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Research on Relationship between Port Logistics and Economic Growth Based on VAR: A Case of Shanghai

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Abstract

This paper considers the relationship between Shanghai port logistics and regional economic growth. Vector autoregression (VAR) model, Granger causality test, impulse response functions(IRF) are used based on the statistical data of Shanghai for the years from 1990 to 2017. The results indicate a long-term equilibrium relationship among variables. Besides, cargo throughput and container throughput, the chosen indexes to study port logistics exist a bidirectional causality. Cargo throughput is unidirectionally causal to economic growth.

Keywords

Port Logistics, Economic Growth, VAR, Shanghai

1. Introduction

As transportation hubs, ports play the important roles in the connection between water and land as well as supporting foreign trade. Integrating modern information and infrastructure, ports provide logistics activities to hinterlands. Port logistics expands the traditional warehousing and transportation functions of the port. Coordinating services such as warehousing, transportation, loading and unloading, distribution, packaging, processing, and shipping documents, port logistics activities extend the value chain of the port supply chain [1], and it can also drive the development of industry and commerce of the hinterland, which stimulates employment increase and promotes the upgrading of industrial structure. Considering the relationship between port logistics development and regional economic growth can measure the status of port logistics in the regional economy, and the interaction and mutual promotion of port logistics and regional economy can achieve common development.

Shanghai Port is one of the most important ports in China, and it is an important engine in economic growth for Shanghai and surrounding areas. With the development of the Shanghai International Shipping Center and the continuous expansion of the services and functions of Shanghai Port, the construction of the Shanghai Port Logistics System has gradually become a focus. At present, most of the research in the relationship between Shanghai Port Logistics and the regional economy is based on qualitative analysis, and there is still no quantitative analysis of the relationship between the two and the degree of mutual influence.

In this paper, we try to use quantitative analysis method to research the relationship between Shanghai's economic growth and port logistics, which provides better reference for the former qualitative research. Actually, the quantitative method is insufficient in the research for the relationship of economic growth and port logistics in Shanghai. Selecting the statistical data of Shanghai from 1990 to 2017, we try to establish a vector autoregression (VAR) model. Granger causality test and impulse response analysis (IRF) are also used to study the relationship between regional economic growth and port logistics.

Because of the limitation of objective factors such as lacking special index of measure the port logistics, the substituted indicators we choose may not represent the development of port logistics in Shanghai precisely. Furthermore, in the context of the global supply chain, the complexity of the international political and economic situation such as Sino-US trade war may contribute to a complicated influence for port industry and regional economy, which also affect the accurateness of our research.

This paper is organized as follows: Section 1 introduces the purpose and importance of researching for relevance between economic growth and port logistics in Shanghai. Section 2 gives a brief overview of research for the relationship between economic growth and port logistics. Section 3 considers the introduction for choosing econometric model and variables, including preliminary processing of data. Based on Section 3, a vector autoregression model through variables is built and we try to apply Granger causality test and impulse response analysis to analyze the empirical results. A conclusion and suggestions are given in Section 5.

2. Economic Growth and Port Logistics: Literature Review

In the context of global supply chains, ports have become important core in the supply chain for a country or region, so studying the relationship between ports and regional economies is necessary. In the relationship between the port and the city, many scholars have conducted research. Dong and Liu (2008) analyzed the diffusion effect and multiplier effect of regional economic growth, and proposed the coordinated development model of the port logistics and the regional economy [2]. Shen and Yang (2012) considered the synergy of regional logistics with port logistics by using qualitative and quantitative analysis methods, and analysed the influence upon the regional economy. The empirical analysis found out that the interactive relationship between port logistics and regional economic development in the Pearl River Delta [3].

Wu (2012) qualitatively analyzed the collaborative relationship of port and area economy, and investigated the degree measurement model between those. The result found out that the synergy measurement model can reflect the level of joint development of Liaoning coastal economic zone [4]. Zhang and Ning (2012) used the data of Hebei province in GDP and port throughput from the year 1990 to 2010 and built grey relational analysis. The result proved port logistics and economic growth have close correlation [5]. Deng (2010) found the relevance of regional economy and port logistics under the circumstance of the regional economic growth theory. Based on empirical analysis, the paper measured the degree of relevance in five coastal ports of China [6]. Lv and Tang (2012) expounded the interrelationship between the port logistics and regional economy and analyzed the relativity between Chongqing port logistics and economy based on the grey synthetically relational degree, which revealed that the two indexes are highly relative. According to the level of coordination between the two aspects using the multi-dimension grey GM (1, N) mode, they found that Chongqing port logistics and economic are coordinate as a whole system and have a certain development ability, but there are some un-cooperative factors between them [7].

