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Market demand dynamic induced mechanism in China's steel industry

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ABSTRACT

Using the example of iron and steel industry, this paper aims to reveal the market demand effect and the mechanism on investment and capacity allocation. Based on building the theoretical model containing demand dynamic gap with the quarterly data of iron and steel industry since 2004, time-varying parameter model is used to empirically test the asymmetric adjustment mechanism of the productivity allocation under demand inducing and the effect of policies. The results show that obvious asymmetric features in the formulating and withdrawing phases of iron and steel productivity caused by inducing demand dynamics and its asymmetric periodic motion; self-correction mechanism of productivity under the situation of frequent switching between supply and demand is limited. Once the deviation from the equilibrium level of production capacity exceeds its own threshold adjustment mechanism, it is unable to restore equilibrium through market regulation, and leads to the extraordinary "trial and error" cost; further takes the correlation mechanism among industries as the breakthrough point to do more empirical tests of the effects of downstream industry dynamic demand on the steel industry capacity. It also indicates that the development of the real estate industry when Chinese economic environment is good directly introduces the steel industry capacity allocation, Grasping accurately the above rules is the premise of achieving market's decisive role in the resource allocating process while giving full play to government function.

1. Problems development

Since the reform and opening-up of China 30 years ago, China's economy not only has realized the continuous expansion of the GDP, but has sustained its high speed growth of 10% per year. In particular, from the WTO accession until the financial crisis, China's economical growth experienced over 11% per year. As a developing country, China provides the premise of the massive infrastructure investment demand in the economical take-off with its rapid accumulation of national wealth. For example, the investment of transportation、warehousing and post industry in 2003 is 567 billion Yuan and the investment is 4289 billion Yuan. Steel is a pillar of china's economic development industries. Its development should satisfy the infrastructure construction on one side, and provide the raw materials to the downstream industries on the other side. In this period, China's steel industry's fixed assets investment had increased by nearly 3 times. The demand-expanding period produces strong induction to the investment while the demand-shrinking time does not help the capacity withdraw find the right routes. The massive investment followed the excess production capacity. In order to prevent the waste of resources from excessive investment, the government resolutely adopts macro-control policies to curb investment and achieves notable intervention effects on the market. But the subsequent economic situation gives a forceful response to this adjustment which is completely anti-market, showing that there is a collective misjudgment for China's economic development trend prediction by the related government departments at that movement (Chen, 2013). As an economic entity, which realized its economic overall growth within a considerably short time, its market demand and supply dynamic transformation is far beyond the market background in the western mainstream economic theory and its special laws are different from the other economies. The new government suppressed on the market function to make the economical growth sustainable. The paper takes the steel industry as an example to reveal the working mechanism and effect on the investment and capacity allocation of market needs to make the world understand objectively the development features of China's economy on one hand, and provides the references for the new round of regulation and selection in China on the other hand.

The earliest employment of demand and supply to explain investment is in the acceleration principle of neoclassical investment theory.

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To overcome the assumption deficiency of quick realization of investment plan in the original acceleration principle, Chenery (1952) and Koyck (1954) introduce the output adjustment coefficient to revise the principle based on their expectation of the former and current output impacting on the current capital stock, making the principle closer to the real economy. Eisner and Strotz (1963) introduce the adjustment costs into the neoclassical investment theory proposed by Jorgenson (1963). With the later promotion by Lucas (1967), Gould (1968), etc., it becomes the principle theory in the research of over-capacity.

