Study on the Non-linear Relationship of Agricultural Product Processing Industry Agglomeration Affecting Economic Growth in Hubei Province

Quan Meng

School of Business Administration

Zhongnan University of Economics and Law

Wuhan, China 430073

Abstract—**This paper uses the county-level panel data of Hubei province from 2012 to 2016 to calculate the agglomeration degree of agricultural products processing industry in Hubei province, and empirically studies the impact of agricultural product processing industry agglomeration on county economic development. The conclusions of this paper indicate that the agglomeration of agricultural products processing industry in Hubei province is more obvious, but there are large differences in different regions. On the whole, the agglomeration of agricultural products processing industry has a significant impact on county economic growth, showing an inverted U-shaped relationship of first rising and then falling.**

Keywords—agricultural product processing industry; industrial agglomeration; economic growth; county economy

I. INTRODUCTION

The report of the Nineteenth National Congress of the Communist Party of China put forward the strategy of rural revitalization, which pointed out the direction for the work of "agriculture, rural areas, and rural residents" in the new period. The key to the rural revitalization is to revitalize the industry (Xi Jinping, 2018), and then all the industries will be prosperous. Agricultural product processing industry, as the main form of rural industry, has been playing the role of communication between urban and rural areas, linking workers and farmers, and is known as the 1.5th industry. With the attributes of "labor-intensive" and "resource-intensive" industries, the agglomeration of agricultural products processing industry will provide a broader raw material market and labor market, which will inevitably have a profound impact on the local economy. The Rural Revitalization Plan (2018-2022) provides a complete schematic diagram for the full implementation of rural revitalization. The Plan clearly states that "the county economy should be strengthened, industries and enterprises with strong employability should be vigorously developed, and the labor force should be actively supported to find jobs nearby." The unique industrial attributes of agricultural product processing industry coincide with the requirements of rural industry revitalization. The development of country economy is a detailed theme of implementing the strategy of rural revitalization, and the realization of the strategic goal of Rural Revitalization ultimately falls on the county level (Ye Xingqing, 2018). Therefore, it is of great significance to study the impact of agricultural product processing industry agglomeration on the county economic growth.

II. MEASUREMENT AND ANALYSIS OF THE AGGLOMERATION OF AGRICULTURAL PRODUCT PROCESSING INDUSTRY IN HUBEI PROVINCE

By sorting out the literature, location quotient index, EG index, industrial concentration ratio, DO index, Herfindahl index and location Gini coefficient can accurately reflect the agglomeration ratio of the research object, which is widely used by scholars in China and foreign countries. There are many ways to measure industrial agglomeration. However, none of them has universality. There is no universal measurement rule. Therefore, the research object and research content should be combined in the actual measurement (Yang Rong, 2018). The use of location quotient index can reflect the difference of regional scale and also reflect the position and role of an industry in high-level regions (Tang Jianrong, 2018). It can truly reflect the spatial distribution of an industry in geography. It is one of the representative methods of industrial agglomeration measurement. Therefore, this paper uses location quotient to measure the agglomeration ratio of agricultural product processing industry in various counties of Hubei Province. The calculation formula is as follows:

$$\text{LQ}_{ij} = \frac{q_{ij}}{\sum q_j} / \frac{Q_i}{Q} \tag{1}$$

In the above calculation formula, q_{ij} represents the production value of i industry in j region. $\sum q_j$ represents the gross value of production of j region. Q_i represents the production value of i industry in higher level of regions. Q represents the gross value of production in higher level of regions. If the ratio is greater than 1, it indicates that there is industrial agglomeration within the region. The larger the ratio is, the higher the ratio of industrial agglomeration in the region is. The calculation results are shown in "Table I". In

order to more intuitively observe the agglomeration distribution of agricultural product processing industry in the counties of Hubei Province, this paper uses ArcGIS software, takes the location quotient of "Table I" as the measurement index, draws the spatial distribution map of agricultural product processing industry agglomeration in the counties of Hubei Province according to location quotient (0-1), (1-2) and above 2. The deeper the color is, the higher the agglomeration ratio of agricultural product processing industry in county (city, district) is. (As shown in "Fig. 1" and "Fig. 2")

