8. AN EMPIRICAL ANALYSIS OF THE IMPACT OF RMB EXCHANGE RATE'S CHANGES ON INDUSTRIAL RESTRUCTURE[1]

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Abstract

This paper establishes a nonlinear semi-logarithmic model to empirically test China's economic data from 1994 to 2014 in order to analyze directly the impact of RMB exchange rate's changes on industrial restructuring. We draw the conclusion that the appreciation of nominal effective exchange rate hastens the development of the tertiary industry, while it restrains the secondary industry, and it shows non-significant effects on the primary industry. Different from most previous studies, it comes to the conclusion that RMB nominal effective exchange rate has more influence on the tertiary industry than on the secondary industry, and it supports more strongly that RMB appreciation raises the tertiary industry's position in the national economy. The reform of exchange rate regime in 2005 has reduced the exchange rate's impact on economy, so a mature foreign exchange market is conducive to economic development.

Keywords: nominal effective exchange rate, industrial restructure, RMB exchange rate regime reform, incomplete pass-through, nonlinear semi-logarithmic model

JEL Classification: F31, O24, L00

I. Introduction

Exchange rate influences the industrial structure through price level, international trade and international capital flows, and it is closely related to industrial structure with

[1] *This paper was presented at 2013 Global Business, Economics and Finance Conference, Wuhan University, China, 9-11 May 2013.*

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the deepening of economic globalization. Since the reform of RMB exchange rate system in July 2005, when People's Bank of China announced the implementation of "a managed floating exchange rate system with reference to a basket of currencies, which is based on market supply and demand", the foreign exchange market has been more mature and exchange rate has been playing a more and more important role in China's economy. Studying the impact of RMB exchange rate on the industrial restructuring has, thus, practical significance.

Studying from the price point of view, the scholars basically agree that the exchange rate pass-through is incomplete. Micro-level studies support that structural difference in commodity market leads to incomplete pass-through. Dornbusch (1987) and Dixit (1989), respectively, pointed out that price stickiness and the existence of sunk costs reduce the flexibility of pass-through to some extent. The macro-level studies mainly focus on inflation, economic openness and monetary system. Taylor (2000) argued that exchange rate pass-through weakened in condition of increasing global competition and a low and stable inflation environment by staggered pricing models. Exchange rate pass-through is incomplete and time-lagged in China (Yongxiang Bu, 2001; Yang Zhou, 2011). And exchange rate's shock on price is declining along the chain of commodity circulation (Qiang Fu and Maohui Wu, 2011).

Empirical research on the relationship between exchange rate and international trade is controversial. Chowdhury (1993) concluded that continuously substantial exchange rate fluctuation is bad for trade development. Klein (1990) put forward that exchange rate's effects on trade are various with different countries and industries. Exchange rate affects different products in varying degrees, and it has greater impacts on labor-intensive products than on capital-intensive products in China (Zheng Zeng and Yabin Zhang, 2007). Foreign trade promotes the optimization and upgrading of China's industrial structure, while causing some problems (Xiaobing Huang, 2011).

The impact of exchange rate's changes on FDI is on dispute. Caves (1989), Froot and Stein (1991) found that the depreciating dollar contributed to United States large FDI inflows, while Goldberg and Kolstad (1995) found that depreciation has no obvious impact on foreign direct investment. Secru and Vanhulle (1992) considered that exchange rate volatility would inhibit foreign direct investment, while Cushman (1988) held the opposite view. FDI contributes to Chinese economic growth and promote the optimization of industrial structure (Wenguang Bo, 2005; Wang Zhang, 2009).

Exchange rate has a certain impact on employment, and the degree varies with industry (Dixit, 1989; Lebow, 1993). Exchange rate's changes can cause the variation in trade prices, factor price and, then, lead to the reallocation of factor resources and adjustment of industrial structure (Kejian Gu and Jian Yu, 2008).

Summarizing the existing theoretical and empirical research results, we can find that exchange rate's changes have an impact on the adjustment of industrial structure through price pass-through, international trade and investment. Incomplete exchange rate pass-through affects different industries differently, and exchange rate promotes the optimization of industrial structure through international trade and investment.

There is little research about the direct relationship between industrial structure and exchange rate, and the complex nonlinear relationship between factors affecting industrial structure has been rarely considered in empirical research. Aiming at this

deficiency, this paper establishes a nonlinear semi-logarithmic model based on Chenery and Syrquin's method to directly analyze how exchange rate impacts on China's industrial structure. This paper is organized as follows. Section II theoretically studies the effects of exchange rate on industrial restructuring by price pass-through, international trade and investment. Section III establishes the nonlinear model, and Section IV empirically analyzes relevant data for China. Section V comes to the conclusion and puts forward policy recommendations.

