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Does Change in the Employment Structure Cause Baumol's Disease? Evidence from Shenzhen and Hong Kong, China

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Abstract

"Baumol's disease" refers to the phenomenon whereby labour flows from a high growth sector to a low growth sector, which eventually leads to a decline in regional economic growth. In this paper, we constructed an alternative model for evaluating Baumol's disease, and conducted an empirical analysis of the industry sectors in Shenzhen and Hong Kong, China. The results showed that 1) from 2005 to 2016, labour flowed from the high growth sectors to the low growth sectors in both Shenzhen and Hong Kong, and the labour costs increased in the inflow sectors. 2) Shenzhen showed symptoms of the first stage of Baumol's disease; that is, a change in the total factor production (TFP) growth rate led to a change in the employment structure. 3) Hong Kong showed symptoms of the second and third stages of Baumol's disease, which meant that the change in the employment structure increased the labour costs of the inflow sector, which slowed the rate of regional economic growth. 4) The changes in the employment structure in Hong Kong indicated that the region had been infected with Baumol's disease, while Shenzhen was at risk of being infected. The research can provide a method to judge Baumol's disease in the different regions and provide suggestions for formulating the relevant policies.

Keywords

Baumol's Disease, Total Production Growth Rate, Employment Structure, Labour Costs, Economic Growth

1. Introduction

Baumol, an American economist, found that all industries can be divided into

two sectors: a progressive sector with positive growth and a stagnant sector with zero growth (Baumol, 1967). He further found that changes in economic growth were related to the structure of employment. Specifically, labour flows from the progressive sector to the stagnant sector, resulting in high labour costs in the stagnant sector and low labour costs in the progressive sector. Moreover, because the products produced by the stagnant sector usually have low elasticity of demand, labour continues to transfer between the two sectors in search of higher earnings. As a result, the input-output efficiency of the stagnant sector continues to decline, and eventually the national economic growth rate declines or even becomes zero. This phenomenon is now known as Baumol's disease.

However, other economists have carried out research on related issues and reached different conclusions to Baumol. Some scholars have proposed that Baumol's disease exists in many developed countries. For example, using industry data from 1948 to 2001 in the United States, Nordhaus (2008) found that the relative prices and proportion of employment in the stagnant sectors increased and the relative output decreased, resulting in a decrease in overall productivity. These findings indicated that Baumol's disease was present in the United States. Hartwig (2011) analysed the labour transfer and economic growth rates from 1948 to 2001, and concluded that Baumol's disease also existed in the EU. Last, A.-K. & Wetzel, H. (2011) and Bates (2013) concluded that employment growth in the service industry caused Baumol's disease in specific industries. However, some scholars have argued that Baumol's disease does not exist in developed countries. Oulton (2001) suggested that the transfer of labour resources to the service sector may promote total productivity growth without causing Baumol's disease. Triplett & Bosworth (2003) found that after 1995, the growth in labour productivity in the United States' service industry was higher than that of the whole economy, indicating that Baumol's disease was not present in the United States. Tan (2018) proposed that the global division of labour meant that some places no longer displayed the typical characteristics of Baumol's disease.

The lack of unified and reasonable standards for evaluating Baumol's disease in the literature, especially for selecting the evaluation indicators, has led to significant differences in the results. The key factor in determining whether Baumol's disease is a valid phenomenon is to analyse the differences in the growth rates among different sectors. First, there are varying definitions of "growth rate" in the literature. Some scholars have used the growth rate per capita of the output value to express the growth rate (Gao & Xiao, 2013; Liu & Hu, 2018), whereas others have used the index of the production function elements (Yu & Cai, 2017). However, these indicators are one-sided, because the growth of an industry is a systematic process with multiple factors, and it is impossible to comprehensively measure the growth of an industry using a single factor. Second, the indicators of the "different sectors" have not been clearly defined and there is no clear boundary between high growth and low growth rates. For this reason, most studies simply classify the industrial sector as high growth and the service sector as low growth based on experience, which is not objective (Baumol et al., 1985). For

example, as the sectors develop, new industries emerge. These new industries include not only labour-intensive industries such as wholesale and retail, but also technology-intensive industries such as the communication technology and software service industries. As the growth rates of these industries are clearly different, they cannot be simply merged into the same sector (Jiang et al., 2007).

Therefore, to define the relevant indicators and unify the evaluation standards, this paper constructs a procedure for evaluating Baumol's disease based on the relationship between the change in the employment structure and economic growth. As we know, China is the largest industrial country in the world whose number of industrial employment is quite large (Li, 2003). For example, in 2005, China's industrial employment accounted for 25% of the total employment, while in 2016, the number became 28%. Because the TFP growth rate of industrial industry is usually higher than others, while the industrial employment in China is still growing. It means that China is similar to the situation in the early stage of developed countries. On the other hand, Baumol's disease is a social phenomenon that has long-term effects. However, China's market economy reform began relatively late and thus cannot reflect the symptoms of all stages of Baumol's disease. So it is not suitable to directly take the whole China as a case. A better way is to choose two representative regions of China for analysis. This paper selected Shenzhen and Hong Kong as the case areas. Shenzhen is the gathering place of China's high-end manufacturing industry. At the same time, the modern service industry is also developing rapidly, which can represent the future development direction of China to some extent. As for HongKong, Almost all the main industries of Hong Kong are service industries, reflecting some characteristics of developed countries. The degree of development of the two regions is different, so the combination of the two studies can more fully reflect the stage characteristics of Baumol disease.

2. Theory and Methods

2.1. Evaluation of Baumol's Disease

In Baumol's original formulation, the growth rate indicator represents the level of industrial growth, which is determined by the properties of the industry itself (Wang et al., 2009). However, the total factor productivity (TFP) growth rate provides a more suitable expression of this indicator. The TFP growth rate is essentially an indicator of technological progress. In other words, it is not constrained by time and space and does not depend on the various factors of production to achieve output growth, which have been shown to be the real inexhaustible source of economic growth (Cai & Lin, 2018). Sectors with a high TFP growth rate also fit Baumol's description of a "progressive sector".

