quick updates and controllable costs emerged in the market, Japan still sticked to the mainframe computer and DRAM system. Failure to catch up with the conversion from storage chips to logic chips led Japan transform from a major chip manufacturer to a semiconductor equipment manufacturer and raw material supplier (Yunogami, 2015). Vertical production could not support huge investment in both manufacturing and design segments in personal computer manufacturing. In order to increase market share, Japanese manufacturers had decided to lower prices without compromising quality, which resulted in great losses. The vertical production ignored the global division system g which stressed the dividing design and manufacturing in the 1990s. Japan's greed for the entire industry chain led to its strategic errors (Nishimura,2016). In the meantime, the United States supported South Korea to replace Japan's position in the electronics production chain, which caused Japan to further lag behind. According to the level of R&D intensity, the manufacturing industry is divided into high R&D intensity industries, medium to high R&D intensity industries, medium to low R&D intensity industries, and low R&D intensity industries. Electronics industry is the high R&D intensity industry (Stancik and Biagi, 2015). There are many factors affecting corporate R&D investment. Although executives realize that R&D investment may be profitable in the future, they often hold a skeptical attitude towards whether or how much R&D investment to invest. This contradictory mentality is due to concerns about large-scale and sustained investment; Failure to realize profits in the short term; The high uncertainty of research and development prospects, as well as the potential impact of the CEO's tenure on their performance evaluation. Therefore, to ensure the long-term development of enterprises, it is necessary to find ways to incentivize management to pursue innovation and value creation through research and development investment

(Shapiro, Tang, Wang and Zhang, 2017). CEOs and management which look for short-term profit are more likely to reduce R&D investment (Hur, Kim and Cheung, 2019). Executive incentive contracts are a key measure that can guide executives in supporting investment and other behaviors that promote technological innovation. It is showed that executive salaries and R&D investment have an inverted u-shaped correlation (Lu, Sheng and Wang, 2020). R&D investment is also related to the CEO personality. R&D cost behavior may vary depending on CEO characteristics (Zavertiaeva, 2018). Overconfident managers have stronger R&D investment motivation (Malmendier and Tate, 2005). Overconfident CEOs underestimate the possibility of failure, they are more likely to pursue innovation, and this impact is greater in more competitive industries. The research results indicate that overconfident CEOs are more likely to push companies towards new technological directions (Galasso and Simcoe, 2011). It is found that the impact of corporate governance on innovation depends on the measurement of innovation activities. In terms of new patents, certain aspects of corporate governance are related to innovation (Shapiro, Tang, Wang and Zhang, 2015).

This paper provides a new, long-run intergenerational perspective on Japanese economy. The stagnation of Japanese economy is related to the stagnation of the electronics industry. One important reason for the dilemma of Japanese electronics industry is the stagnation of R&D investment. The long-term stagnation of R&D investment in electronics industry is caused by the social whole standing low confidence in electronics development, rather than the personal confidence of the CEOs and managers. R&D is a kind of business climate index.

The remainder of the paper is organized as follows. Section 2 shows the relationship between GDP and gross output. Section 3 shows the relationship between gross output and R&D. Section 4 analyzes the stagnation in Japanese electronics industry. Section 5 summarizes and concludes.

2. GDP AND GROSS OUTPUT

GDP annual growth rates in Japan from 1990 to 2015 are mainly below 2% and the curve of GDP presents a horizontal trend after 1990, which indicates Japan is now still in the stagnation after economy bubble in 1990s.

