Evaluation on Synergetic Development of Guangxi Automobile Manufacturing Industry Cluster and Regional Logistics - Analysis Based on Synergetic Theory

Zhi-ping LU and Juan-li ZHU*

School of Economics and Management, Guangxi University of Science and Technology, Liuzhou, Guangxi, China

*Corresponding author

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Abstract. Based on the synergetic theory, with Guangxi automobile manufacture industrial cluster and regional logistics as the research object in this paper. From the aspects of scale, management and sustainable development to build index system and the appraisal model of collaborative development, quantitative analysis the synergetic development of regional logistics and automobile manufacture industry cluster of Guangxi.

Introduction

In recent years, with the development of industry cluster, the relationship between regional logistics and industrial clusters has been widely concerned by scholars. Pei Binghe (2014) taking Quanzhou city of Fujian province as an example analyzed the development status of Quanzhou industrial cluster and regional logistics as well as the impact of Quanzhou industrial cluster on regional logistics, and pointed out that Quanzhou industrial cluster economy developed rapidly, and the development of Quanzhou logistics industry was far from meeting the needs of industrial cluster economic development

Guang Guanguan (2015) analyzes three kinds of development mechanisms and modes of development, summarize different development paths for different mechanisms

Liu Ping, He Wu et al. (2015) analyzed the connotation and mode of logistics chain integration of trade circulation industry cluster and pointed out that the integration of information and logistics in trade circulation could promote the upgrading of trade circulation industry cluster

Gao Xing and Peng Pin (2017) made qualitative analysis on the linkage development between Jiangxi furniture industry cluster and regional logistics by using the grey correlation model, and pointed out that Jiangxi furniture industry cluster has a high correlation and coordination with regional logistics

Gong Xianwen (2017) analyzed the degree of integration between Chongqing regional logistics and other industries by using the integration coordination degree model, and found that the collaborative development of Chongqing regional logistics and manufacturing industry was at a barely collaborative level. Due to the different research methods and selected research areas, the conclusions obtained by various scholars are not the same. So, based on previous research, this paper using synergetic theory measures the degree of synergy between Guangxi automobile manufacturing industry cluster and regional logistics.

Analysis of Automobile Manufacturing Industry Cluster and Regional Logistics Synergetic Development

Selection of Order Parameter Index

According to synergetic theory, each system with different properties and spontaneous movement has a cooperative and interactive relationship in the overall environment. When the evolution of system from disorder to order, the dominant order parameter plays an important role in promoting the cooperative development of subsystems. According to the characteristics of the automobile manufacturing industry and the rule of cluster development from the aspects of scale, operational, sustainable three respectively choose automobile industrial output: added value of auto industry,
auto production, auto industry enterprise profit, number of fixed assets investment, waste water and waste gas treatment facilities as a measure of order parameter of automobile manufacturing industry cluster in this paper. According to the rules of regional logistics, the length of transportation routes, the volume of goods and vehicles, the volume of freight volume, the volume of freight turnover, the investment in fixed assets, and the proportion of logistics expenses in GDP are selected as the order parameters to measure the order degree of regional logistics from three aspects of scale, operation and sustainable development.

Synergy Model

Order Degree Analysis. According to the principle of synergetic theory, the order parameter of the automobile manufacturing industry cluster’s subsystem is $P = (P_1, P_2, P_3 \cdots P_m)$, where $p_1, p_2, p_3 \cdots p_m$ is the positive index, which is positively correlated with the order degree of the subsystem of automobile manufacturing industry cluster. $P_{k+1} \cdots P_m$ is a reverse indicator, which is negatively correlated with the order degree of subsystem of automobile manufacturing industry cluster, the larger the value is, the lower the order degree of the system will be. The order degree of the order parameter component of the subsystem of automobile manufacturing industry cluster in the $j$th year can be obtained:

$$u(p_i) = \begin{cases} 
\frac{p_i - \beta_i^{(1)}}{\alpha_i^{(1)} - \beta_i^{(1)}} & i \in [1, k] \\
\frac{\beta_i^{(1)} - p_i}{\alpha_i^{(1)} - \beta_i^{(1)}} & i \in [k+1, m]
\end{cases}$$

