Evaluation on the Process of Supply-Side Structural Reform: An Empirical Analysis Based on Economic Composite Index

Ying Wang, Wenjie Pan*

Since 2015, the supply-side structural reform has promoted the transformation of China's economy to high-quality development with "capacity reduction, de-stocking, deleveraging, cost reduction and improving underdeveloped areas" as the main line. This paper constructs the supply-side composite index and the supply-side reform index to track the economic supply-side status and supply-side reform process at the national level and in 31 provinces (municipalities), and analyzes the relationship between supply-side structure and economic growth by combining the SOLOW model. Based on that, this paper proposes that the reform of "optimizing stock allocation" to achieve "capacity reduction, de-stocking, deleveraging, and cost reduction" has achieved remarkable results, and follow-up focus should be put on promoting the reform of "expanding quality increment" to "improve underdeveloped areas", so that innovation-driven high-quality development can be truly realized.

Keywords: supply side, capacity reduction, de-stocking, deleveraging, cost reduction, structural reform

1. Introduction

Since the implementation of supply-side structural reform in china, the academic community has gradually focused on the issue of reform implementation effects. The research results are divided into two categories, one of which is the judgment and evaluation on individual reform measures, and the other is the understanding and evaluation of the overall process of reform. There are two research methods, one of which is normal logical judgment, and the other is the empirical model test, and the empirical data is mostly derived from the results of questionnaire survey and field research.

Seen from the existing research results, most of them focused on the normative research, expounding the theoretical framework and implementation path of supply-side structural reform. The empirical research mostly used the quantitative analysis of single indexes,

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and few evaluated the supply-side reality of the economic structure from national and provincial administrative divisions and tracked supply-side structural reform process. The main contributions of this paper are as follows. Firstly, following the main line of "capacity reduction, de-stocking, deleveraging, cost reduction and improving underdeveloped areas" of supply-side structural reform, this paper selects indexes from such four aspects as "capacity reduction", "de-stocking", "deleveraging" and "cost reduction", and compiles supply-side composite indexes for 31 provinces (municipalities) in China, to examine the supply-side status and development trend of the economic structure of each province (municipality). Secondly, this paper further compiles supply-side reform index to examine the promotion of supply-side structural reform in each province, and proposes reform recommendations. Thirdly, this paper studies the relationship between supply side and economic growth, to provide evidence for supply-side structural reform.

2. Selection of Indexes

Based on the foregoing research, this paper selects the indexes that best represent the reform process and effects according to the key contents of various reform aspects such as capacity reduction, de-stocking, deleveraging, and cost reduction, and because the provinces (municipalities) have different shortcomings, it is difficult to determine the uniform undeveloped-area index because the undeveloped areas vary among different provinces (municipalities), and the reform of improving undeveloped areas is not considered in this paper.

2.1. "*Capacity Reduction*" *Index*

Capacity utilization is a direct index to measure overcapacity in an industry and also an important index to measure macroeconomic cycle. According to the compilation idea of the Federal Reserve Board (FRB Index), this paper uses the ratio of actual output to potential output to measure the capacity utilization of an industry, i.e., the capacity utilization rate u_{ij} of the industry j in the region i is calculated using the following formula:

$$u_{ij} = \frac{Y_{ij}}{Y_{ij}^*} \tag{1}$$

where Y_{ij} represents the actual output, Y_{ij}^* represents the potential output. In region i, the average capacity utilization $\overline{u_l}$ is equal to the arithmetic mean of the capacity utilization of each industry in the region, namely:

$$\overline{u_l} = \frac{1}{n}\sum_{j=1}^{n} u_{ij}, j = 1,2,...,n \tag{2}$$

The potential output is determined by the peak method. The advantage is that the operation is simple and the data requirements are not high, but the disadvantage is that the peak selection in each period will result in different capacity utilization. In response to this shortcoming, this paper further uses the Bry-Boschan method (B-B method) proposed by Bry and Boschan (1971) to make a peak diagnosis of the output of various industries.[1]

The definition of capacity reduction industries comes from the "Government Work Report" 2014, which states that China's five major surplus industries are steel, cement, sheet glass, coke, and pig iron. This paper calculates the quarterly data of output of five major surplus industries in 31 provinces (municipalities) obtained from the China Economic Net database. For some annual data, the quadratic interpolation is used to convert annual data to monthly data, and the X12 method is used for seasonal adjustment. The statistical results are shown in Table 1.

Table 1. Statistical Results of Capacity Utilization of Five Major Industries in 31 Provinces (Municipalities) in China

	Mean	Variance between groups	Intragroup ariance	Overall variance
Sheet glass	81.40%	0.0603	0.0511	0.1091
Cement	73.11%	0.014	0.0609	0.074
Pig iron	73.59%	0.0555	0.0661	0.1193
Steel	63.34%	0.0346	0.0841	0.1169
Coke	84.07%	0.028	0.1565	0.1822

