Grey Correlation analysis Between the Throughput of Port Goods and GDP in Guangdong Province

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Abstract: By showing the current situation of Guangdong's port cargo throughput and GDP and the determination of the correlation degree between GDP and port cargo throughput, this paper uses the grey correlation degree to obtain the relationship between Guangdong's port cargo throughput and GDP, and studies and analyzes the relationship between the cargo throughput of some major cities and the growth of Guangdong's GDP.

1. Introduction

The construction of port facilities is closely related to the throughput of port goods. At the same time, the good development of port construction also affects the development of a region or even a country's GDP. With the rapid economic development of Guangdong Province, the growth rate of port cargo throughput is gradually accelerating, and the economic growth driven by the development of port is gradually recognized by the government [1-2]. By analyzing the situation of container transportation in the port and using quantitative indicators, he systematically analyzed the balance of supply and demand, as well as the future development trend. Through the gray correlation analysis of port cargo throughput, the correlation degree with the growth of GDP can let you know that if a city, a region, a country's economy wants to develop rapidly, the port cargo throughput has a greater impact.

2. Basic Theory

2.1 Port Throughput Status

The throughput of port cargo transportation refers to the total amount of all goods transported in and out by sea every year. The throughput of port goods transportation is an important index reflecting the effect of port operation. The port plays an important role in the transportation industry system of our country, and also plays a pivotal role in the transportation of various resources. The transportation throughput of port goods can promote the development of trade and society rapidly, and support the economy and GDP of Guangdong Province [3]. There are many industries that can make social development and national economic progress, in which the port plays an important role.

2.2 Current Situation of GDP

The two important influencing factors of GDP are volume change and value change. With the continuous change and development of value economy, the value economy of various industries will change constantly. In order to more accurately show the impact of these changes on value economy, GDP will be re calculated and updated in the first quarter or one year, that is to say, GDP is one that can reflect the change of value Index system.

2.3 Determination of the Correlation between GDP and Port Cargo Throughput

The measurement of the size of the internal relations of each system, their changes with time and the influence of various factors, is called relevance. In the process of development, if there are similar trend changes among objects, that is, the change of large specifications with the same trend change, the degree of correlation between them is relatively high; otherwise, it is relatively low. According to the given comparison sequence, the gray correlation system evaluates the proximity of

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the reference sequence and the comparison sequence by analyzing the correlation between the calculated reference sequence and the evaluation scale of each comparison sequence.

3. An analysis of the Relationship between Port Cargo Throughput and GDP

3.1 Research Data of Port Cargo Throughput and GDP

3.1.1 Cargo Throughput and GDP Statistics of 11 Major Cities

As shown in Table 1, Y represents the regional GDP of Guangdong Province; Y1 represents the port cargo throughput of Guangzhou City; Y2 represents the port cargo throughput of Shenzhen city; Y3 represents the port cargo throughput of Zhuhai City; Y4 represents the port cargo throughput of Shantou City; Y5 represents the port cargo throughput of Foshan City; y6 represents the port cargo throughput of Huizhou City; Y7 represents the port cargo throughput of Dongguan City Quantity; Y8 refers to the cargo throughput of Zhongshan port; Y9 refers to the cargo throughput of Zhanjiang port; Y10 refers to the cargo throughput of Maoming port; Y11 refers to the cargo throughput of Jiangmen port [4-6].

3.1.2 Trend Chart of Cargo Throughput of Major Cities with Time

As can be seen from the trend chart of cargo throughput change in major cities, the trend of throughput change is shown in Figure 1. The cargo throughput of each port shows an upward trend with the change of time, of which the cargo throughput of Dongguan port is the most obvious, the cargo throughput of Maoming port is not particularly obvious, and the cargo throughput of Shantou port changes slowly, showing an overall trend Expansion direction.

3.2 Preprocessing of Original Data of Cargo Throughput in Each Port

3.2.1 Dimensionless Processing of the Original Data of Cargo Throughput of Each Port

As the throughput of cargo in each port can have a certain impact on the GDP of Guangdong Province, the initial value phase of each sequence is calculated, and the calculation formula and results of the initial value phase are shown in Table 2.

$y_i'=\frac{y_i}{y_i(1)}=$（y_i'（1）,y_i'（2）,…,y_i'（n））

i=0,1,2,…,m

Table 1 Data of GDP and port cargo throughput in 2002-2018.

