Study on the Measurement of China RMB Exchange Rate Misalignment Evidence From 1994 to 2019

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Abstract— China RMB exchange rate is becoming more and more important nowadays. Since the financial crisis broke up in 2008 which happened in United States, the western countries started to charge China is an exchange rate manipulator and force the exchange rate of RMB undervalued of the normal level. This study use BEER(Behavior Equilibrium Exchange Rate) Model to analysis the real effective exchange rate of China RMB and try to explain if there has an exchange rate misalignment during 1994 to 2019 and if the U,S' charge about China is an exchange rate manipulator is true or not.

Index Terms—*China RMB, Exchange rate, Misalignment, Exchange rate manipulator.*

I. INTRODUCTION

What is the exchange rate misalignment? Collins (1997) explains the exchange rate misalignment means the real exchange rate misalignment which refers to the state of a country's real exchange rate deviating from its ideal real exchange rate. Under the conditions of open economies, if the real exchange rate has deviated the equilibrium exchange rate clearly, it will affect the stability and growth of a country's economy, and will have adverse effects on social welfare and international relations. Assuming other related factors remain unchanged. Exchange rate misalignment broadly affect the competitiveness of all producers of tradable goods and services in a country relative to producers in trading partners by changing the foreign currency price of home exports and domestic currency price of foreign imports.

With the progress of China's reform and opening up pushing on and the fast

development of China's economy, China's position in the world economic system has significantly improved, after ranking sixth in the world in China's economic aggregate in 2002, it was promoted to fourth place in 2006. In 2008, it surpassed Germany to become the third largest economy in terms of economic aggregates. In 2010, the total economic output exceeded Japan and became the second largest country in the world. Figure 1 below shows China will still be the No.2 largest economy in the world.

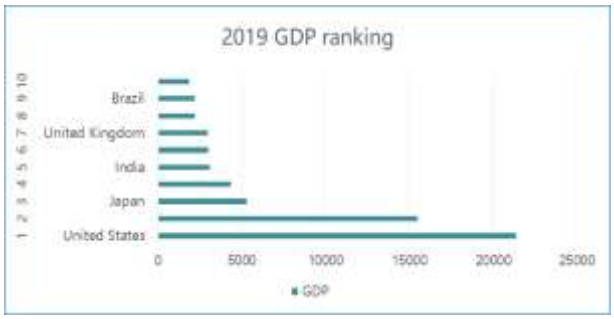

Figure 1: 2019 GDP ranking
Source: IMF data

China also became the third largest trading nation in 2005. For the first time in 2006, foreign exchange reserves surpassed Japan to become the largest reserve country. Figure 2 below shows the china's foreign reserve is increasing in recent years.

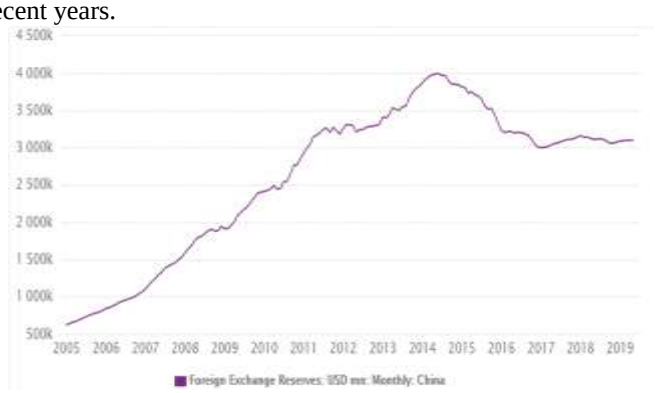

Figure2: China's Foreign exchange reserves
Source: CEICDATA

Because of the fast development of China's economy, the balance of china's economy and China RMB exchange rate is becoming more and more important for not just the Chinese people but also for the entry of the world. To this end, Western countries will also point to the goal of fulfilling their economic adjustment obligations. Among them, the use of external equilibrium and balanced balance of payments as an excuse to force China to implement the appreciation of the RMB exchange rate is a continuing issue in recent years.