(1)

The total contribution of order parameter to order degree of subsystem of automobile manufacturing industry cluster is $u(P_i)$. The linear weighted summation method be adopted in this paper:

$$\mathbf{u}^{(1)}(P) = \sum_{i=1}^{m} \theta_i^{(1)} \{u(p_i)\}, \theta_i^{(1)} > 0, \sum_{i=1}^{m} \theta_i^{(1)} = 1$$

(2)

So, the order parameter of regional logistics subsystem is $Q = (Q_1, Q_2 \cdots Q_m)$, $Q_i = (q_{i1}, q_{i2}, \cdots q_{ij})^T$, $j \in [1, n]$, $\beta_i^{(2)} \leq q_i \leq \alpha_i^{(2)}$. The order degree of the order parameter component of the regional logistics system in $j$th year is:

$$u(q_{ij}) = \begin{cases} 
\frac{q_{ij} - \beta_i^{(2)}}{\alpha_i^{(2)} - \beta_i^{(2)}} & i \in [1, k] \\
\frac{\beta_i^{(2)} - q_{ij}}{\alpha_i^{(2)} - \beta_i^{(2)}} & i \in [k+1, m]
\end{cases}$$

(3)

The total contribution of order parameter $Q$ to the order degree of regional logistics system is:

$$\mathbf{u}^{(2)}(Q) = \sum_{i=1}^{m} \theta_i^{(2)} \{u(q_{ij})\}, \theta_i^{(2)} > 0, \sum_{i=1}^{m} \theta_i^{(2)} = 1$$

(4)
**Weight Analysis.** The weights of \( \theta_i \) are determined by the incidence matrix method, \( r_{il} \) represents the correlation degree between subsystem indicators \( i \) and indicators \( l \). So, the incidence matrix of each index of the subsystem is:

\[
R = \begin{bmatrix}
    r_{11} & r_{12} & \cdots & r_{1m} \\
    r_{21} & r_{22} & \cdots & r_{2m} \\
    \vdots & \vdots & \ddots & \vdots \\
    r_{m1} & r_{m2} & \cdots & r_{mm}
\end{bmatrix}
\]

\[ (1) \]

\[
r_{ij} = \frac{\text{cov}(X_i, X_j)}{\sqrt{D(X_i)} \cdot \sqrt{D(X_j)}} \quad (i, l = 1, 2, \cdots m)
\]

\[ (2) \]

\[
r_{ij} = 1 \quad X_i \text{ and } X_j \text{ are the } i \text{ and } l \text{ column vectors. Meanwhile, } R_i \text{ is defined as the sum of the correlation degree between the index } i \text{ and the other three indexes.}
\]

If \( R_i \) is larger, it indicates that the index \( i \) plays a larger role in the whole index system. Therefore, the definition of order degree assigns greater weight to the corresponding order parameter of the index \( i \). When \( R_i \) be normalized, we can obtain that:

\[
\theta_i = \frac{R_i}{\sum_{i=1}^{n} R_i} \quad (i = 1, 2, \cdots n)
\]

\[ (3) \]