TABLE I.   Location Quotient of Agricultural Product Processing Industry in Each County from 2012 to 2015

| CI	2012	2013	2014	2015	2016	CI	2012	2013	2014	2015	2016
Yangxin County	0.25	0.39	0.48	0.55	0.57	Hanchuan City	3.31	3.18	3.22	3.24	3.28
Daye City	0.71	0.68	0.69	0.73	0.80	Jiangling County	1.39	1.56	1.76	2.03	1.19
Yunyang District	0.22	0.77	1.07	1.26	1.40	Gong'an County	1.60	1.50	1.52	1.62	1.76
Yunxi Country	0.11	0.18	0.26	0.22	0.18	Jianli County	2.22	2.07	2.10	2.10	2.08
Zhuxi County	0.52	0.54	0.53	0.48	0.57	Shishou City	1.11	1.13	1.37	1.41	1.53
Zhushan County	0.73	0.60	0.59	0.50	0.53	Honghu City	1.29	1.67	1.79	1.87	2.00
Fangxian Country	0.85	0.97	0.89	0.96	0.98	Songzi City	1.89	1.80	1.84	1.95	1.89
Danjiangkou City	0.62	0.72	0.78	0.95	1.07	Tuanfeng County	0.69	0.66	0.80	0.69	0.74
Yiling District	2.10	2.22	2.57	2.74	2.79	Hong'an County	0.76	1.02	0.83	0.95	0.80
Yuan'an County	0.61	0.64	0.76	0.79	0.93	Luotian County	0.37	0.43	0.48	0.50	0.52
Xingshan County	0.57	0.52	0.48	0.41	0.44	Yingshan County	0.67	0.79	0.90	0.95	0.98
Zigui County	1.22	1.09	1.07	1.16	1.25	Xishui County	0.96	0.95	1.04	0.94	0.70
Changyang county	0.99	0.93	0.99	0.96	0.99	Qichun County	1.48	1.36	1.39	1.39	1.34
Wufeng County	1.11	0.98	0.91	0.86	0.87	Huangmei County	1.46	1.86	1.86	1.41	1.33
Yidu City	0.85	1.21	1.21	1.17	1.26	Macheng City	0.40	0.50	0.69	1.09	0.65
Danyang City	1.64	1.35	1.41	1.45	1.54	Wuxue City	0.85	1.00	0.76	0.76	0.71
Zhijiang City	2.06	1.92	1.87	2.12	2.29	Jiayu County	2.26	2.18	2.21	2.22	2.26