Xie (2011) measured the relationship between Shandong port logistics and economic development. He found that there is a long-term equilibrium relationship between Shandong port logistics and regional economic development, and economic development promotes the development of port logistics [8]. Xu and Li (2015) formulated a synergy degree model for the relationship between logistic of Chongqing Free Trade Port Area and regional economic. The finding of which demonstrated that the development of two subsystems are synergistic, and it provided some references for Chongqing bonded port area to improve the collaborative development level of multi-system [9].

It can be seen from the existing literature that the relationship between port logistics and economic growth is different for different regions, and the degree of mutual influence is also different. With the variety of global trading trend, economy in different countries or regions is changing frequently and the mutual influence between port logistics and economy is becoming more and more complex. There is an obvious theoretical and practical significance in the research for the relevance between port logistics and economic growth, so this problem is still worth studying.

3. Econometric Models

3.1. VAR Method

The vector autoregression (VAR) model is a model that is constructed by using each endogenous variable in the system as a function of the hysteresis value of all endogenous variables of the system. It is quite often applied to predicting the interconnected system and analyze the dynamic impact of random disturbances on the variable system, and it is available to explain the impact of economic variables on economic shocks [10].

A VAR model can be applied to study the relationship between different variables when those variables show significant characteristic of time series. Tao (2012) and Zhang (2014) constructed vector auto-regression model and system dynamics methodology to analyze causality of regional GDP, employment and transportation analysis in Dalian, and the results show that there are long-term equilibrium relationship and interaction in port logistic and regional economy [11] [12]. Chen (2015) used the vector auto-regression model to study the interaction between economic growth and port logistics of the city and found that there existed a bi-way causality between port throughput and container throughput and that these two indexes were unilaterally causal to economic growth while the contribution of container throughput was more pronounced [13]. Based on the feature of data, VAR method can be expanded to panel vector autoregression (PVAR), global vector autoregression (GVAR) and time verifying vector autoregression (TVAR), such as Gabriel and Ribeiro (2019) investigated how manufacturing affects economic growth over time using panel vector autoregression [14].

This paper aims to measure the relationship between the regional economy and port logistics in Shanghai. It is considered that the pre-selected indicators have obvious time series characteristics, and each variable is affected by itself and other variables in the current period as well as the previous periods. Therefore, the VAR model is used to the relationship between Shanghai port logistics and economic growth is analyzed. The basic form of the VAR model is as follows:

$$y_t = a_1 y_{t-1} + a_2 y_{t-2} + \cdots + a_p y_{t-p} + bx_t + \mu_t \tag{1}$$

where

y_t is endogenous vector,

x_t is exogenous vector,

μ_t is disturbance vector,

$a_1, \cdots, a_p$ and b is estimated coefficient matrix.

3.2. Data Processing

One of the most notable indicators of economic development is the gross regional product (GDP). As an important index for measuring the total amount of the economy, GDP can better represent the scale of the country's economic volume and can measure economic changes. Port logistics is a relatively new problem. There is still no unified definition and no specific statistical indexes. As a system, port logistics is the integration of many logistics services, which can provide goods, funds and information services, and the services are mainly around the goods. Therefore, port cargo throughput and container throughput can be selected as indicators to measure port logistics development.

In order to study the relationship between Shanghai's regional economy and port logistics, we select Shanghai GDP (SGDP) index to measure Shanghai's economic development, Shanghai Port Container Throughput (SJ) and cargo throughput (SH) as the indexes for measuring port logistics in 1990-2017. We choose the natural logarithm of three indexes to eliminate the effects of heteroscedasticity and dimension, and the processed variables are recorded as LNSGDP, LNSH and LNSJ. Table 1 gives the statistical values of Shanghai's GDP, port cargo throughput and container throughput from 1990 to 2017 after natural logarithm processing.

