Changing of Land Use Type and Structure of Production in Pudong District, Shanghai, China Since Opening

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Abstract. Since the opening of Shanghai's Pudong New Area in 1990, Pudong has transformed its previously poor and backward appearance by introducing a large number of advanced manufacturing and service industries, making it the largest region in Shanghai in terms of economic output. Currently, due to the changing economic conditions in China, the development of the Pudong area needs to focus more on land intensification and industrial modernization, actively using stock resources for development and adjusting policies to respond to the changes in each industry. Therefore, by analyzing the changes in land area and output value of each industry in Pudong and the changes in the economic structure of Pudong, this paper concludes that the share of agriculture in the total economy of Pudong is decreasing year by year, the total amount of heavy industry exceeds that of light industry, the financial industry is growing as the pillar industry of Pudong, and the import volume is larger than the export volume. The conclusion is that Pudong should improve the level of agricultural production, increase the proportion of heavy industry in the development, improve the bank supervision policy and increase the imports to cultivate trading partners. These ideas will serve as a guide for the future quality development of Pudong and as a reference for new urban districts in domestic and foreign cities.

Keywords: Agriculture, industry, tertiary industry, gross domestic production, urban planning and development.

1. Introduction

Internationally, the development of Pudong in Shanghai has always been a focal point. Shanghai has been rapidly developing since 1990. There is a significant urbanization and internationalization trend. Pudong was formed in 1993 by combining Sanlin township, Huangpu district, Nanshi district, and a portion of Yangpu district. Pudong has transformed from a rural area to an international finance center and a Shanghai landmark in less than 30 years. Pudong has advanced in a variety of industries, from primary to tertiary. A vast amount of farmland was converted into buildings and factories. These changes have aided economic development and infrastructure development in both Pudong and Shanghai. In 2022, Shanghai Pudong New Area overcame the impact of the epidemic and other adverse effects to achieve total regional GDP of 1,601.3 billion yuan, an increase of 1.1%, 1.3 percentage points higher than the city's growth rate, and Shanghai's proportion of regional GDP reached 35.9%, 0.5 percentage points higher than the previous year, continuing to play the city's economic stabilizer, ballast, and power source [1]. Despite the negative effects of the epidemic, Pudong shows its strong ability of production and export and plays an crucial rule in the Overall GDP in Shanghai. There is a lot of evidence suggesting he trend of developing and growing of industries in Pudong. The traditional industrial land use policy is increasingly being challenged by new circumstances, such as the transition of economic form to service economy, the transition of development impetus to innovation, and the transition of spatial pattern to urban and rural coordination [2]. This is an unavoidable result of urbanization, which is caused by a growing demand for various services as well as an overpopulation in agriculture. However, the changes in land use type and industrial structure, along with the correlations between Pudong's development, must still

be studied. The research and analysis on changes in land use type and industrial structure can assist Pudong and Shanghai governors and citizens in forecasting and organizing plans for sustainable future development. The industry analysis is divided into three categories: primary industry, secondary industry, and tertiary industry.

This study covered agriculture, industry, finance, transportation, international business, and the cultural and tourism industries. The change in land use type and the shift in industrial structures over the last 30 years for each industry was discussed. The change in land use type in Pudong was visualized using Landsat-5 satellite images created by Quantum Geographic Information System (QGIS). Data and various graphs can be used to analyze changes in industrial structure. Then, as a whole, we examined Pudong's Gross Domestic Product and its contribution to Shanghai. Finally, based on the trends of the various industries and the problems we discussed, we proposed several methods to help improve the situation and made several predictions about Pudong's future development.

2. Changing of Land Sort

2.1. Agriculture

2.1.1 Rural indicators

Table 1 shows some parameters about rural in Pudong District, Shanghai City during the period from 1995 to 2020. The number of household was about 137.4 thousand in 1995, which was close to that of 2000 and was 136.7 thousand. However, it rose sharply and reached the peak during the period in 2010, which was 329 thousand approximately. After that, it showed the downward and decreased to 284.1 thousand in 2020 due to poverty alleviation promoted revolutionarily during the period. While the population in Pudong District, Shanghai had the same trend as that of the number of household.