**Construction Collaborative Degree Model.** At the initial moment \( T_0 \), we set the order degree of order parameter \( P \) of the subsystem of automobile manufacturing industry cluster as \( u_0^{(1)}(P) \), the order degree of order parameter \( Q \) of regional logistics subsystem is \( u_0^{(2)}(Q) \). It takes time to reach the moment \( T_1 \), the order degree of two system order parameters is \( u_1^{(1)}(P) \) and \( u_1^{(2)}(Q) \). If \( u_1^{(1)}(P) - u_0^{(1)}(P) > 0 \) and \( u_1^{(2)}(Q) - u_0^{(2)}(Q) > 0 \) are both true at the same time, it shows that two systems develop cooperatively during the period of time \( T_0 \) to \( T_1 \). Therefore, the synergy degree is:

\[
U = \lambda \sqrt{|u_1^{(1)}(P) - u_0^{(1)}(P)| \cdot |u_1^{(2)}(Q) - u_0^{(2)}(Q)|} \quad U \in [-1, 1]
\]

\[ (4) \]

\[
\lambda = \begin{cases} 
1 & u_1^{(1)}(P) - u_0^{(1)}(P) > 0 \text{and } u_1^{(2)}(Q) - u_0^{(2)}(Q) > 0 \\
-1, & \text{others}
\end{cases}
\]

The \( U \) closer to 1, indicates that the degree of cooperation between automobile cluster industry and regional logistics is higher.

**Empirical Analysis**

According to the indexes selected above, select relevant data from *Guangxi Statistical Yearbook* and *China auto industry statistical Yearbook*, which are shown in table 1 and table 2 and used Matlab R2015 to conduct empirical analysis on the data in this paper.
### Table 1. Indicator data of Guangxi automobile manufacturing industry cluster.

<table>
<thead>
<tr>
<th>Years</th>
<th>Total industrial output value ($P_1$ million)</th>
<th>Total asset ($P_2$ million)</th>
<th>Main business income ($P_3$ million)</th>
<th>Total Profit ($P_4$ million)</th>
<th>Investment in fixed assets ($P_5$ million)</th>
<th>Number of waste water and waste gas treatment facilities ($P_6$ set)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>62487.22</td>
<td>39171.54</td>
<td>62487.22</td>
<td>2631.71</td>
<td>5893.83</td>
<td>104</td>
</tr>
<tr>
<td>2009</td>
<td>95861.82</td>
<td>60758.24</td>
<td>93229.39</td>
<td>4497.83</td>
<td>9578.86</td>
<td>116</td>
</tr>
<tr>
<td>2010</td>
<td>126657.76</td>
<td>82431.77</td>
<td>124376.04</td>
<td>7063.79</td>
<td>13829.46</td>
<td>114</td>
</tr>
<tr>
<td>2011</td>
<td>139607.08</td>
<td>98479.12</td>
<td>140979.17</td>
<td>7773.21</td>
<td>21540.40</td>
<td>111</td>
</tr>
<tr>
<td>2012</td>
<td>158979.01</td>
<td>98412.73</td>
<td>150645.52</td>
<td>7140.83</td>
<td>26103.12</td>
<td>109</td>
</tr>
<tr>
<td>2013</td>
<td>191029.87</td>
<td>119571.01</td>
<td>178078.51</td>
<td>8326.82</td>
<td>26139.59</td>
<td>110</td>
</tr>
<tr>
<td>2014</td>
<td>215520.67</td>
<td>130838.66</td>
<td>196207.88</td>
<td>9657.53</td>
<td>30910.25</td>
<td>111</td>
</tr>
<tr>
<td>2015</td>
<td>245480.20</td>
<td>150360.43</td>
<td>229838.37</td>
<td>10331.59</td>
<td>41355.23</td>
<td>114</td>
</tr>
<tr>
<td>2016</td>
<td>268878.12</td>
<td>168830.37</td>
<td>252917.88</td>
<td>11515.54</td>
<td>42990.59</td>
<td>124</td>
</tr>
<tr>
<td>2017</td>
<td>282975.60</td>
<td>17469.05</td>
<td>258672.05</td>
<td>12365.22</td>
<td>51809.43</td>
<td>177</td>
</tr>
</tbody>
</table>