Xiangzhou District	1.44	1.28	1.09	1.07	1.17	Tongcheng County	0.65	0.60	0.63	0.56	0.56
Nanzhang County	1.59	1.26	1.19	1.23	1.25	Chongyang County	0.51	0.47	0.42	0.32	0.37
Gucheng County	2.09	0.96	1.79	1.74	1.89	Tongshan County	0.25	0.57	0.71	1.15	0.87
Baokang County	0.65	0.85	0.87	0.74	0.81	Chibi City	1.77	1.57	1.34	1.42	1.25
Laohekou City	2.60	2.29	2.10	2.15	2.17	Suixian Country	2.10	1.87	2.05	1.97	2.05
Zaoyang City	1.79	2.37	1.89	2.01	2.15	Guangshui City	1.35	1.35	1.68	1.56	1.33
Yicheng City	2.77	2.52	2.52	2.68	2.81	Enshi City	0.88	0.91	0.90	1.04	1.11
Jingshan County	3.18	3.03	3.16	3.21	3.20	Lichuan City	0.94	0.86	0.78	0.74	0.69
Shayang County	2.20	2.04	2.20	2.12	1.98	Jianshi County	0.19	0.41	0.42	0.44	0.45
Zhongxiang City	1.79	2.37	1.89	2.01	2.15	Badong County	0.54	0.57	0.82	0.81	0.81
Xiaochang County	0.80	0.57	0.33	0.42	0.35	Xuan'en County	0.75	0.82	0.81	0.81	0.85
Dawu County	0.56	0.49	0.48	0.46	0.50	Xianfeng County	0.85	0.87	0.81	0.85	0.84
Yunmeng County	2.21	2.02	1.77	2.22	1.94	Laifeng County	0.66	0.60	0.50	0.64	0.60
Yingcheng City	1.61	1.39	1.27	1.11	1.11	Hefeng County	1.31	1.61	1.74	1.71	1.88
Anlu City	2.34	1.93	1.95	1.91	2.11	Xiantao City	2.34	2.80	1.91	1.68	1.49
Qianjiang City	1.76	1.79	1.87	1.92	1.78	Tianmen City	2.14	1.88	1.88	1.72	1.70
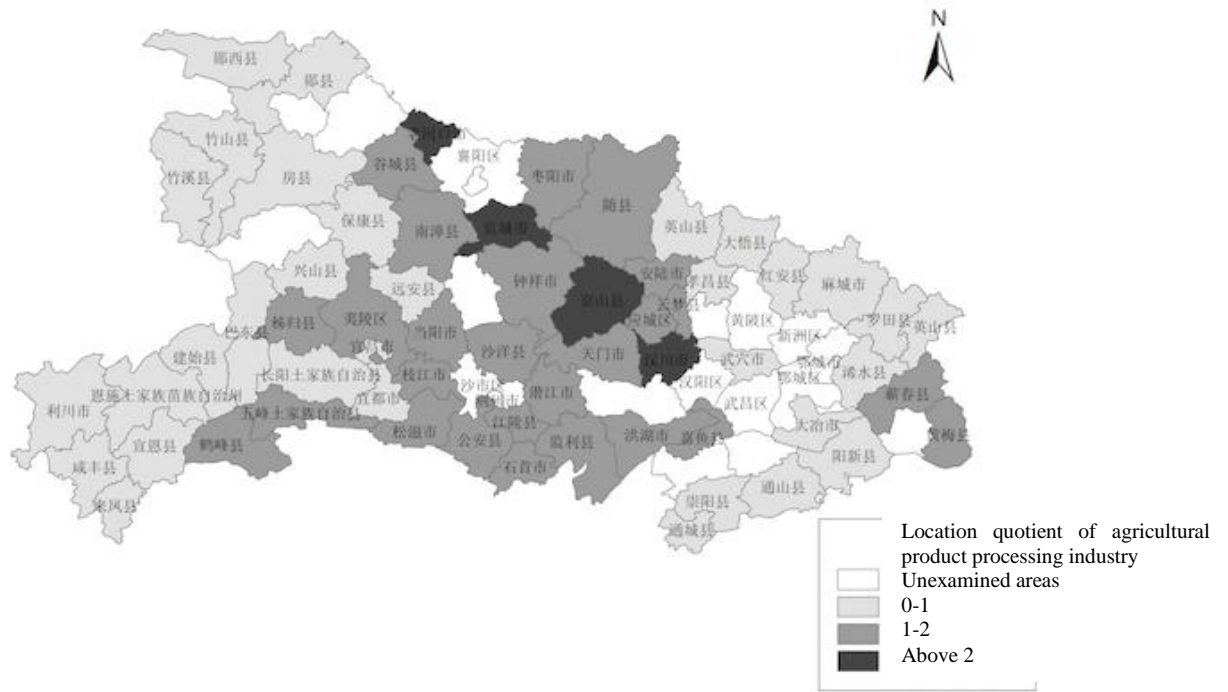
Fig. 1. Spatial distribution of agricultural product processing industry agglomeration in the counties of Hubei Province in 2012.
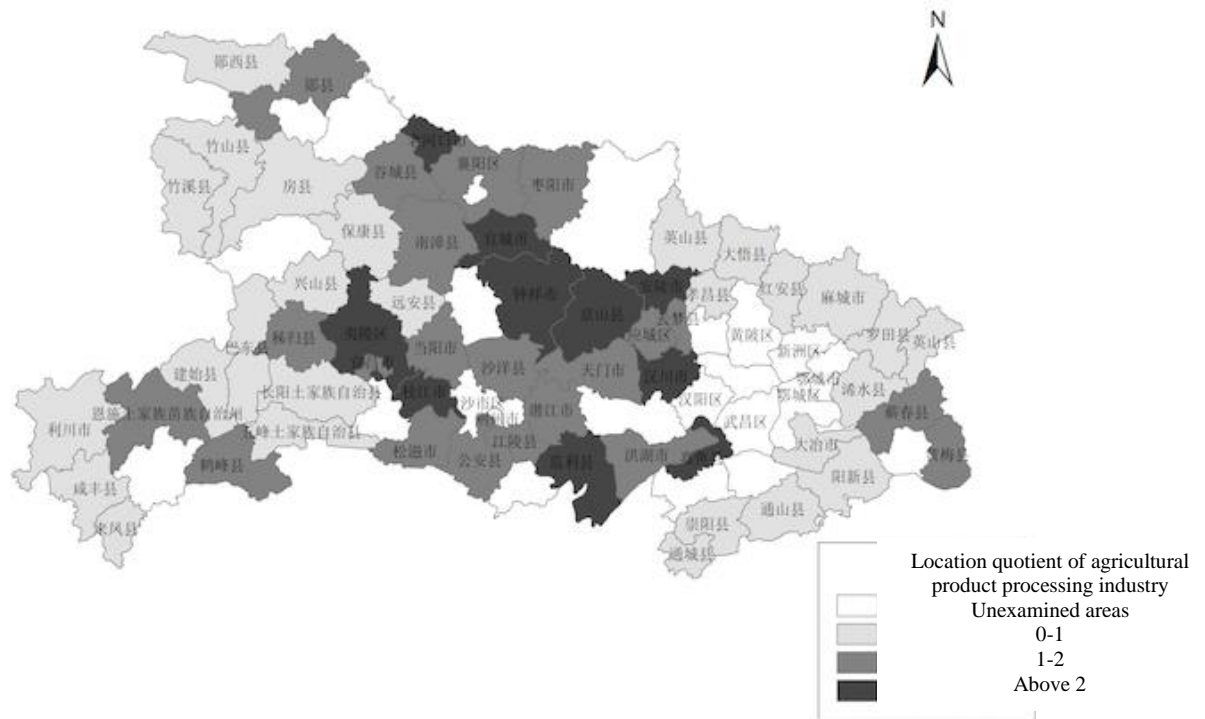