The proportion of workforce in agriculture contributing to workforce in Pudong District fluctuated between 1995 and 2010, which was about 20.5%. However, that indicators dropped to 18.29% because of suffering from COVID-19 epidemic seriously. While that of from other provinces had an obvious upward trend between 1995 and 2005 and rose about 7% approximately and dropped sharply in two decades from 2000 and 2020. The proportion of workforce in agriculture from other provinces contributing to workforce from other provinces was 5.20% in 2020.

Table 1. Changing of rural population and cultivated area in Pudong District in 1995, 2000, 2010, 2020 [3-6]

Indicators	Unit	Year			
		1995	2000	2010	2020
Household	10 thousand households	13.74	13.67	32.90	28.41
Population	10 thousand persons	38.58	36.82	82.96	66.23
Workforce in Agriculture	10 thousand persons	4.63	4.04	10.62	7.11
The proportion of workforce in Agriculture contributing to workforce	%	20.27	20.34	21.81	18.29
Migrant Workforce from other provinces in Agriculture	10 thousand persons	0.45	1.47	4.08	2.43
The proportion of workforce in Agriculture from other provinces contributing to workforce from other provinces	%	9.36	16.10	6.25	5.20
Cultivated Area	Hectares	15045.45	12666.10	2296.10	1660.00
Paddy Field		13480.00	11239.10	2188.40	1328.00
Non-irrigated Land		1565.50	1427.00	107.70	332.00

2.1.2 Cultivated area

Table1 shows the changing in cultivated area and its components including paddy field and non-irrigated land between 1995 and 2020. Cultivated area in Pudong District, Shanghai City dropped obviously during the period from 1995 to 2020. While it started from 15045.45 hectares in 1995, however, the indicator had a downward trend in the next 2 decades and 5 years and finally reached the minimum which was about 1660 hectares in 2020. Its components such as paddy field and non-irrigated land had similar trends to that of cultivated area, which decreased from 13480 hectares to 1328 hectares and descended 332 hectares from 1565 hectares diversely.

Fig. 1 clearly shows the trend of proportions of paddy field and non-irrigated land contributing to cultivated area in Pudong District from 1995 to 2020 [3-6]. The proportion of both paddy field and non-irrigated land contributing to cultivated area stabilized to a constant proportion during the period, which was about 85% and 15% individually, although they fluctuated sharply in 2010.

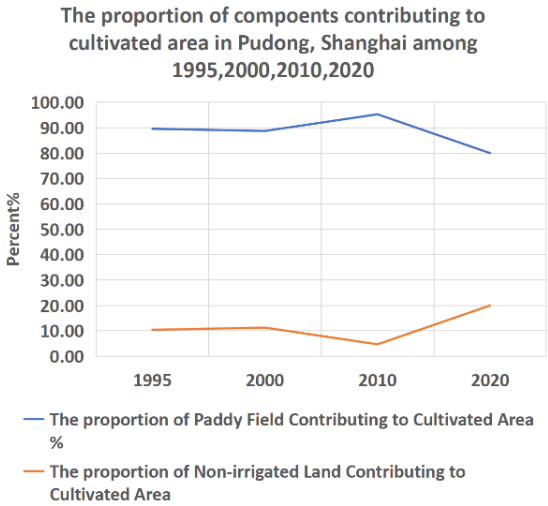

Figure 1. Proportions of Paddy Field and Non-irrigated Land Contributing to Cultivated Area in Pudong District from 1995 to 2020. (Photo/Picture credit: Original)

2.2. Industry

Table 2 shows the changing in industrial land and its components in Pudong district, Shanghai, including factories and warehouses between 2000 and 2020. Industrial area has absolutely increased from 2000 to 2020. The factories area was about 421 ten thousands square meters and in 2020, it was about 6175 ten thousands square meters. Between 2010 and 2014, Pudong has the highest average increasing rate of the area of factories. Besides factories, warehouses also experienced an overall increase in the area. However, between 2005 and 2010, there is a decreasing trend of the area of warehouses. After 2010, the area of warehouses started to increase again. The industrial area is keep increasing from 2000 to 2020, which also implies the growth of the whole secondary industry.

