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An Analysis of Employment Ripple Effects of the PMI of Guizhou in China

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Abstract: *The Pharmaceutical Manufacturing Industry (PMI) is one of the major fostering industries of high-tech manufacturing industry in Guizhou Province. This study is to analyze the employment ripple effects of the PMI, which is very important to induce policies on the industry and technology development of the PMI, is also important to create jobs of Guizhou. To achieve this aim, the Input-Output table of Guizhou published in 2019 was rewritten into 20 industries, and the PMI is regarde as an exogenous sector rather than an endogenous one. Then, the wage-inducing effect, employment-inducing effect and linkage effects of inter-industry of the PMI were measured using I-O analysis.The results are summarized as follows: First, RMB 1 yuan of production or investment in the PMI induced about 0.1331 yuan of wages and 0.0176 persons of employment. In particular, the Agriculture, Forestry, Animal Husbandry and Fishery industry has been affected heavily by the PMI in overall industries. Second, the backward linkage effect of the PMI is greater than the forward linkage effect, which shows that the PMI can be classifified into fifinal manufacture.*

Keywords: *Employment-inducing effect, Wage-inducing effect, Linkage effects of inter-industry, Exogenous, The Pharmaceutical Manufacturing Industry.*

1. Introduction

With the continuous integration of the new generation of IT industry and artificial intelligence with the manufacturing industry, the accelerating of population ageing and the sluggish of global economic, All over the world face great pressure on employment. The COVID-19 epidemic in 2020 has exacerbated the employment pressure in all countries. The employment problem not only has a negative impact on individuals, but also may lead to the economic and social instability of a country. As a populous country, the Chinese government has always attached great importance to the employment issue. There is clearly points out that 'Employment is pivotal to people's wellbeing, and we must strive to achieve fuller employment and create better quality jobs' in the report to the 19th National Congress of the Communist Party of China. 'Employment' was also mentioned 39 times in the report on the Work of the Government 2020, the Chinese government will make every effort to stabilize and expand employment.

To achieve this aim, it is necessary that increasing employment support for key sectors. It is also necessary to uphold the current situation and characteristics of economic development in each region, comprehensively consider factors such as environment and resources so as to deliver the sustainable development in the regional economy. And promote the increase of employment opportunities and relieve the increasingly severe employment pressure[1].

Guizhou Province is located in the southwest of China and is an important transportation hub for the provinces in the southwest. The economy of Guizhou remained rapidly overall in the past ten years. Gross Domestic Product (GDP) increasing by more than three times, ranking the top three in China's GDP growth rate[2]. However, the phenomenon that rapid economic development coexists with unemployment is a global problem. At present and in the future, the employment situation in Guizhou is still grim.

Guizhou is rich in wild plant resources and is one of the four major production areas of Chinese medicinal materials in China. There are more than 3700 kinds of medicinal plants, accounting for 80% of Chinese medicine materials. There are 6 kinds of precious medicinal plants such as pearl ginseng,

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Chinese fir, fan fern, Chinese cordyceps sinensis, chicken fir and Ainarum(natural borneol) and 32 kinds of genuine regional medicinal plants well-known all over the world, such as Gastrodia elata, Dendrobium and Eucommia ulmoides[3]. Therefore, Guizhou has a unique advantage in the development of the pharmaceutical manufacturing industry(PMI) with its obvious advantages in resource endowment. The GDP of the PMI in Guizhou was RMB 9.612 billion in 2006, which increased to RMB 36.108 billion in 2019, with an average annual growth rate of 10.7%[4]. And it is one of the fastest developing industries in Guizhou.

The PMI is recognized as one of the fastest growing and most competitive industries in the world, and is known as the 'new engine' of economic growth in the 21st century. After decades of development, the PMI of China has formed a complete pharmaceutical industry and circulation network. At present, China has become the second largest country of active pharmaceutical ingredients (APIs) in production and export, and is the second largest pharmaceutical market in the world after the United States [5]. With the strong promotion of national strategies and policies such as 'Tutorial for Outline of the Healthy China 2030 Plan' and 'Traditional Chinese Medicine Strategic Plan', the aggravation of the aging population and the increase of pehe nation health awareness, the PMI will have a new accelerated development opportunities. Not only economic growth is boosted but also employment is expanded with the rapid development of PMI. The PMI can directly promote employment through its own development,on the other hand, it can also indirectly promote employment growth through with other association industries. Therefore, it is of great practical significance for regional economic development to study the employment ripple effects of the PMI in Guizhou.