II. Theoretical Background

The path how exchange rate impacts the industrial structure can be divided into price pass-through, international trade and investment. As a relative price, the exchange rate's changes influence the abundance of production factors and capital stock, which leads to the reallocation of resources. Finally, it promotes the adjustment of industrial structure.

Price pass-through path works through two stages of transmission mechanism. Based on the incomplete pass-through, the impact of exchange rate's changes on import price, producer price and consumer price weakens along the chain of commodity circulation, and there is time-lag. Changes in relative prices in different sectors promote the industrial restructuring. For example, the fluctuations of exchange rate change for tradable and non-tradable goods' relative price. Although the exchange rate appreciation increases non-tradable goods' price, higher profit is obtained in the tradable goods sector when the productivity in tradable sector is significantly higher than in the non-tradable one.

International trade path refers to exchange rate movement affecting foreign trade through the shift in terms of trade, and then promoting economic growth and industrial restructuring. Exchange rate movements change the relative price of import and export commodities. As a result, it affects the demand for domestic and foreign commodity, namely the foreign trade condition. The growth of foreign trade affects industrial structure in two ways. Firstly, it directly affects the output and profit in tradable goods sector, which promotes reconfiguration between different sub-sectors. On the other hand, foreign trade promotes economic development as the engine of economic growth.

International investment path plays its role in two stages. The change in exchange rate generates the wealth effect, namely the relative wealth changes at home and abroad. And exchange rate's fluctuation changes the international investment's risk and investors' expectation. Then, it promotes the international transfer of assets, which changes the return from investment. Between the two forms of international investment, direct investment's effect on industrial structure is more obvious than the indirect investment. Direct investment directly increases the supply of capital and employment. The technology spillover effects can enhance the level of production technology and management. It improves the productivity of relevant sectors and impacts on industrial restructuring.

III. The Semi–logarithmic Model

Chenery and Syrquin (1975) thought that there is a nonlinear structure among economy, policy and other factors in economic development process. By expressing the factors affecting industrial structure separately, they put forward the classical semi-logarithmic model:

$$X = \alpha + \beta_1 \ln y + \beta_2 (\ln y)^2 + \gamma_1 \ln N + \gamma_2 (\ln N)^2 + \sum \delta_i T_j + \varepsilon F \quad (1)$$

where: X is the proportion of economic structure, y represents per capita GNP, N is population (in millions), T is a dummy variable for time periods taking a non-zero value for different periods, and F is the net resource inflow, measured as imports minus exports of goods and nonfactor services as a share of total GDP.

They pointed out that the complete model is suitable for multinational cross-section analysis, while the simplified formula is needed for analyzing a specific country. The population (N) which is used to distinguish different scale economies may lead to serial correlation, thus omitting N.

Based on the Chenery-Syrquin model and the theoretical considerations, this paper adds as variable the exchange rate, which has important influence on industrial restructuring. Exchange rate has important influence on international investment and international trade, and it directly impacts on import, export, savings and investment. which directly decide F. Thus, we can substitute exchange rate for variable F. Compared with GNP, GDP is more accurate to describe the economic structure, and it still considers the influence of economic scale after removing the population (N). Taking China's reality into consideration, adding the exchange rate regime reform in July 2005 as a dummy variable is more appropriate than pure time period, while interactive items can highlight the effect of the reform. According to the above statement, this paper establishes the nonlinear model:

$$\mathrm{X}_t = \alpha + \beta_1 \ln \mathrm{Y}_t + \beta_2 (\ln Y)^2_t + \beta_3 E_t + \beta_4 DUME + u_t \quad (2)$$

where: X is each industry[4] accounted as the proportion of GDP, Y represents GDP, E is exchange rate, and DUME is the interaction of exchange rate and the dummy variable representing 2005 exchange rate regime reform, and it is the product of DUM and E.