In terms of the division between different sectors, the standard definition of Baumol's disease starts with the change in the labour force. However, this paper proposes that the change in the employment structure should be used as the basis for the division (Song, 2015). Based on the employment in each industry each

year, this paper calculates the annual proportion of employment in each industry, and classifies industries with positive changes in the level of employment as the inflow sector and industries with negative growth rates as the outflow sector according to the annual average changes in the levels of employment. Theoretically, the growth rate of the inflow sector is lower than that of the outflow sector (Wang & Hu, 2012).

The reconstruction of the two core indicators makes the relationship between the internal elements of Baumol's disease more logical. In the first stage, because of the natural difference in the TFP growth rates between industries, the demand for labour in the outflow sector is reduced because it does not rely on more labour inputs. Thus, the difference in the TFP growth rates gives the original thrust to the change in the employment structure, and induces the labour force to flow from the outflow sector to the inflow sector (Zhao & Liu, 2010). In the second stage, as a result of the flow of labour, the costs in the inflow sector begin to increase. Due to the low TFP growth rate, the continuous increase in costs is likely to lead to a decline in the marginal output and the gradual stagnation of the inflow sector (Yang et al., 2014). In the third stage, the continuous increase in the labour costs in the inflow sector and the stagnation of output hinder regional economic growth (Jiang & Li, 2004). Thus, Baumol's disease is essentially a process that is progressively influenced by the TFP growth rate, employment structure, labour costs and economic growth, and shows periodic symptoms.

To sum up, this paper constructs a comprehensive economic model to judge whether a region is suffering from Baumol's disease. First, the model determines whether two symptoms of the disease are observable in the region: 1) the labour force flows from the sector with high TFP growth to the sector with low TFP growth; and 2) the labour costs in the inflow sector increase with the increased level of employment. Second, to explore the causes of the disease and verify whether they correspond with the first two stages of Baumol's disease, this paper examines whether the difference in the growth rates of all factors causes the change in the employment structure, and whether the change in the employment structure causes the change in the costs of the related industries. Finally, we determine whether the disease exists; that is, we determine whether the increase in the labour costs of the inflow sector hinders the growth of the regional economy (**Figure 1**).

2.2. Methods

1) Malmquist index method

The TFP growth rate reflects the specific change in the efficiency of a sector. Using panel data, the TFP growth model based on non-parametric DEA can reflect the change in the production unit efficiency in different periods and analyse how technological progress affects the change in efficiency. To further explain the driving role of some non-physical factors relating to the change in efficiency, this paper uses the Malmquist index to represent the TFP growth rate. Malmquist index method is based on the data envelopment analysis (DEA) method.

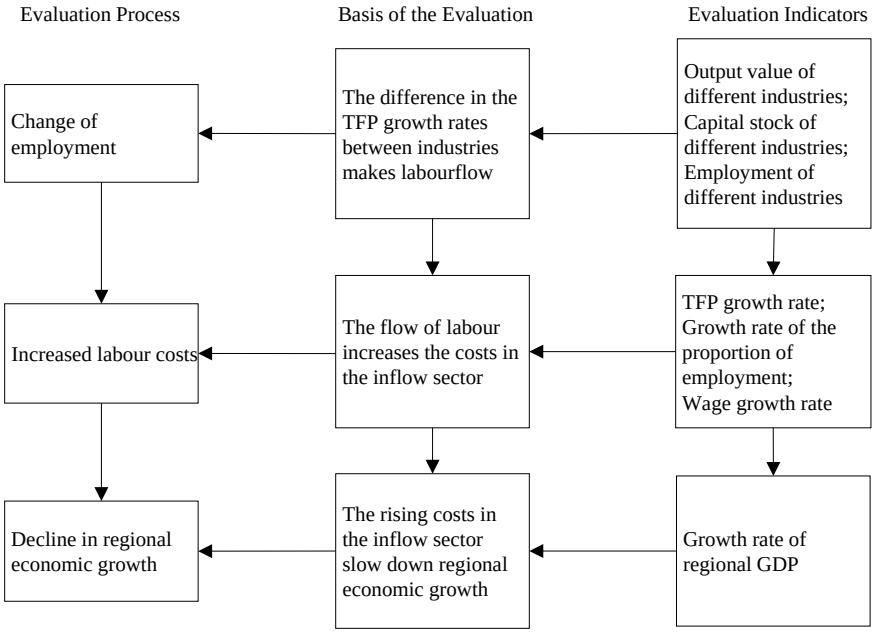

Figure 1. Process, basis and indicators of the evaluation of Baumol's disease.

Nowadays, this method is widely used in the calculation of total factor growth rate of financial, industrial, medical and other sectors, and carries on the international comparison research according to the measured results. The specific model is expressed as follows.

From period (t) to period (k), the Malmquist index can be calculated by the formula (1):

$$M_0\left(x_i, y_i, x_k, y_k\right) = \frac{d_0^k\left(x_k, y_k\right)}{d_0^t\left(x_t, y_t\right)} \sqrt{\frac{d_0^t\left(x_k, y_k\right)}{d_0^k\left(x_k, y_k\right)} \times \frac{d_0^t\left(x_t, y_t\right)}{d_0^k\left(x_t, y_t\right)}} \tag{1}$$

where $\left(x_t, y_t\right)$ and $\left(x_k, y_k\right)$ are the input and output vector matrices of the elements in period (t) and period (k); and d_0^t and d_0^k represent the distance functions between periods (t) and (k) when the frontier of technical efficiency is period (k).