Particular year	y	y_1	y_2	y_3	y_4	y_5
2002	13601.89	16772	8767	2340	1380	2990
2003	15959.25	19200	11220	2470	1470	3076
2004	19005.61	23887	13537	3203	1576	3798
2005	22723.29	27283	15351	3557	1736	3951
2006	26800.32	32816	17598	3561	2014	4417
2007	32063.91	37053	19994	3713	2301	4985
2008	37138.85	36954	21125	4086	2806	5155
2009	39923.24	37549	19365	4407	3102	5099

2010	46544.63	42526	22098	6056	3509	5410
2011	53908.59	44770	22325	7170	4005	5423
2012	57924.76	45125	22807	7745	5253	4563
2013	63357.92	47200	23398	10023	5038	5474
2014	68777.25	50008	22324	10703	5161	5907
2015	73876.37	52096	21706	11209	5181	6147
2016	80666.72	54437	21410	11779	4985	6610
2017	89705.23	59012	24136	13586	4890	7967
2018	97277.77	61313	25127	13799	3963	8973

Particular year	y_6	y_7	y_8	y_9	y_{10}	y_{11}
2002	956	1611	850	3586	1113	1942
2003	1098	2352	1478	3985	1262	1960
2004	1542	2600	1960	5096	1409	2023
2005	1515	2280	2072	6620	1360	2438
2006	2082	1951	2326	8173	1510	3318
2007	2324	2017	2752	9165	1676	4033
2008	2583	3208	2756	10404	1822	4025
2009	3811	3530	3401	11838	2122	4170
2010	4673	5657	4798	13638	2284	4965
2011	5170	6848	5485	15539	2307	5914
2012	5257	9228	5153	17092	2390	6211
2013	8045	11187	6876	18006	2370	6737
2014	6486	12900	7845	20238	2654	7352
2015	7013	13149	7319	22036	2685	7525
2016	7657	14584	6789	25612	2560	7923
2017	7214	15714	8044	28209	2491	8267
2018	8757	16417	11965	30185	2540	9369