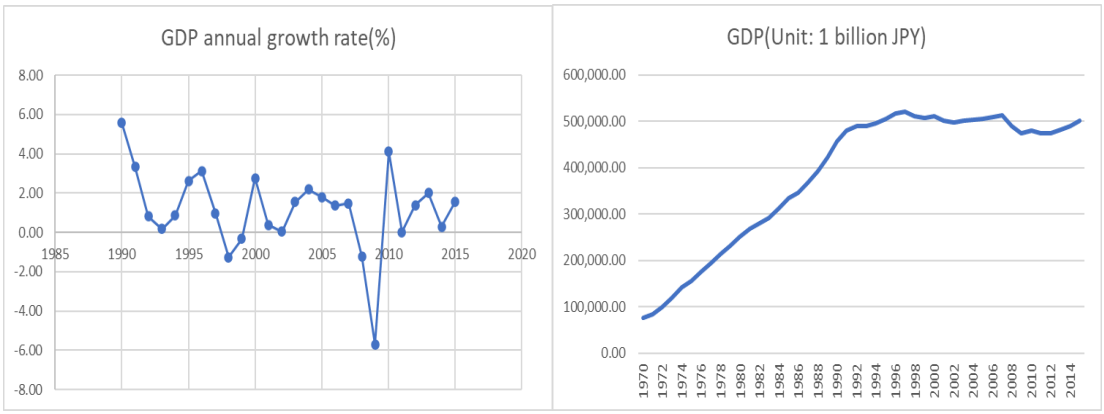


Figure 1: GDP annual growth rate (%) of Japan from 1990 to 2015 and GDP of Japan from 1970 to 2015, unit: 1 billion Japan Yen (JPY)

In this paper, to find out which manufacturing industries affect the Japanese economy, we use data about gross output of manufacturing industries and GDP from 1990 to 2015 in OECD statistics database. Top 10 manufacturing industries in terms of the sum of gross output from 1990 to 2015 in Japan are as follows. 1. Manufacture of machinery and equipment; 2. Manufacture of food products, beverages and tobacco; 3. Manufacture of chemical, rubber, plastics, fuel products and other non-metallic mineral products; 4. Manufacture of electrical, electronic and optical equipment; 5. Manufacture of transport equipment; 6. Manufacture of basic metals and fabricated metal products, except machinery and equipment; 7. Manufacture of motor vehicles, trailers and semi-trailers; 8. Manufacture of basic metals; 9. Manufacture of computer, electronic and optical products; and 10. Manufacture of chemical and pharmaceutical products.

To analyze the top 10 manufacturing industries' relation with the GDP, we use the Pearson correlation. We also use Compound Annual Growth Rate (CAGR) to masseur how fast each industry develops.

Table 1: Pearson correlation between GDP (measured by JPY and Gross output by each industry (measured by JPY); CAGR of Gross output by top 10 industries.

Industry:	Machinery and equipment	Food products, beverages and tobacco	Chemical, rubber, plastics, fuel products and other non-metallic mineral products	Electrical, electronic and optical equipment	Transport equipment	Basic metals and fabricated metal products, except machinery and equipment	Motor vehicles, trailers and semi-trailers	Basic metals	Computer, electronic and optical products	Chemical and pharmaceutical products
Pearson correlation between Gross output by manufacturing industry and GDP	0.434	0.052	-0.145	0.499	-0.05	-0.432	0.005	-0.45	0.542	0.059
Sig.	0.027	0.801	0.48	0.009	0.809	0.027	0.982	0.02	0.004	0.774
CAGR of Gross output by industry	-0.0060	0.0026	0.0054	-0.0116	0.0101	-0.0021	0.0087	0.0025	-0.0174	0.0064

Because Pearson correlation with GDP is between 0.4 and 0.6 of Machinery and equipment industry, Electrical, electronic and optical industry and Computer, electronic and optical industry, it shows that among the top 10 manufacturing industries in the term of gross output from 1990 to 2015 in Japan, the gross output of these three industries have a moderate correlation to the GDP.

To find out how gross output of these three industries affect GDP concretely, we use the regression model.

Table 2: Regression model of GDP (measured by JPY) and Gross output (measured by JPY) by Machinery and equipment industry, Electrical, electronic and optical industry and Computer, electronic and optical industry

	Machinery and equipment	Electrical, electronic and optical equipment	Computer, electronic and optical products
Regression model (Y=GDP, X= Gross output)	Y=0.718X+435267058.147	Y=1.106X+440790971.323	Y=1.491X+449493960.808
R^2	0.189	0.249	0.293
Sig. (ANOVA)	0.027	0.009	0.004
Sig. (Beta)	0.027	0.009	0.004

As beta > 0, gross output of industries has a positive impact on GDP. To be noticed, these three industries all have the negative CAGR of gross output from 1990 to 2015. They are -0.006 in Machinery and equipment industry, -0.0116 in Electrical, electronic and optical industry and -0.017 in Computer, electronic and optical industry respectively. It means that these three industries are in a downward or stagnant trend from 1990 to 2015, and this leads to the stagnation in GDP. The stagnation of Japan's economy is related to the downward development of these three industries.