Table 2. Industrial land area and its components in Pudong, Shanghai in, 2000, 2005, 2010, 2014 and 2020 [7]

Components	Unit	Year				
		2000	2005	2010	2014	2020
Factories	Ten thousands square meters	421.00	684.00	1540.30	4984.00	6175.00
Warehouses		35.00	84.00	78.00	448.00	684.00

2.3. Indicators of Land Usage Change on Tertiary Sectors

2.3.1 Financial industry

Since the reform and opening up of Pudong, Shanghai in 1990, many financial institutes have moved into Pudong, stimulating the formation of the central business district, Lujiazui. Lujiazui core area is 1.7 meter square, while the whole Lujiazui area reaches 31.78 meter square large. The building

of Lujiazui mainly based on removal of original houses and farmlands [8]. Besides, the financial sector has expanded to the inner area of Pudong along the Century Avenue. Lujiazui will promote the construction of world-class commercial district, and commercial complex, promote urban renewal, building upgrading and industrial function agglomeration improvement.

2.3.2 Transportation and international business industry

Among the development of Pudong in 30 years, a significant step is the open of Pudong Airport which allows 106 domestic airlines and 114 international airline to be opened towards 297 cities from Shanghai. It covers 1,456,000 meter square and is built on the fields and farmland near the sea.

2.3.3 Cultural and tourism industry

Shanghai Disneyland Resort opened in 2016 in International Tourism Resort Area in Pudong and covers 3.9 kilometre square. This leads to the development of commercials and hotels surrounded, including the Shopping Villages and Eco Park. Until 2020, the International Tourism Resort Area has grown into a town with 75,000 meter square large [9]. Shanghai International Tourism Resort will focus on cultivating and developing themed amusement, cultural creativity, commercials, sports and hotel industries to build a modern highland of servicing industry, and integrate the joint development of surrounding tourism resources, so as to build an international tourism resort with high energy level and strong radiation.

3. Changing of Production Structure

3.1. Agriculture

3.1.1 Gross production

Fig. 2a shows the trend of agricultural production in Pudong District since the foundation of the new area [3-6]. It rose slightly from 1990, which was just 0.22 billion RMB to 2005 although it dropped down during the period between 1993 to 1995. However, it rose sharply between 2005 and 2006, which rose from 0.6 billion RMB to 2.19 billion RMB because of the increasing of several elementary requirements such as milk, vegetables and fruits. It had a strong upward trend until 2011 and turned to a downward trend in the decade from 2011 to 2020, which was about 1.708 billion RMB.

3.1.2 Contribution to gross domestic production

Fig. 2b illustrates the proportion of agricultural production contributing to GDP in Pudong District, Shanghai City from 1990 to 2020 [3-6]. It had a slight contribution in the beginning year-1990 and was about 3.69%, and then it showed an obvious downward trend in the next 2 decades and 5 years, which could prove that agriculture will gradually replace by other productions which could bring more chances and profits and increase the potential development with the development of urbanization validly. However, it had the phenomenon of rising between 2005 and 2006, which could illustrate the rapid growth of agricultural production during the same period sufficiently and reflect some changing in people's lives and policies in the corresponding era.

