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"Lock-In Effect" of China's Industrialization: An Empirical Analysis of the County-Level Cities in Southern Jiangsu

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Abstract: This paper defines and explains the "lock-in effect" in China's industrialization process using the county-level cities in southern Jiangsu while considering both internationalized and localized views. An empirical analysis of two typical representative indicators, per capita economic output and economic structure, using 2002, 2005, 2010, 2015 and 2019 official statistical data demonstrate that capital, labor and other traditional factors still play a role in the current "lock-in effect". New elements, such as human capital, are manifesting their growing importance. Public services, such as science and technology, education, medical and health care, social safety and employment, are gradually exerting their influence to optimize the economic structure. This paper promotes pertinent development decisions associated with the "lock-in effect" that must be considered during current industrialization processes.

Keywords: industrialization; county-level city; lock-in effect; urbanization; economic structure

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1. Introduction

Arthur [1] first presented the concept of the "lock-in effect" by using studies of technological innovation. He believes that the mechanisms of increasing returns will lead to a "lock-in effect" on the technology conditions and technological innovation. His research uses the scope of economic growth mode and describes a phenomenon whereby the economy is in a stable state from which it is hard to escape. This stable state is not conducive to industrialization and the upgrading of industrial structures. Grabher's research [2] on Ruhr Industrial Zone in Germany found that the initial strength of the industrial zone—industrial environment, highly developed and specialized division of labor infrastructure, close inter-enterprise relations, and strong political support of regional systems—will bring serious obstacles to innovation, thus forming a "lock-in effect". Under the economic growth mode, North [3], Foxon [4], and Isaksen [5] propose technical path dependence and the "lock-in effect" from the perspective of institutional change. Scholars such as Liebowitz and Margolis [6], Seto and etc. [7], Cantner and Vannuccini [8], Shih-Kung and Po-Chen [9], and Acquila-Natale [10] have also referred to and deepened the concept of the "lock-in effect" from other perspectives. However, they all use the economic growth mode. Other scholars discussed the concept of "lock-in effect" from the perspective of technological innovation, such as Spulber [11], Foxon [12], Spiegel Marxt [13], etc.

In China, the concept of the "lock-in effect" is more diverse. Yan and Jiang [14], Zhen, etc. [15] applied this concept to the study of industrial clusters and analyzed the impact and the formation mechanism of "lock-in effect" on them, as well as put forward corresponding policy recommendations. Lin and Lv [16] explained the lock-in situation by referencing international research theories and experiences. Zhang [17], Li and Ma [18], Gao and Li [19], and Chen [20] discussed the "lock-in effect" of social capital, technology, human capital, economic system, geographical position, etc., respectively. Chen et al. [21], Yang and Reng [22] analyzed the relationship between "lock-in effect" and industrial

structure evolution. Lu, Chen [23], Yu, etc. [24] have also discussed the impact of "lock-in effect" from the perspective the comparison of regional development. Du and Zhou [25] conducted an empirical study on "lock-in effect" with the panel data of the manufacturing industry. Xu et al. [26] put China's manufacturing industry on the global value chain, and put forward lock-in phenomenon and upgrading opportunity raises. However, they have all used the characteristics of path dependence and usually referred to an immobile industrial development and economic growth state as lock-in. Lock-in thus appears to be the accepted term for any stable state, rather than only its originally specified meaning.

In China, county-level cities are the basic units promoting industrialization and urbanization, maintaining the overall plan of their towns and implementing the requirements of their corresponding prefecture-level cities. Liu et al. [27], Qian et al. [28], Wang et al. [29] have emphasized the importance of county-level cities from the perspective of urbanization and land space planning, respectively. Southern Jiangsu, located in the Yangtze River Delta (shown in Figure 1), includes Nanjing, Suzhou, Wuxi, Changzhou and Zhenjiang. Southern Jiangsu became famous in China due to the "Sunan model" developed in the 1980s. The concept of the "Sunan model" was first put forward by Fei [30], which refers to the way that farmers in southern Jiangsu rely on their own strength to develop township enterprises to achieve non-agricultural development. Many enterprises were begun at the township level as a result.

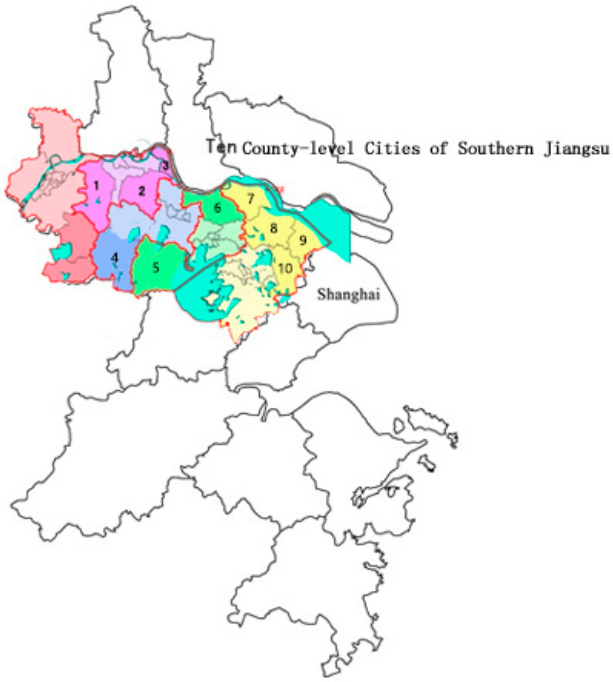

Figure 1. Yangtze River Delta and the location of the county-level cities (1—Jurong, 2—Danyang, 3—Yangzhong, 4—Liyang, 5—Yixing, 6—Jiangyin, 7—Zhangjiagang, 8—Changshu, 9—Taicang, 10—Kunshan) in southern Jiangsu.

Driven by China's fast economic growth in the late 1990s and a great deal of domestic and foreign investment, the county-level cities in southern Jiangsu attained remarkable economic growth. Their relatively large enterprises have allowed county-level cities to take the lead characters of their towns instead. Since the rise of the southern Jiangsu with the "Sunan model", it has inherited the existing development achievements and foundations and have been in the forefront of national regional economic growth. From the resource organization mode led by the township government to the urban economic growth promotion mode that widely attracts domestic and foreign investment, in this process, the county-level cities in southern Jiangsu gradually changed their role from coordinating and organizing their own internal sector economy to seeking the overall development of the

city. There are currently 10 county-level cities in southern Jiangsu, including Changshu, Zhangjiagang, Kunshan and Taicang in Suzhou; Jiangyin and Yixing in Wuxi; Liyang in Changzhou; and Danyang, Yangzhong and Jurong in Zhenjiang.

Official data show that the county-level cities in southern Jiangsu have played a decisive role in the economic development of their corresponding prefecture-level cities, especially Suzhou City, and the GDP of county-level cities together account for 52.96% of the whole prefecture-level city in 2019. In the past two years, three of the four county-level cities of Suzhou have ranked in the top five county-level cities in China, based on their economies. It is easy to see that the county-level cities have indeed been playing a vital role in southern Jiangsu and that they demonstrate and lead the development of all county-level cities in China.

International data indicate that the increasing share of the economy held by secondary industry (which mainly relies on the raw materials provided by nature and the primary industry for processing, including mining, manufacturing, power, heat, gas and water production and supply, construction, etc.) each year is a clear sign of industrialization. There are simultaneous changes in other common indicators, such as the per capita GDP, the primary and tertiary industry share and the employment structure of the three industry types. These indicators have all shown changes as the county-level cities in southern Jiangsu industrialized.