The indicators we selected are typical time series. Exploring the characteristics of time series helps to further process, thus after the non-dimensionalization of data, we try to analyze the statistical characteristics of the indicators. Table 2 shows Descriptive statistics.

A set of quantifiable time series usually has a time trend and instability. It is easy to generate pseudo-regression risk when performing regression analysis on non-stationary time series. To eliminate pseudo-regression, the unit root test is used to test the stability of variables. Non-stationary time series can be adjusted by making the first-order difference of the time series. If the first-order difference sequence is still not a stationary sequence, the second-order difference can be performed. Table 3 shows the unit root test results of each variable.

As is shown in Table 3, the ADF value of LNSH is greater than the critical values corresponding to the 1% and 5% test levels, so the null hypothesis cannot

Table 1. Processing result of LNSGDP, LNSJ and LNSH, 1990-2017.

Year	Variable			Year	Variable		
	LNSGDP	LNSH	LNSJ		LNSGDP	LNSH	LNSJ
1990	6.6280	9.5439	3.8286	2004	8.9160	10.5426	7.2828
1991	6.7957	9.5942	4.0604	2005	9.1209	10.6991	7.5000
1992	7.0157	9.6987	4.2905	2006	9.2396	10.8921	7.6834
1993	7.3205	9.7754	4.5433	2007	9.3927	10.9357	7.8690
1994	7.5868	9.7160	4.7875	2008	9.5250	10.9711	7.9377
1995	7.8091	9.7152	5.0304	2009	9.6092	10.9888	7.8240
1996	7.9732	9.7051	5.2832	2010	9.7507	11.0873	7.9749
1997	8.1197	9.7049	5.5334	2011	9.8625	11.1949	8.0627
1998	8.2128	9.7042	5.7268	2012	9.9125	11.2058	8.0873
1999	8.3028	9.8331	6.0450	2013	9.9805	11.2590	8.1203
2000	8.4231	9.9252	6.3297	2014	10.0673	11.2323	8.1662
2001	8.5073	10.0033	6.4520	2015	10.1252	11.1808	8.2033
2002	8.5958	10.1805	6.7581	2016	10.2463	11.1588	8.2196
2003	8.7405	10.3616	7.0282	2017	10.3298	11.2259	8.2998

Source: Shanghai statistical yearbook and author calculated.

Table 2. Descriptive statistics, 1990-2017.

	LNSGDP	LNSH	LNSJ
Mean	8.789624	10.42984	6.676013
Median	8.828233	10.45210	7.155481
Maximum	10.32983	11.25900	8.299783
Minimum	6.628041	9.543880	3.828641
Std. Dev.	1.103350	0.659504	1.490258
Skewness	−0.363805	−0.009629	−0.549488
Kurtosis	2.040676	1.265426	1.852740
Jarque-Bera	1.691339	3.510636	2.944611

Table 3. Unit root tests, 1990-2017.

Variable	ADF	1% Critical Value	5% Critical Value	p-value
LNSGDP	−4.867064***	−3.699871	−2.976263	0.0006
LNSJ	−4.950277***	−3.699871	−2.976263	0.0005
LNSH	−0.779590	−3.711457	−2.981038	0.8083
DLNSGDP	−1.815209	−3.711457	−2.981038	0.3652
DLNSJ	−2.200736	−3.711457	−2.981038	0.2107
DLNSH	−2.411703	−3.711457	−2.981038	0.1484
DDLNSGDP	−5.338505***	−3.724070	−2.986225	0.0002
DDLNSJ	−6.633921***	−3.737853	−2.991878	0.0000
DDLNSH	−5.788228***	−3.724070	−2.986225	0.0001

Note: ADF with trend and intercept. Lags selection by Akaike Information Criterion (AIC). ***indicates significant at 1% level. D indicates first order difference. DD indicates second order difference.

be rejected. The original sequence has unit roots, which is a non-stationary sequence. After the first-order difference of original sequences, the ADF values of DLNSGDP, DLNSH and DLNSJ are greater than the critical values of 1% and 5% test levels, which are unstable sequences. After the second-order difference, the ADF values of three variables are less than the critical value of the 1% and 5% test levels, which indicate that sequences reject the null hypothesis, and the second-order difference sequences are stable. Therefore, the variables become second-order single-order sequences, and there may be a cointegration relationship.