3. GROSS OUTPUT AND R&D

The regression model is used to analyze the relationship between R&D intensity, rate of innovation and growth rate of output from 17 OECD countries in four manufacturing sectors which are chemicals (excluding drugs and medicines), drugs and medicine, electrical and electronics, and machinery and transport (Ulku, 2007). Researcher found the R&D intensity increases the rate of innovation in the chemicals, electrical and electronics, and drugs and medicine sectors. In addition, the rate of innovation has a positive effect on the growth rate of output in all four manufacturing sectors.

We use the data of Business enterprise R&D expenditure by industry in OECD statistics database. We use the regression model to analyze the relationship between business enterprise R&D expenditure and gross output in each three industries. For the data access limitation, Machinery and equipment industry and Electrical, electronic and optical industry are analyzed from 1990 to 2015. Computer, electronic and optical industry is analyzed from 2005 to 2015.

Table 3: Regression model of GDP (measured by JPY) and Gross output (measured by JPY) and CAGR of Business enterprise R&D expenditure by Machinery and equipment industry, Electrical, electronic and optical industry and Computer, electronic and optical industry

	Machinery and equipment	Electrical, electronic and optical equipment	Computer, electronic and optical products
Regression model (Y=Gross output, X= Business enterprise R&D expenditure by industry)	Y=-0.000028X+144081609.112	Y=0.000006X+21134804.550	Y=0.00001X-4248782.167
R^2	0.228	0.16	0.41
Sig. (ANOVA)	0.014	0.043	0.034
Sig. (Beta)	0.014	0.043	0.034
CAGR of Business enterprise R&D expenditure by industry	2.705%	0.057%	-0.025%

In the regression model of Electrical, electronic and optical industry and Computer, electronic and optical industry, beta>0, Business enterprise R&D expenditure has a positive impact on gross output. The CAGR of Business enterprise R&D expenditure by Electrical, electronic and optical industry from 1990 to 2015 and CAGR of Business enterprise R&D expenditure by from 2005 to 2015 are both near to zero, which means the stagnation in R&D expenditure leads to the stagnation of gross output. And the stagnation of gross output will lead to the standstill GDP.

In the regression model of Machinery and equipment industry, beta < 0, Business enterprise R&D expenditure has a negative impact on gross output. The CAGR of Business enterprise R&D expenditure by Machinery and equipment industry is about 2.7% from 1990 to 2015. Therefore, the increasing Business enterprise R&D expenditure by Machinery and equipment industry leads to the declining gross output. Because the gross output has a positive impact on GDP, the declining gross output will lead to the declining GDP. This may indicate Japan should focus on the important industry which are beneficial to the economy growth, like electronics industry.

4. ANALYSIS OF THE STANDSTILL BUSINESS ENTERPRISE R&D EXPENDITURE BY ELECTRONICS INDUSTRY IN JAPAN

4.1 The Unique of Standstill Trend

Comparing with Japan's competitors, standstill trend in R&D by electronics industry is not universal. Japan is far behind its competitors.

We analyze the Business enterprise R&D expenditure by electronics industry of Chinese Taipei and South Korea, since they are famous electronics manufacturers as well as Japan. The data start from the different year in OECD database. For Business enterprise R&D expenditure by Manufacture of electrical, electronic and optical equipment, Japanese data starts from 1987. South Korean data starts from 1995 to Manufacture of computer, data from Chinese Taipei starts from 1998. For Business enterprise R&D expenditure by Manufacture of computer, electronic and optical products, Japanese data starts from 2007. South Korean data starts from 1995, data from Chinese Taipei starts from 1998. We also calculate the CAGR of two industries.