Since the 1980s, secondary industry, which is accepted as the industrial sector in China, has possessed the dominant, motivational position in southern Jiangsu. For example, the economies of Kunshan, Jiangyin, Zhangjiagang and Changshu, measured by their GDP, have been ranked as the top four county-level cities in China. The statistical records clearly show that the four county-level cities of southern Jiangsu have shown the characteristics mentioned above since the implementation of the reform and opening up policy in China (shown in Figure 2). Their economic structural changes have been driven by changes in the share between the primary industry (which mainly refers to the industries related to breeding, planting and cultivating biological materials, including agriculture, forestry, animal husbandry and fishery, etc.) and tertiary industry (which refers to other industries except the primary and secondary industries, mainly including wholesale and retail industry, transportation, warehousing and postal industry, accommodation and catering industry, information transmission, software and information technology service industry, financial industry, etc.), whereas the share of the secondary industry has always been high. This stable secondary industry share in the county-level cities has persisted since the end of the 1990s and appears to be locked.

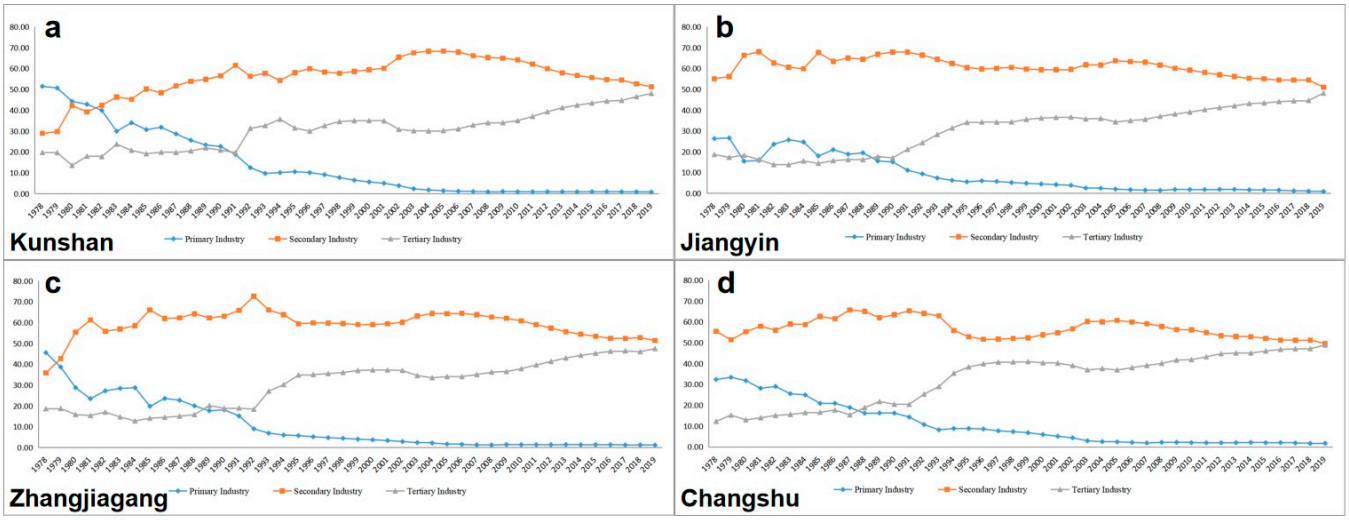

Figure 2. The changes in the economic structure in the county-level cities of Kunshan (**a**), Jiangyin (**b**), Zhangjiagang (**c**) and Changshu (**d**) over the last forty years. Source: Jiangsu Statistical Yearbook 2020.

From the above analysis, it can be seen that these county-level cities are currently the pioneers of China's industrialization. How to accurately position the realistic role of industrialization, grasp the future development direction of "industrialization" and deeply understand the development characteristics and connotation brought about by industrialization is a very critical link and problem for the future realization of sustainable, healthy and orderly development of county-level cities in southern Jiangsu, as well as stabilizing their economic status in Jiangsu Province and even the Yangtze River Delta, and accelerating the transformation of regional economic growth mode. Existing research on this area of China, especially its industrialization, has focused on describing phenomena and making theoretical inferences using qualitative research methods. The industrialization engine of southern Jiangsu has experienced a transition from a period of rapid growth of traditional industries to the upgrading and modernization of industries. Gu [31] systematically analyzed the process of industrialization in southern Jiangsu and summarized its successful experience. Many studies have focused on this transition, such as Shen [32], Li et al. [33], Wang et al. [34], who have analyzed the road selection of industrial promotion in southern Jiangsu in post-industrial period. Han [35] and Zhang [36], Cui [37] and Tian [38] studied the industrialization in southern Jiangsu from the perspective of productive factors of the labor force and human capital, respectively, and made theoretical judgment and guidance over the direction of future industrialization. Most of the studies on the industrialization in southern Jiangsu from an economic structure perspective have concentrated on theoretical optimization ideas, such as Shen [39] and Xu [40]. Quantitative studies are required to strengthen the existing work on the Chinese context.

Therefore, based on the perspective of economic structure, starting from the explanation of industrialization in county-level cities in southern Jiangsu, this paper defines the "lock-in effect". Using panel data and regression model, this paper quantitatively analyzes the phenomenon of "lock-in effect" of industrialization in county-level cities in southern Jiangsu, and then puts forward corresponding solutions to the regression results, with the view of adding a new profile to China's industrialization and urbanization research and experience database.

2. Definition of "Lock-In Effect" of Industrialization

Our study is inspired by Chenery's industrialization stages research [41], which accepts that the most apparent signs of the industrialization process are changes in the GDP, per capita growth, industrial economy, and employment structures. Once the GDP and per capita growth have reached a relatively high post-industrialization level, the economy and employment structures usually show an increase in the tertiary industry share and a decrease in the secondary industry share.

To clearly illustrate China's industrialization conditions, this paper analyses 10 county-level cities using data from 2002, 2005, 2010, 2015, and 2019. The data from 2002 reflect the initial development conditions of the county-level cities in the early 21st century. In this case, 2005, 2010, and 2015 were, respectively, the last years of the Tenth Five-Year Plan, the Eleventh Five-Year Plan and the Twelfth Five-Year Plan, and so are vital statistical points describing China's fast economic growth process at the start of the 21st century, and 2019 was the final year of the study period.

2.1. Structural Changes and Comparisons of Economies and Employment in the County-Level Cities of Southern Jiangsu

We compare the added value share of the three sectors in the county-level cities in southern Jiangsu in Figure 3. We can conclude that the features of economic structure change as follows. The secondary sector (industry that mostly accounts for more than 90% of this sector in county-level cities of southern Jiangsu) has the largest share and that share is relatively stable. The tertiary sector increases slightly, but the rising trend is not obvious. The primary sector tends to have a marginal share and that share decreases significantly.