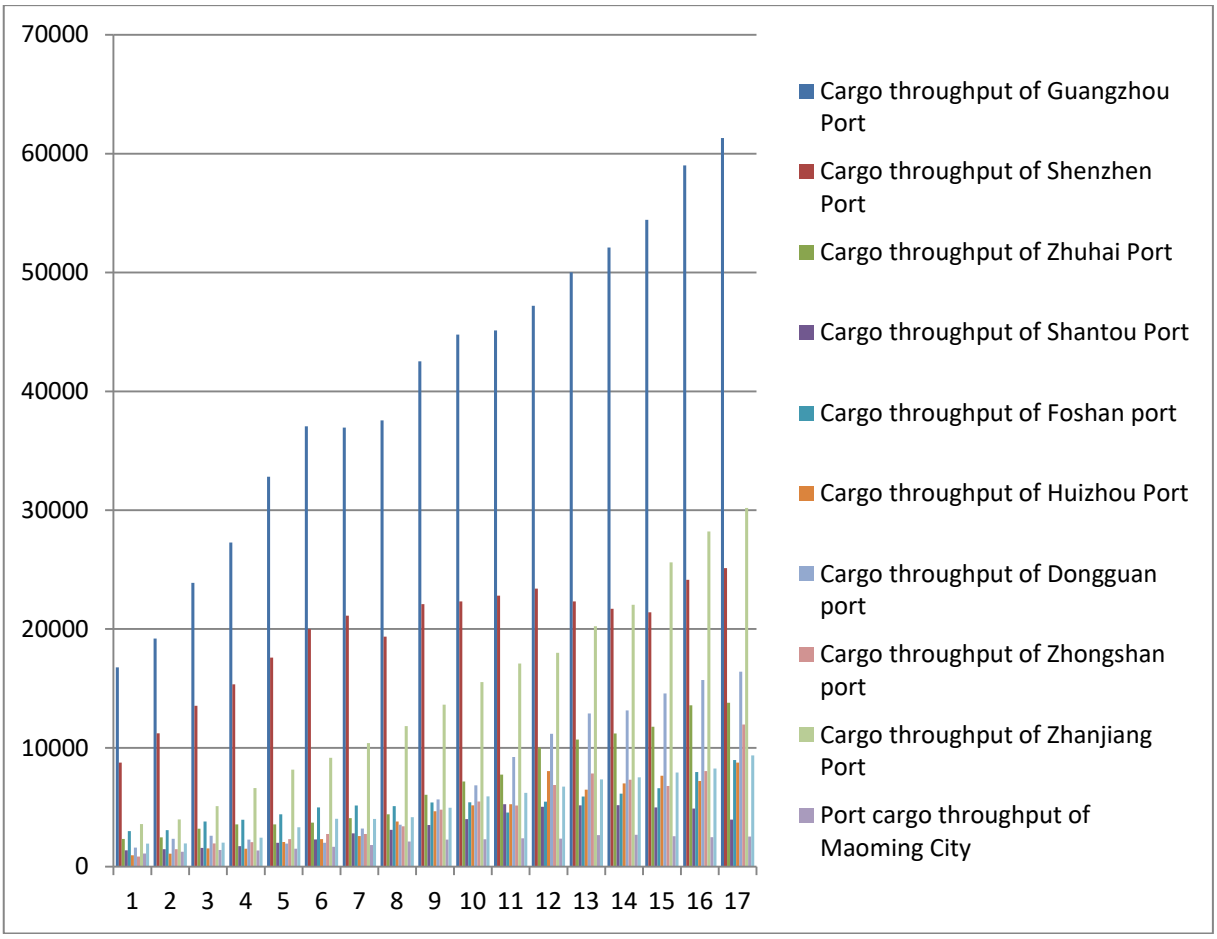

Figure 1 Change trend

Table 2 Initial data of GDP and cargo throughput of each port in 2002-2018.

Particular year	y_0'	y_1'	y_2'	y_3'	y_4'	y_5'
2002	1	1	1	1	1	1
2003	1.173311209	1.144765085	1.279799247	1.055555556	1.065217391	1.028762542
2004	1.397277143	1.424218936	1.544085776	1.368803419	1.142028986	1.270234114
2005	1.670597983	1.626699261	1.750998061	1.52008547	1.257971014	1.321404682
2006	1.970337946	1.956594324	2.007300103	1.521794872	1.45942029	1.477257525
2007	2.357312844	2.209217744	2.280597696	1.586752137	1.667391304	1.66722408
2008	2.730418346	2.203315049	2.409604198	1.746153846	2.033333333	1.724080268
2009	2.935124457	2.238790842	2.208851374	1.883333333	2.247826087	1.705351171
2010	3.421923718	2.535535416	2.520588571	2.588034188	2.542753623	1.809364548
2011	3.963316127	2.669329835	2.546481122	3.064102564	2.902173913	1.813712375
2012	4.258581712	2.690496065	2.601460021	3.30982906	3.806521739	1.526086957
2013	4.65802326	2.814214166	2.668871906	4.283333333	3.650724638	1.830769231

2014	5.056448038	2.98163606	2.546367058	4.573931624	3.739855072	1.975585284
2015	5.431331234	3.106129263	2.475875442	4.79017094	3.754347826	2.055852843
2016	5.930552298	3.245707131	2.442112467	5.033760684	3.612318841	2.210702341
2017	6.595056275	3.518483186	2.753051215	5.805982906	3.543478261	2.664548495
2018	7.151783318	3.655676127	2.866088742	5.897008547	2.87173913	3.001003344

Particular year	y_6'	y_7'	y_8'	y_9'	y_{10}'	y_{11}'
2002	1	1	1	1	1	1
2003	1.148535565	1.459962756	1.738823529	1.111266035	1.133872417	1.009268795
2004	1.612970711	1.613904407	2.305882353	1.421081985	1.265947889	1.041709578
2005	1.584728033	1.415270019	2.437647059	1.846068042	1.221922731	1.255406797
2006	2.177824268	1.211049038	2.736470588	2.279141104	1.356693621	1.708547889
2007	2.430962343	1.252017381	3.237647059	2.555772448	1.505840072	2.076725026
2008	2.701882845	1.991309745	3.242352941	2.901282766	1.637017071	2.072605561
2009	3.986401674	2.191185599	4.001176471	3.301171221	1.90655885	2.147270855
2010	4.888075314	3.511483551	5.644705882	3.803123257	2.052111411	2.556642636
2011	5.407949791	4.250775916	6.452941176	4.333240379	2.07277628	3.045314109
2012	5.498953975	5.728119181	6.062352941	4.766313441	2.147349506	3.198249228
2013	8.415271967	6.944134078	8.089411765	5.02119353	2.129380054	3.469104016
2014	6.784518828	8.00744879	9.229411765	5.643614055	2.384546271	3.785787848
2015	7.335774059	8.162011173	8.610588235	6.145008366	2.412398922	3.874871267
2016	8.009414226	9.052762259	7.987058824	7.142219743	2.300089847	4.079814624
2017	7.546025105	9.754189944	9.463529412	7.866424986	2.238095238	4.256951596
2018	9.160041841	10.19056487	14.07647059	8.417456776	2.282120395	4.824407827