IV. The Empirical Analysis

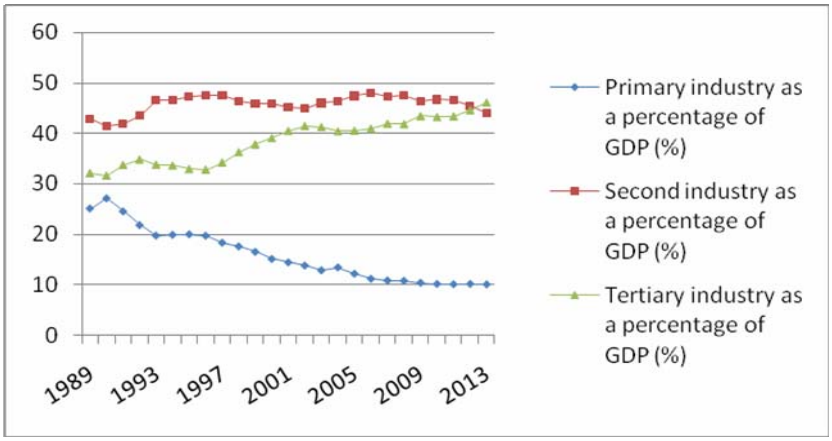
After 1985, the Chinese three industries proportion in GDP shows the pattern of "secondary-tertiary-primary". Primary industry's proportion in GDP showed a declining trend since 1990, and it went down to 10.01% in 2013. Secondary industry's

[4] *This paper adopts the method of three divisions of industry. The primary industry refers to agriculture, forestry, animal husbandry and fishery. The secondary industry refers to industries (including mining, manufacturing, electricity, gas, water, etc.) and the construction industry. The tertiary industry refers to sectors except the primary and secondary industry, and it can be divided into circulation department and service department.*

proportion of GDP has been fluctuating up and down at 45%. Proportion of the tertiary industry in GDP showed a rising trend and it reached 46.09% in 2013, 2.2 percentage points more than the secondary industry. The industrial structure became "tertiary-secondary-primary".

Figure 1

Industrial Structure of China



Note. The figure is based on CEInet Statistics Database.

Judging from the point of view of internal structure, the industrial structure has been optimized to some extent. In primary industry, the share of agriculture decreases, forestry is relatively stable, and animal husbandry and fishery rises. In secondary industry, capital-intensive and technology-intensive industry is gradually developing. There is the rapid development of productive services in tertiary industry, such as financial and insurance industries, information services, while new industries, such as e-commerce, cultural creative industries, have made great progress.

From an overall perspective, China's industrial structure has been gradually optimized, and the tertiary industry has been playing a more and more important role in the national economy. But problems within the industrial structure cannot be ignored. Industrial proportion in China is unbalanced and especially the services sector is under developed. There are different levels of "short board" in the fields of technology, industrial value added for agricultural, industrial and service sectors, and industrial competitiveness is weak. Figure 1 shows that changes in industry structure occurred in 2005 are likely related to the adjustment of exchange rate policy. In the following, the paper conducts an empirical research.

a) Data

On January 1st, 1994, China began to implement a single, managed floating exchange rate system based on market demand and supply, so that we select data after 1994. At the same time, out of the consideration of the availability of data, we use quarterly data ranging from the first quarter of 1994 to the second quarter of 2014.

RMB nominal effective exchange rate is selected from Bank of International Settlements and it is the average monthly data in indirect quotation. This paper takes 2010 as the base year in which the nominal effective exchange rate is 1.

To measure the industrial structure, we choose the three industries' value added (symbolized by FI, SI, TI) as the proportion of GDP. They are chosen from CEInet Statistics Database.

The data is processed as follows. Converse exchange rate to quarterly data after Hodrick-Prescott frequency transformation, and symbolize it by NEER. Take logarithm of GDP and denote it by LY, and denote the corresponding square value by LY^2; The three industries' value added as the proportion of GDP are calculated by FI/Y, SI/Y, TI/Y, respectively, and then recorded as FIY, SIY, TIY. All variables are seasonally adjusted by X-12-ARIMA method. DUME is the product of DUM and NEER, noted as DUMNEER.[5]

$$DUM_t = \begin{cases} 0 & if \ \ t \le 2005 \ Q2 \\ 1 & if \ \ t \ge 2005 \ Q3 \end{cases}$$

b) Stationary Test

FIY, SIY, TIY, LY, LY^2, NEER, DUMNEER is tested by Augment Dicky-Fuller test, and the result is shown in Table 1.