Fig. 2. Spatial distribution of agricultural product processing industry agglomeration in the counties of Hubei Province in 2016.

From "Table I", "Fig. 1" and "Fig. 2", it can be found that the county agglomeration of agricultural product processing industry in Hubei Province is more obvious, showing a steady upward trend. From 2012 to 2016, the agglomeration of 66 counties (cities and districts) examined in this paper increased from 34 to 37, accounting for more than half. On the whole, the agglomeration of agricultural product processing industry in each county has great regional

differences, showing a spatial pattern of "high in the middle, low in the east and west". The counties (cities and districts) with higher concentration of agricultural product processing industry are mainly concentrated in the Jianghan Plain in the central part of Hubei province and the hilly areas of northern Hubei province. The counties (cities and districts) with lower concentration are generally concentrated in the Wuling Mountains in southwestern Hubei province, the Qinba Mountains in southwestern Hubei province and the Dabie Mountains in eastern Hubei province. As can be seen from "Table I", in the counties (cities and districts) observed in 2016, 13 counties in plain area (cities and districts) all formed the agglomeration.[1] Among 18 hilly counties, there is the agglomeration in 12 counties (cities and districts) produce, accounting for 67%. Among 35 mountain counties (cities and districts), there is the agglomeration in 12 counties, accounting for 34%. Plains and hilly areas are relatively flat, densely populated, and rich in agricultural product resources, labor resources, land resources and transportation advantages, facilitating enterprise agglomeration and development. From the overall trend of change, from 2012 to 2016, the four counties with new agglomeration (cities and districts) are from mountainous areas, namely Yunyang District, Yidu City, Guangshui City and Enshi City. Since the implementation of "four batches" in Hubei province, the whole province has vigorously developed agricultural product processing industry. Plain and hilly counties have taken the lead in forming enterprise cluster development because of their own geographical advantages. In recent years, mountainous counties have made great efforts to catch up with each other. Through increasing policy support, we encourage the one-stop development of characteristic agricultural products in mountainous areas, namely "production — processing — sale", with a strong momentum for the development of agro-industrial processing industry.