The U.S charged China as an exchange rate manipulator in 2017, it is very important to figure out the condition of the RMB exchange rate misalignment to prove if China is an exchange rate manipulator or not. If there has an exchange rate misalignment of RMB, we need to know it is overvalued or undervalued, because if the China RMB undervalued at this period of time, it means China government tried to manipulate the exchange rate of RMB and force the RMB depreciation. It made the China get advantages when trading with other counties and protected the Chinese companies in the international trade. If there is no exchange rate misalignment happened of RMB, we can prove the U.S' charge is wrong, and China is not the exchange rate manipulator. This is the first study to focus on the RMB exchange rate misalignment

under the condition of U.S' charge and try to give some recommendations in recent years.

II. MATH

A. ADF Test:

The unit root test, in time series analysis, provides important information to choose an appropriate technique for investigating the independent variables. Let Y_t is a time series. In the case that time series data is stationary; it needs to have three features:

Mean is constant: $E(Y_t) = \mu$ (1)

Variance is constant: $Var(Y_t) = E(Y_t - \mu)^2 = \sigma^2$ (2)

Co-variance is constant$Y_{k=}E[(Y_t - \mu)(Y_{t-k} - \mu)] = \gamma_k$ (3)

When time series data is constant in mean, variance, and co-variance in which they are remain the same and does not vary over time, it is called stationary. In contrast, if it does not comply to these conditions, it is non-stationary. Augmented Dickey Fuller (ADF) is employed to test whether the time series is stationary in this study. The regression of ADF test is:

$\Delta Y = \alpha + \beta t + \delta Y_{t-1} + \sum_{i=1}^{m} \theta_i \Delta Y_{t-1} + U_t$ (4)

where, $\Delta$is represented for differential. $\alpha$is the intercept term andβ is times trend.

First difference I (1) is equal to $\Delta Y_{t-1} = Y_{t-1} - Y_{t-2}$. ADF corrects for higher order serial correlation by adding lagged differenced term: $\sum_{i=1}^{m} \theta_i \Delta Y_{t-i}$ (5)

The time series data can be stationary or non-stationary by setting up the null hypothesis for ADF as:

$H_0: \delta = 0$ (There is one unit root) (6)

$H_1: \delta < 0$ (There is no unit root) (7)

To reject or accept the null hypothesis, the critical value of t-statistics is used to make the decision.

B. Error correction model (ECM)

We define the error correction term by:

$\xi_t = y_t - \beta x_t$ (8)

Where β is a co-integrating coefficient. In fact,$\xi$is the error form a regression of y_t on x_t . Then an ECM is simply defined as:

$\Delta y_t = \alpha \xi_{t-1} + \gamma \Delta x_t + u_t$ (9)

Where $u_t$is *i.i.d*. The ECM equation simply says that Δy_tcan be explained by the lagged $\xi_{t-1}$and Δx_t. Notice that ξ_{t-1} can be thought of as an equilibrium error (or disequilibrium term) occurred in the previous period. If it is non-zero, the model is

out of equilibrium and vice versa.

Notice that β is called the long-run parameter, and α and $\gamma$are called short-run parameters. Thus, the ECM has both long-run and short-run properties built in it. The former property is embedded in the error correction term ξ_{t-1} and the short-run behavior is partially but crucially captured by the error correction coefficient,α. All the variables in the ECM are stationary, and therefore, the ECM has no spurious regression problem.

C. Auto regressive distributed lag (ARDL) approach to cointegration

The ARDL approach to co-integration was development by Pesaran(1997), Pesaran and Smith(1998) et al.(2001). This approach is very useful to measure the long-run relationship between independent variables and dependent variables whenever they have integration of different degrees, which is better than other methods for conducting the co-integration. This method was confirmed unbiased and efficient because: (Narayan (2004))

The simplest model of this approach can be written equation (10):

$y_t = \alpha + \beta(x_t) + \delta(z_t) + \mu_t$ (10)

Where

y_t= the dependent variable of the time series data at t-time

x_t= the independent variable of time series data at the time t as the first variable in the model of ARDL approach to co-integration

z_t= the independent variables of time series data at time t is the second variable in the model of ARDL approach to co- integration.