2) Granger causality test

According to the abovementioned logical framework, there is a causal relationship between the TFP growth rate, employment structure, labour costs and economic growth, which can be determined by the Granger causality test. Specifically, where Y and X are the TFP growth rate and the labour costs growth rate, respectively.

$$\begin{cases} Y_t = \phi_1 + \sum_{i=1}^{k} \alpha_i Y_{t-i} + \sum_{i=1}^{k} \beta_i X_{t-i} + u_{1t} \\ X_t = \phi_2 + \sum_{i=1}^{k} \lambda_i X_{t-i} + \sum_{i=1}^{k} \delta_i Y_{t-i} + u_{2t} \end{cases} \tag{2}$$

There are four possible outcomes: Y causes X, X causes Y, Y does not cause X, and X does not cause Y. In the analysis, an autoregression is

first carried out according to the above formula. The significance of the F-statistic is then used to determine the causal relationships between the variables.

3) Vector autoregressive model (VAR model)

The VAR model is mainly used to explain the dynamic influence relationships between the variables, including the impact of the lag order of endogenous variables on itself and the impact of the exogenous variables. Taking the impact of the labour costs growth on economic growth as an example, if x_t and y_t are the labour costs growth rate and the economic growth rate of t period, respectively, the VAR model can be described as:

$$y_t = C_1 y_{t-1} + \cdots + C_t y_{t-p} + Bx_t + \varepsilon_t \tag{3}$$

where p is the period of lag, t is the total number of time series, C and B are the coefficients to be estimated and ε_t is the random disturbances.

The model is used to estimate the impact of the economic growth rate and the labour costs growth rate of the previous periods on the current economic growth rate.

3. Study Area and Data Sources

3.1. Study Areas

ShenZhen and HongKong are all situated in the Guangdong, Hong Kong and Macao Bay Area (GBA) of China, with similar geographical locations and traffic conditions. In 2016, the secondary and tertiary industries in Shenzhen accounted for 45.2% and 54.7% of the employment in the region, respectively, whereas the corresponding figures were 11% and 88% in Hong Kong. Shenzhen is one of the bellwether regions in terms of China's economic growth. Because Shenzhen is representative of the development characteristics of China since the beginning of the reform and opening up in 1978 (Li et al., 2001), symptoms of the early stages of Baumol's disease may be evident in Shenzhen. In contrast, Hong Kong has a higher level of development, and thus may be characterised by the later stages of Baumol's disease. Therefore, combining the two regions enables us to depict the stage characteristics of Baumol's disease and explore whether the change in the employment structure leads to Baumol's disease emerging in one of the areas.

3.2. Data Sources

The data for Shenzhen were retrieved from the Shenzhen Statistical Yearbook (2005-2016). China has made some adjustments to the industry classification standards since 2005. To maintain the consistency of the data, this paper takes 2005 as the base period. The data cover 17 industries: 1) the primary sector, i.e., the agriculture, forestry, animal husbandry and fisheries industries; 2) the industrial sector; 3) construction; 4) wholesale and retail trades; 5) transportation, storage and postal services; 6) hotels and catering services; 7) information transmission, computer services and software; 8) financial intermediation; 9) real estate; 10) leasing and business services; 11) scientific research and technical services; 12) management of water conservancy, environment and public facili-

ties; 13) services to households and other services; 14) education; 15) health and social work; 16) culture, sports and entertainment and 17) public management, securities and social organisation.

The data for Hong Kong were retrieved from the Hong Kong Annual Digest of Statistics (2005-2016). The data cover 13 industries: 1) manufacturing; 2) import and export trade; 3) wholesale; 4) retail; 5) accommodation; 6) catering; 7) transportation, storage and courier services; 8) information and communication; 9) finance; 10) professional science and technology services; 11) administrative and support services; 12) construction and 13) real estate. It should be noted that there are more than 13 industries in Hong Kong, with other industries including health and tourism. Due to the data limitations, we cannot obtain the relevant data directly from all industries. However, as the 13 industries account for 94.97% of the total employment in Hong Kong, we believe that these industries represent the overall employment structure of Hong Kong. When calculating the TFP growth rate, the added value of the abovementioned industries was selected as the indicator of output, the level of employment in each industry was selected as the indicator of the labour input and the total wages of each industry was selected as the production cost indicator. Following Shan (2008), the perpetual inventory method was used to calculate the capital stock of each industry as an indicator of capital input based on the data on each year's fixed asset investment of each industry. Taking 2005 as the base period, all the data were adjusted by the GDP deflator and regional annual price index.

4. Results

4.1. The Change in the TFP Growth Rate and Employment Structure

With respect to the change of employment in various industries, except for the primary industry, the employment in all industries in Shenzhen in 2016 was greater than that in 2005. The level of employment in the wholesale and retail industries increased the most, with an increase of 1,000,328 employees, and the total employment of 1,905,185 in these industries being the second largest after the industrial sector. The industrial sector continued to be the largest employer, with a labour force of 3,795,239, whereas employment in the agriculture, forestry, animal husbandry and fisheries industries decreased from 25,995 in 2005 to 1138 in 2016, with a net outflow of 24,857.

The change in the employment structure of the various industries in Shenzhen is shown in **Figure 2**. It can be seen that the industrial sector had the highest levels of employment in Shenzhen in 2005 and 2016, although the proportion declined from 54.56% to 40.97%, with an average annual decrease of 2.55%. The primary sector had the largest decline in the proportion of employment, with an average annual decrease of 24.33%, with the water conservancy, environment and public facilities management industries having the next largest decline with an average annual decrease of 3.51%. The information transmission, computer