To this end, this study derives the employment ripple effects using I-O analysis through the I-O table of Guizhou recently published in 2019, treating the PMI as exogenous rather than endogenous. First, the wage-inducing effect and employment-inducing effect of RMB 1 yuan of production in the PMI are measured by the demand-driven model. Second, it is found that the status and function of the PMI in the national economy of Guizhou by the inter-industry linkage model.

2. Explanation of the Pharmaceutical Manufacturing Industry (PMI)

The PMI is associated with research and development, production and circulation of all the pharmaceutical companies [6]. According to the explanation and code for sector classification input-output table of Guizhou and the internationnal standard of 'Industrial classification for national economic aceibities (GB/T 4754-2017),' the PMI was used as arefers to the following eight industries are involved: Chemical Crude Material Manufacturing Industry, Chemical Drug Preparation Manufacturing Industry, Pieces of Traditional Chinese Medicine Processing Industry, Chinese Patent Medicine Manufacturing Industry, Veterinary Drugs Manufacturing Industry, Manufacturing Industry of Biological Pharmaceutical Products, Health Materials and Medical Supplies Manufacturing Industry, Pharmaceutical Excipients and Packing Material Manufacturing Industry[7].

For a long time, research on the PMI has mainly focused on the technological innovation of the PMI [8,9], the development of pharmaceutical economy[10], the relationship between the PMI and economic growth[11], industrial efficiency[12], supply chain management[13,14], enterprise operation management[15], new business models and new commercial activities, etc. There are many achievements of theoretical significance and application value have been achieved, which helps to solve some problems of endogenous growth force in the development of the PMI. However, there are few studies on industrial characteristics and positioning from the perspective of medium-economy or macro-economy, and most of them belong to qualitative analysis, the quantitative analysis is lack.

Based on Input-output Tables of China in 2002 and 2007, inter-industry linkage effects and economic effects of the PMI were analyzed quantitatively. It was founded that the sensitivity coefficient and influence coefficient of PMI were close to 1, and showed a trend of increasing year by year in this study[16]. However, the employment ripple effects of the PMI were missing. Therefore, this study will explore quantitatively the employment ripple effects of the PMI in Guizhou using the I-O analysis.

ISSN 2706-6827 Vol. 3, Issue 11: 85-92, DOI: 10.25236/IJFS.2021.031114

3. Methodology

3.1. Method: Input-Output Analysis (I-O analysis)

I-O analysis is also called inter-industry analysis, since the I-O framework is to analyze the interdependence of input and output among industries in an economy [17]. Now, I-O analysis is widely useful for analyzing and forecasting the economic impacts of a particular industry (sector) within an economy [18]. Because the I-O model could be used to identify the impacts of changes in final demand or output of a particular industry (sector) on the economy as a whole and on production, value added, employment, wages, income, etc., in each sector [19]. Jung K.O and Lim E.S analyze by time-series the economic impacts of the Medical Instrument Industry using an inter-industry analysis. The results show that the employment-inducing effect is decreased steadily between 1995 and 2000, but increased after 2000. Also, it is shown that the forward linkage effect is higher than the backward linkage effect[20].

Of course, there are many studies on the employment effects of I-O analysis on a particular industry in China. For example, Liu Z.Q and Liu S.H scientifically measured the impact of the Information Industry on employment in Hebei province using the I-O tables from 2002 to 2007[21]. Liu B measured the direct and indirect effects of five informal sectors on employment in China by compiling I-O tables, including the informal sectors from 2002 to 2017. The results showed that the direct and indirect contribution of the informal sector to employment in five informal economy industries shows a downward trend in the sample period[22]. Based on I-O analysis, Guo F.H made a quantitative analysis of the employment impact of producer services industries in Liaoning Province. That study found that the employment contribution of producer services presents an increasing trend[1].

Compared with the previous research, there are three important points in this study.First, the employment ripple effects focusing on the PMI sector. Second, the PMI sector as exogenous rather than endogenous. Thus, the change in production or investment can be analysed, rather than the change in the final demand or value-added for the PMI sector. This method has a few previously been reported in the literature in China. Traditional I-O analysis regards a sector as an endogenous sector, which neglects that exogenous shocks such as production or investment in the sector will creates the contradictions of production, value added and wages in the sector again. Third, the most recently published I-O table is adopted to obtain convincing results, and is presented to the government and the public.