3.1.3 Distribution

Looking around Fig. 2c, Fig. 2d, Fig. 2e and Fig. 2f, it is clear that planting made the largest contribution to agricultural production among 2010 and 2020 due to its humid and warm climate [3-6]. While the proportion of animal husbandry contributing to agricultural production in Pudong ranked behind that of planting among 10 years and showed the downward trend from 53% in 1995 to 4% in 2020, it was outweighed by forestry which proportion was about 6% in 2020. Moreover, the proportion of fishery contributing to agricultural industry experienced a decreasing trend between 1995 and 2000, however, it rose slightly and stabilized in about 9% in 2010 and 2020, while that of sideline became prosperous in the same period because it was 5% lower than that of fishery in 2010 and was 2% higher than that of fishery in 2020 which owed to diversified development in agriculture.

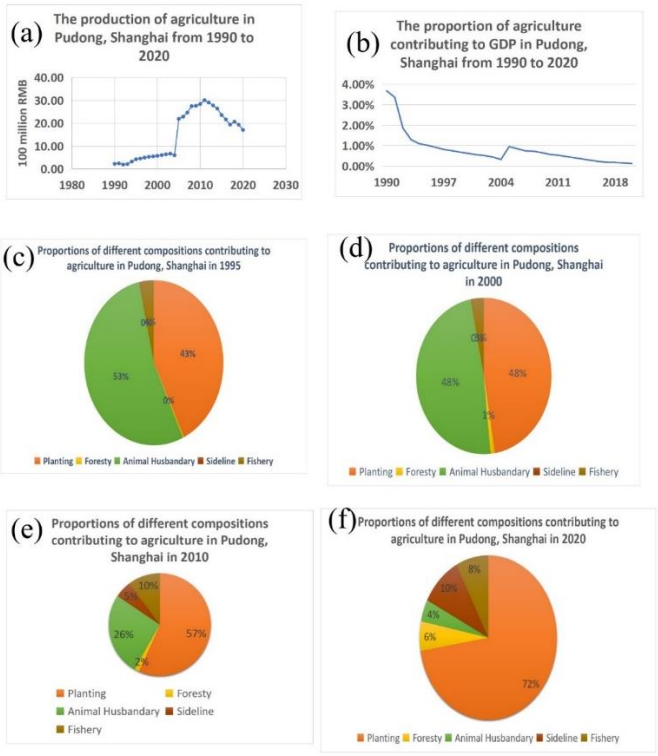

Figure 2. (a) Gross Production and of Agriculture in Pudong District from 1990 to 2020; (b) Contributing to Pudong's Gross Domestic Production of Agriculture in Pudong District from 1990 to 2020; Proportions of different compositions contributing to agriculture in Pudong, Shanghai in (c) 1995, (d) 2000, (e) 2010, and (f) 2020. (Photo/Picture credit: Original)

Looking around Fig. 3a, Fig. 3, Fig. 3c and Fig. 3d, although they have differences on the size of Landsat and band of spectrums. Except for the factors from protecting the ecosystem, the squares of red layers in Pudong District became lower and lower among 25 years, which meant the land using for agricultural activities shrank sharply, due to rapid development in finance and international freight transportation in Pudong District.

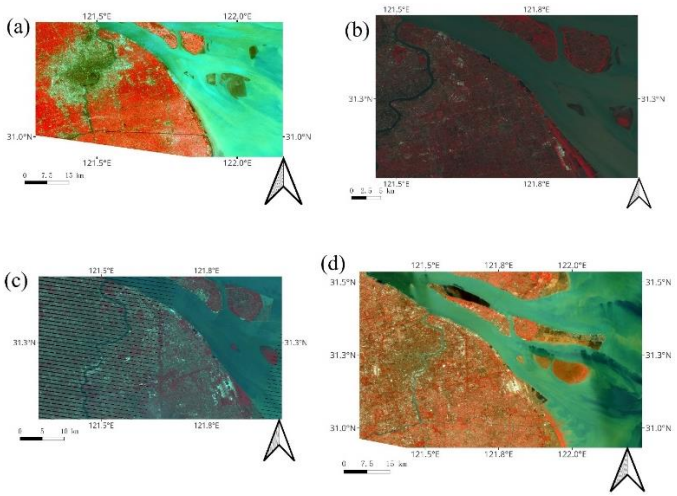

Figure 3. Image which reflected the vegetation in Pudong New Area in (a) 1995, (b) 2000, (c) 2010, (d) 2020. (Photo/Picture credit: Original)

