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An analysis on interaction mechanism of urbanization and industrial structure evolution in Shandong, China

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Abstract

Urbanization and industrial structure are two economic development systems that affect and promote each other. The former's rapid development will contribute to continuous adjustment of the latter and the latter's upgrading and optimization will stimulate the former uninterruptedly. Firstly, the characteristics of urbanization and industrial structure evolution from 1978 to 2009 in Shandong are analyzed in the paper, showing that the urbanization process and industrial structure evolution response to each other sequentially. Next, from the perspective of empirical test, the long-term mechanism involving urbanization, industrialization and tertiary industry development, as well as causal relation between the three factors are investigated by the method of cointegration analysis and error correction model. The empirical results indicate that the tertiary industry stimulates urbanization better than the second industry and long-term stationary equilibrium relationship between the three factors exists. Finally, the Granger causality test reveals that urbanization plays an important role in the development of secondary industry, but the hypothesis that the evolution of industrial structure stimulates the urbanization is not been supported.

Keywords: Urbanization; Industrial structure; Shandong province; Cointegration theory; Granger causality test

1. Urbanization and industrial structure evolution in Shandong province

Urbanization is a complicated process in which rural factors convert to urban ones, including the agglomeration of the secondary and tertiary industry to cities, the conversion of agricultural population to non-agricultural population, as well as expansion of existing cities to outlying areas, from the point of view of economic geography. It gives rise to the evolution of regional economic patterns and helps to form regional economic integration ultimately. Urbanization and industrial structure upgrading work

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together in the regional economic development process and both are manifestation of regional economic progress. On one hand, orderly evolution of the regional industrial structure brings about changes in the motive mechanism of urbanization, urbanization patterns and urban forms, and thereby promotes the urbanization development. On the other hand, the urbanization development affects regional supply, demand and spatial allocation of resource elements, and thus acts on the regional industrial structure upgrade. This paper explores in depth the interaction mechanism of the urbanization process and industrial structure evolution in Shandong province, by means of qualitative analysis and econometric analysis, namely the unit root tests, cointegration test, error correction model and Granger causality test, to provide references for harmonious development of urbanization and industrial structure evolution.

Shandong, situated in eastern coastal China, is one of the leading provinces in both social and economic development in China. Currently, it is among the comparatively well urbanized and well industrialized provinces of the country. To analyze the interaction mechanism of urbanization and industrial structure evolution, we authors believe that Shandong is an ideal case area and the study can get a more practical and sensible outcome.

1.1. In terms of timing sequence, urbanization and industrial structure upgrade promote each other

As a common practice in China, the industrial structure evolution refers to the change in proportionate relationships involving three major industries. That is, the structure that primary industry takes the first place, the secondary industry second, and the tertiary industry third initially, develops to the inverses structure ultimately [1]. In this process, urbanization develops in pace with the industrial structure evolution since agriculture development is the initial driving force, and second and tertiary industry development is the main motivation of urbanization. When the proportionate relationship changes to the ultimate structure, urbanization reaches the best-developed stage. Output value ratio and employment ratio of each industry are usually adopted to measure industrial structure evolution [2], while the percent of urban population in total population is a common indicator of urbanization level in a certain place.