3.2. The General Framework of I-O Analysis

When there are n industry sectors in a economy, the basic balance equations of an I-O model can be expressed as follow:

$$\sum_{j=1}^{n} X_{ij} + Y_i = \sum_{j=1}^{n} a_{ij} X_j + Y_i = X_i \tag{1}$$

Eq. (1) describes the demand-driven mode, where X_i is the total gross output in sector $i, j=1,2,...n$; a_{ij} is the direct input coefficient which divides X_{ij}; the inter-industry purchases of producing sector i from supply sector j, by X_j, the total gross output in sector j.

3.3. The Demand-Driven Model

This study investigates the production-inducing effects, employment-inducing effects, and wage-inducing effects using the demand-driven model.

Eq. (1) can be rewritten in an abbreviated matrix form as follow:

$$X = (I - A)^{-1} Y \tag{2}$$

where, I is an n×n identity matrix, $(I-A)^{-1}$ is usually called a Leontief inverse matrix[23], in which elements a_{ij} represent the outputs in sector i per unit of the final demand in sector j, Y is an n × 1 final demand matrix whose elements are Y_i.

To more exactly evaluate the effects of new production activity in the PMI on all the other sectors

ISSN 2706-6827 Vol. 3, Issue 11: 85-92, DOI: 10.25236/IJFS.2021.031114

of the economy, the individual PMI sector needs to be handled as exogenous and included in the final demand group. Adding the subscript e to the new matrices and subscript Y to the vectors related to the fisheries sector gives x^e.

$$\Delta X^e = (I - A^e)^{-1}(A_H^e \Delta X_H) \tag{3}$$

Eq. (3) can be adopted to evaluate the impacts of a change in the PMI sector's supply investments on the output of all other sectors which is called 'production-inducing effect'.

Here, ΔX^e: how much all other industries will increase or decrease(except the PMI); $(I-A^e)^{-1}$: the Leontief matrix by subtracting the row and column of object industry from A; A_H^e:the column vector except the PMI variable; ΔX_H: the output amount of the PMI sector.

3.4. The Wage-Inducing Effect

Wage-inducing effect refers to how much RMB 1 yuan of production or investment in the sector increases wages in other sectors (except the PMI). Let $\hat{W}$ be the diagonal matrix of wage coefficients, which are defifined as $Wj = wj / Xj$, where W_j is the wage in the j th sector. By multiplying Equation (3), the wage-inducing effect can be represented as follow [24]:

$$\Delta W^e = \hat{W}^e (I - A^e)^{-1}(A_H^e \Delta X_H) \tag{4}$$

where ΔW^e is the (n−1)×1 matrix, meaning changes in wages in other sectors except for sector H, $\hat{A}_w^e$ indicates the (n−1)×(n−1) matrix left after excluding the sector-related row and column from $\hat{W}$.

3.5. The Employment-Inducing Effect

Employment-inducing effect is how many persons all other industries will increase or decrease (except the PMI) when we increase one unit of production of the PMI. The employment-inducing effect can be represented as follow:

$$\Delta L^e = \hat{l}^e (I - A^e)^{-1}(A_H^e \Delta X_H) \tag{5}$$

Eq. (5) can evaluate the impacts of per 1 unit supply investment in the PMI sector on the generated employment of all other sectors.

3.6. The Linkage Effects of Inter-Industry

Since the products produced by various industries can be used as final products as well as used as semi-finished products, there is interrelated relation among industries. The linkage effects usually are classifified into backward and forward linkage effects, which are useful in assessing the impacts of particulars on the national economy as a whole. The backward linage effect indicates that the production activities of the object sector may induce greater use of other sectors as inputs for the object sector's products. The forward linkage effect means that the object sector's products may be used as inputs to other sectors for their own production.

The forward linkage effect can be measured by the sensitivity of dispersion while the backward linkage effect can be observed through the power of dispersion. Both of then can be evaluate by Eq. (6) and Eq. (7) as follows:

$$\mathrm{FL}_i = \frac{\frac{1}{n}\sum_{j=1}^{n} a_{ij}}{\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}} = \frac{n\sum_{j=1}^{n} a_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij}} \tag{6}$$

$$\mathrm{BL}_\mathrm{j} = \frac{\frac{1}{\mathrm{n}}\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{a_{ij}}}{\frac{1}{\mathrm{n}^2}\sum_{\mathrm{i}=1}^{\mathrm{n}}\sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{a_{ij}}} = \frac{\mathrm{n}\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{a_{ij}}}{\sum_{\mathrm{i}=1}^{\mathrm{n}}\sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{a_{ij}}} \tag{7}$$

If the values of both the power and sensitivity of dispersion are greater than 1 in some industries, these industries play a signifificant role in national economic development by supporting (forward linkage effects) as well as boosting (backward linkage effects) other industries.