3.2.2 Calculation of the absolute difference of cargo throughput of each port

Calculate the sequence of absolute difference of the difference within the corresponding component of the initial value data of Y and Yi

as follows:

$\triangle_i$（k）=|y_i'(k)-y_1'(k)|

$\triangle_i$=($\triangle_i$（1）, $\triangle_i$（2）,…)

i=1,2,…,m

(2)

Table 3 Absolute difference corresponding to the initial value of Guangdong's GDP and port cargo throughput in each city in 2002-2018.

Particular year	$\triangle y_1$	$\triangle y_2$	$\triangle y_3$	$\triangle y_4$	$\triangle y_5$	$\triangle y_6$
2002	0	0	0	0	0	0
2003	0.028546124	0.106488038	0.117755653	0.108093818	0.144548667	0.024775644
2004	0.026941793	0.146808633	0.028473724	0.255248158	0.127043029	0.215693568
2005	0.043898722	0.080400078	0.150512513	0.412626969	0.349193301	0.08586995
2006	0.013743622	0.036962157	0.448543074	0.510917656	0.493080421	0.207486322
2007	0.1480951	0.076715148	0.770560707	0.68992154	0.690088764	0.073649499
2008	0.527103297	0.320814149	0.9842645	0.697085013	1.006338079	0.028535501
2009	0.696333615	0.726273082	1.051791124	0.68729837	1.229773286	1.051277217
2010	0.886388302	0.901335147	0.83388953	0.879170095	1.612559169	1.466151596
2011	1.293986292	1.416835005	0.899213563	1.061142214	2.149603753	1.444633663
2012	1.568085647	1.657121691	0.948752652	0.452059973	2.732494755	1.240372263
2013	1.843809094	1.989151354	0.374689927	1.007298622	2.827254029	3.757248707
2014	2.074811978	2.510080979	0.482516414	1.316592965	3.080862753	1.728070791
2015	2.325201971	2.955455792	0.641160294	1.676983408	3.375478391	1.904442824
2016	2.684845167	3.488439831	0.896791614	2.318233458	3.719849957	2.078861928
2017	3.076573089	3.84200506	0.789073369	3.051578014	3.93050778	0.950968829
2018	3.496107191	4.285694576	1.254774771	4.280044188	4.150779974	2.008258523

Particular year	$\triangle y_7$	$\triangle y_8$	$\triangle y_9$	$\triangle y_{10}$	$\triangle y_{11}$
2002	0	0	0	0	0
2003	0.286651547	0.56551232	0.062045174	0.039438792	0.164042414
2004	0.216627264	0.90860521	0.023804842	0.131329255	0.355567565
2005	0.255327964	0.767049076	0.175470059	0.448675252	0.415191186
2006	0.759288908	0.766132643	0.308803159	0.613644325	0.261790057
2007	1.105295464	0.880334215	0.198459604	0.851472772	0.280587818
2008	0.739108601	0.511934595	0.17086442	1.093401275	0.657812785

2009	0.743938858	1.066052014	0.366046764	1.028565607	0.787853602
2010	0.089559833	2.222782164	0.381199539	1.369812307	0.865281081
2011	0.287459788	2.489625049	0.369924252	1.890539847	0.918002018
2012	1.469537469	1.803771229	0.507731729	2.111232206	1.060332484
2013	2.286110818	3.431388505	0.36317027	2.528643206	1.188919244
2014	2.951000752	4.172963727	0.587166017	2.671901766	1.27066019
2015	2.730679939	3.179257001	0.713677132	3.018932312	1.556459967
2016	3.122209961	2.056506525	1.211667445	3.630462451	1.850737674
2017	3.159133669	2.868473136	1.271368711	4.356961037	2.338104679
2018	3.038781548	6.92468727	1.265673458	4.869662923	2.327375491

3.2.3 Correlation analysis and determination of GDP and cargo throughput of each port

According to the calculated absolute difference, we can get the two pole difference of cargo throughput of each city in the past 17 years, that is, the maximum range is m, and the minimum range is m. The results are as follows:

$$M = \max \max \ \triangle_i(k)$$
$$m = \min \min \ \triangle_i(k) \quad (3)$$

M_y=6.92468727 m_y=0

According to the maximum range and the minimum range, the grey relational degree coefficient is obtained, where ε is the resolution coefficient, generally ε is 0.5, and the correlation coefficient is expressed in μ, and the calculation results of the correlation degree are as follows:

$$\mu_{01}（k）=\frac{m+\varepsilon M}{\triangle_i(k)+\varepsilon M}=\frac{3.462343635}{\triangle_i(k)+3.462343635} \quad (4)$$

Table 4 Relationship between GDP of Guangdong Province and port cargo throughput of various cities in 2002-2018.