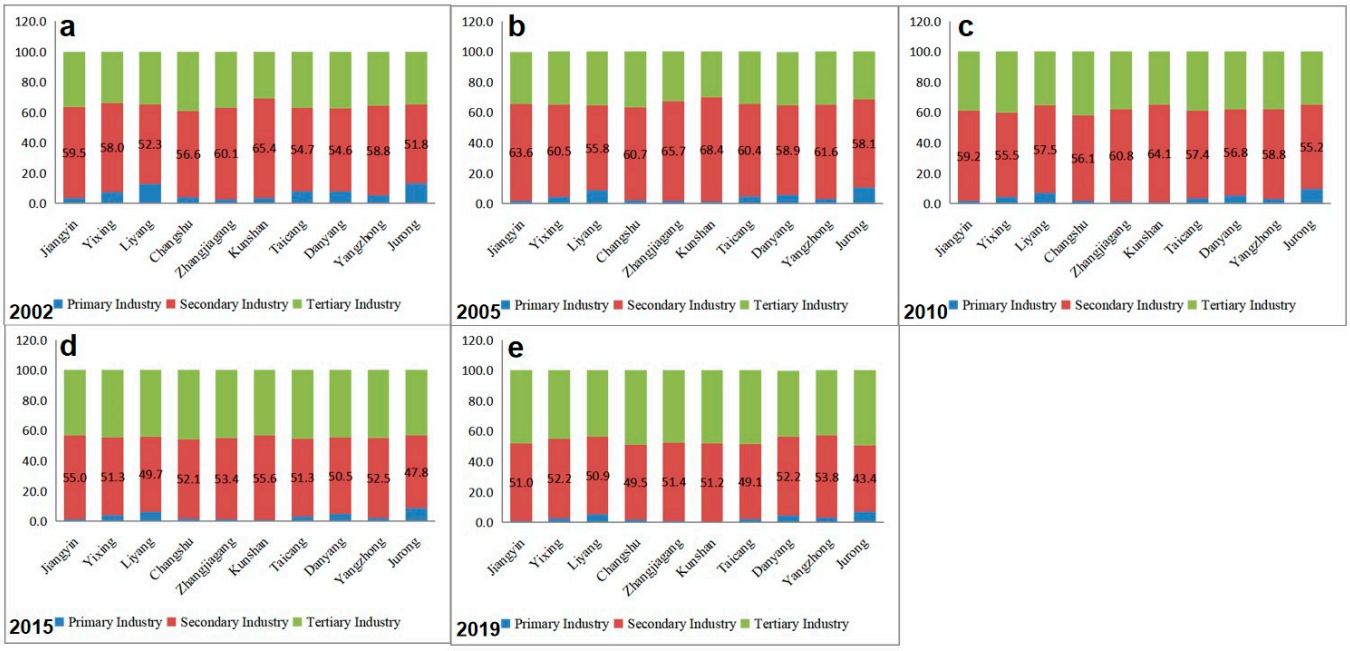

Figure 3. The changes in the economic structure in the county-level cities in southern Jiangsu from 2002 to 2019 ((**a**)—2002; (**b**)—2005; (**c**)—2010; (**d**)—2015; (**e**)—2019), presented as shares of the secondary sector. Source: Jiangsu Statistical Yearbook 2003–2020.

Figure 4 shows the employment share of the three sectors in the county-level cities of southern Jiangsu. The employment share of the secondary sector, which is also commonly accepted as the industry sector in China, grows overall. The employment share of the primary industry declines. The employment share of the tertiary sector fluctuates, but the overall trend is a slow growth.

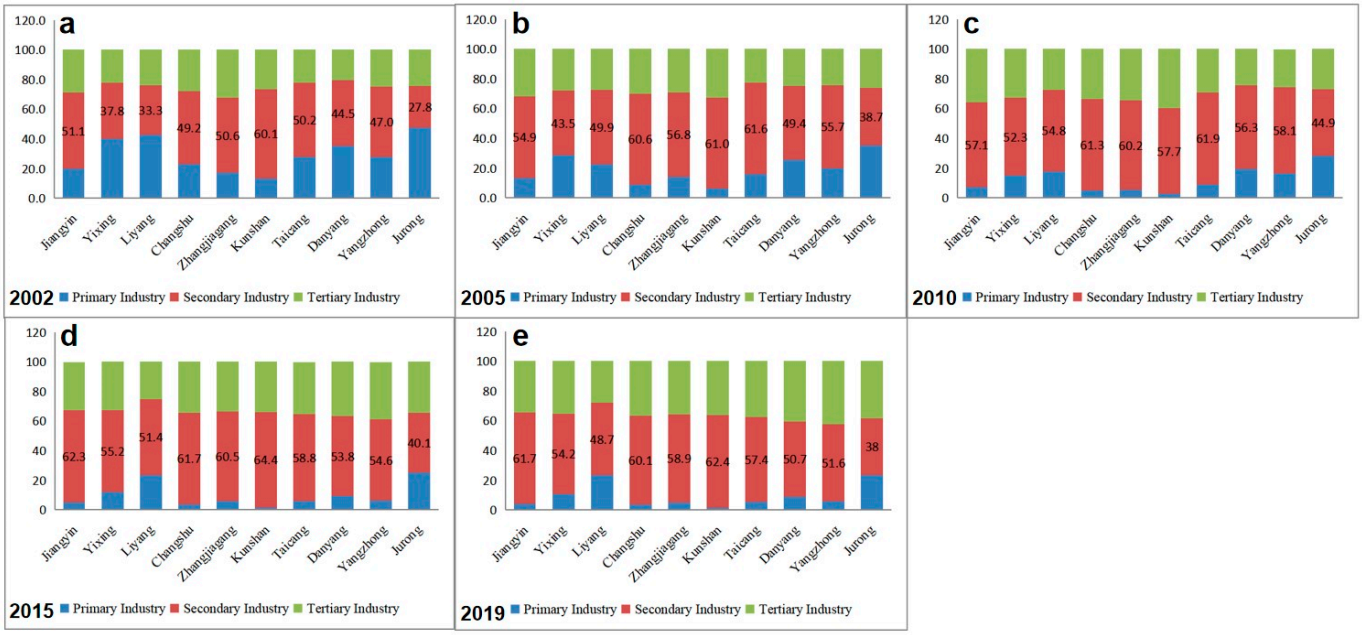

Figure 4. The employment structure changes in the county-level cities in southern Jiangsu from 2002 to 2019 ((**a**)—2002; (**b**)—2005; (**c**)—2010; (**d**)—2015; (**e**)—2019), presented as shares of the secondary sector. Source: Jiangsu Statistical Yearbook 2003–2020.

2.2. Phenomenon of "Lock-In Effect" of Industrialization in County-Level Cities in Southern Jiangsu

According to the analysis above, tertiary industries, which are service industries, still do not provide many job opportunities or support the economy as a whole. Economic and employment growth are instead mostly driven by industry. In sharp contrast to the structural indicators of economy and employment, the county-level cities of southern Jiangsu always have a per capita GDP that indicates rapid growth (shown in Figure 5), especially Kunshan, Jiangyin, Zhangjiagang, Taicang and Changshu.

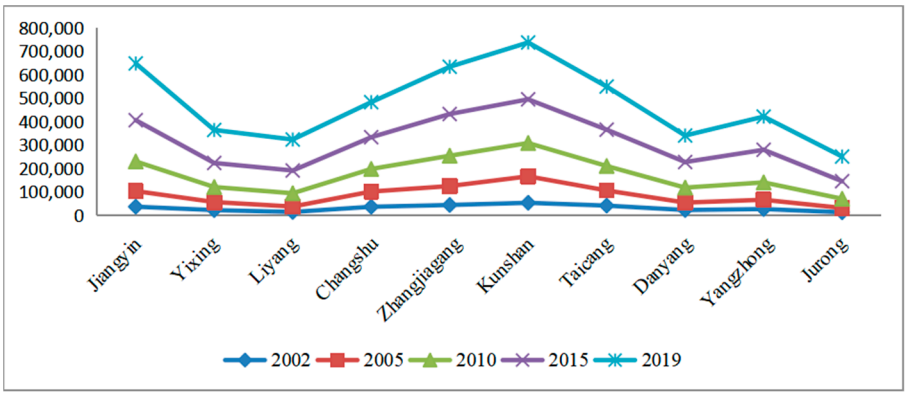

Figure 5. The per capita GDP changes in the county-level cities in southern Jiangsu from 2002 to 2019 (unit: yuan). Source: Jiangsu Statistical Yearbook 2003–2020.