ISSN 2706-6827 Vol. 3, Issue 11: 85-92, DOI: 10.25236/IJFS.2021.031114

4. Results

4.1. Data

To investigate the employment ripple effects of the PMI, this study utilizes the I-O table recently published in 2019. Because of the availability and convenience of data, this study rewriten a 20-sector I-O table. The PMI is extracted from sector 3 using the basic-scale 142-sector I-O table. Thus, the sector classifification adopted in this study including 19 large-scale sectors and the PMI sectors is shown in Table 1.

Table 1: The sector reclassifification adopted in this study.

Code	Sector
1	Agriculture,Forestry,Animal Husbandry and Fishery
2	Mining Industry
3	Manufacturing Industry(excluding the PMI)
4	Production and Supply ofElectric Power,Heat Power,Gas and Water
5	Construction
6	Wholesale and Retail Trades
7	Transport,Storage and Postal Services
8	Hotels, Catering Services
9	Information Telecommunication, Computer and Software Services
10	Financial Intermediation
11	Real Estate
12	Leasing and Business Services
13	Science and Technology Services
14	Management of Water Conservancy, Environment and Public facilities
15	Activities of Households and Other Services
16	Education
17	Social Activities
18	Culture, Sports and Entertainment
19	Public Management,Social Security and Social Organization
20	The Pharmaceutical Manufacturing Industry (PMI)

4.2. Results

4.1.1. Results of the Production-Inducing Effect

The production-inducing effect of the PMI sector on other industries is shown in table 2, which shows the sectoral impacts of supply investments by the PMI sector. Generally, the PMI shows higher total impact of RMB 1 yuan change in the PMI investment on the output of the national economy is RMB 0.5786, the output of other sectors from RMB 0.005 to RMB 0.165 with large fluctuation range. The amounts of total gross output in the PMI sector in 2017 were RMB 38.05 billion, which indicates that the net production of the PMI sector in the other sectors amounted to RMB 22.02 billion.

Agriculture, Forestry, Animal Husbandry and Fishery (1st sector) equally rank the high in the sectoral impacts of PMI investments, followed by Manufacturing Industry (3rd sector). This means that the costs of Agriculture, Forestry, Animal Husbandry and Fishery sector's products play a large part in the production costs of the PMI sector. This means that the costs of Agriculture, Forestry,Animal Husbandry and Fishery sector's products play a large part in the production costs of the PMI sectors. Whereas Public Management, Social Security and Social Organization(19th sector) had no impact no matter production-inducing effect.

Table 2: The PMI sector's Production-inducing coefficient on all other sectors.

Sector	Values	Ranks	Sector	Values	Ranks
1	0.1650	1	11	0.0049	13
2	0.0178	9	12	0.0381	6
3	0.1284	2	13	0.0044	14
4	0.0386	5	14	0.0008	18
5	0.0055	12	15	0.0078	11
6	0.0390	4	16	0.0016	17
7	0.0623	3	17	0.0016	16
8	0.0222	8	18	0.0026	15
9	0.0121	10	19	0.0005	19
10	0.0253	7	Total	0.5786	

ISSN 2706-6827 Vol. 3, Issue 11: 85-92, DOI: 10.25236/IJFS.2021.031114

4.1.2. Results of the Wage-Inducing Effect

The wage-inducing effect of the PMI are summarized in Table 3. The wage-inducing effect of RMB 1 yuan of production or investment in the PMI sector will produces about RMB 0.1331 yuan of wages in the national economy overall. The top three industries affected are Agriculture,Forestry, Animal Husbandry and Fishery(1st sector), Production and Supply of Electric Power,Heat Power,Gas and Water(4th sector) and Wholesale and Retail Trades(6th sector). It is induced RMB 0.0818, 0.0128, 0.0089 yuan of wages respectively, while that of Management of Water Conservancy, Environment and Public Facilities (19th sector) was lowest, 0.0001.

Table 3: The wage-inducing effect and employment-inducing effect of the PMI sector.