Based on economic cycle theory, Fair (1969) puts forward that when the economic operation is undergoing need shrinking, its investment and production capacity do not change simultaneously with need periodically fluctuation. Some researchers argue that the investment originates from the dynamic expectation of economic growth (Kydland and Prescott, 1982; Long and Plosser, 1983; King and Plosser, 1984) . In the abroad research on the industrial investment, Oulton (1981) finds that Tobin's Q has significant impact on factory investment decisions by using the British quarterly data of industry and commerce. Chadh and Sarno (2002) find the uncertainty of price in the short term has greater impact on the investment than the long term counterparts. For the developing country in middle and later stage of industrialization, its market is likely to show wave phenomena of investment (Lin, 2010), resulting in the excess production capacity. From the research results of Chinese scholars (Kong and Gao, 2007; He and Shi, 2012), we find that the market demand has been becoming the main reason affecting Chinese industry investment growth. From the views of Zhou and Fu (2011), Han and Wang (2013), demands had propelling effects on fixed assets investment. But the research based on transition of income distribution by Sun and Su (2013) shows that the sustainable and rapid growth of China's economy drives its 1.3 billion residents' income to change rapidly, resulting in huge consumption potential bursting out within short time and induces a chain of sharp market reaction, like inadequate supply, investment overheating and overcapacity, etc. Although the domestic and abroad research on investment and over-capacity affecting sharp market reaction elementis various, the study of the dynamic adjustment mechanism capacity in the massive emerging economy, which binds the capacity formation and secession in a complete framework based on the features of needs that dynamically induced investment input and dropout from the perspective of market mechanism, under the background of supply and demand switching frequently, has received little attention.

The following will discuss asymmetry dynamic characteristics of capacity adjustment in the process of sustainable and rapid growth of demand by constructing investment and capacity theory framework model, including market dynamic demand gap and characterize asymmetric dynamic features of capacity being adjusted to equilibrium level by the variable capacity error correction model. From all those research results, the paper will make an empirical analysis of the dynamic effect of the main downstream steel industry demand on the investment.

2. Construction of theoretical model

The foresightedness of demand-determined investment and the hysteresis of capacity formation make the real economy demand on investment and capacity show the phased asymmetry features, which is characterized as accelerator theory at the demand upstream stage with the investment pouring in. But when the demand slows down, due to the investment inertia and its fixed cost attributes, the investment slips while its capacity keeps the growing trend, resulting in unrelieved overcapacity. Koyck greatly simplifies the model estimation, but lacks some theory foundation thus has been adjusted partly by Nerlove (1958) and by adaptive expectation model of Cagan (1956), which are the rationalized forms of Koyck model (1954). So the paper takes the partly adjusted model of capital stock and adaptive expectation mechanism as the basis and constructs the theory model for the asymmetrical effect of market dynamics gap need on capacity adjustment.

2.1. Basic model combining adaptive expectations with stock adjustment mechanism

On normal occasions, the capital stock adjustment is incomplete with the binding of regulations and technologies while the main market roles will adjust their output expectation according to their experience. So when we study the effects of market mechanism needs on capacity adjustment, we should fully take those elements into consideration. In this paper, we construct the basic model combining the output and capacity adjustment. Because the ideal capital stock and the equilibrium output can not be expected, we use partial adjustment mechanism for capital stock and adaptive expectation mechanism for output. Then get the model with both capacity partial adjustment and output adaptive expectations mechanism in it:

$$K_t = \beta_0\delta\gamma + \beta_1\delta\gamma Y_t + [(1-\gamma)+(1-\delta)]K_{t-1} - (1-\delta)(1-\gamma)K_{t-2} + [\delta u_t - \delta(1-\gamma)u_{t-1}] \quad (1)$$

where δ is capacity adjustment coefficient and normally $0 < \delta \leq 1$; γ is adjustment coefficient, and normally $0 < \gamma \leq 1$.

Assuming

$$\alpha_0 = \beta_0\delta\gamma$$
$$\alpha_1 = \beta_1\delta\gamma$$
$$\alpha_2 = (1-\gamma)+(1+\delta)$$
$$\alpha_3 = -(1-\delta)\times(1-\gamma)$$
$$v_t = \delta u_t - \delta(1-\gamma)u_{t-1}$$

Then Eq. (1) can be rewritten as:

$$K_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 K_{t-1} + \alpha_2 K_{t-2} + \nu_t \quad (2)$$

Combine Eq. (2) with $I_t = K_t - K_{t-1}$, the investment Equation is available:

$$I_t = \alpha_1 \Delta Y_t + \alpha_2 I_{t-1} + \alpha_3 I_{t-2} + \zeta_t \quad (3)$$

In which $\zeta = v_t - v_{t-1}$, the other parameters are the same as those in productivity equation. So Eq. (3) is the investment theory model combining expected output adaptability with capital stock partial adjustment expectation.