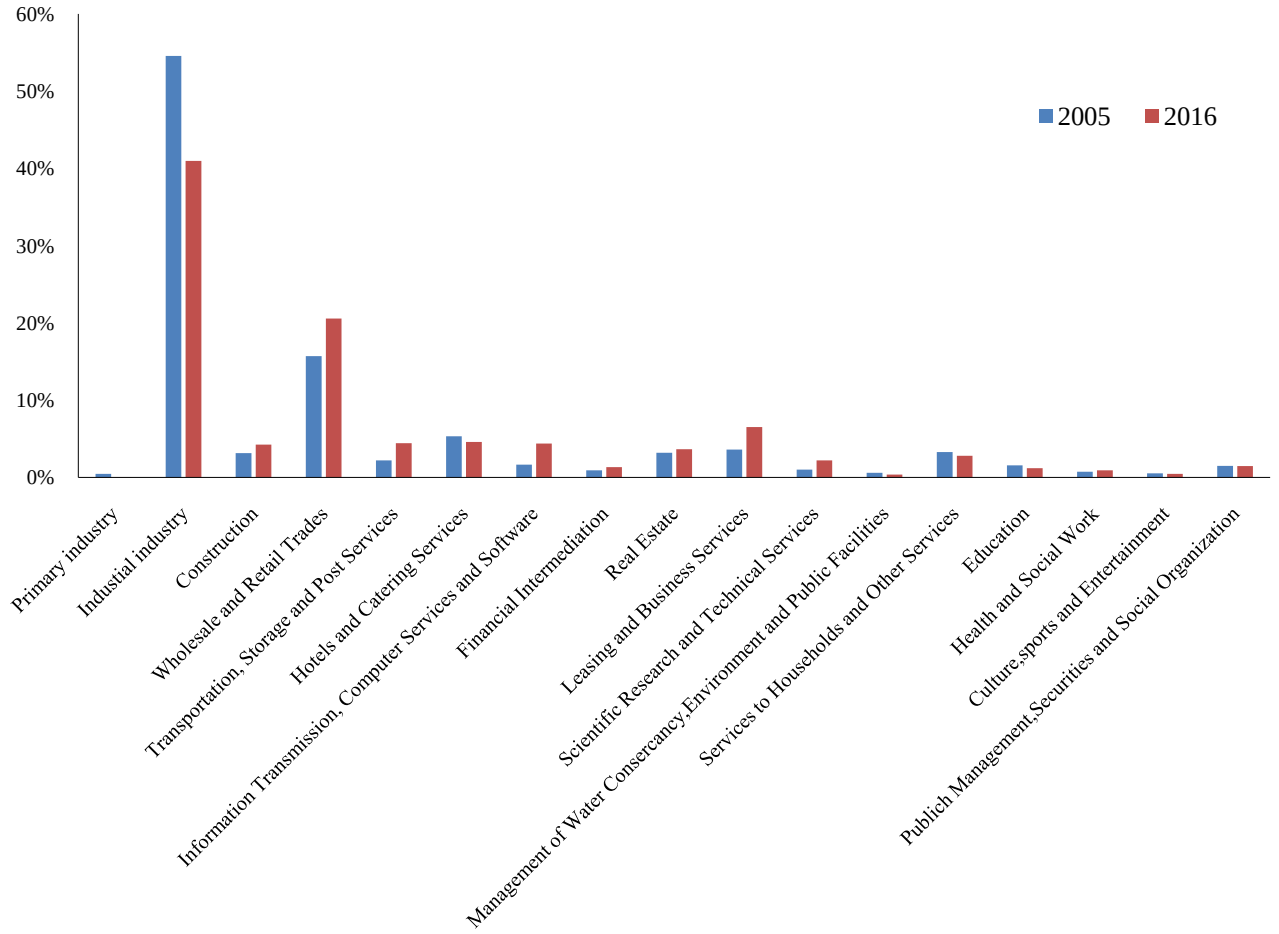

Figure 2. Employment structure in Shenzhen from 2005 to 2016.

services and software industries had the largest increase in the proportion of employment, with the overall share of employment increasing from 1.65% in 2005 to 4.38% in 2016, with an average annual growth rate of 9.84%.

According to the abovementioned industry definition, the 17 industries in Shenzhen can be divided into two sectors: the inflow sector with positive employment growth and the outflow sector with negative employment growth. The inflow sector covers nine industries: construction, wholesale and retail trade, transportation storage and post services, information transmission computer services and software, financial intermediation, real estate, leasing and business services, scientific research and technical services, health and social work. The outflow sector covers eight industries: the primary sector, industrial sector, hotels and catering services, management of water conservancy, environment and public facilities, services to households and other services, education, culture, sports and entertainment, public management, securities and social organisation.

In Hong Kong, the manufacturing, import and export industries had net labour outflows, among which the manufacturing industry only employed 94,098 people in 2016, a decrease of 70,150 compared with 2005. Although employment

in the import and export trade industry declined by 3488, the industry employed 466,155 workers in total in 2016, making it the largest industry in Hong Kong. Employment in the administrative and support services industry increased by 133,822 in 2016.

Figure 3 shows the change in the proportion of employment in the various industries in Hong Kong from 2005 to 2016. In 2005 and 2016, the import and export trade industries employed the highest proportion of workers in Hong Kong, although the proportion dropped from 25.66% to 20.53%, with an average annual decline of 2.08%. The proportion of employment in the manufacturing industry decreased the most, with an average annual decrease of 6.6%. In contrast, the proportion of employment in the information and communication industry increased the most, from 1.7% in 2005 to 4.71% in 2016, with an average annual increase of 15.28%. The administrative and support services industry had the second largest increase, with an average annual increase of 7.02%.

The 13 industries in Hong Kong can also be divided into the inflow and outflow sectors. The inflow sector comprises eight industries: retail, accommodation, catering, information and communication, finance, construction, professional science and technology services and administrative and support services. The outflow sector comprises five industries: manufacturing, import and export trade, wholesale, transportation, storage and courier services and real estate.