Table 4: Comparison of CAGR

	CAGR	
	Business enterprise R&D expenditure by Manufacture of electrical, electronic and optical equipment	Business enterprise R&D expenditure by Manufacture of computer, electronic and optical products
Japan	2.94%	-2.11%
South Korea	10.28%	10.32%
Chinese Taipei	11.24%	11.62%

Table 5: Pearson correlation between GDP annual growth rate and annual growth rate of Business enterprise R&D expenditure by industry

	Pearson correlation between Business enterprise R&D expenditure by Electrical, electronic and optical equipment and GDP	Pearson correlation between Business enterprise R&D expenditure by Computer, electronic and optical products and GDP
South Korea:	0.743	0.807
Sig.	0.000	0.000
Chinese Taipei:	0.604	0.549
Sig.	0.003	0.007

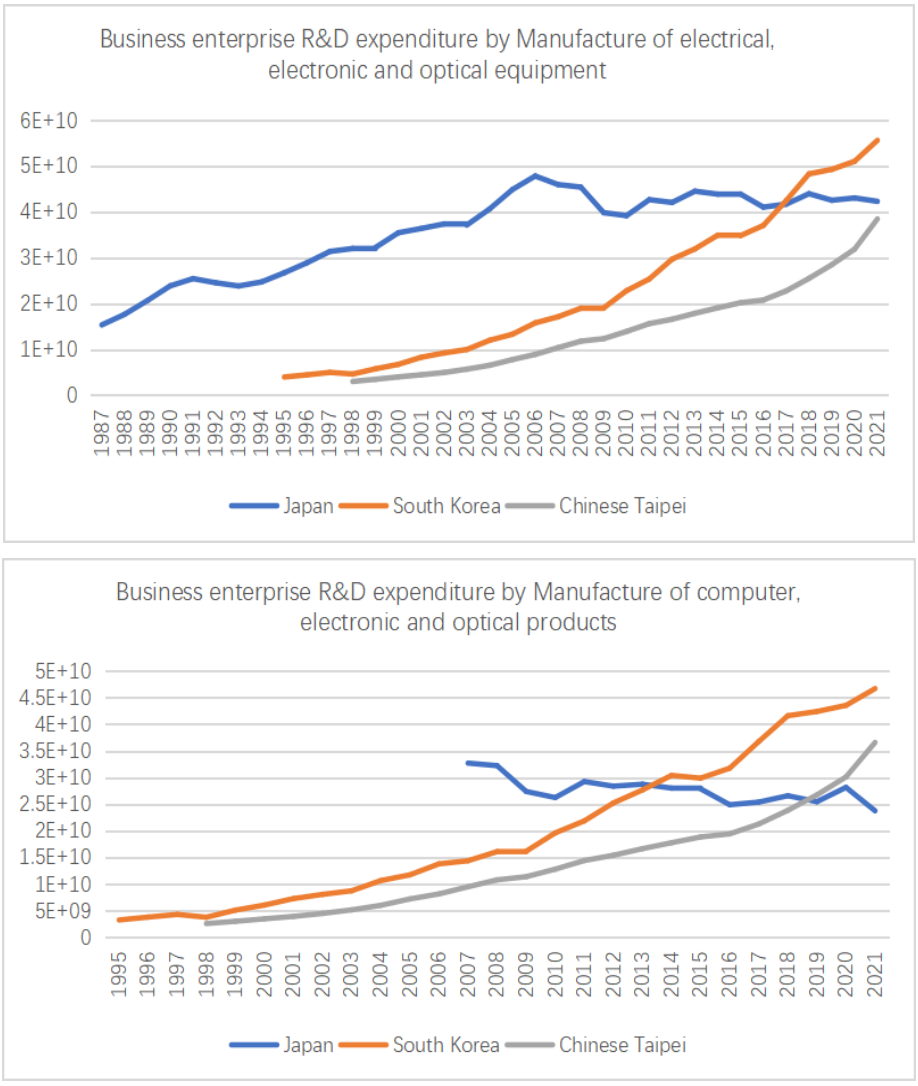
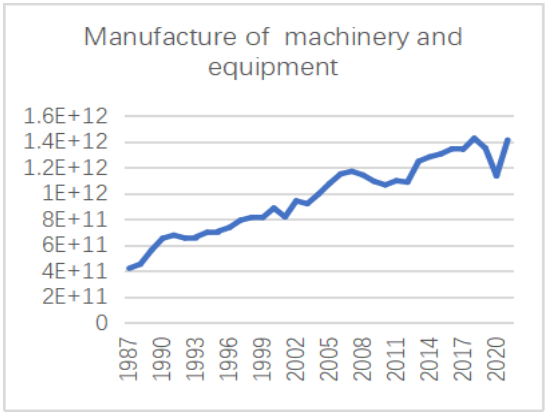
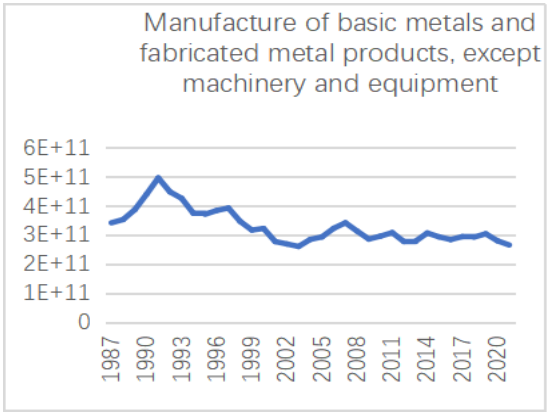