In conclusion, the industrialization of the county-level cities in southern Jiangsu shows the following characteristics. Industry, which is mainly the secondary sector in China, is the primary force driving long-term economic development. Industry also plays a dominant role in absorbing the labor force and has been carried out over a long-term period of time. Other indicators, such as the per capita GDP, have shown rapid growth rates over the past decade, which indicates industrialization.

In the industrialization of the county-level cities in southern Jiangsu, industry is the main body for economic output and employment. Industry is described as the "single-wheel drive" mode of economic growth. However, industry's share of the GDP, from the economic structure perspective, has not risen significantly and appears to be locked in a stable state. In contrast, the rapid growth in the overall and per capita levels of the county-level cities' economies is obvious. This phenomenon does not agree with international industrialization experiences and the corresponding research. It results in a series of problems and specific issues that involve aspects of economic and social development and affect people's living situations.

This paper defines a specific meaning for the "lock-in effect" of industrialization in the county-level cities in southern Jiangsu, based on theoretical references to existing studies on the "lock-in effect" and research into the changes in the economic structures of these cities; more specifically, how the secondary industry plays a major role in supporting economic development in the industrial structure for a long time, and it plays a leading role in the employment population absorption pattern as well as maintains the growth trend.

3. Empirical Research on the "Lock-In Effect"

Our general investigation of the industrialization indicators of the county-level cities in southern Jiangsu shows that the indicators do not comply with existing theories and empirical facts of the industrialization process in developed regions. Thus, we explore the "lock-in effect" in these cities by matching relationships between the per capita economic output and the economic structure status.

3.1. Construction of Measurement Models

The per capita economic output and economic structure are two key economic output indicators of the industrialization of the county-level cities in southern Jiangsu. We explain the indicators using the production function viewpoint. We also consider the typical characteristics of economic development in these county-level cities.

According to Solow's model formula proposed by Solow [36], the relationship between input and output in the production function is expressed as follows:

$$Y = AF(N, K) \tag{1}$$

where Y refers to output, N and K refer to the mean input elements of labor and capital, respectively, and A refers to technical support, including human capital.

To interpret the economic output of these county-level Chinese cities, we must take into account the land factor in addition to traditional factors such as labor, capital and technology. The land factor plays a very important role in the development of Chinese cities and relates to various fields associated with regional economic growth, such as finance, real estate development, and industrial park construction. For China's urban development at this stage, land finance and related real estate development, industrial development, and various park construction are important supports for regional economic growth. In addition, promoting the healthy operation of the economy is also inseparable from the role of public services, so it is necessary to consider it in the study of economic output. As the most developed region in China, southern Jiangsu is now paying attention to the role of public services, which will positively promote the healthy operation of the local economy [42,43].

Drawing on the traditional gravity equation model, we use dependent and explanatory variables based on per capita economic output and economic structure and their relevant factors to construct the following modelling framework:

$$lnPGDP = a_0 + a_1 lnX_1 + a_2 lnX_2 + a_3 lnX_3 + + a_4 lnX_4 + \mu \tag{2}$$

$$lnIDS = a_0' + a_1' lnX_1 + a_2' lnX_2 + a_3' lnX_3 + a_4' lnX_4 + \mu \tag{3}$$

where *PGDP* refers to per capita GDP, which is the measurement indicator of the per capita economic output. *IDS* refers to measurement indicator of the economic structure, given by the ratio of the value added by services (the tertiary sector) to the value added by industry. The two indicators are both dependent variables. X_1 is the input of domestic capital, measured by the fixed asset investment in urban areas. X_2 is the structural characteristics of the labor force, measured by the ratio of the number of service employees to the number of industry employees. X_3 is the technical strength condition, measured by the number of patent applications granted. X_4 is the foreign investment absorption of county-level cities, measured by the exactly used foreign investment. The indicators X_1 to X_4 are explanatory variables referring to basic production elements.

At the same time, based on the most direct analysis object of "lock-in effect"—industrial development—industrial added value is selected as the explained variable. Since this indicator is not only the most widely used indicator of industrial output in measuring economic output, but also has a direct relationship with industrial structure. The same factor of production variable is selected as the two project standard indicators of per capita level of economic aggregate and industrial structure pattern, and only the specific explanatory indicator of employees is replaced by the number of industry employees. Based on this, we formulate the following measurement model:

$$lnIP = a_0'' + a_1'' lnX_1 + a_2'' lnX_8 + a_3'' lnX_3 + a_4'' lnX_4 + \mu \tag{4}$$

where *IP* refers to dependent variable of the added value by industry. Model (4) has the same explanatory variables as models (2) and (3), except that X_2 is replaced by X_8, which refers to the number of industry employees.

Models (2)–(4) use commonly accepted relationships. We can also use the local development characteristics of the land factor and public utilities factor mentioned above. The land factor has typical characteristics of China's economic development. The public services factor is consistent with the recognition of public services, which is highly appreciated in the county-level cities in southern Jiangsu. We set up three models using the land factor.

$$lnPGDP = a_0 + a_1 lnX_1 + a_2 lnX_2 + a_3 lnX_3 + a_4 lnX_4 + a_5 lnX_5 + a_6 lnX_6 + \mu \quad (5)$$

$$lnIDS = a'_0 + a'_1 lnX_1 + a'_2 lnX_2 + a'_3 lnX_3 + a'_4 lnX_4 + a'_5 lnX_6 / X_5 + \mu \quad (6)$$

$$lnIP = a''_0 + a''_1 lnX_1 + a''_2 lnX_8 + a''_3 lnX_3 + a''_4 lnX_4 + a''_5 lnX_5 + \mu \quad (7)$$

X_5 is the measurement indicator of industry development when the land factor is used, measured by the amount of industrial land. X_6 measures the service industry development when the land factor is used, measuring the amount of service land.

We set up another three models that use the public service factor.

$$lnPGDP = a_0 + a_1 lnX_1 + a_2 lnX_2 + a_3 lnX_3 + a_4 lnX_4 + a_5 lnX_5 + a_6 lnX_6 + a_7 lnX_7 + \mu \quad (8)$$

$$lnIDS = a'_0 + a'_1 lnX_1 + a'_2 lnX_2 + a'_3 lnX_3 + a'_4 lnX_4 + a'_5 lnX_6 / X_5 + a'_6 lnX_7 + \mu \quad (9)$$

$$lnIP = a''_0 + a''_1 lnX_1 + a''_2 lnX_8 + a''_3 lnX_3 + a''_4 lnX_4 + a''_5 lnX_5 + a''_6 lnX_7 + \mu \quad (10)$$

X_7 reflects the development of public services, which promotes the economic growth of the county-level cities, and is measured by the proportion of the local fiscal expenditure on social security, science, education, culture and medical and health care.