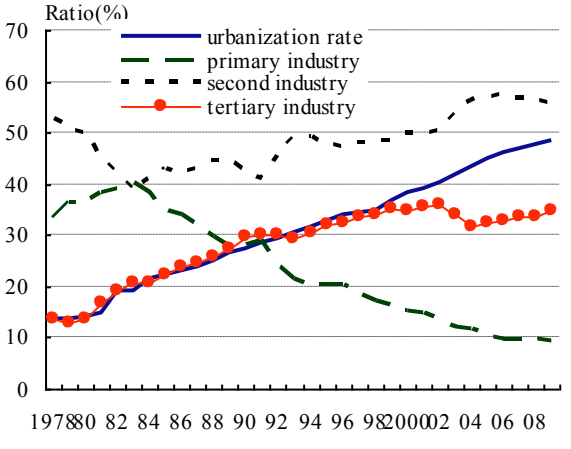

Fig. 1. Urbanization rate and output value ratio by industry

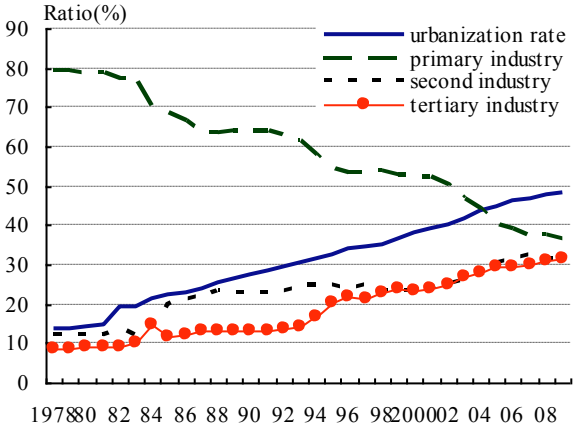

Fig. 2. Urbanization rate and employment ratio by industry

Since 1978, as Fig. 1 and Fig. 2 show, the development of urbanization is being accompanied by industrial structure evolution from low level to high in Shandong province and both have enjoyed good momentum of growth. During 1978-2009, urbanization rate increased from 13.6% to 48.32% and has

entered middle stage of urbanization development. Simultaneously, the output value ratios of primary, secondary and tertiary industry in Shandong in 1978 were 33.3%, 52.9% and 13.8% respectively, while they changed to 9.5%, 55.8% and 34.7% respectively in 2009. Similarly, the employment ratios of primary, secondary and tertiary industry changed from 79.2%, 12.3% and 8.5% in 1978 to 36.5%, 32% and 31.5% in 2009 respectively. Overall, in respect of both output value ratio and employment ratio, the primary industry has been declining, while the secondary and tertiary industry rising, and especially for the latter indicator, the non-agricultural output value ratio has achieved 90.5%.

Since the reform and opening up policy implementation, the urbanization development in Shandong province can be divided into three phases. The first phase lasted from 1978 to 1986 when the urbanization rate increased from 13.6% to 23%. In this period, the employment ratio of the secondary and tertiary industry all along rose, while the primary industry declined. The development of secondary and tertiary industry absorbed large amount of surplus rural labor force, waking up the urbanization process from the stagnating planned economy.

The second phase (1987-1998) is the phase of speeding urbanization when urbanization rate had reached 35% in 1998. In this period, the secondary and tertiary industry underwent booming development. In aspect of output value ratio, the secondary industry was still greater than the tertiary industry, while the primary industry had gone down to the least. Especially, output value ratio of the tertiary industry, which coincided with the increased urbanization rate, ascended significantly. The blossom of non-agricultural industry promoted more rural labor force to shift from the first industry, promoting the speeding development of urbanization.

The third phase lasted from 1999 to 2009 when the rate increased from 36.58% to 48.32%. During this period, urbanization rate in some years increased even 1.5% or 1.7%, which went against universal law of urbanization development. At the same time, the secondary and tertiary industry kept on developing rapidly, while employment ratio of primary industry declined promptly after 2001. The fast urbanization process contributed to the conversion of agricultural population to non-agricultural population, providing an abundance of labor force for secondary and tertiary industry.

1.2. In terms of geography, regional differences in urbanization development comply with that in industrial structure

As a result of diverse geographic conditions and substantial basis variety, there exist obvious differences in urbanization development of three regions in Shandong province [3]. The eastern part has developed the fastest, the western part the slowest, and the central part relatively moderately. The urbanization rates of these three parts were 54.63%, 33.29% and 48.53% respectively in 2008, decreasing from the east to the west in sequence (see Table 1).

Table 1. The contrast of development index by region in Shandong province (2008)

Region	GDP per capita (RMB)	Urbanization rate (%)	Output value ratio (%)	Employment ratio (%)
The eastern part	47499.3	56.35	7.09:58.91:34.00	30.74:37.78:31.48
The middle part	32769.5	50.28	7.67:53.61:38.73	35.03:33.24:31.95
The western part	22599	37.69	13.16:57.17:29.67	45.28:25.23:29.49

Data source: Urbanization Development Report of Shandong Statistical in 2009

Meanwhile, the level of industrial structure evolution has presented an ordinal declining trend from the east to the west as well. Non-agricultural output value ratio and employment ratio of the east have reached 92.91% and 69.26% respectively, and the central 92.33% and 64.97% respectively, indicating a

small gap. Whereas, in western part,the output value ratio of tertiary industry was less than 30%, while employment ratio of primary industry reached up to 45.28%, lagging behind the other two parts and hindering the growth of urbanization rate.