According to the above formula, the capacity utilization ratio of China's five major industries is measured. The results are shown in Figure 1. As can be seen from the figure, the capacity utilization of the five major industries has been on an overall upward trend since 2011. It has gradually risen after falling in the second half of 2015, but it has shown an overall decline since 2017. Among them, the decline slope of steel and coke is the most obvious, which has a lot to do with the mandatory capacity reduction measures set by the provinces with administrative targets. For example, the target of coal capacity reduction in Shanxi Province from 2016 to 2018 was 23.25 million tons, 20 million tons and 23 million tons. From a national perspective, in the two key areas such as steel and coal, steel production capacity of over 110 million tons (excluding the production capacity

[1] When determining the peaks and troughs of an economic sequence according to the B-B method, the following two constraints must be observed: Firstly, the duration between the peak and the trough must be maintained for more than 6 months; Secondly, the interval between two peaks, and that between two troughs must be greater than 15 months.

of strip steel) exited, and the coal production capacity or more than 400 million tons exited in 2016 and 2017.[1]

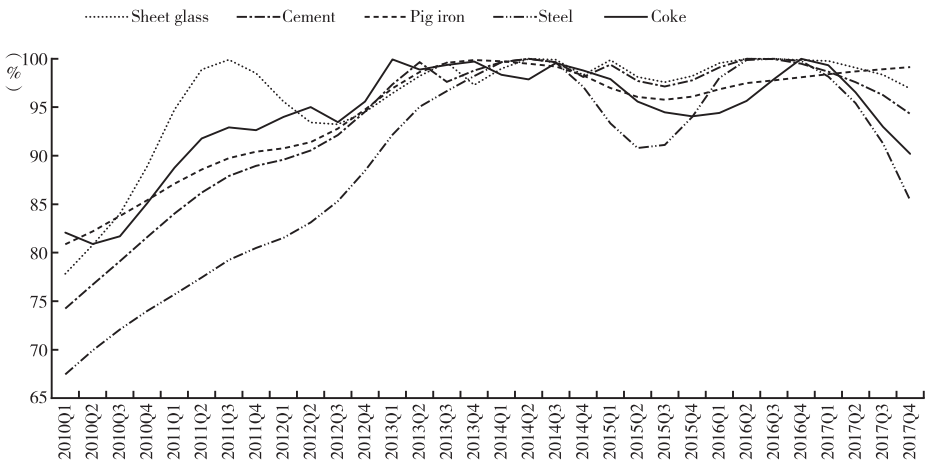

Figure 1. Capacity Utilization of China's Five Major Industries from 2010 to 2017

2.2. "De-Stocking" Index

This paper uses the ratio of the area of commercial housing to be sold at the end of the year to the sales area of the current year, to examine the real estate stocking. According to the classification of the to-be-sold area as given in the *China Real Estate Statistical Yearbook*, this paper further uses the ratio of commercial housing to be sold within 1–3 years to the sales area of the current year to measure short-term stocking, and uses the ratio of commercial housing to be sold beyond 3 years to the sales area of the current year to measure backlog stocking. For the annual data, the quadratic interpolation is used for conversion, and the X12 method is used for seasonal adjustment. The interval is from the first quarter of 2010 to the fourth quarter of 2017. The statistics are shown in Table 2.

Table 2. Statistics of Real Estate Stocking in 31 Provinces (Municipalities) in China

	Mean	Variance between groups	Intragroup ariance	Overall variance
Short-term stocking	10.01%	0.0057	0.0035	0.0072
Backlog stocking	1.72%	0.0029	0.0021	0.003

The calculation of China's overall real estate stocking is as shown in Figure 2. As can be seen from the figure, China's backlog stocking has not grown much in

[1] Source: Xinhua Net, http://www.xinhuanet.com.

recent years but stayed at around 1.72%, and short-term stocking has declined since the beginning of 2015. There are two reasons. Firstly, China's real estate investment growth rate has exceeded 20% since 2000. The large amount of investment over the years has led to excessive development of many cities. In addition, external conditions of long-term monetary easing and abundant liquidity have made it hard to digest backlog stocking in a short time. Secondly, since the supply-side structural reform has been promoted, local governments have adopted temporary measures such as administrative price limits, which have played a certain short-term de-stocking effect. For example, Beijing adopted a series of strict real estate control measures in 2017, including purchase restrictions with inspection of credit registry and house ownership, 60% down payment for second homes, and that non-Beijing household purchases are subject to personal income tax payment of 60 months consecutively.

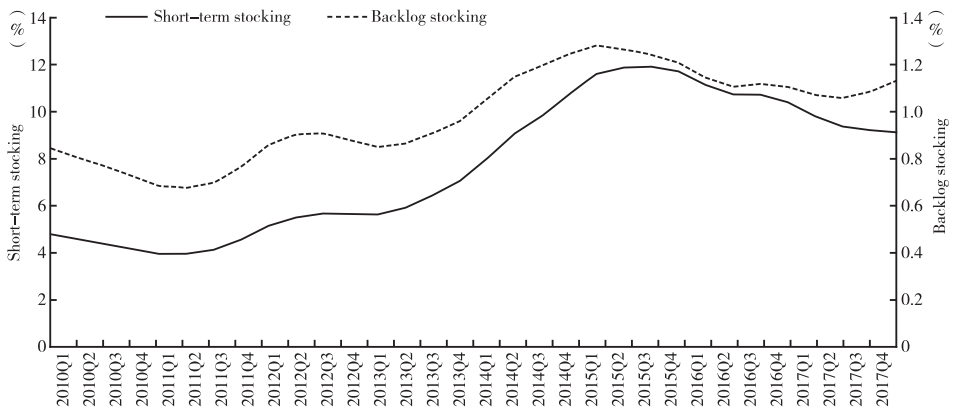

Figure 2. China's Real Estate Stocking from 2010 to 2017

2.3. "*Deleveraging*" *Index*

Because it is difficult to measure the debt balance of a province (municipality) at the provincial level, this paper examines the leverage ratio of provincial government industrial enterprises from a micro perspective. According to the studies of Ji *et al.* (2017), the relationship between micro-leverage ratio and macro-leverage ratio is as follows:

$$Micro\ leverage\ ratio = macro\ leverage\ ratio \times return\ on\ assets = \frac{total\ debts}{GDP} \times \frac{GDP}{total\ assets} = \frac{total\ debts}{total\ assets} \tag{3}$$

According to the above formula, this paper obtains the quarterly data of the

assets and liabilities of industrial enterprises above designated size in 31 provinces (municipalities) in China, and calculates the provincial leverage ratio at the micro level. The statistical results are as shown in Table 3.

Table 3. Statistics of Micro-Leverage Ratios of 31 Provinces (Municipalities) in China

	Mean	Variance between groups	Intragroup variance	Overall variance
Assets (RMB100 million)	71449.91	68037917165	36994346919	71919736133
Liabilities (RMB100 million)	41331.32	22353546972	11914751604	23625650509
Micro leverage ratio	58.64%	0.0054	0.0013	0.0054

The results of the calculation are as shown in Figure 3. The results are basically consistent with the conclusions of the studies of Wang (2017). From 2010 to 2017, the leverage ratio of China's industrial enterprises fluctuated within a narrow range between 60% and 55%, and it showed a downward trend year by year. It is worth noting that, firstly the leverage ratio of real estate enterprises is still rising. In 2017, the sales of commercial housing increased by 13.7%, while the domestic loans as a source of real estate investment capital increased by 17.3%. Secondly, the balance of household loans is increasing, and compared with 2016, the figure in 2017 increased by 21.4% to RMB40.5 billion (Wang, 2017).

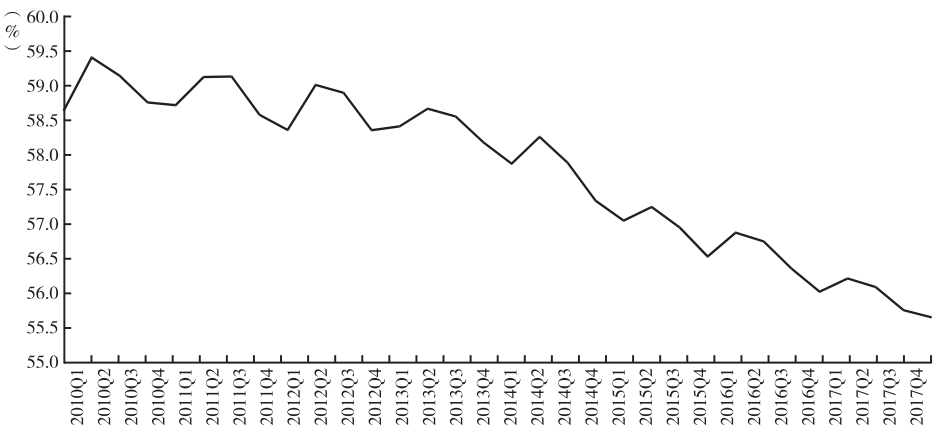

Figure 3. China's Micro-Leverage Ratio from 2010 to 2017

2.4. "*Cost Reduction*" *Index*

For the macro tax burden at the national level, the ratio of tax to GDP is generally used to measure; for the macro tax burden of local governments, this paper refers to the

study of Zhang *et al*. (2014), using the ratio of local tax revenue to GDP to measure; for the micro tax burden, this paper refers to the study of the Chinese Academy of Fiscal Sciences (2016), i.e., the proportion of tax revenue to the main operation income of enterprises. According to the relevant data of industrial enterprises above designated size in 31 provinces (municipalities), the macro tax burden and micro tax burden of each province (municipality) are measured separately. The statistical results are as shown in Table 4.

Table 4. Statistics of Macro and Micro Tax Burdens of 31 Provinces (Municipalities) in China

		Mean	Variance between groups	Intragroup variance	Overall variance
Macro tax burden	National	35.07%			0.0235
	Local	7.76%	0.0008	0.0007	0.0014
Micro tax burden	National	23.89%			0.0154
	Local	8.53%	0.0126	0.0025	0.0129

The calculation results are as shown in Figure 4. It can be seen from the figure that the macro and micro tax burdens show a simultaneous downward trend. The macro tax burden is around 19%, and the micro tax burden is around 12.5%. From a global perspective, the values are not high. Enterprises generally believe that the high operating costs are largely due to the following factors: multi-head management and multiple supervisions increase the cost of institutional transactions, the excessive consumption of goods transit and handling increases the logistics costs, and the large-amount credit-granting power concentration increases the financing costs, and so on.