Table 1

Unit Root Test Results

Level	t-Statistic	Prob.*	1st difference	t-Statistic	Prob.*	Conclusion
FIY	-2.69725	0.24060	D(FIY)	-13.13387	0.00000	I(1)
SIY	-1.98812	0.59880	D(SIY)	-10.90555	0.00000	I(1)
TIY	-1.75574	0.71690	D(TIY)	-2.82467	0.05960	I(1)
LY	-1.47859	0.82890	D(LY)	-6.20867	0.00000	I(1)
LY^2	-1.49975	0.82170	D(LY^2)	-4.06394	0.00190	I(1)
NEER	-2.03306	0.57310	D(NEER)	-2.84214	0.05740	I(1)
DUMNEER	-2.13370	0.51930	D(DUMNEER)	-8.97736	0.00000	I(1)

The result shows that under the confidence level of 10%, these variables are not stable, while their first order difference terms are all stationary, namely they are integrated of order 1.

c) Cointegration Test

Three models to be tested are listed as follows:

$$\mathrm{FIY}_t = \alpha + \beta_1 LY_t + \beta_2 (LY)^2_t + \beta_3 NEER_t + \beta_4 DUMNEER_t + u_t \quad (3)$$

$$\mathrm{SIY}_t = \alpha + \beta_1 LY_t + \beta_2 (LY)^2_t + \beta_3 NEER_t + \beta_4 DUMNEER_t + u_t \quad (4)$$

$$\mathrm{TIY}_t = \alpha + \beta_1 LY_t + \beta_2 (LY)^2_t + \beta_3 NEER_t + \beta_4 DUMNEER_t + u_t \quad (5)$$

[5] *We use Eviews 6.0 to finish the empirical analysis.*

This study adopts the JJ test put forward by Johansen (1988), Juselius (1990) to test the cointegration, and the result is shown in Table 2.

Table 2

The Johansen Cointergration Test Results

Model	Hypothesized No. of CE(s)	Eigenvalue	Trace statistic	0.05 Critical Value	Prob.**
3	None *	0.656128	173.743	69.8189	0.000000
	At most 1 *	0.381717	89.4116	47.8561	0.000000
	At most 2 *	0.278343	51.4277	29.7971	0.000050
4	None *	0.691194	156.186	69.8189	0.000000
	At most 1 *	0.313848	63.3573	47.8561	0.000934
	At most 2 *	0.252828	33.6015	29.7971	0.017387
5	None *	0.625966	157.310	69.8189	0.000000
	At most 1 *	0.419632	79.6207	47.8561	0.000006
	At most 2 *	0.290616	36.6375	29.7971	0.006970

One may see that in each model, namely (3) (4) (5), there are more than two cointegration relationships. Due to the least squares estimation model followed, we do not specify the normalized cointegration relationship

d) The Least Squares Estimation

As the four models were cointegrated, we can study exchange rate's influence on industrial structure with them. After the least squares regression, we get the results as follows:

$$FIY = 0.221071 - 0.0843360*LY + 0.0157776*LY2 - 0.006917*NEER - 0.004880*DUMNEER$$

(13.07512) (-11.65283) (7.551553) (-0.302943) (-0.807726)

R2=0.932351；Adjusted R2= 0.928837；Durbin-Watson stat= 0.529718 (6)

$$SIY = 0.580208 + 0.022826*LY - 0.007004*LY2 - 0.143944*NEER + 0.013745*DUMNEER$$

(49.35980) (4.536475) (-4.821617) □-9.067418□ □3.272139□

R2= 0.753342□Adjusted R2= 0.740528□Durbin-Watson stat= 0.977726 □7□

$$TIY = 0.190379 + 0.062486*LY - 0.009492*LY2 + 0.159894*NEER - 0.007932*DUMNEER$$

(8.920731) (6.840224) (-3.599335) □5.547696□ □-1.040001□

R2= 0.923054□Adjusted R2= 0.919057□Durbin-Watson stat= 0.240892 □8)

Judging from the three equations' D.W., there is magnitude residuals autocorrelation in these models. We solve this problem by the generalized difference method.

e) The Generalized Difference Method

We denote the residuals from equation (6), (7) and (8) as res01, res02 and res03, respectively. Then, we judge their lag after making vector auto-regression. The results are shown in Table 3.