1.3. In terms of structure warp coefficient, the urbanization process is related to industrial structure deviation

The structure warp coefficient is applied to measure the deviation degree of one industry, which is expressed as follows:

$$E=X_i/Y_i-1 \quad (1)$$

where X_i is the output value ratio of i industry, and Y_i is the employment ratio of i industry.

If structure warp coefficient is positive, the employment ratio of this industry falls behind output value ratio with high labor productivity, still leaving space for more jobs; if negative, there exists surplus labor force in this industry; and if 0, a perfect condition, employment number and output value are in equilibrium. How much an industry absorbs labor force could be analyzed through structure warp coefficient. Based on the results, which industry is the major industrial driving force for urbanization development is to be explored [4].

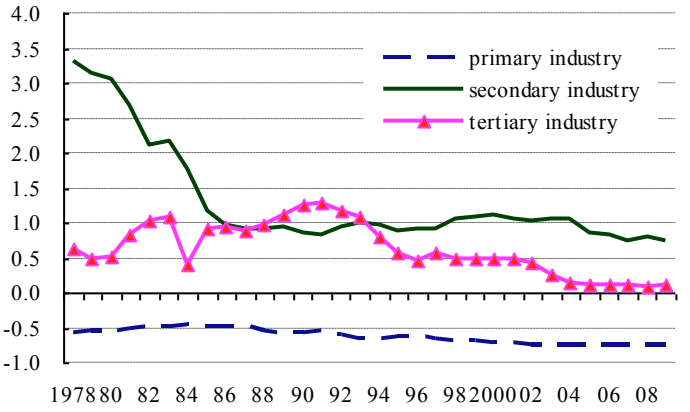

Fig. 3. The structure warp coefficient by industry in Shandong province

As Fig. 3 shows, the structure warp coefficient of primary industry is negative, and its absolute value increases every year from 0.58 in 1978 up to 0.74 in 2009. It suggests that the primary industry has become an industry that provides a net outflow of labor force to non-agricultural departments, serving as original impetus for industrial structure upgrade and urbanization progress.

The structure warp coefficient of secondary industry is positive and relatively high, indicating that absorption capacity for labor force has come to a limit. Its value settled down between 0.7-1.0 after a rapid reduction from1978 to 1986. In other words, the obtain employment number of secondary industry has stabilized and played a minor role in labor absorption, and thereby devotes little to raise the level of urbanization.

The structure warp coefficient of tertiary industry has been positive all the time, and it closes to zero after previous fluctuation. Along with industrial structure evolution, the tertiary industry has made

considerable progress. Simultaneously, it has taken in a great number of the labor force that shifted from other industries, acting as a powerful force for urbanization.

From the above analysis, it is concluded that the structure warp coefficients of Shandong province agree with the urbanization development. With the urbanization acceleration, a large amount of surplus labor outflows from the primary industry as output value ratio drops continuously, providing a precondition for urbanization. At the same time, during the process of transformation from labor-intensive industry to capital-intensive and technology-intensive industry, the secondary industry absorbs part of surplus labor force but limited. Meanwhile, urban population increase stimulates the development of tertiary industry. It takes in a large number of agricultural labors, working as follow-up power for urbanization in turn.

2. The empirical study on the urbanization rate and industrial structure evolution in Shandong

2.1. Index selection and data sources

Urbanization rate can be expressed in two representations, single index and complex index. Considering availability of data and applicability of research, this paper employs the single indicator to express urbanization level (Urban). It is calculated by the proportion of urban population in total population.

In terms of output value ratio, the secondary industry ranks the first, the tertiary industry second, and the primary industry third. This structure is the right industrial structure that corresponds to present urbanization level. Nevertheless, as for employment ratio, the primary industry is in the first place, the secondary industry second, and the tertiary industry third, which does not accurately reflect current industrial structure evolution. As a result, in empirical analysis, output value of the secondary industry in proportion of GDP (G_2) and that of the tertiary industry (G_3) are adopted to express industrial structure evolution. The reason why not considering that of the primary industry is to avoid multicollinearity problem.