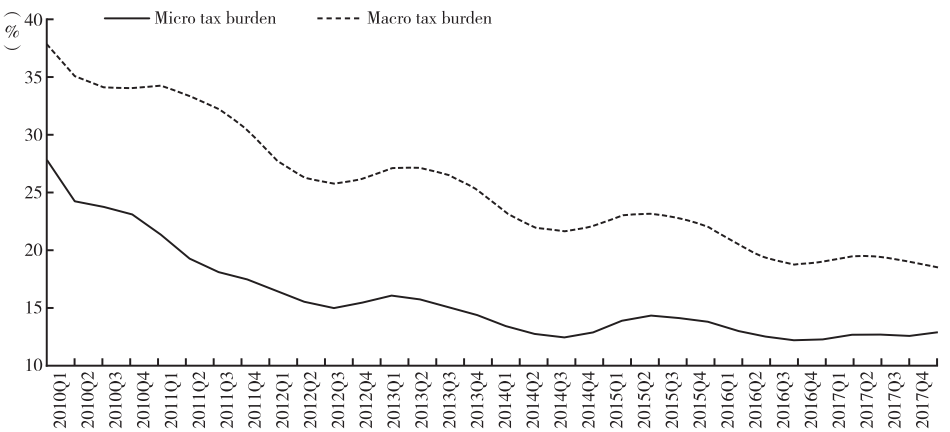

Figure 4. China's Macro and Micro Tax Burdens from 2010 to 2017

3. Index Compilation

Based on the above-mentioned individual indexes, this paper constructs the supply-side composite index and the supply-side reform index. The supply-side composite index reflects the supply-side situation in the economic structure, and the supply-side reform index reflects the reform promotion effect.

3.1. Index Setting

The supply-side composite index is designed to measure the supply-side status of the economic structure of each province (municipality). The larger the index valueis, the better the economic supply-side status of the province (municipality) is, i.e., the lower the production capacityis, the less the stockingis, the lower the leverageis, the lower the costis. Therefore, the Grade-II index of the supply-side composite index must be reversed. The characteristic indexes under the foregoing index and the data sources are as shown in Table 5.

Table 5. Characteristic Indexes under Supply-Side Composite Index and Data Sources

Index	Grade-I index	Grade-II index	Calculation method	Data source
Supply-side composite index	Capacity index	Capacity utilization	Actual output/potential output	China Economic Net
	Stocking index	Short-term real estate stocking	Housing area to be sold within 1-3 years / current housing area for sale	China Real Estate Statistical Yearbook
		Backlog real estate stocking	Housing area to be sold beyond 3 years / current housing area for sale	
	Leverage index	Micro leverage ratio	Liabilities/assets	China Economic Net
	Cost index	Macro tax burden	Tax /GDP	China Economic Net
		Micro tax burden	Tax /main operating income	

The supply-side reform index is designed to measure the improvement of the supply-side structure of each province (municipality). The larger the index valueis, the more obvious the improvement effectis, i.e., the more significant effects of “capacity reduction, de-stocking, deleveraging, and cost reduction” is, and the YOY growth rate of capacity utilization and the YOY growth rate of output should decrease. The other indexes are subject to the same principle.

Therefore, the Grade-II index of the supply-side reform index must be reversed. The characteristic indexes under the foregoing index and the data sources are as shown in Table 6.

Table 6. Characteristic Indexes under Supply-Side Reform Index and the Data Sources

Index	Grade-I index	Grade-II index	Data source
Supply-side reform index	"Capacity reduction" index	Capacity utilization YOY growth rate	China Economic Net
		Output YOY growth rate	
	"De-stocking" index	YOY growth rate of short-term real estate stocking	China Real Estate Statistical Yearbook
		YOY growth rate of backlog real estate stocking	
	"Deleveraging" index	YOY growth rate of micro-leverage ratio	China Economic Net
	"Cost reduction" index	YOY growth rate of macro tax burden	China Economic Net
		YOY growth rate of micro tax burden	

It should also be noted that the supply-side structural reform was officially proposed in November 2015, but the starting point of the study by this paper began in the first quarter of 2010 for two reasons: one is the model's demand for the sample size; the other is to compare the structural changes and reforms on the supply side in the country and various provinces (municipalities) before and after 2015. Therefore, the sample range of the supply-side composite index is set to be between the first quarter of 2010 and the fourth quarter of 2017, and the sample range of the supply-side reform index is between the first quarter of 2011 and the fourth quarter of 2017.

3.2. Compilation Methods

This paper draws on the economic composite index compilation method proposed by the Bureau of Economic Analysis (BEA) of the US Department of Commerce. The reasons for choosing this method are as follows. Firstly, the index of each province (municipality) can be compiled and the trend can be adjusted, and then different provinces (municipalities directly under the central government) can be compared according to the index value. Secondly, the changes in economic reality and reform effects can be grasped, and it can further help to propose countermeasures for the direction of change. Specifically, the compilation method is as follows.

Step 1: Find the symmetry change of the index and normalize it. Set index $Y_{ij}(t)$ as the index i in index group j, and j=1,2,...,32, representing 31 provinces and the country respectively; i=1,2,...,k_j is the serial number of the index within the group, and k_j is the number of indexes within the index group j.