μ_t= a vector of stochastic error terms at the time t

α, β, δ = parameters

Form equation (10) it is modified to be the standard of ARDL approach to co-integration model which is able to be presented by equation (11)

$$\Delta y_{1t} = \alpha + \sum_{i=1}^{p} \beta_i \Delta y_{1t-i} + \sum_{i=1}^{p} \delta_i \Delta x_{1t-i} + \sum_{i=1}^{p} \gamma_i \Delta z_{1t-i} + \lambda_1 y_{1t-1} + \lambda_2 x_{1t-1} + \lambda_3 z_{1t-1} + \mu_{1t} \quad (11)$$

From equation (11) which consists of two parts the addition in the first part has the three parameters which are β_t, δ_t,and γ_t. These parameters were estimated by the OLS estimator for the explanation of the short-run relationship in ARDL approach to co-integration model. In addition, the second part of this equation was used to measure the long-run relationship of this approach. Furthermore, the three parametersλ_1, λ_2, $\lambda_3$were used to estimate what is used to explain the long-run relationship between variables. For the procession of the estimation, the natural logarithm was used to transform the liner model of ARDL to the logarithm form of itself for ease to interpret the results from the estimation. However, the natural logarithm form of the ARDL approach to co-integration would be presented by the equation (12):

$$\Delta \ln(y_{1t}) = \alpha + \sum_{i=1}^{p} \beta_i \Delta \ln(y_{1t-i}) + \sum_{i=1}^{p} \delta_i \Delta \ln(x_{1t-i}) + \sum_{i=1}^{p} \gamma_i \Delta \ln(z_{1t-i}) + \lambda_1 \ln(y_{1t-1}) + \lambda_2 \ln(x_{1t-1}) + \lambda \ln(z_{1t-1}) + \mu_{1t} \quad (12)$$

The null hypothesis of this approach for finding the long-run relationship between variables by testing $H_0: (\lambda_1 = \lambda_2 = \lambda_3 = 0)$ (See equation (11)). The process of testing it is to define that the variables in ARDL approach to co-integration are non-existent in the long-run relationship. In this paper, I use ARDL approach to co-integration to get the long-run relationship among $ln(PORD_{1t})$, $ln(TOT_{1t})$, $ln(TL_{1t})$, $ln(NFA_{1t})$, $ln(GE_{1t})$, $ln(M2_{1t})$. These variables used to estimate by

the ARDL approach to co-integration for the REER.(equation (13))

$$\Delta ln(q_{1t}) = \alpha + \sum_{i=1}^{p} \beta_i \Delta ln(PORD_{1t-i}) + \sum_{i=1}^{p} \delta_i \Delta ln(TOT_{1t-i}) + \sum_{i=1}^{p} \gamma_i \Delta ln(TL_{1t-i})$$

$$+\sum_{i=1}^{p} \varpi_i \Delta ln(NFA_{1t-i}) + \sum_{i=1}^{p} \kappa_i \Delta ln(GE_{1t-i}) + \sum_{i=1}^{p} \varphi_i \Delta ln(M2_{1t-i})$$

$$+\lambda_1 ln(PORD_{1t-1}) + \lambda_2 ln(TOT_{1t-1}) + \lambda_3 ln(TL_{1t-1}) + \lambda_4 ln(NFA_{1t-1} + \lambda_5 ln(GE_{1t-1}) + \lambda_6 ln(M2_{1t-1}) \quad (13)$$

The procession of testing for ARDL approach to co-integration must use F-test for testing existence of long-run relationship among variables which is shown in equation (51). Typically, the null hypothesis of no co-integration among the variables is shown in equation (12) below.

$$(H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = \lambda_6 = 0)$$

The alternative hypothesis is as follows

$$(H_1: \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq \lambda_6 \neq 0)$$

-If the F calculated from the ARDL model is greater than the upper bound critical value, then the null hypothesis will be rejected and it would be pointed out that they have a long-run relationship among their variables.

-If the F calculated from the ARDL model is less than the lower bound critical value, then the null hypothesis will be accepted and it would be pointed out that they do not have a long-run relationship among their variables.

-If the F calculated from the ARDL model data drops down between the upper and lower bound critical value, then the result is inconclusive; the error correction model will be a useful for establishing co-integration.

D. Behavior Equilibrium Exchange Rate Model (BEER)

BEER model is a single-equation model, which can be shown as the equation (29) and (30) and the extend of misalignment can be shown as equation (31) and (32):

$$q_t = \beta_1' Z_{1t} + \beta_2' Z_{2t} + \tau' T_t + \varepsilon_t \quad (14)$$

Z_1 is a basic economic factors vector that are expected to have a sustained impact in the long run.