Urbanization rate and output value proportion of the secondary and tertiary industry for each year derive from *Shandong Statistical Yearbook 2009*.

2.2. *Empirical Analysis*

As is seen from Fig. 1, data of urbanization rate and output value proportion of the secondary and tertiary industry are non-stationary time series. First of all, in order to avoid spurious regression, Augmented Dickey-Fuller (ADF) test is carried out to investigate whether there have unit roots in time series. Secondly, according to Granger's cointegration theory, this paper tries to establish a quantitative relation between urbanization level and development of the secondary industry and tertiary industry. Then, to explain the long-run equilibrium but the short-term imbalance of three variables, the Error Correction Model (ECM) involving all variables is set up on the basis of Autoregressive Distributed Lag (ADL) model. Finally, this paper applies Granger causality test to explore the causal relationship between three variables.

- Stationarity test of time series

Unit root test, by means of ADF method, is applied to assess the stationarity of variables. As the results (see Table 2) show, ADF values of urban, G_2 and G_3 are all higher than critical values at 10% significance level. Therefore, none of them can reject the hypothesis that they have unit roots, which means they are non-stationary time series. Then, the unit root test is performed again after making first order difference of these three time series. ADF values of the three are 4.60, -3.54 and -4.65 respectively,

less than critical values at the significance level of 1%, 5%, 1% respectively. It demonstrates that the time series after a first-order difference are stationary series, i.e. I (1)

Table 2. Unit root test

Variable	Test type (C, T, L)	ADF Test statistic	Test critical value		
			1%	5%	10%
Urban	(C, T, 8)	-2.61	-4.30	-3.57	-3.22
dUrban	(C, T, 8)	-4.58	-3.68	-2.97	-2.62
G_2	(C, N, 8)	-0.98	-3.68	-2.97	-2.62
dG_2	(C, T, 8)	-3.82	-4.30	-3.57	-3.22
G_3	(C, T, 8)	-0.91	-4.28	-3.56	-3.22
dG_3	(C, T, 8)	-4.65	-4.30	-3.57	-3.22

Note: C, T, L in the test indicates that the unit root test equation contains intercepts, trends and lags respectively. N means not having the first two terms. Selection of lags, i.e. L keeps to the Schwarz info Criterion (SIC), of which the maximum value is $[12(T/100)^{1/4}]$, with [x] as the largest integer part of x and T as the number of observations.

- Cointegration test

This paper conducts cointegration test of the three variables by means of Johansen test (see Table 3). At 5% significance level, the null hypothesis that there exist no cointegration vectors is rejected, and that there is at most a cointegration vector is accepted. The results state that there has a unique cointegration relationship of the three.

Table 3. Johansen Cointegration test

H_0: No. of CE(s)	Eigenvalue	Trace statistic	5% Critical value	*p* Value
0**	0.6640	42.15498	29.79707	0.0012
At most 1	0.3848	9.449212	15.49471	0.3255
At most 2	0.2616	0.140363	3.841466	0.7079

Note: ** Denotes rejection of the hypothesis at the 5% level

Cointegration equation of the secondary industry, tertiary industry and urbanization development in Shandong province can be expressed as:

$$Urban_t = 73.8471 + 1.8777G_t + 0.5210G_{3t} + U_t \quad (2)$$
$$(5.6403) \quad (2.7859)$$

This equation indicates that long-term cointegration relationship between the urbanization level and development of the secondary industry and tertiary industry validly establishes. Meanwhile, output value ratios of the secondary and tertiary industry are statistically significant. In the long run, when output value ratio of the secondary industry increases 1%, urbanization rate will rise1.87% synchronously, while that of the tertiary 1%, urbanization level 0.521%. It indicates that the second industry plays a more crucial role in promoting the urbanization than the tertiary industry.

- Error Correction Model and short-term fluctuation test

Supposing for some reason deviations from long-run equilibrium show up in the short term, it is inevitable to correct the error to make variables to return to equilibrium. The Error Correction Model combines short-term fluctuations with long-run equilibrium in a single model. According to the modeling

idea of 'From the general to simple', the most general Autoregressive Distributed Lag (ADL) model is to set up. Next, on basis of it, ECM can be obtained [5].