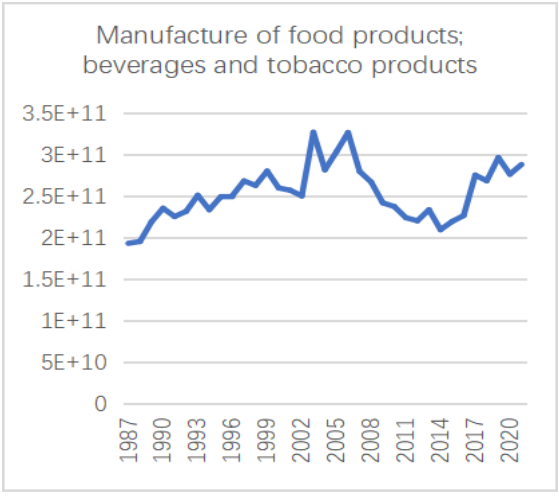
Figure 2: Comparison Charts (Combined unit of measure: US dollars, PPP converted. Price base: Current prices)

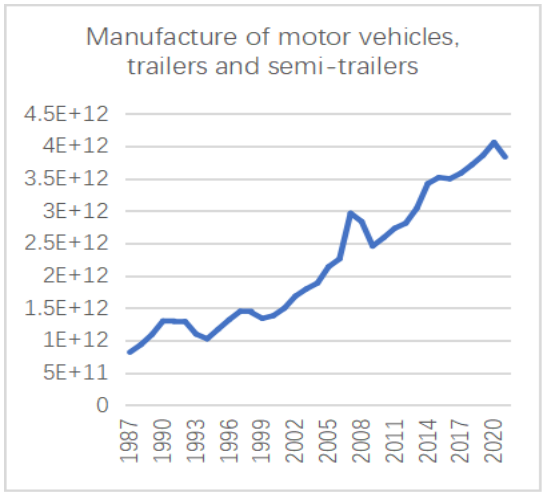
The Pearson correlation shows in the past 20 years, business enterprise R&D expenditure of the electronics industry have a strong correlation with the GDP annual growth rate in South Korea and Chinese Taipei, which means electronics industry in South Korea and Chinese Taipei is very critical.