III. AGRICULTURAL PRODUCT PROCESSING INDUSTRY BASED ON EMPIRICAL ANALYSIS OF COUNTY ECONOMIC GROWTH

A. *Model Construction, Variable Description and Data Source*

1) Model construction: After confirming the existence of geographical agglomeration of agricultural product processing industry in Hubei province and analyzing the geographical distribution characteristics of agglomeration, this paper further explores the impact of agricultural product processing industry agglomeration on county economic growth. In the study of the relationship between industrial agglomeration and economic growth, the C-D function is the most classical and commonly used method. This paper still uses the C-D function as the basis to estimate the economic effect of agricultural product processing industry agglomeration, and introduces the agricultural product processing industry agglomeration index to construct the county production function as follows:

$$Y_{it} = A L_{it}^{\alpha} K_{it}^{\beta} L Q_{IT}^{\beta} \tag{2}$$

Among them, Y_{it} and L_{it}, K_{it}, LQ_{IT} represent GDP, labor input, capital input and agricultural product processing industry agglomeration in i county of Hubei province in t year. A is the constant term. α, β and γ represent the output elasticity of labor force, capital and agricultural product processing industry agglomeration. In Formula (2), the control variables such as regional openness, social consumption capacity, financial environment and urbanization level are introduced, and the extended C-D function is established, which is transformed as the follows according to the value characteristics of each variable.[2]

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[1] According to the classification standard of "China County (City) Socio-economic Statistics Yearbook" in 2012, 66 counties (cities and districts) in Hubei province are divided into 13 plain counties, 18 hilly counties and 35 mountainous counties. Plain counties: Zhijiang City, Jianli County, Huangmei County, Tianmen City, Yunmeng County, Jiangling County, Jiayu County, Hanchuan City, Shishou City, Xiantao City, Gong'an County, Honghu City and Qianjiang City; Hilly counties: Daye City, Dangyang City, Xiangzhou District, Laohekou City, Zaoyang City, Yicheng City, Jingshan County, Shayang County, Zhongxiang City, Xiaochang County, Dawu County, Yingcheng City, Anlu City, Songzi City Tuanfeng County, Xishui County, Qichun County and Wuxue City; Mountainous Counties: Yangxin County, Zhuxi County, Yuan'an County, Wufeng County, Baokang County, Macheng City, Chibi City, Lichuan City, Xianfeng County, Yunxian County, Fangxian County, Xingshan County, Yidu City, Hong'an County, Tongcheng County, Suixian County, Jianshi County, Laifeng County, Yunxi County, Danjiangkou City, Zigui County, Nanzhang County, Luotian County, Chongyang County, Guangshui City, Badong County, Hefeng County, Zhushan County, Yiling District, Changyang County, Yingshan County, Tongshan County, Enshi City, Xuan'en County and Gucheng County.

[2] The agglomeration ratio of agricultural product processing industry (lq) to urbanization rate is specific value. And the other qualitative changes are logarithmic.

$$\ln y_{it} = \alpha + \beta_1 \cdot \ln l_{it} + \beta_2 \cdot \ln k_{it} + \beta_3 \cdot \ln lq_{it} + \beta_4 \cdot \ln open_{it} + \beta_5 \cdot$$

$$\ln comsume_{it} + \beta_6 \cdot \ln finnace_{it} + \beta_7 \cdot urban_{it} + \varepsilon_{it} \qquad (3)$$

2) Variable description: This paper mainly explains the relationship between the agglomeration of agricultural product processing industry and the growth of county economy based on C-D model. Therefore, the main variables of this paper include county economic development level, agricultural product processing industry agglomeration, capital input and labor input. According to the government's economic policy factors, new economic geography and existing research results, this paper selected regional openness, social consumption capacity, financial environment, urbanization level and other factors affecting economic growth as control variables.

a) The level of county economic development: The traditional index to measure the level of economic development is gross national product (GNP). In order to eliminate the price factor and increase the comparability of data, the GDP of each county (city, district) is selected as the explained variable. This paper takes the year of 2012 as the base period, and uses GDP deflator to calculate the real GDP in each county.

b) The agglomeration ratio of Agricultural product processing industry: The author calculates location quotient index of agricultural product processing industry in counties (cities and districts) of Hubei province.

c) Capital input: This paper selects the social fixed assets investment measurement, and takes the year of 2012 as the base period, and uses the fixed assets price deflation index to convert.

d) Labor input: It is measured by the total of quantity of labor force of primary, secondary and tertiary in counties (cities and districts) at the end of the year (the number of employed persons in the whole society).