Table 3

VAR Lag Order Selection Criteria

Series	Lag	LogL	LR	FPE	AIC	SC	HQ
res01	0	283.625	NA	5.00E-05	-7.06562	-7.03584	-7.05368
	1	308.151	47.8254*	2.78E-05	-7.65376	-7.59421*	-7.62989*
	2	309.219	2.05582	2.77e-05*	-7.65546*	-7.56614	-7.61965
res02	0	280.947	NA	3.35E-05	-7.46525	-7.43435	-7.45291
	1	297.240	31.7172*	2.23e-05*	-7.87306*	-7.81126*	-7.84839*
	2	297.304	0.123705	2.29E-05	-7.84812	-7.75542	-7.81110
res03	0	256.357	NA	9.89E-05	-6.38393	-6.35415	-6.37199
	1	309.495	103.618*	2.69e-05*	-7.68737*	-7.62782*	-7.66349*
	2	309.575	0.155299	2.75E-05	-7.66438	-7.57506	-7.62857

Note. * indicates lag order selected by the criterion. ***, ** and * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

The results show that all the autoregressive lag orders of the three models' residuals are 1. Dealing with the residual sequences by vector autoregressive we get res01= 0.677438*res01(-1), res02 = 0.510785*res02(-1), res03 = 0.824656*res03(-1).

Introducing residuals' lag into these models, we establish new models with difference term as follows:

$$\mathrm{FIY}_t = \alpha + \beta_1 LY_t + \beta_2 (LY)^2_t + \beta_3 NEER_t + \beta_4 DUMNEER_t + 0.677438 u_{t-1} + v_t \quad (9)$$

$$\mathrm{SIY}_t = \alpha + \beta_1 LY_t + \beta_2 (LY)^2_t + \beta_3 NEER_t + \beta_4 DUMNEER_t + 0.510785 u_{t-1} + v_t \quad (10)$$

$$\mathrm{TIY}_t = \alpha + \beta_1 LY_t + \beta_2 (LY)^2_t + \beta_3 NEER_t + \beta_4 DUMNEER_t + 0.824656 u_{t-1} + v_t \quad (11)$$

The regression results are shown in Table 4.

Table 4

The Regression Results about the Impact of Exchange Rate on China's Industrial Restructuring

Variable	Dependent Variable		
	FIY	SIY	TIY
C	0.238440*** (-21.8217)	0.585489*** (-56.6862)	0.161588*** (-17.5152)
LY	-0.088280*** (-18.2749)	0.024265*** -5.31399	0.064547*** (-15.8258)
LY2	0.017492*** (-12.5549)	-0.007035*** (-5.34162)	-0.011298*** (-9.60437)
NEER	-0.023956 (-1.64287)	-0.151270*** (-10.9748)	0.191706*** -15.5714
DUMNEER	-0.005073 (-1.31519)	0.012556*** (-3.44384)	-0.006102* (-1.87388)
R-squared	0.970908	2.00565	0.985184
Adjusted R-squared	0.969377	0.799057	2.39056
Durbin-Watson stat	2.39937	0.809104	0.984404

Note. ***, ** and * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

Results of D.W. suggest that the introduction of residuals has eliminated the autocorrelation. And R^2 is obviously improved and it shows the model fit sample observations better.

As for the possible multicollinearity between LY and LY^2, logarithmic quadratic term can fit the gradual development process well, and it is helpful to test the nonlinear relationship among factors in economic development process. Omitting LY^2 will get wrong explanation, which is harmful. What's more, the result shows that LY and LY^2 are both significant, and the comprehensive result of them is more important for the study. As it can be predicted that the collinearity will be existing in the future, there is no problem to forecast.

The results in Table 4 indicate that both exchange rate (NEER) and the interactive variable DUMNEER have barely visible impact on the primary industry. Before the exchange rate regime reform in 2005, when the exchange rate appreciated with 1%, the secondary industry's proportion of GDP decreased by 0.151270%, while the tertiary industry's proportion increased by 0.191706%. After the 2005 reform, the influence of exchange rate is slightly lower. When the exchange rate appreciates by 1% the secondary industry's proportion of GDP decreases by 0.138714%, while the tertiary industry's proportion increases by 0.185604%. The impact of exchange rate on the tertiary industry is greater than on the secondary industry, and exchange rate regime reform affects the secondary industry more.

LY and LY^2 influence the primary industry obviously. When the average GDP increases by 1%, the primary industry's proportion in GDP decreases by 0.000378 percentage points[6], and this result corresponds to China's situation, where the primary industry's status has gradually been declining with the economic development. When the average of GDP increases by 1%, the secondary industry's proportion increases by 0.0000395 percentage points, which is less than the increment of tertiary industry's proportion (0.0003192 percentage points).

V. Conclusions and Policy Recommendations

Conclusions

This paper empirically researches the impact of RMB exchange rate on industrial restructuring by establishing the nonlinear model. It deals with quarterly data from 1994 to 2014 by unit root tests, co-integration tests, least squares estimation and generalized difference method for estimation. The conclusions are as follows.