2.2. The investment and capacity model with market dynamic demand gap

Although the combined model of adaptive expected output and part of the capital stock adjustment mechanism fully considers the rational manufacturer's revision of the expected out based on past market demand information output and capital stock's slow adjustments by limitations of various factors, there is no clear description about impact by the market dynamic demand conversion on capacity adjustment. With China's ten-year sustained and rapid economic growth, significant changes in residents' income level has caused the non - equilibrium effects of all sorts of durable consumer goods market. This dynamic demand is bound to have a special impact on adjusting production capacity. So in this paper, adaptive expectation mechanism is further emended.

As $Y_t^d - Y_t^s = \lambda Y_{t-1}^*$, then$\lambda Y_{t-1}^*$ represents the market gap, if $\lambda > 0$, it indicates that demand exceeds supply, and there is supply gap; $\lambda < 0$, indicating oversupply, and there is overcapacity. After correction, if there is market supply and demand gap, the manufacturers will adjust their expectations according to market dynamics: if the demand exceeds supply in pre-phase, the vendors will raise the equilibrium output next phase; on the contrary, if there is overcapacity in pre-phase, the manufacturers will adjust downward the equilibrium output next phase, the revised adaptation mechanisms are expected to be

Situation 1. $(Y_t^* + \lambda Y_{t-1}^*) - Y_{t-1}^* = \gamma(Y_t - Y_{t-1}^*)$, after revising, it is:

$$Y_t^* = \gamma Y_t + (1 - \gamma - \lambda) Y_{t-1}^* \tag{4}$$

Eq. (4) indicates that although the manufacturer adjusts the expectations of the equilibrium output of the current period according to the market supply and demand gap of previous period, yet for the constraints of production capacity, expected output cannot be achieved in the current production decisions.

Situation 2. $Y_t^* - Y_{t-1}^* = \gamma [(Y_t + \lambda Y_{t-1}^*) - Y_{t-1}^*]$, after revising, it is:

$$Y_t^* = \gamma Y_t + (1 - \gamma + \gamma\lambda) Y_{t-1}^* \tag{5}$$

Eq. (5) indicates that manufacturer adjusts the expectations of the equilibrium output of the current period according to the market supply and demand gap of previous period, and implements it to the current production decisions.

Objectively there is time lag from investment to forming the production capacity to producing finished goods, so Eq. (4) (i.e., when $\lambda > 0$) is likely to describe the state of market supply gap; accordingly, in the Eq. (5) (i.e., when $\lambda < 0$), it is likely to describe the overcapacity in market, and the manufacturers will cut output to adapt the market demand in next phase. If we put the Eqs. (4), (5) into the Eq. (2) respectively, two productivity equations can be obtained as follows:

$$K_t = \delta\beta_0(\gamma + \lambda) + \delta\beta_1\gamma Y_t + (2 - \delta - \gamma - \lambda)K_{t-1} - (1 - \delta)(1 - \gamma - \lambda)K_{t-2} + \omega_t \tag{6}$$

in which $\lambda > 0$,

$$K_t = \delta\beta_0(\gamma - \gamma\lambda) + \delta\beta_1\gamma Y_t + (2 - \delta - \gamma + \gamma\lambda)K_{t-1} - (1 - \delta)(1 - \gamma + \gamma\lambda)K_{t-2} + \omega_t' \tag{7}$$

in which $\lambda < 0$. Combining (6), (7) with $I_t = K_t - K_{t-1}$, two investment equations can be obtained as follows:

$$I_t = \delta\beta_1\gamma\Delta Y_t + (2 - \delta - \gamma + \gamma\lambda)I_{t-1} - (1 - \delta)(1 - \gamma - \lambda)I_{t-2} + u_t^1 \tag{8}$$

$$I_t = \delta\beta_1\gamma\Delta Y_t + (2 - \delta - \gamma + \gamma\lambda)I_{t-1} - (1 - \delta)(1 - \gamma + \gamma\lambda)I_{t-2} + u_t^2 \tag{9}$$