The Deap2.1 software package was used to calculate the Malmquist index, and the TFP growth rates of the various industries in Shenzhen and Hong Kong are

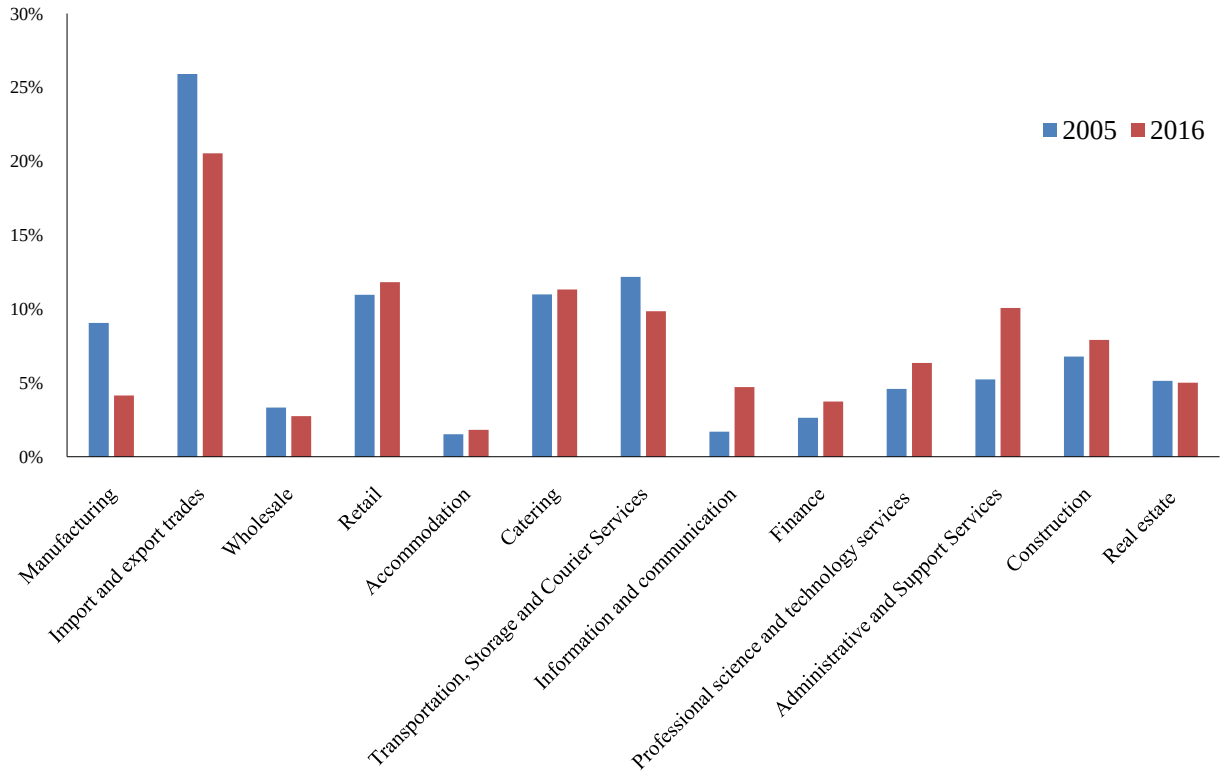

Figure 3. Employment structure in Hong Kong from 2005 to 2016.

shown in Table 1 and Table 2, respectively. The results for Shenzhen show that the average TFP growth rate of the outflow sector was 7.88%, while the average TFP growth rate of the inflow sector was only 3.06%. This means that in terms of the change in the employment structure of Shenzhen, labour tended to flow from the high growth industries to the low growth industries. For several specific industries, such as information transmission, computer services and software, the TFP growth rate and the growth in the proportion of employment show an increasing trend, which also reflects a healthy change in the employment structure in Shenzhen.

In contrast, the TFP growth rate of Hong Kong's industries was lower. Except for the real estate industry, all industries had negative TFP growth rates. The

Table 1. Average TFP growth rate and growth of the proportion of employment of the various industries in Shenzhen from 2005 to 2016.

Inflow sector	TFP growth rate	Employment proportion growth rate	Outflow sector	TFP growth rate	Employment proportion growth rate
Construction	15.80%	4.17%	Primary Sector	27.80%	−24.33%
Wholesale and Retail Trades	5.50%	2.54%	Industrial Sector	4.90%	−2.55%
Transportation, Storage and Post Services	−3.90%	6.84%	Hotels and Catering Services	−2.10%	−1.03%
Information Transmission, Computer Services and Software	5.20%	9.84%	Management of Water Conservancy, Environment and Public Facilities	8.00%	−3.51%
Financial Intermediation	−2.00%	4.52%	Services to Households and Other Services	1.00%	−1.26%
Real Estate	3.40%	2.33%	Education	12.60%	−2.03%
Leasing and Business Services	−5.90%	6.45%	Culture, Sports and Entertainment	4.30%	−0.62%
Scientific Research and Technical Services	3.20%	7.73%	Public Management, Securities and Social Organization	6.50%	−0.09%
Health and Social Work	6.20%	2.33%	Correlation coefficient	−0.725	

Table 2. Average TFP growth rate and growth of the proportion of employment of the various industries in Hong Kong from 2005 to 2016.

Inflow sector	TFP growth rate	Employment proportion growth rate	Outflow sector	TFP growth rate	Employment proportion growth rate
Retail	−1.50%	0.81%	Manufacturing	−0.50%	−6.60%
Accommodation	−0.90%	1.71%	Import and Export Trades	−0.80%	−2.08%
Catering	−3.60%	0.34%	Wholesale	−7.80%	−1.68%
Information and Communication	−2.20%	15.28%	Transportation, Storage and Courier Services	−0.30%	−1.83%
Finance	−9.30%	4.18%	Real Estate	1.00%	−0.11%
Professional Science and Technology services,	−5.70%	3.02%			
Administrative and Support Services	−17.70%	7.02%			
Construction	−4.80%	1.85%	Correlation coefficient	−0.362	

TFP growth rate in the government and support services industry was the lowest, at −17.70%. Similarly, the average TFP growth rate in the outflow sector was −1.68%, and the average TFP growth rate in the inflow sector was −5.71%. This indicates that the change in Hong Kong's employment structure was not simply due to the trend of labour flowing from the high growth sector to the low growth sector. Compared with Shenzhen, Hong Kong also shows a trend of labour flowing from the low growth sector to a lower growth sector.