3.2. Acquisition and Sorting of Variable Data

We calculate the values of *PGDP*, *IDS*, *IP*, X_1, X_2, X_3, X_4, X_5, X_6, X_7 and X_8 as described above using data collected from the Jiangsu Statistical Yearbooks and China City Construction Statistical Yearbooks for the county-level cities in southern Jiangsu, in the sample years 2002, 2005, 2010, 2015, and 2019. The indicators of county-level cities in southern Jiangsu in different years are summarized in Tables 1 and 2:

Table 1. The statistics of dependent variable indicators in county-level cities in southern Jiangsu from 2002 to 2019.

Dependent Variable	Years	JY	YX	LY	CS	ZJG	KS	TC	DY	YZ	JR
PGDP (10,000 RMB/person)	2002	3.6	2.1	1.3	3.5	4.3	5.2	4.0	2.1	2.5	1.2
	2005	6.7	3.4	2.3	6.5	8.1	11.3	4.0	2.1	2.5	1.2
	2010	12.7	6.4	5.7	9.7	13.0	14.2	10.4	6.4	7.4	3.9
	2015	17.6	10.3	9.7	13.5	17.8	18.7	15.5	10.9	13.9	7.5
	2019	24.2	14.1	13.2	15.0	20.2	24.3	18.4	11.3	14.2	10.5
IDS	2002	0.65	0.63	0.87	0.75	0.66	0.51	0.74	0.75	0.82	0.73
	2005	0.56	0.61	0.75	0.66	0.52	0.46	0.64	0.63	0.65	0.57
	2010	0.68	0.81	0.69	0.78	0.64	0.57	0.72	0.70	0.67	0.70
	2015	0.85	1.03	1.04	0.93	0.89	0.85	0.94	0.92	0.89	1.01
	2019	1.04	1.04	1.11	1.07	0.99	1.02	1.06	0.87	0.85	1.42
IP (1000 million yuan)	2002	23.1	12.2	4.1	19.0	20.4	19.1	9.0	8.4	3.0	3.3
	2005	48.0	20.8	8.4	38.2	44.2	47.4	16.0	14.2	5.8	5.8
	2010	114.4	39.9	21.9	78.3	94.2	128.4	39.7	33.1	13.9	12.3
	2015	151.5	56.0	31.2	101.2	113.3	159.8	52.9	51.8	24.1	20.1
	2019	185.2	77.8	40.1	103.3	122.0	191.3	60.7	55.7	24.7	23.0

Source: Jiangsu Statistical Yearbook 2003–2020. The same below. Note: JY: Jiangyin; YX: Yixing; LY: Liyang; CS: Changshu; ZJG: Zhangjiagang; KS: Kunshan; TC: Taicang; DY: Danyang; YZ: Yangzhong; JR: Jurong. The same below.

3.3. Data Analyses and Result

The county-level cities in southern Jiangsu have performed outstandingly in comparison with other cities of the same scale in China. We must consider the differences between these cities, such as the natural conditions, modes of development and policies, which give each city its distinctive characteristics.

Table 2. The statistics of explanatory variable indicators in county-level cities in southern Jiangsu from 2002 to 2019.

Explanatory Variable	Years	JY	YX	LY	CS	ZJG	KS	TC	DY	YZ	JR
X_1	2002	37.5	20.9	20.2	38.9	56.5	60.4	33.9	16.0	9.0	10.2
	2005	142.5	88.2	45.1	119.6	141.6	151.3	128.5	30.9	11.7	17.5
	2010	386.5	199.6	148.2	270.9	267.6	410.3	242.2	118.5	53.1	67.3
	2015	1228.6	663.6	442.4	622.5	733.8	799.2	483.5	457.7	256.2	306.4
	2019	802.9	448.9	617.0	522.3	438.6	719.3	402.6	200.9	77.4	259.8
X_2	2002	0.64	0.71	1.36	0.63	0.72	0.48	0.48	0.54	0.61	1.34
	2005	0.65	0.78	0.88	0.55	0.56	0.58	0.38	0.60	0.49	1.04
	2010	0.69	0.80	0.84	0.60	0.63	0.79	0.51	0.50	0.48	0.89
	2015	0.59	0.73	0.82	0.61	0.61	0.58	0.64	0.79	0.80	1.32
	2019	0.62	0.79	0.97	0.67	0.67	0.63	0.69	0.93	0.92	1.55
X_3	2002	226	134	53	228	157	823	93	60	39	27
	2005	389	214	94	328	427	884	206	206	327	80
	2010	3830	2688	1096	4242	3049	10750	2602	1178	914	914
	2015	7502	2975	944	3267	6791	10947	2871	3758	1461	2857
	2019	5890	4863	1446	4848	5766	17474	3970	3490	2037	1450
X_4	2002	3.74	1.35	0.64	4.85	4.82	10.18	4.00	1.01	0.78	1.06
	2005	4.18	1.73	1.00	5.85	2.81	10.11	2.38	0.88	0.60	1.18
	2010	7.00	5.00	3.54	8.72	8.30	17.25	8.08	2.20	1.02	2.19
	2015	10.11	1.85	1.06	8.05	6.50	11.01	5.01	3.31	1.31	2.80
	2019	9.31	3.79	3.00	4.98	3.98	7.47	4.40	1.41	0.63	1.22
X_5	2002	8.60	8.93	3.72	12.31	3.78	5.29	3.59	3.62	1.44	2.59
	2005	10.39	15.51	4.66	13.08	3.88	9.82	4.23	6.68	1.68	2.68
	2010	9.31	16.68	5.89	21.82	18.87	6.66	10.44	4.52	2.06	3.67
	2015	23.33	23.73	7.03	18.37	18.43	18.07	12.65	7.70	2.64	5.12
	2019	26.0	27.6	7.2	13.1	2.3	15.1	10.4	8.6	3.0	6.3
X_6	2002	4.00	3.57	1.68	6.61	1.61	1.80	1.53	2.05	0.95	3.44
	2005	8.60	8.93	3.72	12.31	3.78	5.29	3.59	3.62	1.44	2.59
	2010	8.89	6.91	2.33	15.22	5.60	3.22	4.19	3.23	1.25	2.03
	2015	5.28	1.55	1.09	1.70	0.81	4.54	1.39	4.17	0.61	0.48
	2019	5.84	1.70	1.15	1.72	0.55	4.34	1.15	4.22	0.64	0.22
X_7	2002	0.17	0.18	0.25	0.13	0.13	0.10	0.14	0.28	0.19	0.29
	2005	0.25	0.28	0.30	0.22	0.19	0.19	0.19	0.25	0.26	0.33
	2010	0.29	0.32	0.34	0.25	0.22	0.24	0.25	0.27	0.29	0.33
	2015	0.23	0.32	0.42	0.32	0.29	0.31	0.30	0.47	0.41	0.38
	2019	0.34	0.41	0.38	0.31	0.29	0.34	0.34	0.43	0.35	0.38
X_8	2002	28.49	15.52	7.20	28.42	19.90	22.53	10.12	16.39	6.39	5.34
	2005	34.54	20.31	13.87	42.27	26.93	31.30	17.80	19.94	8.08	7.53
	2010	49.82	30.35	17.52	50.51	44.91	44.51	23.61	28.01	10.54	10.98
	2015	55.54	33.68	15.13	58.76	42.59	68.55	25.43	29.28	10.53	10.24
	2019	54.53	32.81	14.46	57.01	41.30	67.07	24.79	27.87	10.03	9.78

To select an appropriate regression model, we propose that:

Hypothesis 1. *The dependent variable is not related to all explanatory variables.*

Based on the panel data obtained after the above processing, we use Stata software to set county-level cities and years as panel variables and time variables, respectively. Next, using the Stata command, we estimate the fixed effects and random effects as well as to perform the Hausman test. The test result shows that the p value is 0.0000. Therefore, the original hypothesis is strongly rejected, which means the fixed effect model should be used instead of the random effect model.