e) Consumer power of society: In view of the availability of county data, this paper uses the total retail sales of social consumer goods to measure the market demand of each county (city, district).

f) Regional openness: It is measured by the total amount of foreign trade exports, and the amount of foreign trade exports is converted into RMB at the current exchange rate.

g) Financial environment: As an important factor affecting regional economic development, the better financial environment will be more conducive to the prosperity of regional industries and the faster development of regional economics. This paper chooses the loan balance of various financial institutions at the end of the year to reflect the local financial environment.

h) Urbanization: In this paper, the urbanization level is introduced into the regression model. The urbanization level is the urban population at the end of the year to the permanent population at the end of the year.

3) Data sources: On the basis of data integrity, this paper strives to extend the inspection period. Hubei Statistical Yearbook began to count the output value of agricultural product processing industry in various counties in 2012. Statistics Yearbook of County Statistics in China covers only 66 counties (cities and districts) in Hubei province. The research data selected in this paper are county-level panel data of 66 counties (cities and districts) in Hubei province from 2012 to 2016. Among them, the main indicators involved are from Hubei Statistical Yearbook, Hubei Rural Statistical Yearbook, China County Statistical Yearbook and the statistical bulletins of national economic and social development of counties over the years.

TABLE II.   DATA DESCRIPTIVE STATISTICS

Symbol	Variable name	Observed value	Standard deviation	Minimum value	Maximum	Expected direction
GDP	County GDP	330	131.683	34.97	595.34	
lq	Agglomeration ratio of agricultural processing industry	330	1.2863	0.112	3.315	Positive direction
Invest	capital input	330	181.647	18.86	736.142	Positive direction
Labor	Labor force input	330	4425.054	8.76	102.35	Positive direction
Urban	Urbanization	330	7.464	27.49	64.33	Positive direction
Open	opening degree	330	7.623	0.098	42.927	Positive direction
Finnace	financial environment	330	60.629	11.365	624.00	Positive direction
Consum	consumer power of society	330	51.498	11.74	297.31	Positive direction

B. Empirical Analysis of the Agglomeration of Agricultural Products Processing Industry on County Economic Growth

This paper uses panel data and stata14.0 software to estimate the impact of agricultural product processing industry agglomeration on county economic growth and take Hausman test. It shows that P value (Prob > chi2 = 0.000) is far below 5%. Fixed effect model should be adopted. However, considering that panel data still have simultaneous cross-sectional correlation, inter-group heteroscedasticity and intra-group autocorrelation, this paper adopts Breusch-Pagan LM test for simultaneous cross-sectional correlation, Wald test for inter-group heteroscedasticity and Wald test for intra-group autocorrelation, respectively. The P value of statistics is 0.0000, indicating that there are significant simultaneous cross-sectional correlation, inter-group heteroscedasticity and intra-group autocorrelation. Based on the methods of Reed et al. (2011), a robust feasible generalized least square (FGLS) method is used to estimate the parameters of these problems. The regression results are shown in "Table III". Model 1 and Model 2 introduce main explanatory variables one by one. Model 3 includes all explanatory variables.

TABLE III. FGLS REGRESSION RESULTS OF AGRICULTURAL PRODUCT PROCESSING INDUSTRY AGGLOMERATION ON COUNTY ECONOMIC GROWTH

Variable	Model 1	Model 2	Model 3
lq	0.5611***	1.0357***	0.3263***
	(0.04391)	(0.1642)	(0.0652)
Lq2		-0.1549***	-0.0627***
		(0.0517)	(0.0199)
Lq1			
lninvest			0.4449***
			(0.0408)
lnlabor			0.0242
			(0.0161)
lnopen			0.1050***
			(0.0150)
lnfinnace			0.0123
			(0.0341)
lnconsume			0.1415***
			(0.0483)
urban			0.0168***
			(0.0026)
_cons	4.2747***	3.9993***	0.8931***
	(0.0646)	(0.1118)	(0.1105)
district			yes
year			yes
wald	163.24	176.66	3239.22

a. Note: The values in brackets are standard errors, and *,** and *** indicate P < 0.1, P < 0.05 and P < 0.01, respectively.