It can be inferred from the equations of (8) and (9) that if demand exceeds supply in a previous period, when supply gap exists, short-term multiplier equation is $k_{i1} = 1 - \delta(1 + \gamma + \lambda)$; if there is overcapacity, short-term multiplier equation is $k_{i2} = 1 - \delta\gamma(1 - \lambda)$. Normally, $k_{i1} \neq k_{i2}$, the long-run effect of market demand for investment is $\frac{\delta\gamma\beta_1}{\delta(\gamma+\lambda)}$ and $\frac{\delta\gamma\beta_1}{\delta\gamma(1-\gamma)}$ respectively, that is to say, there is asymmetric induction effect of market demand on investment.

In the following Eqs. (8) and (9), we will discuss coefficient of symbols specifically. For convenience, we first rewrite the Eqs. (8) and (9).

Let $\eta_0 = \delta\beta_1\gamma\eta_1 = (2 - \delta - \gamma - \lambda)\eta_2 = -(1 - \delta)(1 - \gamma - \lambda)$ then the Eq. (8) can be rewritten as:

$$I_t = \eta_0\Delta Y_t + \eta_1 I_{t-1} + \eta_2 I_{t-2} + \mu_t^1 \tag{10}$$

Let $\varphi_0 = \delta\beta_1\gamma$, $\varphi_1 = (2 - \delta - \gamma + \gamma\lambda)$, $\varphi_2 = -(1 - \delta)(1 - \gamma + \gamma\lambda)$ then the Eq. (9) can be written as:

$$I_t = \varphi_0\Delta Y_t + \varphi_1 I_{t-1} + \varphi_2 I_{t-2} + \mu_t^2 \tag{11}$$

For Eq. (10), $\lambda > 0$, from the previous setting of δ, γ, the bigger the value of λ is, the larger the market supply gap is. The parameters of the Eq. (10) will appear as: $\eta_1 < 0$, $\eta_2 > 0$.

For equation (11), $\lambda < 0$, from the previous setting of δ, γ, the bigger the value of $|\lambda|$ is, the larger the market demand gap is. Then there are a lot of overcapacity, and the parameters of the Eq. (11) will be: $\varphi_1 < 0$, $\varphi_2 > 0$. When the market is switching from the supply gap to the equilibrium, the parameters of the equation will shift from $\eta_1 < 0$, $\eta_2 > 0$ into $\eta_1 > 0$, $\eta_2 > 0$, showing the market gap is gradually shrinking, then transit into $\eta_1 > 0$, $\eta_2 < 0$. When $\eta_1 > 0$, $\eta_2 < 0$, the market is close to the equilibrium of supply and demand. When market transits from demand gap to equilibrium state, the transition path of the Eq. (11)'s parameters symbol is consistent with Eq. (10), but the adjustment is transmitted from insufficient demand to balanced supply and demand.

With the introduction of dynamic transformation information of market demand, the two states of investment and production capacity equations can be obtained with the demand gap and supply gap respectively. Output adjustment of demand gap is easy to implement, but there is lag effect from investment to the formation of capacity, which means the establishment of new capacity includes two phases of investments and capacity adjustment. The optimal output adjustment when the supply gap exists can not be achieved in the current period, which is subjected to production capacity. Therefore, asymmetric characteristics are caused by demand for investment and capacity under the two market states. In the process of China's sustained and rapid economic growth, the frequent transition of dynamic market gap makes it difficult to be tested through the general model, thus the paper selects the time-varying parameter model to test capacity expansion and concludes with two phases of dynamic characteristics determined by market demand.