To further determine whether to use the individual fixed effect model or the mixed effect model, we propose the hypothesis again:

Hypothesis 2. *The values of all explanatory variables are 0.*

We use the Stata command to estimate fixed effects, and the output result shows constant terms "_cons", which means the average value of the explanatory variables in all individual effects is greater than 0. Therefore, the variance of the explanatory variables

mainly comes from the changes of the explanatory variables in individual effects. We continue to carry out F test through Stata command. The test result shows that the p value is at a 95% significance level, so we strongly reject the original hypothesis and believe that the individual fixed effect regression is better than the mixed regression.

We therefore use an individual fixed effect regression model to analyze the sample data. The individual fixed effect regressions of models (2)–(10) gives the regression results shown in Table 3.

Table 3. Regression results of models (2)–(10).

Variable	Coefficients of Models								
	Model (2)	**Model (3)**	**Model (4)**	**Model (5)**	**Model (6)**	**Model (7)**	**Model (8)**	**Model (9)**	**Model (10)**
a_0	8.3087 ***	−0.7466 ***	1.4181 ***	8.4151 ***	−0.4109 ***	1.4217 ***	8.7506 ***	−0.2924	3.1283 ***
$\ln X_1$	0.4266 ***	0.1125 *	0.2851 ***	0.4007 ***	0.0515	0.2842 ***	0.3783 ***	0.2839	0.2342 ***
$\ln X_2$	0.3053	0.3207 *		0.2614	0.2275		0.2297	0.1958	
$\ln X_3$	0.1244 *	0.3043	0.2078 ***	0.1218 *	0.0201	0.2079 ***	0.1113	0.0092	0.2048 ***
$\ln X_4$	−0.0013	−0.1440	−0.0983	0.0311	−0.0938	−0.0991	0.0058	−0.0717	−0.0305
$\ln X_5$				0.0277		0.0071	0.0278		0.0050
$\ln X_6$				−0.0754			−0.0888		
$\ln X_7$							0.1363	0.1134	0.4959 **
$(\ln X_6 - \ln X_5)$					−0.1378 ***			−0.1488 ***	
$\ln X_8$			0.51653 **			0.5123 **			0.2367
Fixed Effects (Cross)									
JY	0.0410	−0.1675	0.2594	0.0681	−0.1027	0.2602	0.0717	−0.0979	0.2248
YX	−0.2991	−0.2013	−0.1710	0.2967	−0.2182	−0.0523	−0.3108	−0.2349	−0.3980
LY	−0.3748	0.1960	−0.3762	−0.3754	−0.1295	−0.3756	−0.4127	−0.1570	−0.8294
CS	-	-	-	-	-	-	-	-	-
ZJG	0.1875	−0.1953	0.2253	0.1413	−0.2048	0.2300	0.1484	−0.1863	0.2048
KS	0.1486	−0.2281	0.1148	0.1272	−0.2131	0.1183	0.1377	−0.1949	0.1168
TC	0.1713	0.0002	−0.1522	0.1230	−0.0332	−0.1510	0.1072	−0.0398	−0.3747
DY	−0.0774	−0.1761	−0.2033	−0.0591	−0.0875	−0.2010	−0.1022	−0.1228	−0.5079
YZ	0.4970	−0.1586	−0.3436	0.4457	−0.1249	−0.3391	0.3959	−0.1551	−0.8526
JR	−0.4631	−0.2227	−0.3740	−0.4979	−0.1937	−0.3732	−0.5543	−0.2356	−0.9976
(2): Adjusted R^2 = 0.9388; (3): Adjusted R^2 = 0.6087; (4): Adjusted R^2 = 0.9691; (5): Adjusted R^2 = 0.9422; (6): Adjusted R^2 = 0.7382; (7): Adjusted R^2 = 0.9691; (8): Adjusted R^2 = 0.9428; (9): Adjusted R^2 = 0.7451; (10): Adjusted R^2 = 0.9760									

Note: ***, ** and * denote the significance levels of 1%, 5% and 10%, respectively. Changshu data missing. CS: Changshu; DY: Danyang; JR: Jurong; JY: Jiangyin; KS: Kunshan; LY: Liyang; TC: Taicang; YZ: Yangzhong; YX: Yixing; ZJG: Zhangjiagang.

Table 3 shows that "the fixed asset investment in urban areas" (X_1) and "the number of patent applications granted" (X_3) are the significant explanatory variables of model (2), while "the fixed asset investment in urban areas" (X_1) and "the ratio of the number of service employees to the number of industry employees" (X_2) are the significant explanatory variables of model (3). The significant explanatory variables in model (4) are "the fixed asset investment in urban areas" (X_1), "the number of patent applications granted" (X_3) and "the number of industry employees" (X_8).

The regression results of models (5)–(7), which include the land factor, show that the significant explanatory variables in model (5) are "the fixed asset investment in urban areas" (X_1) and "the number of patent applications granted" (X_3). The significant explanatory variables in model (6) are "the total amount of land for public facilities/the total amount of industrial land" (X_6/X_5). The explanatory variables in model (7) are "the fixed asset investment in urban areas" (X_1), "the number of patent applications granted" (X_3) and "the number of industry employees" (X_8).

The regression results of models (8)–(10), which include the elements of public services, show that the explanatory variables in model (8) is "the fixed asset investment in urban areas" (X_1). The explanatory variables in model (9) is "the total amount of land for public facilities/the total amount of industrial land" (X_6/X_5). The explanatory variables in model (10) are "the fixed asset investment in urban areas" (X_1), "the number of patent applications granted" (X_3) and "the proportion of the local fiscal expenditure on social security, science, education, culture and medical and health care" (X_7).

In the above regression analysis, the p values of most explanatory variables are less than 0.05. We have reason to believe that these explanatory variables are strongly related to the dependent variables.

3.4. Conclusions

The regression results of econometric models (2)–(10) allow us to draw the following conclusions:

The per capita GDP of the county-level cities in southern Jiangsu is affected by both the capital investment and technological strength. An increase in capital investment has a positive effect on the per capita GDP. An increase in technological strength also boosts the per capita GDP growth. Powerful industry development fosters fast, continuous growth in the per capita GDP of the county-level cities in southern Jiangsu. This explains the inconsistency between the per capita GDP and economic structure patterns, which do not agree with existing international industrialization experiences.

The regression results show that an important feature of this period is that the economic structure is mainly affected by the employment structure factor. The high level of economic development in the county-level cities in southern Jiangsu has partly promoted their simultaneous comprehensive development, which has involved public service provisions and the promotion of hi-tech, among others. Thus, we can conclude that the factors affecting the economic structure are gradually becoming more diversified.

Regarding the industry development of the county-level cities in southern Jiangsu, the industry output in the examined period is promoted by not only capital investment and technological strength, but also, and sometimes primarily, by labor force absorption. Domestic capital investment plays the greatest capital investment role in promoting industry growth.