Find the symmetric change rate $C_{ij}(t)$ of $Y_{ij}(t)$ so that the positive and negative

changes have a symmetrical form, i.e.,

$$C_{ij}(t) = 200 \times \frac{Y_{ij}(t) - Y_{ij}(t-1)}{Y_{ij}(t) + Y_{ij}(t-1)} \tag{4}$$

When there is a zero or negative value in $Y_{ij}(t)$ or when the index is a ratio sequence, adopt the first-order difference $C_{ij}(t)=Y_{ij}(t)-Y_{ij}(t\text{-}1)$.

Normalize the symmetric change rate $C_{ij}(t)$ of each index, to make its average absolute value be 1. So, find the normalization factor A_{ij}, i.e.,

$$A_{ij} = \sum_{t=2}^{T} \frac{|c_{ij}(t)|}{T-1} \tag{5}$$

Normalize $C_{ij}(t)$ using A_{ij} to get normalization change ratio:

$$S_{ij}(t) = \frac{C_{ij}(t)}{A_{ij}} \tag{6}$$

Step 2: Find the normalized average change ratio of each index group.So, find the average change ratio $R_j(t)$ of each index group, i.e.,

$$R_j(t) = \frac{\sum_{i=1}^{k_j} s_{ij}(t) w_{ij}}{\sum_{i=1}^{k_j} w_{ij}} \tag{7}$$

Then, calculate the exponential normalization factor F_j, i.e.,

$$F_j = \left[\sum_{t=2}^{T} |R_j(t)| /(T-1) \right] / \left[\sum_{t=2}^{T} |R_2(t)| /(T-1) \right] \tag{8}$$

Finally, calculate the normalized average change ratio $V_j(t)=R_j(t)/F_j$, and use the amplitude of the average change ratio of national index sequence to adjust the average change ratio of the index sequence of each province, the purpose of which is to treat index as a coordinated system and make a comparison.

Step 3: Compile the index $I_j(t)$, and set $I_j(1)=100$, to get:

$$I_j(t) = I_j(t-1) \times \frac{200 + V_j(t)}{200 - V_j(t)} \tag{9}$$

3.3. Analysis of the Compilation Results of Supply-Side Composite Index

According to the results of the index self-measurement, China's supply-side composite index is shown in Figure 5. Since 2010, the index has continued to decline. It has gradually recovered after falling to the peak valley in the first quarter of 2015. This at least indicates the following two points. Firstly, since the global financial crisis in 2008, China has adopted the demand-side stimulus policy of "using a deluge of stimulus" type, which has saved the economic growth rate, but situation on the economic supply side has been deteriorating, with highlighted manifestation in overcapacity, excessive real estate stocking, high leverage, and heavy corporate burden. Secondly, the introduction of supply-side structural reform is at the appropriate time. When the supply-side of the economic structure in 2015 showed a worse trend, the timely launch of the reform undoubtedly has effectively curbed the further deterioration of the economic structure and helped the economy to stabilize on the "L-shaped" platform.

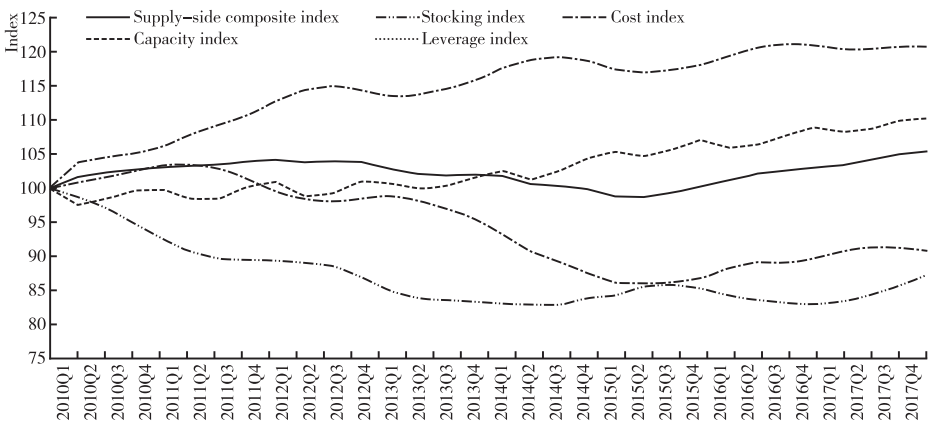

Figure 5. China's Supply-Side Composite Index from 2010 to 2017

In order to better examine the reality of the supply-side structure of each province (municipality), this paper can rank provincial administrative divisions by quarter, by year and by sample interval, and due to the limitation of length, this paper only analyzes the comprehensive ranking during the sample period. Table 7 shows that Heilongjiang, Guizhou, Henan, Fujian, and Gansu rank among the top five in terms of supply-side composite index. The ranking includes both the top 10 provinces and the provinces ranking after 20 in terms of economic aggregates. This result should

be considered from the perspective of economic development mode. For Henan and Fujian whose economic aggregate ranks high, their economic development modes have their own characteristics. Henan focused on the transformation and upgrading of the manufacturing industry and gave full play to the advantages of the agricultural province. Fujian focused on optimizing the industrial structure and gave full play to the operation vitality of private enterprises. The two provinces did not rely on excessive investment or excessive borrowing to promote economic growth. For Heilongjiang, Guizhou and Gansu, which rank lower in terms of economic aggregates, their economic development relied on neither large investment nor borrowing. The problems of "capacity reduction, de-stocking, deleveraging, and cost reduction" were not prominent, but due to the reform insufficiency, low degree of openness and slow economic transformation, the economic growth cannot be significantly increased, and the quality of economic development cannot be improved.