3. Empirically test of asymmetric adjustment mechanism of production capacity based on the time-varying parameter model

1. Time-varying parameter model

Time-varying parameter model[2] is one of the special cases of state space model, which includes the signal (measurement) equation and state equation.

$$\text{Signal equation: } y_t = x_t'\beta_t + w_t'\alpha + u_t \quad t = 1, 2 \ldots, T \tag{12a}$$

$$\text{Signal equation: } \beta_t = \psi\beta_{t-1} + \xi_t \tag{12b}$$

$$(u_t, \xi_t) \sim N\left(\begin{pmatrix}0\\0\end{pmatrix}, \begin{pmatrix}\sigma^2 0\\0 \ \ \Omega\end{pmatrix}\right) \quad t = 1, 2 \ldots, T \tag{12c}$$

where w_t is a collection of explanatory variables with the fixed coefficients; x_t is a collection of explanatory variables with random coefficient β_t, the time-varying parameter, is the unobservable variable, needing to be estimated by using the observable variables y_t and x_t. In the state equation, we assume that the variation of β_t is subject to first-order autoregressive model. u_t and ξ_t are mutual independent, conforming to the normal distribution whose mean is 0, variance is σ^2, and covariance matrix is Ω.

2. The asymmetric effect analysis of the market demands for iron and steal industry on investment and capacity

The paper selects the investments in fixed assets and the quarterly income data[3] of main business in black metal smelting and rolling processing industry from year of 2004–2014 to study the dynamically induced effect of demand change to the investment and capacity of iron and steel industry. To remove the interference of price factors, we use the Ex factory price index of industrial products of 2004 as base period for deflator processing in fixed assets and fixed assets investment data.[4] To eliminate the influence of seasonal factors, we choose the X-12 method what makes seasonal adjustment in quarterly investment and the data of main business income, keeping its trend components as proxy variable of investment in fixed assets and the market demand. In order to remove time series heteroscedasticity, the paper makes a

[2] Refer to Hamilton, J.D 1994, Time Series Analysis, Princeton University Press. Chapter 13, Translated by Liu Mingzhi.

[3] Quarterly data is obtained by the author through monthly data collection. In this paper, if not particularly stated, all the data is from National Bureau of Statistics of China web site.

[4] Fixed assets (capital stock) = total assets - current assets.

logarithmic scale to the above trend data, using $li1$, $lk1$ and $ly1$ as fixed asset investment, capital stock and the market demand respectively. Determining the lag length, we use OLS or VAR method to estimate the coefficients of different variable lag. Choose the variable lag, of which the coefficient is highest and fit for the theoretic model.

The following investment and energy (signal) measurement equation and state equation are established.

$$\text{Signal investment equation: } li1_t = sv1_t \times ly1_{t-1} + sv2_t \times li1_{t-1} + sv3_t \times li1_{t-4} + sv4_t \tag{13a}$$

$$\text{Investment state equation: } \begin{cases} sv1_t = sv1_{t-1} \\ sv2_t = sv2_{t-1} \\ sv3_t = sv3_{t-1} \\ sv4_t = a_1 + a_2 \times sv4_{t-1} + \varepsilon_t \\ \varepsilon_t \sim N(0, e^{a_3}) \end{cases} \tag{13b}$$

$$\text{Capacity signal equation: } lk1 = \beta_1 + sh1_t \times ly1_{t-1} + sh2_t \times lk1_{t-1} + sh3_t \times lk1_{t-2} + \zeta_t \tag{14a}$$

$$\text{Capacity state equation: } \begin{cases} sh1_t = sh1_{t-1} \\ sh2_t = sh2_{t-1} \\ sh3_t = sh3_{t-1} \\ \zeta \sim N(0, e^{\beta_2}) \end{cases} \tag{14b}$$

[5]Investment state Eq. (13b) describes the four basic state variables in the signal investment equation, in which state variable sv1, sv2, sv3 are in recursive form, state variable sv4 is AR(1) process with constant terms. Figs. 1 and 2 describe its dynamic changes respectively. It is the same that the state Eq. (14b) describes[6] state variables in the capacity signal equation. Fig. 4 shows the dynamic elasticity of demand for production capacity.

investment equation to estimate the results are shown in Eq. (13a′) and (13b′):

$$li1_t = sv1_t \times ly1_{t-1} + sv2_t \times li1_{t-1} + sv3_t \times li1_{t-4} + sv4_t$$
$$(4.495)^{***} \quad (5.343)^{***} \quad (-1.636) \quad (18.541)^{***} \tag{13a′}$$

$$sv4_t = 1.670 - 0.113 \times sv4_{t-1} + [\text{var} = \exp(-5.075)]$$
$$(3.084)^{***} \quad (-2.204)^{**} \quad (-20.808)^{***} \tag{13b′}$$