3.2. Industry

3.2.1 Production of secondary industry in Pudong

Table 3 shows the Gross Output Value(GOV) of all three industries in Pudong, Shanghai between 2000 to 2020.

Table 3. The production of primary, secondary, and tertiary industry in Pudong, Shanghai in 2000, 2005, 2010, 2014 and 2020 [10]

Gross Domestic product of industry	Unit	Year				
		2000	2005	2010	2014	2020
Overall GDP	RMB hundred million	923.51	2299.82	4964.85	7656.68	13207.03
Primary industry		5.72	21.93	28.39	26.44	17.08
Secondary industry		488.60	1131.08	2048.65	2373.35	3040.21
Tertiary industry		429.19	1146.81	2887.81	5256.89	10149.74

According to Fig. 4a and Fig. 4b, it is obvious that the secondary industry in Pudong, Shanghai, shows an overall increase in the GOV from 2000 to 2020. The GOV of secondary industry in Pudong, Shanghai, increased from 488.60 hundred million Yuan in 2000 to 3040.21 hundred million Yuan in 2020. Comparing to primary and secondary industry, tertiary industry is gaining the dominance place in the total GOV in Pudong. Excluding the tertiary Industry, GOV of primary industry and secondary industry are both increasing. However, according to Graph 1 and 2, secondary industry shares a lower portion in the total GOV in 2020 than in 2000. The percentage of the GOV of secondary industry decreased from 53% in 2000 to 23% in 2020. The increasing rate of the GOV of secondary industry is lower than the increasing rate of the GOV of industry. The growing trend of secondary industry isn't changing, but it is gaining less proportion in the total GOV, which suggests the growth of other industries.

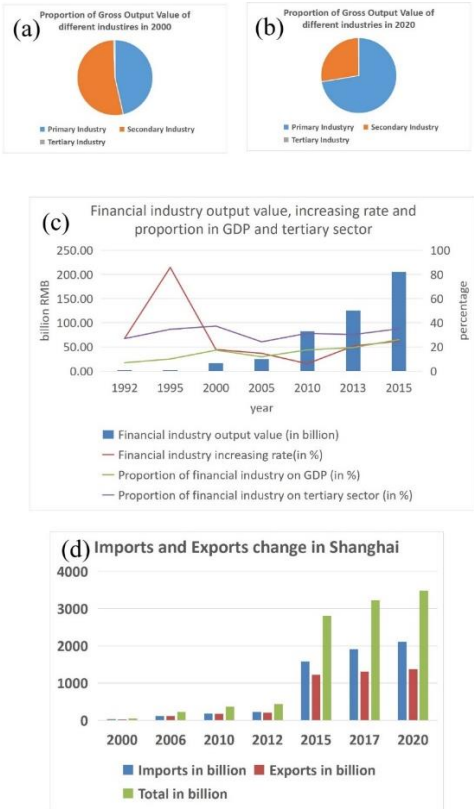

Figure 4. Proportion of Gross Output Value of differentindustires in (a) 2000 and (b) 2020; (c) Financial industry output value, increasing rate andproportion in GDP and tertiary sector; (d) lmports and Exports change in Shanghai. (Photo/Picture credit: Original)