The appreciation of RMB nominal effective exchange rate has no obvious influence on the primary industry. The appreciation of RMB nominal effective exchange rate, to a certain extent, inhibits the development of China's secondary industry while it promotes the development of tertiary industry. Compared with the secondary and tertiary industries in China, the primary industry is weak in economic outward-orientation and has low sensitivity to changes in the exchange rate, and the

[6] *It can be calculated from the model* $\overline{\partial X / \partial LY} = \beta_1 + 2\beta_2 \overline{LY}$ *, and* $\overline{LY}$ *= 1.443856.*

productivity of primary industry is particularly low, especially in agriculture. Then, it has little effect on the allocation of resources.

RMB appreciation increases the relative price of China's export commodities in international trade. As a result, trade volume reduces. On the other hand, due to Chinese export-oriented enterprises' generally weak international competitiveness, export enterprises would reduce commodity price to maintain market share. This results in reducing profit more in condition of low average profit, which is bad for further development. RMB's appreciation can affect the relative demand for domestic and foreign goods in domestic market, which would weaken the competitiveness of export-oriented enterprises in the domestic market. The appreciation of nominal effective exchange rate would inhibit the development of secondary industry. In recent years, high-tech industries, represented by information technology industry in the tertiary industry, rose rapidly and have been showing gradually increased competitiveness in the international markets. By increasing corporate profits, RMB appreciation promotes the development of the tertiary industry.

Changes in RMB nominal effective exchange rate influence the tertiary industry deeper than the secondary industry. This conclusion is different from previous studies. In most previous studies, due to the lagging development of the tertiary industry and a number of controls out of a variety of consideration, the appreciation of RMB influenced secondary industry deeper than the tertiary industry, as secondary industry accounted much more in the international trade. But this study indicates that China's tertiary industry has been developing faster and its share in foreign trade has been increasing, and its position in foreign trade was enhanced significantly with deregulation of the tertiary industry. RMB appreciation would attract international investment flows, increase the proportion of capital-intensive and technology-intensive industries, eliminate part of sectors with low productivity, and promote the development of high-tech industries and services, so that tertiary industry's status in national economy increases compared with the secondary industry. A certain range of RMB appreciation can further promote the optimization and upgrading of industrial structure.

The exchange rate regime reform in 2005 has been declining the degree of exchange rate's impact on China's industry structure. Exchange rate regime reform is conducive to mature China's foreign exchange market, and makes independent pricing and exchange rate risk management convenient for market participants. The declining impact of exchange rate's changes is helpful for the long-term economy development.

With increasing GDP, the primary industry's proportion of GDP declines while the secondary industry's contribution to GDP increases less than the tertiary industry. This conforms to the general trend of economic development. With the augmentation of economic strength, the industrial structure has been optimized gradually.

As the internal development of secondary industry is unbalanced with low international competitiveness, secondary industry remains extremely important in promoting China's economic development. Considering economic security and stability, RMB appreciation should be within a certain range to guarantee the optimization and upgrading of industrial structure.

Policy Recommendations

To promote the optimization of the industrial structure, a variety of policies needs to be implemented comprehensively and flexibly. According to the above-mentioned analysis, this paper puts forward policy recommendations as follows.

1. Gradually increase the elasticity of exchange rate, and promote the marketization of exchange rate deciding mechanism. Progressively liberalize controls on capital market to facilitate risk management for export enterprise to use kinds of financing ways in international financial market, and hedging the risks of exchange rate changes more actively.
2. Increase the investment in independent innovation field. Improve the technology innovation system and gain self-sufficiency in key technical sectors. Enhance export enterprises' international competitiveness and brand's influence. Gradually relax the constraints of access to the tertiary industry and introduce competition mechanism. Support high-tech industries by export tax rebates and other relevant policies to promote the further development of tertiary industry.
3. Actively guide the market demand, continue to implement policy to boost domestic demand. Get domestic demand into full play in stimulating economic growth and expand domestic market. Reduce overreliance on abroad demand.
4. Actively guide the industry development, accelerate the industry merger and reorganization, and forces out the lagging enterprise. At the same time, actively guide the structure and flow of foreign direct investment, optimize the import and export commodity structure, and optimize the secondary industry's internal structure. Promote the transformation and upgrading of traditional industries and foster strategic emerging industry vigorously.

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