Furthermore, the Pearson correlation coefficient was calculated to determine the correlation between the TFP growth rate and growth of the proportion of employment. The results show a negative correlation between the TFP growth rate and employment growth for both Shenzhen and Hong Kong. The overall correlation coefficient for Shenzhen is −0.725, while that for Hong Kong is −0.362. According to the abovementioned definition of the two symptoms of Baumol's disease, Shenzhen and Hong Kong likely experienced the first symptom of Baumol's disease; that is, labour flowed from the high TFP growth sector to the low TFP growth sector. At the time, Shenzhen was in the process of changing its employment structure from the primary and secondary industries to the tertiary industry. As the primary and secondary industries usually have a high TFP growth rate, the negative correlation was more significant. In contrast, as the tertiary industry was the pillar industry in Hong Kong, the TFP growth rates of most industries were low, and there was not much room for TFP growth to decline. Thus, the difference in the correlation coefficients of the two regions is reasonable.

4.2. The Changes in the Employment Structure and Labour Costs

The results for the changes in the labour costs in the inflow and outflow sectors are shown in Table 3. It can be seen that the total wages and average wages in Shenzhen's inflow sector were higher than those in the outflow sector, and the annual growth rate was as high as 16.26%. In terms of the average wage, in 2005 and 2016, the average wage in the inflow sector was higher than that in the outflow sector, but the annual growth rate of the average wage was slightly lower than that of the outflow sector. However, the situation was different in Hong Kong, with the annual increase in total wages and the average wage in the inflow sector being higher than the corresponding figures in the outflow sector.

Table 3. Wage changes in Shenzhen and Hong Kong.

Region	Sector	Total wages (million Yuan/HK$)		Average wage (Yuan/HK$)		Annual growth rate of total wages	Annual growth rate of the average wage
		2005	2016	2005	2016		
Shen Zhen	Inflow	62,539.78	318,800.43	33,730	48,361	16.26%	3.44%
	Outflow	100,194.03	270,125.69	25,635	38,122	9.64%	3.70%
Hong Kong	Inflow	164,898	303,825.41	204,863	231,834	5.85%	1.30%
	Outflow	205,801	214,827.05	204,151	223,772	0.43%	0.85%

The changes in the wage levels in the two regions reflect their different development stages. Although the total wages in Shenzhen exceeded those in Hong Kong (calculated at the current exchange rate of the Hong Kong dollar to RMB of 1:0.85), there was still a large gap in the average wage. The total wage growth and average wage growth in Shenzhen were higher than the corresponding figures for Hong Kong, whereas the average wage growth in the inflow and outflow sectors was similar in the two areas. Moreover, the average wage growth in the outflow sectors was slightly higher, which suggests that Shenzhen was still in a normal phase of development, with the outflow sector not being weakened due to the outflow of labour. In contrast, the development momentum of Hong Kong's outflow sector was weaker than that of the inflow sector due to the loss of labour.

Comparing the two areas, it can be found that the total wages of the inflow sectors in Shenzhen and Hong Kong exceeded the total wages of the outflow sectors, which suggests that the labour costs of the inflow sectors were rising as a result of the increasing number of employees. When the labour costs of the inflow sector are higher than those of the outflow sector, the growth rate of the inflow sector will be higher than that of the outflow sector, and the labour costs of the inflow sector will continue to rise, which also proves that the second symptom of Baumol's disease existed in the two areas. Specifically, the industry costs increased with the increasing proportion of employment, and the situation in Hong Kong appears to have been more serious.

4.3. The Links between Employment, Labour Costs and Economic Growth

4.3.1 Causality Analysis

Thus far, the results have reflected the trend of the total factor growth rate, employment structure and labour costs, and demonstrated that several trends in Shenzhen and Hong Kong were consistent with the two symptoms of Baumol's disease. However, we cannot evaluate Baumol's disease only by these symptoms, because the analysis does not reflect the "causes of the disease". For example, although the results showed that labour flowed from the low-cost sector to the high-cost sector, it was impossible to determine whether the labour flow led to the higher costs or whether the increased wages led to the labour flow. Therefore, we need to verify the causality of the first two symptoms before we can 'diagnose' whether the symptoms belonged to the specific stages of Baumol's disease. Thus, we need to further study the causality.

The Granger causality test is used to explain the influence relationship between different variables and determine the interaction relationship according to the order of variables (Fu, 2010). Based on the previous analysis, we used the average TFP growth rate of the outflow sector, the growth of the proportion of employment in the inflow sector, the total wages growth rate of the inflow sector and the regional GDP growth rate as indicators, and tested the causal relationships between them in order. First, all of the indicators passed the stability of in-

dicators test. Then, using LR, FPE, AIC and other methods for comparison, the causality analysis of the TFP growth rate and employment growth rate showed that lag period 2 was the best choice. The analyses of the employment growth rate and labour costs growth rate and the labour costs growth rate and economic growth rate showed that lag period 1 was the best choice. The results are shown in Table 4.

The results of the Granger causality test showed that at the 10% significance level, the TFP growth rate in Shenzhen was the one-way Granger cause of the employment growth rate, and that the labour costs growth rate in Hong Kong was the one-way Granger cause of the economic growth rate. At the 1% significance level, the employment growth rate in Hong Kong was the one-way Granger cause of the labour costs growth rate. These findings confirm that Shenzhen only had the characteristics of the first stage of Baumol's disease, because the change in its employment structure was caused by the change in the TFP growth rate. Although there was evidence of a symptom of the second stage of Baumol's disease in Shenzhen, no causal relationship was observed between the labour costs growth rate and the employment proportion growth rate. This means that the increase in the labour costs of Shenzhen's inflow sector did not interact with the change in the employment structure, and thus it can be concluded that Shenzhen was not infected with Baumol's disease. In contrast, Hong Kong conformed to the characteristics of the first and second stages of Baumol's disease. That is, the changes in the employment structure contributed to the changes in the labour costs of the inflow sector, which ultimately affected regional economic growth.

4.3.2. Impulse-Response Analysis

The next factor that needs to be determined is whether the growth of the labour

Table 4. Causality test.