To establish ADL model, it is essential to determine the lags number. However, there are no universally accepted criteria for lagging number selection. In this paper, Lagrange Multiplier autocorrelation test is used to determine the lags, in which the first-order lag of variables is tested. By this method, the *t* value of first-order lagged residual series (RESID (-1)) equals to 6.86 and the *p* value 0.0000, less than 1% significance level obviously. Thereby, the significance test has been passed to reject the null hypothesis, showing that there exists first-order autocorrelation in this model. Accordingly, ADL (1, 1) model is selected and then the error correction model will be established. The result of ADL (1,1) estimation is expressed as follows：

$$Urban_t=1.9382+0.9942Urban_{t-1}+0.0266G_{2t}-0.0447G_{2t-1}-0.0260G_{3t}+0.0349G_{3t-1} \quad (3)$$

of which $R^2 = 0.995$, adjusted $R^2 = 0.994$, D.W. value is 2.2889.

From the above result, it is concluded that the secondary industry in current period and the third industry in first-order lag play a positive role in urbanization, and the secondary industry in first-order lag and the third industry in current period play a negative role, while urbanization itself in first-order lag has the greatest impact on explained variable.

The Error Correction Model based on ADL (1, 1) is:

$$\Delta URBAN_t=0.0665\Delta G_{2t}+0.0435\Delta G_{3t}-0.0118ecm_t+1.0829 \quad (4)$$

of which $R^2 = 0.021$, D.W. value = 2.269.

The difference items calculated in ECM reflect the influences on short-term fluctuations, which could be divided into two parts: one is the impacts of industrial structure adjustment on urbanization level, and the other is effects of short-term deviations from long-run equilibrium.

Coefficients of output value ratio for the secondary and tertiary industry are 0.066 and 0.044 respectively, meaning that short-term changes in the secondary industry sector affect more than the tertiary industry. For one thing, in the long term, cointegration relationship of the three is to contain the fluctuation. The estimation value of adjustment coefficient is -0.0118, conforming to the reverse adjustment mechanism. For the other thing, however, *t* value of the error correction term coefficient is not significant, showing that the cointegration relationship plays a limited role in containment. These conclusions meet the employment ratio and industry structure deviation analyzed before. The main way that industrial structure evolution affects urbanization process is the transference of the rural population. Yet, inferred by the structure warp coefficient, the absorption capacity of secondary industry for labor force is relatively limited. It restricts the non-agriculturalization of rural population. Hence when short-term fluctuations deviate from the long-run equilibrium, the adjustment to equilibrium does not function obviously.

- Causality test

As not considering non-stationarity of a single variable and cointegration of variable system, it is not the best option to conduct causality test based on level VAR model for multi-variable system. Likewise, information deficiency and requirements to test stationarity and cointegration first confine the applicability of the causality test based on differential VAR models.

When not the cointegration of variables but only the causal relations are concerned, or causal relations are needed to study but cointegration relationship does not exist, a new test method is required. It is carried out to test causal relationship without considering the cointegration and integration. The causality

test based on Lag-Augmented VAR Model proposed by Toda & Yamamoto (1995) can draw more accurate conclusions [6].

Toda & Yamamoto recommended to add an extra lag order d (d is the maximum order of integration in the system) to level VAR (L) model, and then to estimate VAR (L + d) model by using OLS. Finally, causality test will be performed based on the new model. As the Table 4 shows, LR, FPE, AIC, SC and HQ indicators all suggest to establish VAR (2) model. Furthermore, as all variables are first-order integrated, d equals 1, resulting in setting up VAR (2+1) model to test casualty relations.

Table 4. Lagging orders of level VAR model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-204.6874	NA	963.6470	15.38425	15.52824	15.42707
1	-83.34868	206.7253	0.235940	7.062865	7.638793	7.234119
2	-65.71319	26.12665*	0.128208*	6.423200*	7.431073*	6.722893*
3	-57.81745	9.942787	0.149907	6.504996	7.944815	6.933130
4	-53.66221	4.309138	0.249278	6.863868	8.735632	7.420441
5	-40.71019	10.55350	0.244596	6.571126	8.874836	7.256139

Note: * Denotes selection of the order according to the criteria.