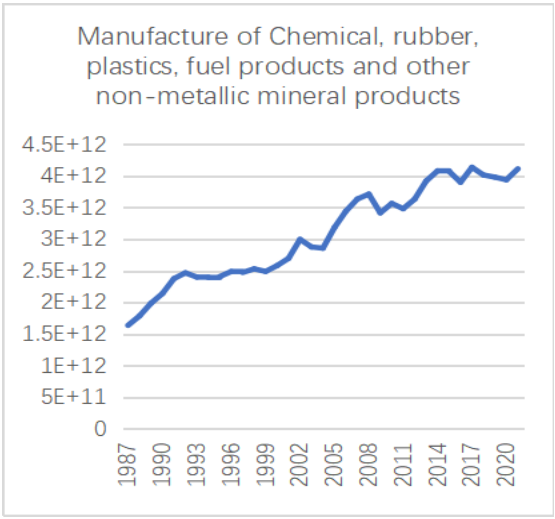
Comparing with other leading industries in terms of gross output, standstill trend in R&D by electronics industry is considerable. We use trend charts of Business enterprise R&D expenditure by top 10 manufacturing gross output industries.

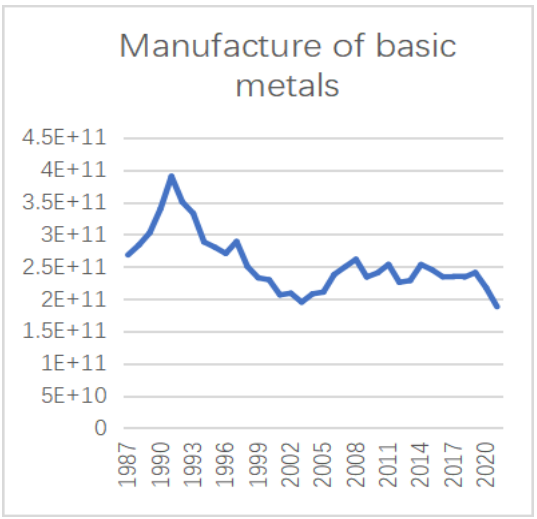

Manufacture of machinery and equipment
1.6E+12
1.4E+12
1.2E+12
1E+12
8E+11
6E+11
4E+11
2E+11
0
1987 1990 1993 1996 1999 2002 2005 2008 2011 2014 2017 2020


Manufacture of basic metals and fabricated metal products, except machinery and equipment
6E+11
5E+11
4E+11
3E+11
2E+11
1E+11
0
1987 1990 1993 1996 1999 2002 2005 2008 2011 2014 2017 2020


Manufacture of food products; beverages and tobacco products
3.5E+11
3E+11
2.5E+11
2E+11
1.5E+11
1E+11
5E+10
0
1987 1990 1993 1996 1999 2002 2005 2008 2011 2014 2017 2020


Manufacture of motor vehicles, trailers and semi-trailers
4.5E+12
4E+12
3.5E+12
3E+12
2.5E+12
2E+12
1.5E+12
1E+12
5E+11
0
1987 1990 1993 1996 1999 2002 2005 2008 2011 2014 2017 2020


Manufacture of Chemical, rubber, plastics, fuel products and other non-metallic mineral products
4.5E+12
4E+12
3.5E+12
3E+12
2.5E+12
2E+12
1.5E+12
1E+12
5E+11
0
1987 1990 1993 1996 1999 2002 2005 2008 2011 2014 2017 2020


Manufacture of basic metals
4.5E+11
4E+11
3.5E+11
3E+11
2.5E+11
2E+11
1.5E+11
1E+11
5E+10
0
1987 1990 1993 1996 1999 2002 2005 2008 2011 2014 2017 2020