3.2.2 Structure of secondary industry

Table 4 shows the structure of secondary industry and divides them into light and heavy industry. Both light and heavy industry experienced an overall increase in the output. Light industry produced from 424.42 hundred million Yuan in 1995 to 1630.91 hundred million Yuan. Heavy industry produced from 543.61 hundred million Yuan in 1995 to 8790.16 hundred million Yuan. Both of light

and heavy industry had boomed between 2005 and 2010. Light industry reached to a maximum output value after 2015 and become fixed around 1600 hundred million Yuan. Besides, Heavy industry is keep increasing. After 23 years, the structure of secondary has change a lot. The light industry portion had dropped from 43.8 percent to 15.7 percent. The heavy industry portion increased from 56.2 percent to 84.3 percent. On one hand, it reflects that heavy industry was growing at a faster rate. On the other hand, it reflects that the output of light industry was saturated.

Table 4. The structure of secondary industry by using light and heavy industry in Pudong, Shanghai between 1995 to 2018 [19]

Structure	Unit	1995	2000	2005	2010	2015	2018
Light industry	Hundred million RMB	424.42	514.58	825.4	1535.63	1690.52	1630.91
Heavy industry		543.61	1111.19	3417.07	7055.87	7764.36	8790.16
Light industry	%	43.8	31.7	19.5	17.9	17.9	15.7
Heavy industry		56.2	65.3	80.5	82.1	82.1	84.3

3.3. Tertiary Industry

Tertiary sector is the main industry in Pudong New Area and contribute to most proportion to the total output value of Pudong.According to Fig. 2a and Fig. 2b, it is easy to find that in 2022, the output value is 1195.783 billion which is 74.7% of the total output value in Pudong. Although Pudong experienced a series of negative impacts from locked down, the tertiary sector still increases at a rate of 0.5%, but lower than primary or secondary sectors. By industry, Financial industry grows the most at 3.8%, while hotel and restaurant industry and transportation, warehousing and postal industry drops the most by 11.4% and 9.5% respectively. Other increase came from information technology industry and scientific research and technical servicing industry. This shows the strength of the financial industry basis in Pudong and the diversity of types of tertiary sector industries.

3.3.1 Financial industry

As shown in Fig. 4c, the financial industry grew rapidly after 1992 [11]. The increasing rate reached its peak at 1995 and slowed down later due to the financial crisis in 1998. Both three lines show a bottom at 2005 which was caused by the macroeconomic policies change to prevent overheating in 2002. The financial crisis in 2008 had little impact on Pudong and since 2010 it has shown an increasing trend again. Another feature is that the proportion of financial industry on tertiary sector did not show a clear trend, while the proportion of financial industry on GDP steadily increases. This is likely caused by the rise in proportion of total output value of the whole tertiary sector in GDP of Pudong [11].

Overall, all four groups of data has proved the significance of financial industry in economy of Pudong. The financial industry in Pudong expands at a higher rate than the GDP increasing rate of Pudong, indicating the dominant position of financial industry in tertiary sector. The process of concentrating financial resources is not only the cultivation of the whole industrial trend, but also the improvement of manufacturing industry, resulting in the upgradation of industrial structure [20]. As the economic growth point of Pudong, the financial industry drives the rapid development of other industries, which increases the proportion of the tertiary industry in the industrial structure of Pudong, and has an obvious promoting effect on the economy.

3.3.2 International business industry

As shown in Fig. 4d, both imports and exports show an increasing trend in last 20 years, after China became a member of WTO in 2001 [12-18]. Before 2012, the imports and exports steadily grew in a slow rate. During this time, China invested a large amount of budget to improve the productivity of manufacturing industry and cultivate domestic firms. In 2015 the total imports and exports had been 5 times than the amount 3 years before. This increasing trend continues in the following years after 2015.

It is remarkable that imports grew much faster than exports, resulting in trade deficit. However, the basic reason of the trade deficit is increase of percentage of servicing industry in domestic

economy. Along with the faster and further adjustment in economic structure in Shanghai, this trade deficit may exist for a long period and could be even wider [21]. Overall, the rise in both imports and exports indicates the development of domestic manufacturing industry in Shanghai and the progress of opening up.