Sector	Wage-inducing effect		Employment-inducing effect	
	Values	Ranks	Values	Ranks
1	0.0818	1	0.0047	1
2	0.0015	9	0.0001	13
3	0.0052	6	0.0007	6
4	0.0128	2	0.0002	10
5	0.0002	18	0.0001	17
6	0.0089	3	0.0046	2
7	0.0057	4	0.0005	7
8	0.0024	8	0.0026	3
9	0.0054	5	0.0003	8
10	0.0008	12	0.0003	9
11	0.0014	10	0.0002	11
12	0.0003	16	0.0022	4
13	0.0008	13	0.0001	14
14	0.0001	19	0.0000	18
15	0.0036	7	0.0007	5
16	0.0007	14	0.0001	12
17	0.0004	15	0.0001	16
18	0.0009	11	0.0001	15
19	0.0003	17	0.0000	19
Total	0.1331		0.0176	

4.1.3. Results of the Employment-Inducing Effect

The employment-inducing effect of PMI sector on all other sectors are shown in Table 3., which indicates that the PMI supply increase of RMB 10 billion yuan induced 1.76 persons of all other sectors in 2017. According to the employment data in Guizhou, the employment rate of all other sectors for the PMI showing a tendency to decrease. Such decrease means the trend of industry from labor intensiveness to technology intensiveness.

Agriculture,Forestry,Animal Husbandry and Fishery(1st sector) was affected heavily, followed by Wholesale and Retail Trades(6th sector), whereas the Management of Water Conservancy, Environment and Public Facilities(19th sector) was had no impact no matter employment-inducing effect.

4.1.4. Results of the Linkage Effects of Inter-Industry

The linkage effects of inter-industry of Guizhou in 2017 are shown in Table 4. There are two important and interesting results. First of all, the sensitivity of dispersion of the PMI sector is 0.7466 less than 1 and ranks 12nd, which indicating that the forward linkage effect of the PMI is smaller than that of the entire industry. That means the PMI is not influenced much by economic fluctuations and is a vital input to national existence. Thus, the PMI sector will be less stimulated by overall industrial growth than other sectors when the economy is booming. Secondly, the power of dispersion of the PMI is 1.0096 who a little greater than 1 and ranks 8th, which means that the PMI has bigger impacts in terms of investment expenditures on the national economy than other industries. That is, the PMI has a relatively strong capacity for pulling in other industries. In conclusion, the PMI has a low forward linkage effect and a high backward linkage effect. It can be classifified into final manufacture.

ISSN 2706-6827 Vol. 3, Issue 11: 85-92, DOI: 10.25236/IJFS.2021.031114

Table 4: The linkage effects of inter-industry of Guizhou.

Sector	Sensitivity of dispersion	Ranks	Power of dispersion	Ranks
1	0.9996	6	0.9004	17
2	1.2201	5	1.1550	3
3	2.9863	1	0.9322	15
4	1.6232	2	1.5258	1
5	0.7281	13	1.1568	2
6	0.9048	9	0.7191	20
7	1.4202	3	0.9558	12
8	0.9712	7	0.9551	13
9	0.7835	11	1.0392	7
10	1.2508	4	0.9912	9
11	0.7019	14	0.8166	18
12	0.9673	8	1.0843	5
13	0.6347	18	0.9228	16
14	0.6338	19	0.9486	14
15	0.8040	10	1.0908	4
16	0.6817	15	0.7813	19
17	0.6349	17	0.9630	11
18	0.6777	16	1.0700	6
19	0.6296	20	0.9825	10
20	0.7466	12	1.0096	8

5. Discussion

The PMI of Guizhou has been providing stable pharmaceutical products and jobs for human survival. Therefore, the government is implementing various policies to promote the PMI and needs quantitative information on the economic role and effects of the PMI. In particular, how much production or investment is made in the PMI has causes the production, wages, and jobs in other sectors.

This study has several important findings that can be utilized in policy analysis and evaluation. First of all, the Agriculture,Forestry,Animal Husbandry and Fishery is affected heavily by the PMI not only wage-inducing effect but also employment-inducing effect. Given the PMI sector has high employment ripple effects, The Guizhou government should improve the vitality of the PMI by intensively promoting health tourism and supporting people who migrate from urban areas to the villages with planting medicinal materials.

Secondly, scientific and accurate information of the wage-inducing effects of the PMI can help the government play an important role in supporting educational training to cultivate talents of the PMI and formulating the development policy of PMI and jobs creation.

Thirdly, the results of this study show that the PMI may have more strength in absorbing the products of related industries, rather than being used as inputs by other industries. With regard to the economic importance of the PMI cluster, the government should consider policies that facilitate the development and growth of the PMI cluster. Because globally competitive industries generally occur in the form of specialized clusters linked together, through vertical relationships or horizontal relationships.

Finally, as a follow-up to this study, future related studies may be carried out in comprehensive economic impacts of the PMI such as value-added, supply shortage effects and price effects. It is also necessary to perform multi-period I-O analysis so that analysing the dynamics of economic ripple effects in the PMI.

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ISSN 2706-6827 Vol. 3, Issue 11: 85-92, DOI: 10.25236/IJFS.2021.031114

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