*1) Agricultural product processing industry agglomeration:*The regression results of model 1, model 2 and model 3 show that the agglomeration of agricultural product processing industry is positively correlated with county economy, and all pass the 1% significance level test, which is in line with the expectation of this paper. The square term of agricultural product processing industry agglomeration is negatively correlated with county economy. The regression results show that the impact of agricultural product processing industry agglomeration on economic growth is inverted U-shaped. The conclusion confirms the Williamson hypothesis in agricultural product processing industry. The economy in the early stage of agglomeration increases with agglomeration ratio, while the economy in the late stage of agglomeration decreases with agglomeration ratio. The conclusions of this paper are consistent with the conclusions of the scholars (such as Wu Xiaoming, 2017; Shao Yihang, 2017; Li Jun, 2018, etc). However, from the overall county data of Hubei province, the agglomeration ratio of agricultural product processing industry in each county (city, district) of Hubei province has not reached the critical value of "crowding effect", and the agglomeration of agricultural product processing industry can significantly promote economic growth.

2) Capital input, consumer power of society and the degree of openness: The regression results of model 3 show that capital input, consumer power of society and the degree of openness have significant positive effects on county economic growth, and it has passed the 1% significance level test, which is in line with the expectations of this paper. This means that investment, consumption and opening up, the traditional Troika driving economic growth, are still the strong driving force of county economic growth, which is consistent with the reality of county development.

3) Labor input: The regression results of model 3 show that the input of county labor force has no significant effect on county economic growth, which is not in line with the expectations of this paper. The possible reasonable explanation is due to the "homogeneity" of county labor

force. At present, the county economy is mostly supported by traditional industries. The traditional industries with low technology content, low innovation and low employment threshold have caused vicious competition of "homogeneity" labor force, and even have adverse factors for economic growth.

4) Financial environment: The regression results of model 3 show that the county financial environment has no significant impact on the county economy, which is inconsistent with the expected results. It is related to the current situation of the county financial industry development. At present, the main business of the financial industry in the county is to absorb and store, and the loan business is often carried out in the more developed areas. It is difficult for the county finance to play its service and support role in the county economic growth.

5) Urbanization: The regression results of model 3 show that urbanization rate has a significant positive impact on county economy, and it has passed the 1% significance level test, which is in line with the expectations of this paper. Urbanization, as one of the new economic geography factors, is an important product of industrial agglomeration and economic development. The rural surplus labor forces transfer to non-agricultural production in cities and towns, which has improved the labor productivity of the whole society and provided strong support for the balanced and full development of the economy.

IV. CONCLUSION

This paper uses location quotient to measure the agglomeration of agricultural product processing industry in 66 counties (cities and districts) of Hubei province from 2012 to 2016, and empirically studies the impact of agglomeration of agricultural product processing industry on the economic growth of counties in Hubei province as a whole and in different terrain regions. The main conclusions are as follows. Firstly, from the spatial distribution of agglomeration, the agglomeration of agricultural product processing industry in Hubei province has distinct regional differences. According to the location quotient value of agricultural product processing industry in 66 counties (cities and districts) of Hubei province, the agglomeration ratio of Jianghan Plain and Northern Hubei hilly land is relatively high, and the agglomeration trend of agricultural product processing industry in Hubei province is generally "high in the middle, low in the east and west". Secondly, on the whole, the agglomeration of agricultural product processing industry has a significant positive impact on county economy, but it shows an inverted U-shaped relationship. The improvement of the agglomeration ratio of agricultural product processing industry in the early stage will effectively promote the development of county economy. When the agglomeration ratio of agricultural product processing industry reaches a certain degree, the agglomeration will restrain the growth of county economy.

According to the conclusions of this study, the following policy implications are put forward. First is to accelerate the promotion of agricultural product processing industry, increase capital investment and infrastructure construction, provide convenient conditions for cluster development of agricultural product processing industry, and further release the externality of agricultural product processing industry agglomeration to economic growth. Second is to give full play to the government's macro-control ability, adopt differentiated agglomeration policy, optimize the geographical distribution of agricultural product industry in plain, hilly and mountainous counties, and create conditions for balanced and coordinated development of county dynamic economy. Third is to establish a moderate agglomeration scale and focus on improving the agglomeration quality of agricultural product processing industry, so as to avoid the "crowding effect" of excessive agglomeration and restrain economic growth.

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