Z_2 is the basic economic factor vector that affects the real exchange rate in the medium term.

T is a temporary factor vector that affects the real exchange rate in the short term.

$\beta_1 \beta_2 \tau$ are the parameters to be estimated of the equation.

q_t is the observed value of the real exchange rate.

q_t' is the estimated value of the real exchange rate.

$$q_t' = \beta_1' Z_{1t} + \beta_2' Z_{2t} \quad (15)$$

Current misalignment: cm_t

$$cm = q_t - q_t' = \tau' T_t + \varepsilon_t \quad (16)$$

Total Misalignment: tm_t

$$tm_t = q_t - \beta_1' \overline{Z}_{1t} - \beta_2' \overline{Z}_{2t} \quad (17)$$

The Behavioral Equilibrium Exchange Rate Analysis Method (BEER) constructs a simplified econometric model based on the behavioral relationship between the real effective exchange rate and the relevant basic economic factors. The econometric method is used to estimate the model parameters and the value of the equilibrium real exchange rate. As a condition, it has strong operability. In addition, the BEER method considers the basic economic factors more comprehensively than other methods. It considers the medium- and long-term basic economic factors to help analyze the long-term trend of the exchange rate, and also considers the short-term temporary factors to facilitate the study of short-term exchange rate fluctuations. In this study, PROD, TOT, TL, GE, NFA, M2 are chosen as the variables to test the long-run effects, and the short-run term need to be confirmed by the ECM. In addition, it is difficult to adopt methods such as MB and FEER due to objective factors such as data collection. Therefore, this paper chooses BEER as the research method.

III. EMPIRICAL RESULTS

1. Unit root test

Variable	Level	1st Difference	Order of Integration
lreer	-3.867398***	-	I (1)
ltot	-4.543625***	-	I (0)
ltl	-0.738129	-3.638722**	I (1)
lprod	-3.475130*	0.0158**	I (1)
lm2	-3.894119***	-	I (0)
lnfa	0.148676	-4.208762**	I (1)
lge	1.053118	-4.846245***	I (1)

Note: (1) The null hypothesis: series has a unit root. (2) ***, **, * is significant at 1%,5%, 10% level, respectively.

Table1: Unit root test (ADF Test)

To examine the stationarity of these variables in the study, the unit root test is required, the unit root test was conducted to avoid spurious regression problem. All variables need to be stationary at any point estimated, a non-stationary time series will become stationary after difference several times. All the data are transformed to natural logarithms. Stationary of variables is pretested by the conventional augmented Dickey-Fuller (ADF) tests. The results are reported in Table 4.1. The ADF test reject the unit root null hypothesis for all difference log variables. The results indicate that all log variables are I(0), I(1) series. Stationary of variables is pretested by PP-test. The PP test reject the null hypothesis too. The results are reported in Table 4.2. The results indicate that all log variables are I(0) or I(1)series. The PP test uses non-parametrically adjusted test statistics. Compared to the ADF test this fact should increase the power of tests and improve test results (Markéta andDarina,2016). ARDL model which may include I(1) and I(0) variables, but not I(2). So the ARDL model can be used to estimate.

2. ARDL Approach to co-integration

Explanatory Variable	T-value	Significant Level
LREER(-1)	18.01868	0.0000***
LM2	-3.808884	0.0029***
LM2(-1)	-4.587218	0.0008***

LTOT	4.412011	0.0010***
LTOT(-1)	-3.984945	0.0021***
LTOT(-2)	3.089234	0.0103**
PROD	4.100667	0.0018***
PROD(-1)	-4.383904	0.0011***
LNFA	4.343708	0.0012***
LNFA(-1)	-2.983215	0.0124**
LNFA(-2)	1.522089	0.1562
Serial Correlation Test		0.0993***
F-Bounds Test		11.48924 ***

Notes: (1)***, **, *is significant at 1%, 5%, and 10% level. (2)AIC(Akaike Information Criterion) used in length selection criteria for ARDL specification.

Because the Serial Correlation Test can't pass with these variables, the LGE and LTL needed to be gave up.