Next, stationary test of the VAR (2) model and VAR (2+1) model is taken. For the VAR model, there are totally NK roots, where N is the number of endogenous variables, and K expresses the maximum lag orders of the model (see Table 5 & 6).

Table 5. Parameters of level VAR (2) model

Root	Parameter
0.990570	0.9906
0.884422	0.8844
0.291507 - 0.477140i	0.5591
0.291507 + 0.477140i	0.5591
0.529945	0.5299
-0.284987	0.2850

Table 6. Parameters of level VAR (2+1) model

Root	Parameter
0.975032	0.9750
0.311031 - 0.727413i	0.7911
0.311031 + 0.727413i	0.7911
0.779058	0.7791
0.706181	0.7062
-0.355338 - 0.562878i	0.6657
-0.355338 + 0.562878i	0.6657
-0.459034	0.4590
0.386413	0.3864

All parameters' value of these two models are less than 1, that is, all roots fall in the unit circle, showing VAR (2) model and VAR (2+1) model are both stationary. Then, Granger causality test is made on the basis of VAR (2+1) model (see Table 7).

Table 7. Granger causality test

Null Hypothesis:	F-Statistic	Prob.	Conclusion
G_2 does not Granger Cause Urban	0.94888	0.4341	Not Rejection
Urban does not Granger Cause G_2	10.4564	0.0002	Rejection
G_3 does not Granger Cause Urban	0.23652	0.8699	Not Rejection
Urban does not Granger Cause G_3	1.01893	0.4033	Not Rejection
G_3 does not Granger Cause G_2	7.27859	0.0014	Rejection
G_2 does not Granger Cause G_3	0.66254	0.5839	Not Rejection

From the results, it can draw conclusions that the theoretical hypothesis that industrial structure evolution promotes the urbanization process is not fully supported, and the theoretical hypothesis that urbanization process boosts industrial structure evolution is supported to some extent. Combined with the previous industrial structure deviation analysis, the reason why such results come out is that the industrial structure supererogation performs quite differently when measured by output value ratio and employment ratio respectively. From the former point of view, the non-agricultural output value ratio has reached 90.5%, reflecting the industrial structure evolution and upgrade. Even through, the non-agricultural labor force is not drawn into non-agricultural industries as enough as it should be, which does not correspond to industrial structure evolution. As the crucial way of urbanization development is the transformation of rural population to urban population, industrial structure supererogation measured by output value proportion does not have an effect on urbanization development.

3. Conclusion

Since reform and opening-up policy implementation, the continuously increased urbanization level and the unceasingly industrial structure upgrade in Shandong province have affected and promoted each other, functioning together to promote regional economic development. Empirical test results show that the secondary industry plays a more critical role in promoting urbanization development than the tertiary industry, and that there has the long-term stationary mechanism between the development of the secondary and tertiary industry, and urbanization process. When the short-term fluctuations deviate from the long-term equilibrium, the internal adjustment mechanism could adjust them to equilibrium through the reverse adjustment (adjustment coefficient is -0.0118). Granger causality test confirms that the industrial structure evolution is not Granger cause of the urbanization process, while urbanization is the Granger cause of the development of secondary industry.

As the econometrics results reveal, the improvement of the secondary industry output value is the main impetus of urbanization process. Nonetheless, current development of the secondary industry in Shandong province depends mainly on traditional manufacturing industry and heavy industry, while technology-intensive industry advances relatively slowly. As a result, output value of this industry is marginally-improved. Shandong province should endeavor to push forward the development of high-end industries through policy guidance and encouragement for technological advances. Only in this way can the overall quality and competitiveness of industrial enterprises be improved. As the quality of the secondary industry development increases, the urbanization rate will go up accordingly.

In the perspective of industrial structure deviation, the tertiary industry is greatly capable of absorbing redundant labour force. It promotes non-agriculturalization of rural population better. Shandong province should continue to accelerate the development of traditional service industries, such as transportation and warehousing, wholesale and retail industry, and catering industry, to suck up the labour force that just

shifts from rural areas. As well, it is essential to boost the development of banking and insurance industry and technology service industry to enhance urban functions. That will be great help of attracting more employed population and living population into cities.

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