3.4. Gross Domestic Production

3.4.1 Overview

Fig. 5a shows the development of Gross Domestic Production in Pudong District from 1990 to 2020 vividly [3-6]. Pudong's Gross Domestic Production was only 6.024 billion RMB in 1990 and showed the rapid speed of increasing in the next period. Gross Domestic Production in Pudong grew more brutally and energetic after 2001, the year China joined in the WTO, and outweighed 200 billion RMB in 2005. The time of breaking 400 billion RMB was much shorter than that of 200 billion RMB, which meant that Pudong's Gross Domestic Production rose from over 200 billion RMB in 2005 to much more than 400 billion RMB in 2010. Although Gross Domestic Production in Pudong was influenced by unstable international financial environment and COVID-19 epidemic, it still reached the maximum which was just about 1320.7 billion RMB among 30 years in 2020.

3.4.2 Increasing rate

Fig. 5b illustrates the increasing rate of Gross Domestic Production in Pudong District, Shanghai City among 30 years [3-6]. The increasing speed was just below 20% in 1990 and then had a sharp increase until 1995, the main reason of which was about the squares of available land was so abundant that governors could use those to develop financial and international freight transportation, which were the pillar productions of Pudong all the time. However, the increasing rate of Gross Domestic Production decreased sharply from 1996 to 2000 because of suffering from international financial crisis, while the increasing rate rose slightly which owed to joining in the WTO in 2001. In the 21st century, the increasing rate of Gross Domestic Production fluctuated and decreased slightly and finally reached 3.71% in 2020.

3.4.3 Contribution to Shanghai's gross domestic production

There is a saying goes, "Pudong District contributed to one eightieth of Gross Domestic Production in China (not including Hong Kong, Macao and Taiwan)". From a number of Chinese people's perspective, Pudong represents the vitality of Chinese economical development. From Figure 5(c), it is so clear thatPudong's Gross Domestic Production made an outstanding contribution to that of Shanghai, which was just about 10% in 1990 and rose sharply with a stable and high increasing speed among 30 years and finally reached the maximum which was close to one third in 2020.

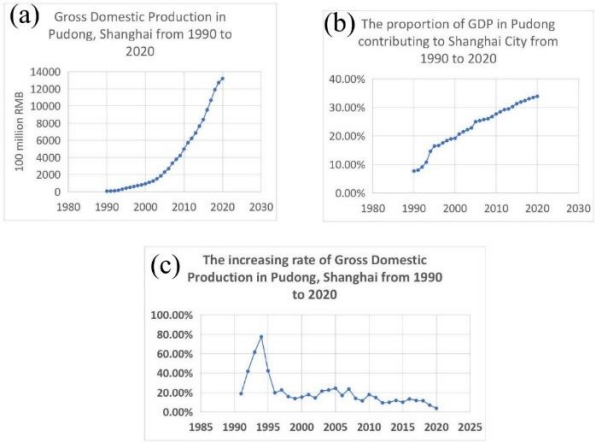

Figure 5. (a)Gross Domestic Production's Overview in Pudong from 1990 to 2020; (b)Gross Domestic Production's Increasing Rate in Pudong from 1990 to 2020; (c)Gross Domestic Production's Contribution to Shanghai in Pudong from 1990 to 2020. (Photo/Picture credit: Original)

4. Future Expectation

4.1. Agriculture

With the in social and economical development promoting rapidly in the new era, the status of agriculture in Pudong and Shanghai may be descended. However, a Chinese idiom says: “Bread is the staff of life”, agriculture plays an important role in people’s every aspect of daily life. In the forthcoming time, Pudong can take some actions to make agricultural production on new progress.