Particular year	μ_1	μ_2	μ_3	μ_4	μ_5	μ_6
2002	1	1	1	1	1	1
2003	0.99182268	0.970161653	0.967108272	0.969725329	0.959924318	0.992895097
2004	0.992278708	0.959323237	0.99184325	0.931340456	0.964605923	0.941356339
2005	0.987479838	0.977305703	0.958339744	0.893514813	0.908385172	0.975799104
2006	0.996046238	0.989437289	0.885309111	0.87141101	0.875340693	0.943461598
2007	0.958981412	0.978323291	0.817959338	0.833844538	0.833810958	0.979171481
2008	0.867875596	0.915199374	0.778648248	0.83240847	0.774802024	0.991825698
2009	0.832558871	0.826607892	0.767000504	0.834371647	0.737906513	0.767087832
2010	0.796173157	0.793446037	0.805902171	0.797496876	0.682248265	0.702515367
2011	0.727944379	0.709616083	0.793831991	0.765414937	0.61695939	0.705596017
2012	0.688279954	0.676309617	0.784916812	0.884513704	0.558907822	0.73624342
2013	0.652514885	0.635118191	0.902349062	0.774635516	0.5504873	0.479576058
2014	0.625292818	0.579721614	0.877684783	0.724500851	0.529150913	0.667064968
2015	0.598240406	0.539490783	0.843752972	0.673695915	0.506351821	0.645142798

2016	0.563240165	0.498122787	0.794273047	0.598961588	0.482073282	0.624835804
2017	0.529498047	0.474011275	0.81439756	0.531529825	0.4683367	0.78452266
2018	0.497573917	0.446867135	0.73399549	0.447193258	0.45478621	0.632899914

Particular year	μ_7	μ_8	μ_9	μ_{10}	μ_{11}
2002	1	1	1	1	1
2003	0.9235391	0.859599666	0.98239548	0.988737509	0.954764217
2004	0.941117429	0.792126323	0.993171593	0.963455423	0.906868561
2005	0.931320463	0.818638484	0.951764968	0.885279191	0.892923931
2006	0.820143298	0.818815906	0.918114257	0.849448936	0.929704442
2007	0.758016025	0.797283095	0.945787962	0.80261729	0.925035277
2008	0.824082589	0.871188033	0.952971474	0.759995062	0.840342764
2009	0.823136259	0.764585055	0.90438625	0.77096718	0.814631285
2010	0.974785398	0.609017946	0.900820799	0.716521502	0.80005635
2011	0.923340038	0.581714021	0.903471192	0.64681842	0.790427037
2012	0.702033071	0.657475905	0.872110305	0.621206876	0.765551975
2013	0.602308614	0.502245165	0.905066279	0.577925428	0.744387863
2014	0.539865541	0.453464867	0.855003181	0.564428615	0.731531975
2015	0.559071606	0.521311627	0.829101154	0.534207101	0.689874303
2016	0.52582815	0.627366849	0.740764961	0.488148639	0.651663966
2017	0.522895945	0.54690315	0.731422482	0.442794312	0.596909661
2018	0.53257606	0.333333333	0.732303536	0.415547397	0.598015821

Table 5 Correlation between GDP and port cargo throughput.