4. Empirical Results

4.1. VAR Method

After the unit root tests of indicators, we find that the original data are not stationary sequences. Despite the traditional VAR model requires stationary of each sequence, with the development of cointegration theory, non-stationary sequences can also directly used in VAR models, as long as there is a cointegration relationship among the variables. In order to reflect the practical significance of the relationship among variables, we consider using non-stationary original sequences to establish a VAR model, and verifying the cointegration relationship later.

Before constructing the VAR model, we should define the lag order of the VAR model at first. Using the AIC, SC, and HQ criteria, we determine the lag order of the model to 1, thus VAR(1) model is established and shown in **Table 4**.

We consider the robustness of VAR(1) model. Robustness test is one of the important tests for the establishment of the model. The robustness test for the VAR model is performed by calculating the eigenvalues of the eigenvectors of the model. The necessary and sufficient condition for the stability of the VAR model is that the eigenvalues of the model should all be within the unit circle, or the eigenvalues should be less than 1, (*i.e.* within the unit circle). After determining the number of variables and the lag order of the model is 3 and 1 respectively, we obtain a feature vector (3 × 3) of the model. The calculated eigenvalues are 0.97, 0.97 and 0.94, which are less than 1 (or within the unit circle). The results mean that the model passes the robustness test and the model is stable.

4.2. Cointegration Test

After constructing a stable VAR(1) model, we verify whether there is a cointegration relationship among the variables in the model, which is the key to the establishment of the VAR(1) model. The cointegration test is used to test whether the non-stationary time series has a long-term equilibrium relationship. Using cointegration test, we can avoid the possible pseudo-regression problem. In this paper we use Johansen Cointegration test. **Table 5** shows the results of the cointegration test.

Table 4. VAR estimation results.

	LNSGDP	LNSH	LNSJ
LNSGDP(−1)	0.882523	−0.212918	−0.057954
	(0.04434)	(0.05793)	(0.07049)
	[19.9046]	[−3.67543]	[−0.82220]
LNSH(−1)	0.106654	0.874460	−0.206475
	(0.03964)	(0.05179)	(0.06301)
	[2.69089]	[16.8860]	[−3.27685]
LNSJ(−1)	0.011556	0.207451	1.075164
	(0.03211)	(0.04196)	(0.05105)
	[0.35986]	[4.94422]	[21.0601]
C	−0.022715	1.854811	2.321818
	(0.30918)	(0.40397)	(0.49152)
	[−0.07347]	[4.59149]	[4.72372]
R-squared	0.998592	0.993836	0.998065
Adj. R-squared	0.998408	0.993032	0.997813
S.E. equation	0.041423	0.054122	0.065853
Log likelihood	49.81888	42.59897	37.30225

Table 5. Cointegration test results.

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Prob.**
None*	0.736015	63.29347	29.79707	0.0000	None*	0.736015	33.29655	21.13162	0.0006
At most 1*	0.523777	29.99692	15.49471	0.0002	At most 1*	0.523777	18.54670	14.26460	0.0099
At most 2*	0.367458	11.45022	3.841466	0.0007	At most 2*	0.367458	11.45022	3.841466	0.0007

Note: **indicates significant at 5% level.

From Table 5, the results indicate that there is a cointegration relationship among LNSGDP, LNSJ and LNSH at a significant level of 5%, which represents that there is a long-term equilibrium relationship among LNSGDP, LNSJ and LNSH, and confirms the effectiveness of VAR(1) model we built. According to Table 4, we find that cargo throughput and container throughput have positive effects on GDP. 1% increase in cargo throughput can boost GDP growth by 0.11%, and 1% increase in container throughput can drive GDP growth by 0.012%, which is not obvious. Container throughput has a positive effect on cargo throughput, because 1% increase in container throughput can drive a 0.21% increase in cargo throughput.