Causality (cause-result)	Shenzhen			Hong Kong		
	Obs	F-Statistic	Prob	Obs	F-Statistic	Prob
TFP growth rate- Employment proportion growth rate	9	5.5287	0.0706*	9	0.0157	0.9845
Employment proportion growth rate - TFP growth rate		0.3676	0.7136		1.7641	0.2823
Employment proportion growth rate - Labour costs growth rate	10	0.1961	0.6712	10	16.5130	0.0048***
Labour costs growth rate- Employment proportion growth rate		0.4207	0.5373		0.9835	0.3544
Labour costs growth rate - Economic growth rate	9	5.5287	0.0706*	9	0.0157	0.9845
Economic growth rate - Labour costs growth rate		0.3676	0.7136		1.7641	0.2823

a. *, **, and *** indicate significance at the 10%, 5%, and 1% levels.

costs had a positive or negative impact on regional economic growth. Based on the causal relationship between these two variables, the impulse response function of the VAR model can be used to analyse how the result variables respond to the impact of the unit cause variables, and determine the direction and degree of impact between the variables (Zheng et al., 2018). Specifically, the model includes the response of the change in the employment structure of the inflow sector to the TFP growth rate in the outflow sector in Shenzhen, the response of the change in the labour costs in the inflow sector to the change in the employment structure of the inflow sector in Hong Kong and the response of economic growth to the change in the labour costs in the inflow sector in Hong Kong. However, before conducting the VAR analysis, the stability of each index needs to be tested. The results show that the reciprocals of all of the characteristic root modules are in the unit circle, which means the indexes passed the stability test. The results of the VAR model are shown in **Figure 4**. Among them, the vertical coordinate in the figure represents the degree of the response, the horizontal coordinate represents the number of lag periods, the dotted line represents the confidence interval and the central black curve represents the direction and degree of the impact.

Figure 4(a) shows that the impact of the TFP growth rate of Shenzhen's outflow sector on the employment structure starting from 0. After two periods, it reaches a peak value of 0.035 in the third period, then maintains an essentially positive impact before the fluctuation decreases and then gradually tends to 0. This means that the total factor growth rate of the outflow sector had a positive effect on the employment growth rate of the outflow sector, and the first three periods were the most significant. The results also show that the TFP growth rate in the outflow sector increased, which reduced the labour force and made more labour flow to the low growth sector. Compared with Hong Kong, the difference in the growth rates of the industries in Shenzhen is more obvious.

Figure 4(b) shows that the impact of the changes in the employment structure of Hong Kong's inflow sector on the increased labour costs in the sector also starts from 0, reaches a peak of 0.033 in the second period and then maintains a positive impact with strength of 0.01. These findings show that the employment growth in the inflow sector had a sustained and far-reaching impact on the

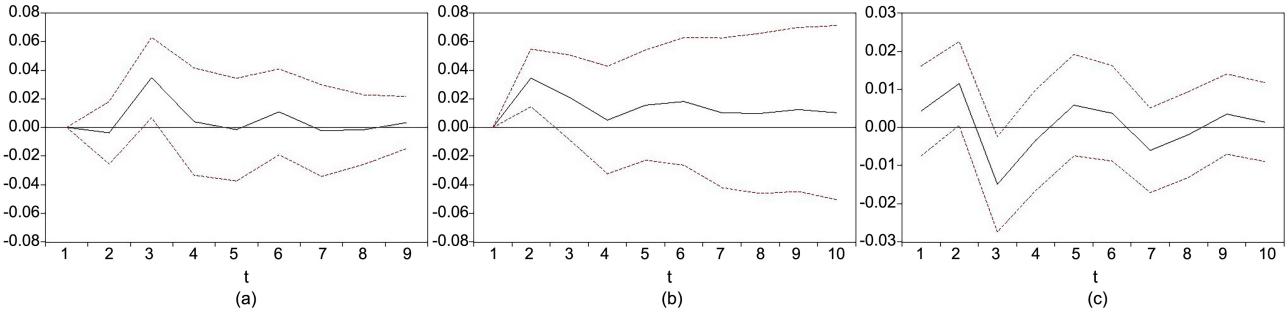

Figure 4. Impulse response function. (a) The response of employment structure to the TFP growth rate; (b) The response of labour costs growth to the employment structure; (c) The response of economic growth to the labour costs growth.

rise in labour costs in this sector, and the response was fast. Essentially, the increase in the proportion of employment in the inflow sector in the previous period led to an increase in the labour costs of this sector in the later period. These results are in line with the significant increase in the labour costs of Hong Kong's service-oriented employment structure.

Figure 4(c) shows that the impact of the rising labour costs of Hong Kong's inflow sector on the economic growth of the region was complex. Specifically, the first two periods show a positive interaction and peak at 0.011, while negative shocks occur in the third period, with the intensity reaching −0.015, followed by a decline in the positive and negative exchange fluctuations, which gradually tend to 0. On the whole, the intensity of the negative impact is higher than that of the positive impact, which indicates that the increased labour costs of the inflow sector hindered economic growth. A credible explanation is that most of the industries in the inflow sector had low TFP growth rates and the increased labour force initially had a scale effect. However, as the scale effect decreased, the increased labour costs gradually led to a decrease in the output growth rate, and finally slowed the regional economic growth. These results indicate that Baumol's disease did exist in Hong Kong.