[7]productivity equation to estimate results are shown in (14a):

$$lk1 = 0.481 + sh1_t \times ly1_{t-1} + sh2_t \times lk1_{t-1} + sh3_t \times lk1_{t-2} + [\text{var} = \exp(-7.825)](4.730)^{***} \quad (2.978)^{***} \quad (4.783)^{***} \quad (1.957)^{*} \quad (-26.891)^{***} \tag{15a}$$

The pink line presents the dynamic induced elasticity on one lag phase, the yellow line the dynamic induced elasticity on four lag phase.

Based on the proposed two stage characteristics formed by investment and production capacity, investment and productivity equation are constructed to depict the effects of actions of investments and productivity by the market demand. Then, the results of the empirical test are to be analyzed in the following.

(1) The analysis of the dynamic effects of market demand on investment

From Fig. 1, we can see that the elasticity of market demand fluctuates widely during the sample period for the steel industry investment with elasticity value being between 0.05–1.9. From 2006Q1 to 2007Q1, the pulling speed of steel market demand expansion on investment experienced a dynamic process: uplink - peak -downlink. In Chinese steel market the injected volume of investment is quite amazing when the market capacity rapidly expands, whereas the investment has its own inertia characteristics. Taking into the consideration of investment inertia movement per se, the asymmetric induction effect will be analyzed in detail.

2006, the sales growth of iron and steel demand was slowing, compared to reach over 30% in 2004 or 2005, the growth of income only experienced 14%. And to avoiding the manufactures' blind investment, on the March and July of 2006, the government comes on the policies to restrict the over-investment and backward productivity. At the begin of 2006, because of the momentum investment, the investment of the iron and steel industry maintains at high level and the market demand grows slow. So the induced elasticity rose from 0.27 at the begin of 2006, and the induced elasticity experienced at 1.9 at the second season of 2006. Under the effect of policies and market, after the third season of 2006, the elasticity dropped down, and after 2007, the elasticity went to stable state, the induced elasticity fluctuated between 0.07 and 0.4.

During the period of 2004–2006, the Chinese steel market has experienced the large-scale supply gap, which is directly related to the recent fast lane that development of China's economy has driven on. The rapid expansion of infrastructure construction, heavy industry and other industries' market demand for raw materials, making the steel market performance in short supply.

(2) The dynamic effect analysis of market demand to production capability

Since 2007, the direct induction effect of demand on investment has tended to be stable, but under the effect of inertia itself, investment keeps asymmetric periodic motion, making the influence of demand on capacity fluctuates greatly, capacity demand elasticity between 0.077–0.39 (see Fig. 4). Investment demand elasticity has expanded more than 5 times. Combining with the scale of market demand for iron and steel industry to convert the elastic effect to stock effect, it can be inferred that the gap between capacity inventory formed during peak and formed and that of withdrawing is quite striking, which is the quantitative reflection of asymmetric characteristic production of capacity adjustment determined by demand. It is also the direct reflection of limited effect of spontaneous adjustment capacity formation and withdrawal by market mechanism.

From the above we can get the following preliminary conclusions: asymmetric effect of the demand to investment, originates from the asymmetric direct impact mechanism of market demand and the government policies to investment, and also includes the startup asymmetric organic combination of inertial motion of investment. In the dynamic transformation of market supply and demand situation, sustained demand growth period determines investment to accelerate formation and access into an capacity; in demand growth deceleration period, smearing effect is formed by the influence of the asymmetric inertial motion characteristics of investment itself; time lag formed by investment and capacity makes the fluctuation of production capability determined by demand become more notable. It presents the obvious asymmetry zone systematic characteristics between the capacity formation and withdrawing. This kind of asymmetric effect of investment and capacity adjustment determined by market demand makes the market show the blindness and a degree of invalidity in the allocation of resources in the iron and steel industry, eventually leading to industry overcapacity.

3. The analysis of the Time-varying parameter model of the mechanism of market to production capacity adjustment.

[5] Four state variables are described in the capacity state equation: among them, the state variables sh1, sh2, sh3 respectively are in the recursive forms.