From the perspective of individual indexes, the municipalities such as Beijing, Tianjin and Shanghai have optimized industrial structure earlier, so there were no obvious overcapacity problems in the above five major industries. Provinces such as Gansu and Heilongjiang are trapped in economic development levels and population inflow restrictions, so their real estate market development was limited, and the stocking problem did not appear. The debts of industrial enterprises in central provinces such as Hunan and Anhui were below the national average. Some studies have shown that the macro and micro leverage ratios of Hunan Province in 2014 were much lower than the national average (Liang, 2016).[1] However, although the problems of "capacity reduction, de-stocking, and deleveraging" in economically developed provinces (municipalities) such as Shanghai were not prominent, the problem of "cost reduction" was quite obvious. The average cost index of Shanghai in 2017 was 80.75, ranking the lowest in the country.

Table 7. Supply-Side Composite Index for 2010-2017 and the Top Five Provinces for Each Index

	Supply-side composite index	Capacity index	Stocking index	Leverage index	Cost index
1	Heilongjiang	Beijing	Gansu	Hunan	Guangxi
2	Guizhou	Tibet	Heilongjiang	Anhui	Fujian
3	Henan	Heilongjiang	Guangdong	Henan	Anhui
4	Fujian	Tianjin	Guizhou	Jiangsu	Hunan
5	Gansu	Shanghai	Xinjiang	Hainan	Shaanxi

[1]According to Liang's research, the ratio of Hunan's total government debts to the province's GDP at the end of 2014 was 26.4%, significantly lower than the national average and international general level; the ratio of non-financial enterprises' debts to provincial GDP at the end of 2015 was 59.4%, lower than the national average of 143.5%; the ratio of financial institutions' debt balance to GDP was 1.6%, lower than the national average of 21%; the ratio of residential loan balance to GDP was 26.8%, lower than the national average of 39.9% over the same period.

3.4. Supply-Side Reform Index Compilation Results

China's supply-side reform index is as shown in Figure 6. As can be seen from the figure, the index gradually rebounded after falling to the peak valley in 2015. In terms of segmentation, the index was around 99.5 from the first quarter of 2015 to the fourth quarter of 2016, but since 2017, the index has fallen back below 98. On the one hand, it indicates that the awareness of the nationwide supply-side structural reform is being strengthened and consolidated. On the other hand, it indicates that the reforms in 2017 were not as effective as in 2016, partly because some provinces completed the goal of "capacity reduction, de-stocking, and deleveraging" three years ahead of schedule in 2016.

Since the supply-side reform was proposed in 2015, the supply-side reform index and various sub-indexes have improved, especially the supply-side reform index, the "de-stocking" index and the "cost reduction" index have shown an obvious upward trend. It indicates that some progress in the supply-side reform has been achieved nationwide under the guidance of the policy.

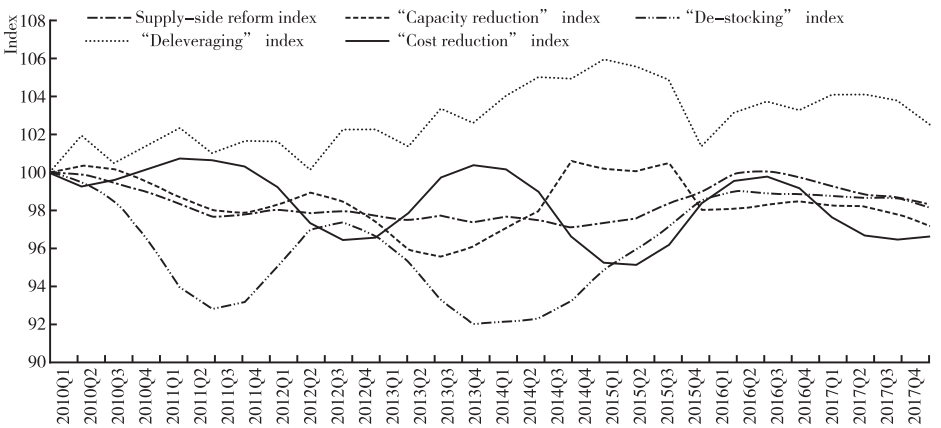

Figure 6. National Supply-Side Reform Index from 2011 to 2017

From the perspective of specific provinces, Shaanxi, Yunnan, Tibet, Ningxia and Chongqing rank among the top five. The reason is that these five provinces put different emphasis on "capacity reduction, de-stocking, deleveraging, and cost reduction", and the results were relatively significant. For example, in Shaanxi Province, the "capacity reduction" has achieved remarkable results. In 2016, the task of steel capacity reduction assigned by the country was completed three years ahead of schedule, with steelmaking capacity of 1.6 million tons and ironmaking capacity of 700,000 tons reduced, 42 coal mines shut down and capacity of 18.24 million tons exited in the year. In 2017, Shaanxi Province resolved excess steel capacity of 2.1 million tons, and coal capacity reduction

completed 64% of the "13th Five-Year" mission. For example, the ranking of the supply-side composite index of Yunnan and Tibet was lower in the country for a long term, and the small-scale reform efforts can achieve greater results. At the same time, they have obvious effects on "cost reduction". In 2016 and 2017, Yunnan has introduced nearly 100 measures to reduce enterprises' tax burden by more than RMB100 billion (Deng, 2017). Since 2012, the macro and micro tax burdens of Tibet have dropped significantly. It is an important reason for its ranking improvement.