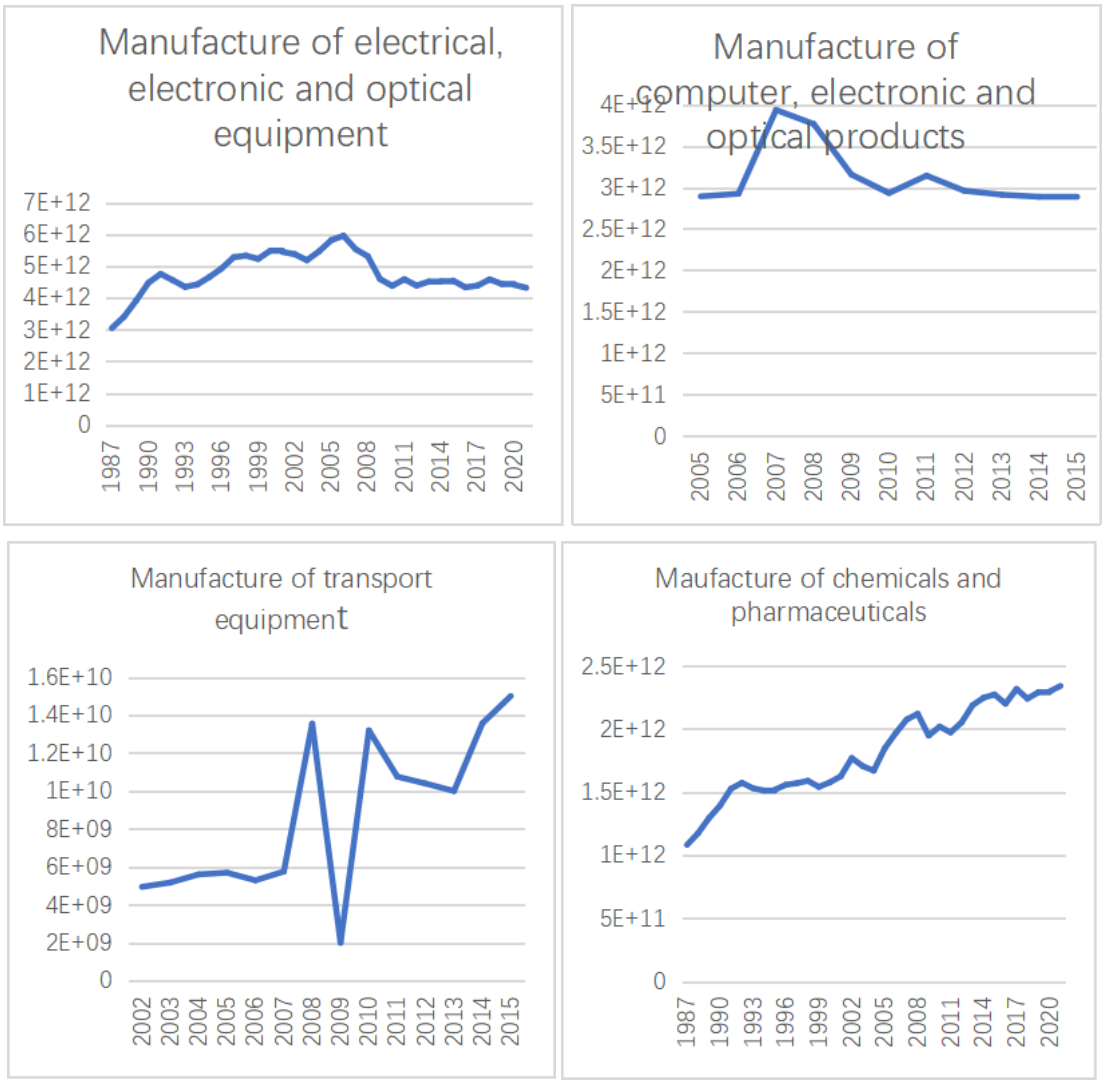


Figure 3: Comparison Charts: Business enterprise R&D expenditure by top 10 manufacturing gross output industries (measured in JPY).

Except Manufacture of electrical, electronic and optical equipment, Manufacture of computer, electronic and optical products, Manufacture of basic metals and fabricated metal products, except machinery and equipment and Manufacture of basic metals, other six industries' business enterprise R&D investments' trend generally had a slow development during 1990s, a slightly decrease after 2007, but still went upwards. It means R&D investment in these six industries are affected by the economy bubble in 1990s and financial crisis in 2008 but overcome already. The overall upward curves represent that business enterprises are confident now and invest more. While the standstill or decreasing trend in curves of Manufacture of electrical, electronic and optical equipment industry and Manufacture of computer, electronic and optical products industry may indicate business enterprises do not overcome from the dilemma in the semiconductor industry and economy bubble in 1990s and financial crisis in 2008.