4.3. Granger Causality

In this section, we analyze the relationship among variables by using Granger causality test. Granger causality test can be used to test whether the lag term of a variable in the vector autoregression model affects the current value of other variables, that is, forecast the causal relationship between the variables. The unit root test shows that the variables selected in this paper are unstable sequences, but after passing the cointegration test, the Granger causality test is still worked, and the results are still valid. Table 6 gives the Granger causality test results.

Determining the cointegration relationship of variables, we try to find the relationship among regional GDP, port cargo throughput and container throughput in Shanghai based on VAR model. The results show a unidirectional causality from cargo throughput to GDP in Shanghai and bidirectional causality between cargo throughput and container throughput.

4.4. Impulse Response Functions

We have already discussed the causal relationship between variables. In this section, we analyze the degree of interaction among variables, that is, whether variables respond to changes of other variables. We use the impulse response function (IRF) for analysis, which refers to the change of the current value and the future value when a variable is impacted by a standard deviation of the system. The impulse response function graph of the variable is obtained by using the Eviews 10 software, and Figures 1-3 show the results of the impulse response analysis.

Table 6. Granger causality tests.

Null Hypothesis	F-Statistic	Prob.	Inference
LNSH does not Granger Cause LNSGDP	8.53523	0.0075	LNSH → LNSGDP
LNSGDP does not Granger Cause LNSH	0.53577	0.4713	No causality
LNSJ does not Granger Cause LNSGDP	0.88429	0.3564	No causality
LNSGDP does not Granger Cause LNSJ	2.23184	0.1482	No causality
LNSJ does not Granger Cause LNSH	7.88568	0.0097	LNSJ → LNSH
LNSH does not Granger Cause LNSJ	13.3798	0.0012	LNSH → LNSJ

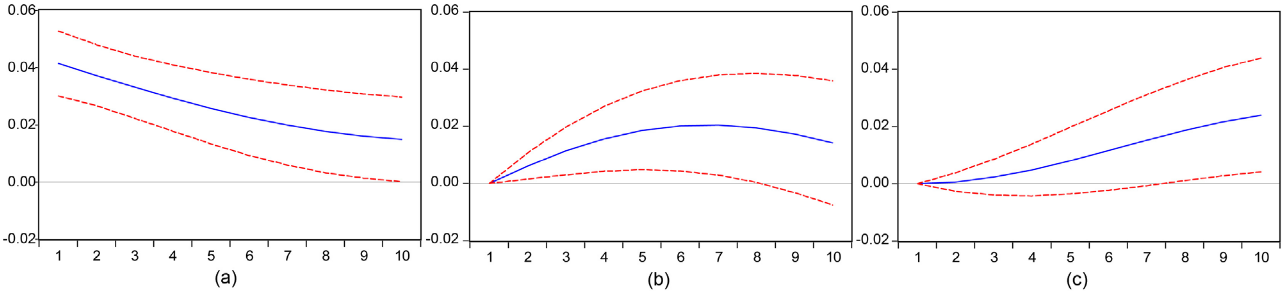

Figure 1. Impulse-response functions of LNSGDP for 10 periods. (a) Response of LNSGDP to LNSGDP. (b) Response of LNSGDP to LNSH. (c) Response of LNSGDP to LNSJ.

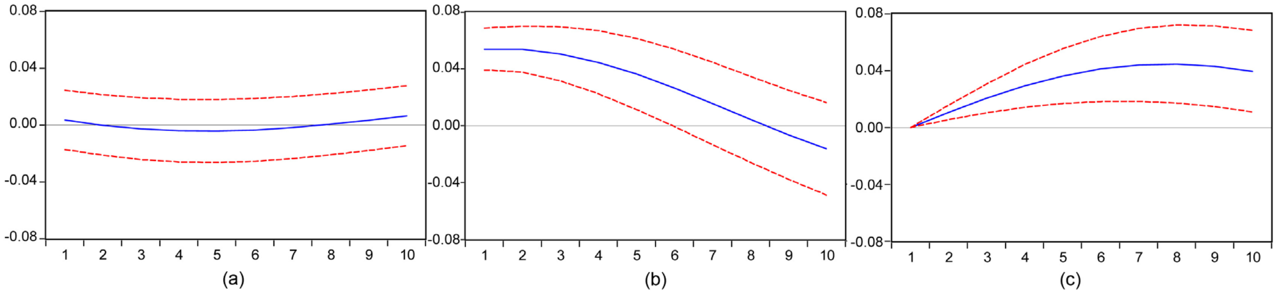

Figure 2. Impulse-response functions of LNSH for 10 periods. (a) Response of LNSH to LNSGDP. (b) Response of LNSH to LNSH. (c) Response of LNSH to LNSJ.