From the perspective of individual indexes, Shanghai's "de-stocking" index ranks first in the country. On the one hand, since real estate control measures have been introduced by the whole country and Shanghai, the effect of combination of point and face is formed; on the other hand, the number of state-owned land auctions gradually declines, the area used for real estate development has gradually decreased, and given the strong demand in one-tier cities, there is basically no stocking problem. Shandong's "deleveraging" index ranked first, mainly because the province vigorously expanded direct financing channels and actively carried out reform measures such as debt-to-equity swaps. Statistics show that for every 100 yuan value created by enterprises, Shandong only needs to grant 88 yuan loans, while the national average is 139 yuan; and since 2015, the leverage ratio of Shandong enterprises has achieved drops in three consecutive years, 10.8% lower than the national level (Wang, 2017).

Table 8. Supply-Side Reform Index for 2011-2017 and the Top Five Provinces for Each Index

	Supply-side reform index	"Capacity reduction" index	"De-stocking" index	"Deleveraging" index	"Cost reduction" index
1	Shaanxi	Shaanxi	Shanghai	Shandong	Ningxia
2	Yunnan	Jiangxi	Shaanxi	Hebei	Yunnan
3	Tibet	Shanxi	Beijing	Gansu	Shaanxi
4	Chongqing	Tianjin	Tibet	Guangdong	Xinjiang
5	Ningxia	Hainan	Ningxia	Henan	Tibet

4. Analysis of the Effect of Supply-Side Structure on Economic Growth

Supply-side structural reform aims to improve the quality and quantity of economic growth through the adjustment of economic structure. To this end, this paper intends to further study the relationship between supply-side structure and economic growth. As can be seen from Figure 7, there is a "U" type nonlinear relationship between supply-side composite index and the per capita GDP.

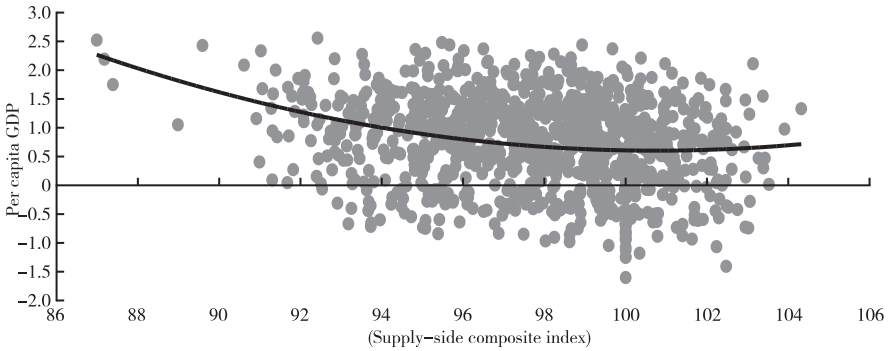

Figure 7. Supply-Side Composite Index and Per Capita GDP

To further study the effect of supply-side structure on economic growth, combined with Solow's economic growth model, the following verification model is set:

$$\log\left(rgdp_{i,t}\right) = \alpha + \beta_1 supply_{i,t} + \beta_2 supply_{i,t}^2 + \beta_3 \log\left(K_{i,t}\right) + \beta_4 \log\left(L_{i,t}\right) \tag{10}$$

In the formula, $\log(rgdp_{i,t})$ indicates the per capita GDP of province i in period t after logarithmic processing; $supply_{i,t}$ represents the supply-side composite index of province i in period t or a sub-index of supply-side composite index; $\log(K_{i,t})$ represents the capital stock of province i in period t, and $log(L_{i,t})$ represents the labor force scale of province i in period t.

This paper first refers to the research of Zhang *et al.*(2003, 2004) to calculate the national capital stocking, and uses the resident savings deposit to convert the capital stock of the i-th province; then adopts the panel regression of two-way fixed effect. The data comes from China Economic Net. The results are as shown in Table 9.

Table 9. Supply-Side Composite Index and Regression Results of Per Capita GDP

Panel	log(*rgdp*)		
supply	–0.1707 (0.0486)***		
$supply^2$	0.0010 (0.0003)***		
capacity		0.0229 (0.0176)	
$capacity^2$		–0.0001 (0.0001)	
inventory			–0.0308 (0.0088)***
$inventory^2$			0.0002 (0.0001)***

Panel	log(*rgdp*)				
leverage				–0.0003 (0.0105)	
$leverage^2$				0.0001 (0.0001)	
cost					–0.0322 (0.0122)**
$cost^2$					0.0002 (0.0001)**
log(*K*)	0.4851 (0.0371)***	0.5071 (0.0381)***	0.5187 (0.0376)***	0.5407 (0.0370)***	0.5227 (0.0399)***
log(*L*)	1.0749 (0.1572)***	1.0731 (0.1648)***	1.0583 (0.1633)***	1.3328 (1.3328)***	1.1556 (0.1631)***
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	957	957	957	957	957
R-squared	0.2477	0.1901	0.1947	0.2312	0.1967

Note: ***, ** and * indicate the 1%, 5% and 10% significance level, respectively.