4.2 Representing the Decline of Electronics Industry

The standstill Business enterprise R&D expenditure by electronics industry can show the decline of industry. In September 1986, the Japanese Ministry of Industry and Commerce signed the Japan-US semiconductor agreement with the US Department of Commerce, aimed at 1, limiting Japanese semiconductor exports to the United States and 2, expanding US and other foreign semiconductor market share in Japan. The Japan-US semiconductor agreement lasted from 1986 to 1996. The study shows that the agreement was not able to expand Japan's import as expected. The fast growth of imports during the 1980s and 1990s was attributed to growth in real GDP and change in relative prices alone and was not related to the Voluntary Import Expansion (VIE) policy from the Japan-US

semiconductor agreement (Parsons, 2002). However, in the long run, the first objective was achieved. The impact of the agreement was indirectly realized a few years later, as the US government adopted a minimum pricing policy to prevent Japanese companies from dumping products in the US market. Therefore, the prices of Japanese semiconductor products rose substantially (Kim, 2011). Japan-US semiconductor agreement is an important reason for the decline of Japanese electronics industry. The numerical targets stipulated in the Japan-US Semiconductor Agreement have affected fair competition in the market and suppressed the development of Japanese high-tech enterprises. The signing has had a negative impact on equipment investment in Japanese semiconductor industry, causing interruptions in equipment investment and affecting the upgrading and replacement of semiconductor products. The signing also has hindered the further upgrading and transformation of Japanese semiconductor industry technology. Japanese high-tech enterprises have been in a passive position since the 1990s, with technological innovation and product upgrades hindered. The United States, relying on its technological advantage in CPU, has regained its leading position in the semiconductor industry. At the same time, the global market share of DRAM products valued by Japanese high-tech enterprises is constantly eroded by enterprises in South Korea and Chinese Taipei. It can be said that the impact of the Japan-US Semiconductor Agreement and the failure of the Japanese enterprises to take effective strategies were the significant reasons for the decline of the Japanese semiconductor industry after the 1990s, but they were not the only reason. Japan's own strategic and tactical mistakes also result of decline (Tian, 2020).

4.3 Representing the Loss of Confidence

As the CEOs and managers decide the amount of R&D investment, and overconfident CEOs may invest more, nearly 35 years stagnant enterprise R&D investment in electronics industry may indicate Japanese enterprises lose and fail to restore confidence over a long period of time after the signing of Japan-US Semiconductor Agreement. R&D expenditure plays a role as business climate index in the long run.

4.4 Explaining the Stagnant Economy

We find the gross output by electronics industry increases Japanese GDP and the business enterprise R&D expenditure by electronics industry has a positive effect on the growth of gross output by electronics industry. Therefore, the standstill business enterprise R&D expenditure by electronics industry leads to the stagnant GDP. Stopping invest more on R&D in electronics industry is one reason for Japan’s failure in economy development. To get out of the stagnation period, the R&D investment in electronics industry should be increased. Enterprises are reluctant to the R&D investment as they concern about large-scale and sustained investment. They are worried about failure to realize profits in the short term. They have high uncertainty of research and development prospects and whether R&D investment will rescue the decline of the electronics industry. Enterprises are defeated by their fading confidence and ambition, which leads to the long-term stagnant economy.

This may also indicate if a country wants to crush a certain industry from another country, it needs to crush the R&D investment and confidence. Enterprises realize that R&D investment may be profitable in the future, but they often hold a skeptical attitude towards whether or how much R&D investment to invest, since they need to consider their capacity. In this way, government should step forward to help enterprises and play the function of state intervention. Researcher examined why Britain has had slower growth in R&D compared to other countries. The conclusion shows it was partially accounted by lower demand growth and faster withdrawal of government funding for R&D in the 1980s (Van Reenen, 1997).

5. CONCLUSION

In top 10 manufacturing industries in terms of gross output from 1990 to 2015 in Japan, Machinery and equipment, Electrical, electronic and optical equipment, and Computer, electronic and optical products are the three industries which affect GDP. The stagnant gross output in electronics industry is caused by standstill R&D investment. And standstill R&D investment is influenced by the long-term low confidence in the electronics industry. In order to get out of the dilemma, we recommend a powerful government funding for R&D to let enterprises regain confidence.

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