3. Error Correction Model

Explanatory Variable	T-value	Significant Level
Δ_{LTOT}	8.574862	0.0000
$\Delta_{LTOT(-1)}$	-4.205578	0.0015
Δ_{LM2}	-8.212000	0.0000
$\Delta_{LM2(-1)}$	-4.587645	0.0008
Δ_{PROD}	-7.941017	0.0000
Δ_{LNFA}	5.508399	0.0002
$\Delta_{LNFA(-1)}$	-2.929407	0.0137
ECM(-1)	8.850747	0.0000

Notes: (1)***, **, *is significant at 1%, 5%, and 10% level.

IV. CONCLUSIONS

A. The results of Long run Effect Estimate of China Exchange Rate Misalignment

Figure 1: The Estimated Real Effective Exchange Rate and Real Effective Exchange Rate

The figure 1 shows the estimated real effective exchange rate and real effective exchange rate, figure 4.2 shows the condition of total misalignment of China RMB, and we can get to know that the exchange rate misalignment of China RMB reached the highest point in 1996 at the 10% undervalued and reached the lowest point in 2010, which at the 2% undervalued.

B. The results of Short run Effect Estimate of China Exchange Rate Misalignment

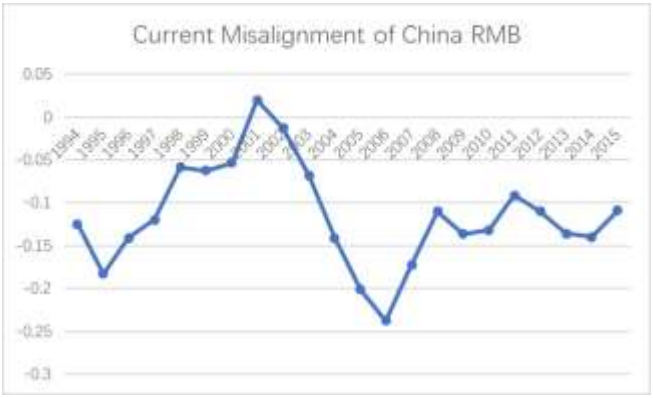

Figure 2: The Current Misalignment condition of China RMB

In the short run, the misalignment condition of China RMB exchange rate is overvalued in the most of the time, it reached the highest point in1998 which is 3.6% overvalued in that year. Besides, from the 2000 to 2003, China RMB shown the undervalued trend. The highest point reached in 2001, which was 2.9% undervalued. As a consequence, we can know there are overvalued and undervalued of China RMB exchange rate misalignment from the short run.

C. Conclusions

Based on the measurement and analysis of the annual effective RMB exchange rate and related basic economic variables from 1994 to 2019, the following conclusions are drawn: First, there is a co-integration relationship between the interpreted variable, the actual effective exchange rate of RMB, and the selected explanatory variable. Among them, labor productivity, terms of trade, and foreign net assets have a positive effect on the effective exchange rate. The elastic coefficients are 4.100667, 4.412011, and 4.343708, respectively. The increase in labor productivity is the main reason for the rise in the RMB's equilibrium exchange rate. The effect of broad money supply on the effective exchange rate is negative. The elasticity coefficient of broad money supply is -3.8808884, indicating that loose monetary policy tends to lower the equilibrium exchange rate. Second, the calculation results show that there has been an overall upward trend in the long-term equilibrium RMB exchange rate since 1994. Corresponding to this, the consumer consumption index is a reflection of the increase in China's overall national strength. The rising trend of the long-term equilibrium exchange rate shows that the equilibrium exchange rate is also an important indicator reflecting the comprehensive national strength of a country. Finally, the calculation results indicate that the real effective exchange rate of the RMB has been overvalued during the observation period, but the long-term trend between the actual effective exchange rate of the RMB and the long-term equilibrium exchange rate is consistent. In general, there are no serious exchange rate misalignments. Therefore, since the observation There was no serious misalignment in the RMB exchange rate during the period, and it was unnecessary to artificially adjust the exchange rate for this purpose. Properly handling the external public opinion on the appreciation of the RMB and avoiding the formation of expectations for exchange rate adjustment will

help to achieve exchange rate balance, thereby creating a favorable external environment for the domestic and international economic balance. As a consequence, we can consider that the U.S' charge about China is exchange rate manipulator is wrong. The misalignment percentage in 2016 and 2017 is 3.7% and 4.4%, which is far less than 10% in 1996.

We can consider the exchange rate of China RMB is fluctuated in the normal level.