It can be seen from the regression results that the first-degree term coefficient of the supply-side composite index is negative, the quadratic coefficient is positive, and both are significant at the 1% significance level, and the "U" relationship between supply-side structure and economic growth is verified.

Specifically, this "U"type relationship is significantly reflected in the relationship of stocking index and cost index with economic growth, while no nonlinear relationship has been found between capacity index and leverage index and the economic growth. If the quadratic terms in the model are further eliminated, and the two are re-regressed, the results obtained are as shown in Table 10. As can be seen from the regression results, production capacity has a certain inhibitory effect on economic growth, and leverage has a weak acceleration effect on economic growth.

Table 10. Capacity Index, Leverage Index, and Regression Results of Per Capita GDP

Panel	log(*rgdp*)	
capacity	–0.0033 (0.0001)***	
leverage		0.0017 (0.0007)**
log(*K*)	0.5051 (0.0381)***	0.5209 (0.0379)***

Panel	log(*rgdp*)	
log(*L*)	1.1081 (0.1632)***	1.0861 (0.1642)***
Individual fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Observations	957	957
R-squared	0.1882	0.1832

Note: ***, ** and * indicate the 1%, 5% and 10% significance level, respectively.

5. Conclusions

By selecting the representative indexes of capacity reduction, de-stocking, deleveraging and cost reduction, this paper constructs the supply-side composite index and the supply-side reform index respectively to objectively describe the supply-side structure facts and improvement degree of China's economy, and get the following basic conclusions.

Firstly, the supply-side structural reform with "capacity reduction, de-stocking, deleveraging, cost reduction and improving underdeveloped areas" as the main line was officially proposed in 2015, but the reform practice of each province (municipality) should be earlier than that year. This may be because some provincial governments have realized in the process of deepening the reform that the economic growth mode relying on excessive investment and excessive borrowing is unable to solve the sustainable development of the province (municipality), and thus actively promoted the reform of "capacity reduction, de-stocking, deleveraging, and cost reduction".

Secondly, this paper selects indexes according to the reform practice of "capacity reduction, de-stocking, deleveraging, and cost reduction", and evaluates the supply-side structure of each province. This paper finds that those provinces that adhere to the traditional economic development mode and lack major reform measures have no prominent contradictions in the areas of "capacity reduction, de-stocking, deleveraging, and cost reduction", but this does not represent the high quality of their economic development. "Capacity reduction, de-stocking, deleveraging, and cost reduction" can only represent several areas of the supply side that need to be optimized, not all of them. In the past three years or even longer period, these areas had priority to reform.

Thirdly, if the reform progress of the whole country and each province (municipality) is measured according to "capacity reduction, de-stocking, deleveraging, and cost reduction", the intensity in 2017 was weaker than in 2016 at national level, which may be because the reform of reductions has a bottom line in quantity, e.g., the leverage can not be zero; the margin of benefit will be diminishing. From the perspective of the provinces, the effectiveness of the reform depends to a large extent on the original economic development mode of each province (municipality). The provinces that rely

on the natural resources and take extensional development path will achieve outstanding effects in reform as long as they are willing to set high-standard administrative indexes.

Fourthly, from the perspective of economic growth, the supply-side structure has a nonlinear effect on the acceleration and deceleration of the economy, and the nonlinear relationship is mainly affected by stock and cost. "Capacity reduction" can release the suppression of the economy. Leverage has a slight acceleration effect on the economy, but excessive leverage is the most critical factor leading to over-investment, overcapacity, inefficient investment and financial risks, and "deleveraging" is a key to structural reform.

Fifthly, from the perspective of high-quality economic development, the focus of future supply-side structural reform is "improving underdeveloped areas", and each province (municipality) should make scientific and prudent assessment on the promotion effect and further reform space of "capacity reduction, de-stocking, deleveraging, and cost reduction". In addition, each province (municipality) should identify undeveloped areas and strengthen reform to improve undeveloped areas. However, there is no doubt that the common shortcomings of the provinces (municipalities) are the low total factor productivity (TFP) caused by the lack of innovation.

"Capacity reduction, de-stocking, deleveraging, and cost reduction" is a short-term palliative measure for structural adjustment. It has achieved remarkable results in "optimizing stock allocation" for three consecutive years. However, in the process of transforming China's economy into high-quality development, "improving underdeveloped areas", i.e., "expanding quality increments" is the real long-term solution. The follow-up focus should be put on stimulating the vitality of the market micro-subjects through optimization of supply-side factors such as institutional innovation and technological innovation, to truly realize the decisive role of the market in resource allocation and enable the economy to achieve sustainable and healthy development.

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