4.3.3. Variance Decomposition

Variance decomposition was used to measure the proportion of a variable's own factors in all factors that caused the variable to change at different times. The results of the variance decomposition are shown in Figure 5. First, Figure 5(a) shows the variance decomposition of the employment structure. From the third period, 46% of the changes in the employment structure are caused by the TFP growth rate and the remaining 54% are caused by the employment structure itself. Subsequently, almost the same proportion is maintained in each stage, which shows that the improvements in the growth rates of all factors were an important factor in driving the flow of labour. Figure 5(b) shows the variance decomposition of the growth in labour costs. After the second period, more than 80% of the labour cost growth in the inflow sector is caused by the changes in the employment structure, and this proportion continues to rise. As can be seen, the proportion in the second period is 82% and that in the tenth period is 88%,

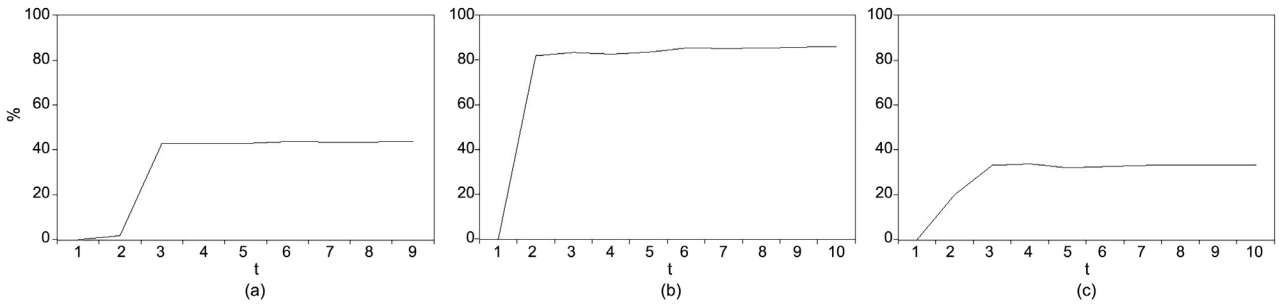

Figure 5. Variance decomposition. (a) Variance decomposition of employment structure; (b) Variance decomposition of labour costs growth; (c) Variance decomposition of economic growth.

which means that the continuous inflow of labour was the main cause of the increased costs in some industries in the long term. Figure 5(c) shows the decomposition of the variance in economic growth. After the third period, 33% of the economic growth is caused by the increased costs in the inflow sector, which slightly increase to 35% in the tenth period. This shows that while the increased costs of some industries had a strong impact on economic growth and were an important driving force, they were not a decisive factor.

5. Conclusions and Discussion

5.1. Conclusions

This paper constructed an alternative model for evaluating the presence of Baumol's disease, and determined the impact of the change in the employment structure on regional growth through a comprehensive analysis of the TFP growth rate, employment structure, labour costs growth and economic growth of industries in Shenzhen and Hong Kong, China. The results are as follows.

1) Two symptoms of Baumol's disease were observed in Shenzhen and Hong Kong. Specifically, the labour force flowed from the sector with a high TFP growth rate to the sector with a low TFP growth rate, and the labour costs of the inflow sector increased more than those of the outflow sector. The causality test results showed that the first symptom in Shenzhen and the second symptom in Hong Kong were both manifestations of Baumol's disease. That is, some industries in Shenzhen, such as the industrial sector, had high TFP growth rates for all factors, a reduced dependence on labour and labour flowing to industries with a low TFP growth rate. In contrast, the labour force in Hong Kong continuously flowed into industries with a low TFP growth rate and increased the labour costs of these industries.

2) The TFP growth rate of Shenzhen's outflow sector had a positive and stable impact on the employment growth of the inflow sector, with a contribution rate of more than 40%. Hong Kong's inflow sector also had a positive, direct and far-reaching impact on the labour costs of this sector, with a contribution rate of more than 80%. Moreover, the rising labour costs of Hong Kong's inflow sector had a positive impact on regional economic growth and its contribution rate was over 30%, which also showed that Hong Kong's economic growth had long been affected by the rising labour costs.

3) Shenzhen displayed the characteristics of the first stage of Baumol's disease and showed a trend of transitioning to the second stage. Hong Kong showed the characteristics of the second and third stages of Baumol's disease. Hence, the change in the employment structure of Hong Kong led to the emergence of Baumol's disease in the area, while Shenzhen faces the risk of being infected with Baumol's disease.

5.2. Discussion

Changes in the employment structure are inevitable during periods of so-

cio-economic development and industrial upgrading. Because China is still transitioning from the industrial stage to the post-industrial stage, the change in the employment structure means that the proportion of primary and secondary industries is declining while the tertiary industry is expanding. However, the changes in the employment structure carry the risk of Baumol's disease and will ultimately affect China's long-term economic growth. The difference in the TFP growth rates between industries promotes the flow of labour to low growth industries and thus increases their labour costs. However, in the long run, this will also affect high growth industries. According to the theory of endogenous growth, TFP growth is essentially caused by technological progress, which in turn stems from improved labour skills. If the high growth industries constantly lose their labour force, the growth rate of the industry as a whole will also be reduced, which will eventually lead to declining economic development.

Our results show that although Shenzhen, which is more developed than the rest of China, still has a long way to go before it will be infected with Baumol's disease, it has still displayed a series of symptoms that cannot be ignored. Owing to the risks brought by the change in the employment structure, China should alter the direction of the transformation of the employment structure to reduce the risk of developing Baumol's disease. The key to optimising the employment structure lies in industrial upgrading because labour always follows industrialisation. Strengthening the development of the high TFP growth industries and thus forcing them to absorb more and more labour could reduce the spread of Baumol's disease. Therefore, the following suggestions are put forward. First, as the tertiary sector gradually becomes the leading industry in China, the traditional manufacturing sector should be upgraded and the industrial chain should be extended through technological innovation to provide more employment opportunities. Second, the modern high growth service industries, such as software and information technology and scientific research and technology, should be developed vigorously to absorb more labour and promote the TFP growth of the tertiary sector as a whole. Third, producer services, such as the finance industry, cannot serve as engines of economic growth because of their low growth rate. Thus, these industries should serve to provide efficient services for the manufacturing industry rather than be regarded as pillar industries at all costs. Finally, there needs to be increased focus on educating and training the labour force to generate an endogenous source of growth based on talent.

In future research, we plan to use longer time series based on a larger spatial scale, possibly even the whole of China, and analyse the possible development of Baumol's disease in China to provide more reliable suggestions for the relevant departments.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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