V. POLICY RECOMMENDATIONS

A. Deepen the reform of the RMB exchange rate system.

The reform of the RMB exchange rate system is to meet the inherent requirements of establishing and perfecting the socialist market economic system and giving full play to the fundamental role of the market in resource allocation. It is also an important content for deepening the reform of the economic and financial system and improving the macro-control system. The overall goal of the RMB exchange rate system reform is to establish and improve a managed floating exchange rate system based on market supply and demand, and to maintain the basic stability of the RMB exchange rate at a reasonable and balanced level.

B. Actively promote the process of RMB internationalization.

The ultimate goal of the reform of the RMB exchange rate system is to realize RMB internationalization, which also means the free floating of the RMB exchange rate. At present, the RMB does not yet have the conditions for free floating, but it is possible to create conditions for the future free floating through the implementation of a progressive RMB internationalization strategy. Since my country achieved free conversion of RMB under current account in 1996, it has been committed to promoting the convertibility of RMB capital account. By 2009, the process of RMB internationalization has accelerated significantly. The process of internationalization has generally followed the steps of first peripheralization, then regionalization, and final internationalization, and has promoted the RMB 's role in trade settlement, international investment, and international reserves from easy to difficult. use. In July 2009, a pilot RMB settlement for cross-border trade was launched in 5 cities including Shanghai and Guangzhou. In June 2010, the pilot scope was extended to 20 provinces. In January this year, a pilot RMB settlement for overseas direct investment was launched. This series of measures will eventually lead the RMB to take the lead in achieving internationalization in areas such as trade settlement and foreign direct investment. The fundamental purpose of renminbi internationalization is to win a place for the renminbi as a reserve currency in the international monetary system, and it can also dilute the status of the US dollar and reduce China 's excessive dependence on the US dollar in trade valuation settlement, which is also objectively conducive to exchange rate mechanism reform China gradually got rid of its excessive dependence on the dollar. As the internationalization process continues to advance, the renminbi has gradually become a freely convertible currency, and the formation of the renminbi exchange rate can truly be based on market supply and demand.

C. Adjusting economic development strategy to reduce dependence on foreign demand.

(1).Expand domestic demand and reduce the dependence of China's economic growth on external demand. From 2006 to 2010, the contribution rate of domestic demand to economic growth was 83.9%, 81.9%, 91.0%, 138.9%, and 92.1% respectively. Overall, the contribution rate of domestic demand to economic growth was gradually increasing. Fully realize that domestic demand is the real engine of China's sustained economic growth, and consumption is the ultimate effective power. The driving force driving economic growth should be gradually returned to the track of expanding domestic consumer demand. The focus of economic restructuring should also be on reducing excessive investment growth and vigorously increasing final consumption. (2).Actively expand imports and promote trade balance. This is a major strategic decision made by the Party Central Committee and the State Council after a profound understanding of the international and domestic development situation. Increasing imports can help improve domestic supply, promote competition, increase economic efficiency, make up for domestic resource gaps, and reduce trade surpluses and trade frictions. As with exports, they are an important driving force for domestic economic growth. Increasing imports is also a good strategy to deal with the

pressure of RMB appreciation. As a developing country in a period of rapid economic progress, importing foreign machines and equipment with high technological content is also a requirement for economic development. On the other hand, increasing imports can also ease the dissatisfaction of international public opinion and reduce the pressure of appreciation due to high foreign exchange reserves. (3).Adjust the structure of export trade, and promote the transformation of export trade from scale and speed to quality and efficiency. Most of China 's export commodities are labor-intensive products with low technological content and low added value. Competition in the international market relies mainly on the low cost of production factors such as labor and the advantages of policies such as export tax rebates granted by the government. In recent years, with the rising cost of production factors and the implementation of anti-subsidy and anti-dumping measures in trading partner countries, this advantage has been few. Therefore, it is necessary to optimize the structure of export products as soon as possible and increase the proportion of high value-added products in export trade. First of all, the incentive policy for export enterprises should be targeted to encourage high value-added enterprises to earn foreign exchange through export. Second, accelerate the technological transformation of traditional industries, and improve the competitive advantages of high-tech products through the development and application of new equipment, new technologies, and new formulations. Third, vigorously develop knowledge-intensive and technology-intensive industries, increase the added value of export products, increase non-price competitiveness, and promote the sustainable development of export trade

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