4.1.1 Improving the way of agricultural production

Improving the way of taking agricultural productions is a necessary and undoubtable action. Pudong’s governors can take privilege policies to attract people who specialize in agriculture and mechanics so that it can help the technique of cultivating make on progress. What’s more, governors and specialists can teach rural individuals about how to use modern agricultural techniques and machines, which can improve the efficiency of agricultural activities and increase the agricultural production validly.

4.1.2 Planning and developing some lands for agricultural activities

According to Agricultural Location Theory by Johan Heinrich von Thunnen, the first circle is called free agricultural circle, which is the nearest circle to the city center among six circles. Governors in Pudong District, economists and urbanists should use remote sense and GIS to analyze the real-time city center and high dense population spots such as communities and villages. Then they can equip and plan for sufficient and moderate lands to take agricultural activities such as planting fresh vegetables and nurturing cows, which could offer convenience to residents and villagers in their daily lives.

4.2. Industry

Industry plays an significant rule in daily life. Secondary industry involves in from raw materials to all the kinds of products. The production of different goods usually provide people a better life. The progress of the secondary industry can be revolutionary, which can completely change the way people live, for example, the invention of the steam engine and assembly line. The new technology provides more efficiency. The growth of secondary industry is inevitable, same as in Pudong, Shanghai. The area of factories and warehouses increased from 4560 thousands square meters to 68590 thousands square meters. The increasing trend of the industrial area suggests that it will be still increasing in the future. For the structure of secondary industry in Pudong, Shanghai, the heavy industry is taking a larger part. The output of heavy industry increased from 543 hundred million Yuan to 8790 hundred million Yuan, which is more than ten times larger. It implies that heavy industry is very crucial and the demand of heavy industry isn’t saturated. However, light industry reached its peak. The output wasn’t increasing and become stable around 1600 hundred million Yuan. In the future, we expect that heavy industry will show an increasing trend and light industry will not have significant growth.

4.3. Tertiary Industry

4.3.1 Future development of financial industry

Since 2020, the world economy has entered a downturn time due to low expectation and regional conflict. In order to maintain the economic fundamentals, it is essential to maintain the dominant position of financial industry in tertiary sector. This involves the enlargement of financial market size by encouraging small and medium firms to participate into financial industry. Financial market environment should be optimized and continue to improve the proportion of financial industry in GDP. In details, government should complete the monitoring policies for Bank and encourage security and insurance industry to participate into financing [12].

4.3.2 Future development of international business industry

Along with the increase in labour price and world situation change, while China and Shanghai need to be more positive and welcome to open up, they need to strengthen their domestic industrial basis and improves efficiency and quality of products to cope with competition and maintain the growing trend of exports. Also, it is crucial to encourage domestic consumptive power to grow up to consume domestic products and increase imports to cultivate trade partners.

5. Conclusion

Pudong District has shown the strong, irreversible and irresistible potential in some productions including financial and imports since 1990s. The rate of agriculture contributing to Pudong's Gross Domestic Production dropped sharply year by year, but planting, which had the function of providing citizens with daily necessaries, was the pillar way of agricultural production during the period. However, industry and tertiary industry's production contributing to Gross Domestic Production showed the opposite trend to that of agriculture. The structure of industry had an obviously change and the contribution of heavy industry's production to Pudong's industrial Gross Domestic Production rose sharply during the period due to the output of light industry became saturated. Tertiary industry had a faster rate of development, a larger rate of contribution to Pudong's Gross Domestic Production and higher Gross Domestic Production than that of industry in 4 decades. Financial industry gradually became the pillar production in Shanghai City, though the increasing of rate always fluctuated. By the advantage of irreplaceable location, import's production gradually exceeded that of export which could reflect clearly development of domestic manufacturing industry in Shanghai and the progress of opening up. In the forthcoming time, Pudong can take some actions like improving the way of agricultural production, increasing the proportion of heavy industry and increasing imports to cultivate trade partners etc. to promote healthy and rapid development. The purpose of making the research is to help governors in Pudong and Shanghai make greater plans to promote stable and consecutive development in the future.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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