Correlation between GDP and port cargo throughput	2002-2005	2006-2009	20010-2013	2014-2018
Guangzhou port cargo throughput	0.992895306	0.913865529	0.716228094	0.562769071
Shenzhen port cargo throughput	0.976697648	0.927391961	0.703622482	0.507642719
Zhuhai port cargo throughput	0.979322816	0.8122293	0.821750009	0.81282077
Shantou port cargo throughput	0.94864515	0.843008916	0.805515258	0.595176287
Foshan port cargo throughput	0.958228853	0.805465047	0.602150694	0.488139785
Huizhou Port cargo throughput	0.977512635	0.920386652	0.655982715	0.670893229
Dongguan port cargo throughput	0.948994248	0.806344543	0.80061678	0.53604746
Zhongshan port cargo throughput	0.867591118	0.812968022	0.587613259	0.496475965
Zhanjiang port cargo throughput	0.98183301	0.930314985	0.895367144	0.777719063
Maoming port cargo throughput	0.959368031	0.795757117	0.640618056	0.489025213
Jiangmen port cargo throughput	0.938639177	0.877428442	0.775105806	0.653599145

$\mu_{01}=\frac{1}{17}\sum_{k=1}^{17}\mu_{01}(k)=0.782694181$ $\mu_{02}=\frac{1}{17}\sum_{k=1}^{17}\mu_{02}(k)=0.762885998$

$\mu_{03}=\frac{1}{17}\sum_{k=1}^{17}\mu_{03}(k)=0.85395955$ $\mu_{04}=\frac{1}{17}\sum_{k=1}^{17}\mu_{04}(k)=0.786150514$

$\mu_{05}=\frac{1}{17}\sum_{k=1}^{17}\mu_{05}(k)=0.700239841$ $\mu_{06}=\frac{1}{17}\sum_{k=1}^{17}\mu_{06}(k)=0.79823495$

$\mu_{07}=\frac{1}{17}\sum_{k=1}^{17}\mu_{07}(k)=0.759062329$ $\mu_{08}=\frac{1}{17}\sum_{k=1}^{17}\mu_{08}(k)=0.679709966$

$\mu_{09}=\frac{1}{17}\sum_{k=1}^{17}\mu_{09}(k)=0.889332698$ $\mu_{10}=\frac{1}{17}\sum_{k=1}^{17}\mu_{10}(k)=0.707535228$

$\mu_{11}=\frac{1}{17}\sum_{k=1}^{17}\mu_{11}(k)=0.801922907$

It can be seen from the above that in 2002-2005, the correlation between GDP and port cargo throughput is: Y1 Guangzhou City > Y9 Zhanjiang City > Y3 Zhuhai City > Y6 Huizhou City > Y2 Shenzhen City > Y10 Maoming City > Y5 Foshan City > Y7 Dongguan City > Y4 Shantou City > Y11 Jiangmen City > Y8 Zhongshan City.

In 2006-2009, the correlation between GDP and port cargo throughput is: Y9 Zhanjiang City > Y2 Shenzhen City > Y6 Huizhou City > Y1 Guangzhou City > Y11 Jiangmen City > Y4 Shantou City > Y8 Zhongshan City > Y3 Zhuhai City > Y7 Dongguan City > Y5 Foshan City > Y10 Maoming City.

In 2010-2013, the correlation between GDP and port cargo throughput is: Y9 Zhanjiang City > Y3 Zhuhai City > Y4 Shantou City > Y7 Dongguan City > Y11 Jiangmen City > Y1 Guangzhou City > Y2 Shenzhen City > Y6 Huizhou City > Y10 Maoming City > Y5 Foshan City > Y8 Zhongshan City.

In 2014-2018, the correlation between GDP and port cargo throughput is: Y3 Zhuhai City > Y9 Zhanjiang City > Y6 Huizhou City > Y11 Jiangmen City >Y4 Shantou City > Y1 Guangzhou City > Y7 Dongguan City > Y2 Shenzhen City > Y8 Zhongshan City > Y10 Maoming City > Y5 Foshan City.

From the correlation coefficient, we can know that Zhanjiang City has the greatest correlation, followed by Zhuhai City, then Jiangmen City, Huizhou City, Shantou City, Guangzhou City, Shenzhen City, Dongguan City, Maoming City, Foshan City, Zhongshan City.

4. Conclusion

If the ports of Guangdong Province develop well, and the GDP growth rate is fast. The throughput of port transportation is particularly important, but there are many ports in Guangdong Province. According to the gray correlation analysis, which port cargo throughput can have a greater relationship with the increase of GDP. Port shipment is an indispensable part of the cargo transportation in Guangdong Province. The increase in the cargo throughput of Zhanjiang port has the greatest impact on the economic growth of Guangdong Province, which may be related to the fact that Zhanjiang port is the shortest voyage from mainland China to Southeast Asia, Africa, Europe and Oceania. In recent years, the relationship between the cargo throughput of Shenzhen port and the GDP of Guangdong Province has declined, which may be related to the transformation of Shenzhen from a new city with geographical location as its advantage to a new city with scientific and technological innovation as its advantage.

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