### Table 2. Regional Logistics Index Data of Guangxi.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mileage of transportation route ($Q_1$ km)</th>
<th>Cars ownership ($Q_2$ unit)</th>
<th>Freight ($Q_3$ million tons)</th>
<th>Freight turnover ($Q_4$ million tons/km)</th>
<th>Fixed asset investment ($Q_5$ million)</th>
<th>Logistics costs as a percentage of GDP ($Q_6$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>112034</td>
<td>244800</td>
<td>84950</td>
<td>221023</td>
<td>40429.45</td>
<td>4.8</td>
</tr>
<tr>
<td>2009</td>
<td>114060</td>
<td>368200</td>
<td>95076</td>
<td>236562</td>
<td>83188.33</td>
<td>4.9</td>
</tr>
<tr>
<td>2010</td>
<td>114222</td>
<td>368200</td>
<td>95076</td>
<td>292677</td>
<td>109354.02</td>
<td>5</td>
</tr>
<tr>
<td>2011</td>
<td>117291</td>
<td>429000</td>
<td>113445</td>
<td>347823</td>
<td>108549.77</td>
<td>5</td>
</tr>
<tr>
<td>2012</td>
<td>120355</td>
<td>429000</td>
<td>136143</td>
<td>411064</td>
<td>133152.46</td>
<td>4.8</td>
</tr>
<tr>
<td>2013</td>
<td>126367</td>
<td>557400</td>
<td>161368</td>
<td>385637</td>
<td>100665.25</td>
<td>4.7</td>
</tr>
<tr>
<td>2014</td>
<td>131361</td>
<td>573300</td>
<td>151155</td>
<td>386991</td>
<td>119268.66</td>
<td>4.7</td>
</tr>
<tr>
<td>2015</td>
<td>136453</td>
<td>587100</td>
<td>137794</td>
<td>406182</td>
<td>146642.21</td>
<td>4.8</td>
</tr>
<tr>
<td>2016</td>
<td>139157</td>
<td>621300</td>
<td>149727</td>
<td>406182</td>
<td>184520.54</td>
<td>4.7</td>
</tr>
<tr>
<td>2017</td>
<td>142081</td>
<td>684500</td>
<td>160774</td>
<td>461332</td>
<td>202631.58</td>
<td>4.6</td>
</tr>
</tbody>
</table>

According formulas (1) to (8), the synergy degree between Guangxi automobile manufacturing industry cluster and regional logistics is calculated, as shown in table 3.

### Table 3. Order degree of automobile manufacturing industry cluster and regional logistics.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Order degree automobile manufacturing industry cluster</td>
<td>0.148</td>
<td>0.234</td>
<td>0.354</td>
<td>0.44</td>
<td>0.469</td>
<td>0.510</td>
<td>0.6278</td>
<td>0.732</td>
<td>0.789</td>
<td>0.891</td>
</tr>
<tr>
<td>Regional logistics order degree</td>
<td>0.032</td>
<td>0.167</td>
<td>0.224</td>
<td>0.355</td>
<td>0.538</td>
<td>0.639</td>
<td>0.7067</td>
<td>0.755</td>
<td>0.877</td>
<td>1</td>
</tr>
<tr>
<td>Synergy degree</td>
<td>-</td>
<td>0.178</td>
<td>0.082</td>
<td>0.105</td>
<td>0.072</td>
<td>0.064</td>
<td>0.089</td>
<td>0.072</td>
<td>0.83</td>
<td>0.112</td>
</tr>
</tbody>
</table>
Summary and Conclusion

Through empirical analysis, the result show that the order degree of Guangxi automobile manufacturing industry cluster and regional logistics have been continuously improved from 2008 to 2017, indicating that the automobile manufacturing industry cluster and regional logistics have gradually developed from disorder to order. However, the synergy degree between them are still at a lower level. As the economy turn to high quality development, the government of Guangxi pay more attention to the environment protection. So, joined the waste water, waste gas treatment facilities in residential index to measure the automobile industry cluster in Guangxi in environmental protection investment is an innovation.

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