The "lock-in effect" appears in the industrialization of the county-level cities in southern Jiangsu. Industry boosts their economic growth and improves their overall social welfare by concentrating capital, labor, human capital and other production elements. The regression results suggest possible solutions and measures to optimize the "lock-in effect". The "lock-in effect" can be gradually decreased by adjusting the employment structure and the total capital investment amount and its internal structure, improving the quality of employees and the level of technology used, and by examining local features. The indicators of industrialization, such as the per capita GDP and economic structure, will then develop toward progressive harmonization.

4. Reactions That Occur with the "Lock-In Effect" and Proposed Solutions

There are a number of phenomena and problems related to the "lock-in effect" in the industrialization of the county-level cities. We use our empirical findings to illustrate a series of reactions that occur simultaneously with the "lock-in effect" and make suggestions to optimize the current conditions.

4.1. Reactions That Occur with the "Lock-In Effect"

There are a number of reactions that occur with the "lock-in effect". They involve aspects of the development of industry, the capital output and employment-absorbing efficiency and the consumption atmosphere in the county-level cities in southern Jiangsu.

4.1.1. The Degradation Phenomenon of Industrial Transformation

We use the rate of value added by industry as a representative indicator of industrial efficiency, which is the net added value efficiency. Figure 6 shows that behind the "lock-in effect" of industrialization, the rate of value added by industry follows a downward trend in the county-level cities in southern Jiangsu from 2002 to 2019. This downward trend reflects an increase in the intermediate consumption of these cities and suggests a bottleneck in the improvement of the value added by industry. Thus, the technical content of different industry sectors must be improved and updated, especially the leading sector in each industry. This method is currently very popular and is called industry transformation in China.

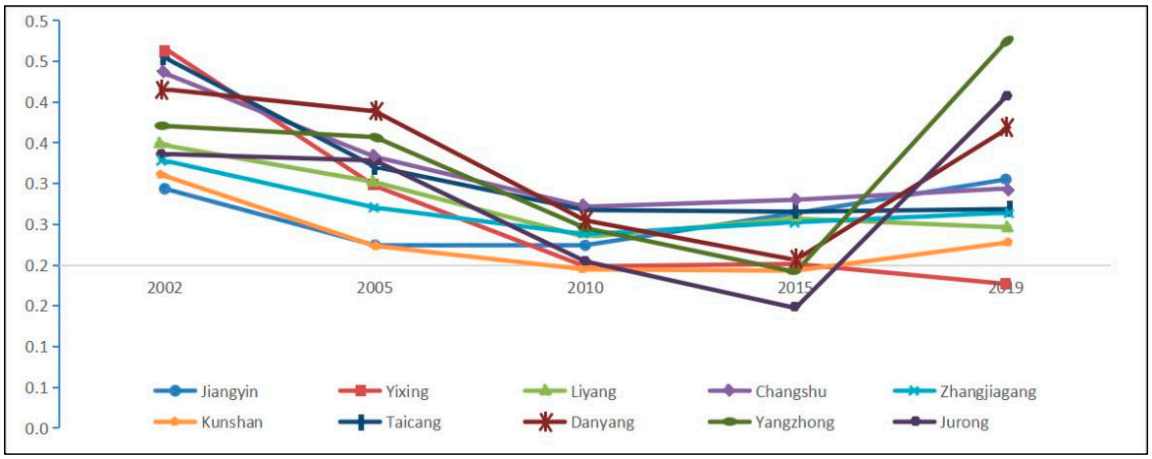

Figure 6. The changes in the rate of the value added by industry in the county-level cities in southern Jiangsu from 2002 to 2019. Source: Jiangsu Statistical Yearbook 2003–2020.

4.1.2. Comparing the Quality of Capital Efficiency

Domestic capital plays a very important role in promoting the industrialization process in the county-level cities in southern Jiangsu. There are also many foreign capital investments, especially from Hong Kong, Macao and Taiwan. The characteristics of the types of capital investment in the county-level cities must be compared.

Table 4 shows a comparison of the investment types in 2019. Thus, we conclude that the capital invested in industry occupies a relatively high proportion of the total fixed asset investment. From the perspective of investment entities, domestic-funded enterprises are the main source of fixed asset investment. Hong Kong, Macao and Taiwan-invested enterprises and foreign-invested enterprises have also played an important role. Regarding the open economy, the foreign capital economy of the county-level cities in southern Jiangsu is very active, and the level of openness continues to expand.

Table 4. The composition of fixed asset investment and foreign investment in each county-level city in southern Jiangsu in 2019 (Unit: 100 million yuan).

	Total Investment in Fixed Assets	Industrial Investment	Domestic Enterprises	State-Owned Enterprise	Hong Kong, Macao and Taiwan Investment Enterprises	Foreign Investment Enterprise	Registered Foreign Capital	Actual Use of Foreign Capital
JY	802.89	376.74	717.95	51.44	70.83	13.72	60.24	60.24
YX	448.86	249.25	372.16	12.29	70.40	5.12	25.88	24.52
LY	617.03	442.14	-	-	-	-	120.02	19.41
CS	522.28	209.45	422.84	24.00	24.90	74.54	70.20	32.22
ZJG	438.54	160.14	387.52	33.64	14.08	36.98	104.56	25.75
KS	719.26	192.38	578.74	48.96	49.87	90.96	143.12	48.33
TC	402.59	128.24	330.52	35.99	17.50	54.56	72.53	28.47
DY	200.94	91.91	160.66	8.32	10.44	4.58	-	9.12
YZ	77.44	45.84	72.93	-	3.06	1.45	-	4.08
JR	259.80	66.83	238.73	33.64	5.37	15.74	40.11	7.89

Source: Jiangsu Statistical Yearbook 2020 and National Economic and Social Development Statistical Communiqués of all county-level cities in 2019. Note: CS: Changshu; DY: Danyang; JR: Jurong; JY: Jiangyin; KS: Kunshan; LY: Liyang; TC: Taicang; YZ: Yangzhong; YX: Yixing; ZJG: Zhangjiagang.

4.1.3. The Local Characteristics of the Consumption Atmosphere

The "lock-in effect" in the county-level cities in southern Jiangsu also reflects the relatively weak development of their service sectors. The development of the service sector has a close relationship with a consumption atmosphere. We must, therefore, also examine the consumption environment when investigating the "lock-in effect", as it will have a long-term influence on the industrialization of the county-level cities in southern Jiangsu.

Table 5 shows the total retail sales of consumer goods and their rankings. These ranking are not similar to the industrial conditions, summarized by the rankings of the value added by industry given previously. For example, Kunshan, with its most prominent industry, lags behind Changshu, Jiangyin and Yixing in terms of the total retail sales of consumer goods at first. Similarly, Taicang lags behind Liyang.

Table 5. The total retail sales of consumer goods and the resulting rankings in the county-level cities in southern Jiangsu from 2002 to 2019 (Unit: million).

	2002	2005	2010	2015	2019
JY	88.61/2	173.12/1	384.90/1	705.16/2	695.95/4
YX	73.09/3	123.53/3	277.34/4	506.96/4	508.19/5
LY	46.98/6	65.17/7	147.54/7	275.30/7	321.48/7
CS	97.54/1	151.04/2	360.19/2	675.64/3	1031.00/2
ZJG	55.07/4	95.87/5	267.86/5	494.87/5	718.26/3
KS	47.32/5	114.96/4	356.64/3	714.68/1	1391.72/1
TC	32.07/10	47.87/10	141.43/8	264.70/8	424.79/6
DY	41.24/8	65.37/8	151.57/6	283.94/6	305.49/8
YZ	17.25/12	29.93/12	66.37/10	126.77/10	134.55/10
JR	18.34/11	31.00/11	69.28/9	129.16/9	155.60/9

Source: Jiangsu Statistical Yearbook 2003–2020. Note: CS: Changshu; DY: Danyang; JR: Jurong; JY: Jiangyin; KS: Kunshan; LY: Liyang; TC: Taicang; YZ: Yangzhong; YX: Yixing; ZJG: Zhangjiagang.