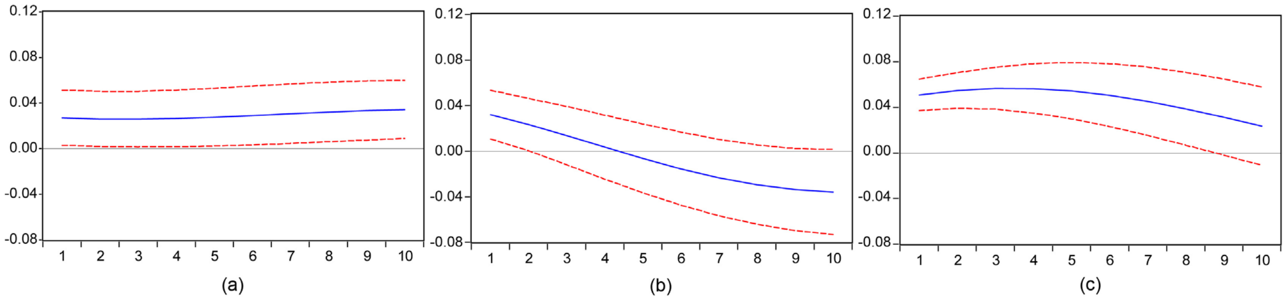

Figure 3. Impulse-response functions of LNSJ for 10 periods. (a) Response of LNSJ to LNSGDP. (b) Response of LNSJ to LNSH. (c) Response of LNSJ to LNSJ.

In Figures 1-3, the solid lines indicate the cumulative impulse response function after the impact, and the dotted lines indicate the positive and negative standard deviation bands. The horizontal axis represents the number of lag periods after the impact, and the vertical axis means the intensity of the impulse response function after the impact. **Figure 1(b)** shows that the positive impact of Shanghai port cargo throughput in the current period will lead to the growth of Shanghai GDP, and reach the maximum between the sixth and seventh periods, and then decline slowly. The result indicates that cargo throughput brings the same impact to GDP, and the effect last longer. **Figure 1(c)** shows the positive impact of Shanghai port container throughput in the current period will lead to an increase in GDP, and the effect will continue to strengthen and last during observation periods.

Figure 2(a) shows that the positive impact of Shanghai's GDP in the current period will lead to an increase in cargo throughput, but the effect is weak. **Figure 2(c)** indicates that the positive impact of Shanghai port container throughput during current period will lead to an increase in cargo throughput, and the impact reaches a maximum in the period of 7th to 8th and then decline slowly, which indicate the same direction between the two variables. The change is positive and the effect is strong.

Figure 3(a) shows that impact of Shanghai's GDP in the current period will lead to an increase in Shanghai's container throughput, and the effect is stable and lasts longer. **Figure 3(b)** indicates the impact of the Shanghai port cargo throughput on the current period will cause the container throughput to be positively impacted (period1-period4), but the effect is gradually weakened and becomes a reverse shock in the fifth period.

5. Conclusion

In our study, VAR model and related test methods are used to empirically analyze the relationship between Shanghai port logistics and economic growth. The results show that there is a long-term equilibrium relationship among port cargo throughput and container throughput, which are selected to measure the port logistics of Shanghai, and GDP index which is used to measure Shanghai's regional economic growth. The effect of port container throughput on economic growth is not significant, but the growth of port cargo throughput can significantly promote economic growth. There is a unidirectional causality between cargo throughput and GDP. These results show that port logistics development is an important engine for Shanghai's economic growth. Port cargo throughput and container throughput interact with each other and have a bidirectional causality, which shows the interaction within the various systems of port logistics.

Considering the accelerating position of port logistics on Shanghai's economic growth, Shanghai should make full use of the policy advantages of international shipping center and free trade zone, grasp the trend of supply chain synergistic development, broaden the scope of port logistics services, play the roles in the radiation effect and promote the economic development.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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