As we pointed out above, we must consider local characteristics when examining this phenomenon. The majority of the Chinese population have heard of Changshu Garments, Yixing Purple Sand, Danyang Glasses and similar brands. These brands have local characteristics that create an active social and economic atmosphere, stimulating the accumulation of the local people's wealth and encouraging consumption. We must, therefore, pay attention to the county-level cities' local characteristics when trying to guide them out of their "lock-in effect" traps.

4.2. Suggestions for Escaping the "Lock-In Effect"

Based on our analysis of the "lock-in effect" and the reactions that occur with it, we make suggestions for optimizing the current conditions in the county-level cities in southern Jiangsu.

The first is to pursue high-quality economic development, which is not only the primary goal of the industrial development of county-level cities in southern Jiangsu, but also the inevitable requirement of its transformation and upgrading. Future industrial transformations should be made so that each industry maintains a perfect spiral growth in its self-improvement, through technology updates and perfection [44]. In terms of the choice of industrial development, this entails focus on the development of high-end manufacturing and advanced strategic emerging industries. This also includes making full use of the resource advantages of the rich advanced manufacturing leading enterprises, industry university research institutions, various entrepreneurial incubation carriers, economic parks and other resources in southern Jiangsu, carrying out industry incubation linkage, and constantly opening up the R&D chain, technology achievements transfer chain, incubation chain, industrial chain and other industrial entities to promote the landing of the industry, forming a new pattern of two wheel drive of "development zone and scientific innovation belt" linkage, and creating a distinctive intellectual cluster and high-tech industrial cluster. By making good use of the leading enterprises and scientific and technological innovation enterprises of high-quality key industries in the region, linking up and implementing the industrial financing development, promoting the upgrading and development of the industrial level of the innovation source, and promoting high-quality economic growth. In addition, it is also necessary to increase and make up for shortcomings, constantly sort out the chain of high-tech key industry carriers, find out the shortcomings in the industrial chain, drive the incubation cultivation with industrial investment attraction, and constantly supplement the weaknesses with the incubation mode. Focusing on the goal of "innovation

leading" accelerates the cultivation of multiple key industries. At the same time, the service industry growth rate will increase through strong industry support, improvement of the socio-economic environment, and diversified production and living needs. This will lead the cities onto a sound road of economic structure optimization. Removing the traditional development mode of relying on a relatively low-end industrial transfer and improving the industrial output quality will effectively accelerate economic and social development, improve the rate of value added by industry, and achieve the "double-wheel drive" mode of both industry and service growth.

The second is to improve the output efficiency of capital. The transformation and upgrading of the industry cannot be separated from the promotion of innovative intellectual capital. First of all, it is important to establish a multi-level technology development strategy, including enterprise production process technology innovation, cooperative research and development with other enterprises, research institutes, universities, collaborative innovation, and re-innovation after obtaining foreign advanced technology through international technology licensing, as well as technology spillover through foreign enterprises. Promoting technological innovation in Hong Kong, Macao, Taiwan or other foreign-invested manufacturing enterprises will lay the foundation for the development of high-end industries and productive services industries. Therefore, county-level cities in southern Jiangsu should not only vigorously introduce leading enterprises and capital from all parts of the country and even the world to settle down and start business in southern Jiangsu, but should also actively cultivate and support the growth of local leading enterprises in the industry. In addition, creating a benign environment for technological innovation is equally important. Due to the existence of technological externalities, technological innovation achievements are easy to be imitated and illegally used. Therefore, the government's innovation environment may be more important than R&D investment support. In addition, guiding the public policy to tilt is also an important guarantee to improve the efficiency of capital output. We should not only focus on R&D activities, but also on downstream activities of the innovation process, including testing, technology adjustment and commercialization. The industrialization of technological innovation achievements is as important as technological innovation. The optimization of the economic structures of the county-level cities requires a mode that generates different types of capital that can be used and allows each city's characteristics to develop. Thus, the county-level cities in southern Jiangsu can fundamentally improve their capital output efficiency and eliminate the negative effects of lock-in.

The third is to enhance the vitality of social consumption. The rankings of the county-level cities' value added by industry and GDP are consistent with one another, according to Jiangsu Statistical Yearbook. However, the total retail sales of consumer goods and industry rankings are inconsistent. This inconsistency shows that the cities' development modes have diversified because of local characteristics, although industry currently plays a major role in promoting economic growth. The consumption environment directly benefits from the optimization of the business environment. The optimization and upgrading of the business environment drive the improvement of the consumption environment. The two complement each other and interact well, which is a force that cannot be ignored to promote economic growth. Therefore, the government should streamline administration and delegate power as much as possible, and use the market's own adjustment mechanism to drive social consumption. At the same time, the government should release the policy dividend and fully stimulate the innovation and entrepreneurship vitality of market players. Infrastructure is also the key to optimize the business environment, improving the configuration of infrastructure to provide one-stop services for enterprises. The county-level cities with advantages over their service (tertiary) sectors can make full use of their active business environments to promote modern service development, in order to achieve rapid progress and optimization of the economic structure.

In addition to the three main suggestions above, we can also consider removing the "lock-in effect" of industrialization from the aspects of optimizing the allocation of public

services, improving the level of scientific and technological innovation, and increasing the strength of talent introduction, etc.

5. Discussion

Rapid economic growth and high employment absorption are the two most important goals of various regions in China during the 21st century. The county-level cities in southern Jiangsu have performed outstandingly in pursuing these goals through industrial development in recent decades. However, this paper argues that industrialization has not only brought economic prosperity, but also the "lock-in effect" to the county-level cities in southern Jiangsu. This is a new profile of the urbanization process from both international and local viewpoints.

Our analysis shows that the "lock-in effect" comes from the 'single-wheel drive' mode of economic growth found in the industrialization of the county-level cities. Industry is the main driver of economic output and employment, improving the total and average economic and social development. Capital, labor and other traditional elements also have effects. Human capital is a typical new element and has grown increasingly important. Public services, such as social security, science, education, culture and medical and health care, are gradually becoming apparent and active in promoting the optimization of economic structures.

Using an empirical analysis of the "lock-in effect" in the county-level cities in southern Jiangsu, this paper proposes that the single indicators can be gradually coordinated with each other. The coordination can be driven by adjustments to the employment structure and the total and internal capital investment structure, improving the quality of employees and the level of technology, renovating the benefit deploying mechanisms and using perceptions of local characteristics (such as famous commercial brands and titles). The "lock-in effect" is part of a particular stage in the industrialization process and is not an inescapable circle.

Under the background of Fourteenth Five-Year Plan in China, the county-level cities in southern Jiangsu plan to take concrete action to speed up their innovative development, promote a "double-wheel drive" mode of industry and service growth and accelerate the restructuring of their economies. They have recently achieved some success in the equalization of basic public services, the further consolidation of industrial information exchange platforms, the introduction of high-tech talent, the training of practitioners and the improvement of management mechanisms. These actions and initiatives will all help to reduce the "lock-in effect" in the county-level cities in southern Jiangsu. As they follow world development trends, we are investigating the further development of this phenomenon.

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