[6] In equation sh1, sh2, sh3, it indicates respectively the influence elasticity of demand for steel production capacity, the influence elasticity of previous capacity to current capacity, the influence elasticity of second phase capacity on current production capacity.

[7] In brackets are the coefficient vector last element Z - statistics, * indicates 10% significance level, ** 5% indicates significance level, ** * indicates 1% significance level, the same below.

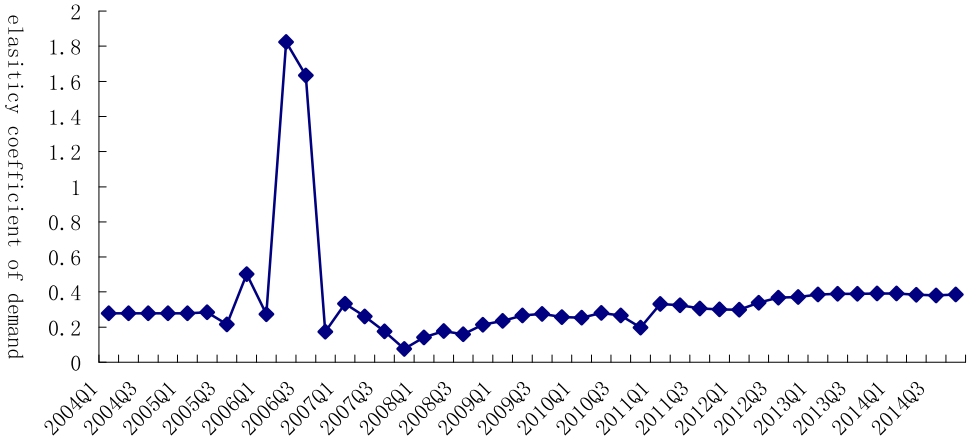

Fig. 1. dynamically induced elasticity of the market demand for iron and steel industry investment (sv1).

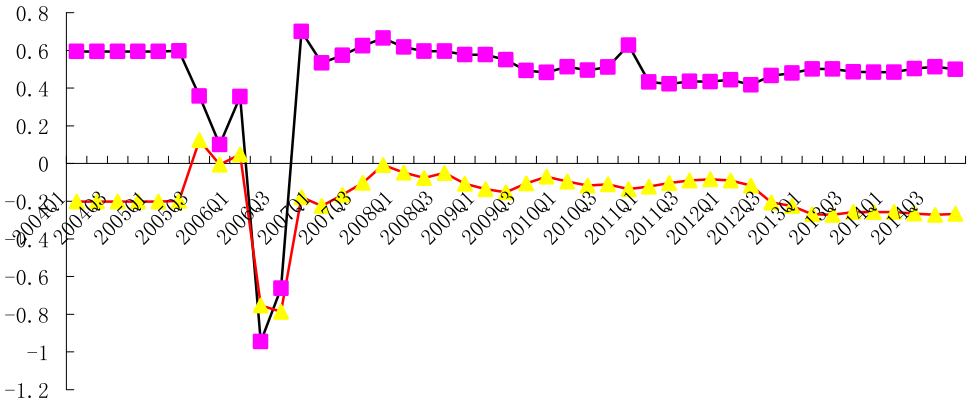

Fig. 2. upfront investment dynamic induced elasticity of earlier stage (sv2, sv3).

As capacity shows an obvious asymmetry district system characteristics under the effect of demand, this paper continues to make a deep analysis of production capacity's dynamic adjustment mechanism determined by demand. From the capacity Eqs. (6) and (7), we can get the corresponding capacity error correction Eqs. (16) and (17) respectively.

The error correction model of corresponding Eq. (6) is:

$$\Delta K_t = \delta\beta_1\gamma\Delta Y_t - (\delta+\gamma+\lambda-1)\left[K_{t-1} - \frac{\delta\beta_0(\gamma+\lambda)}{\delta+\gamma+\lambda-1} - \frac{\delta\beta_1\gamma}{\delta+\gamma+\lambda-1}Y_{t-1} - \frac{(\delta-1)(1-\gamma-\lambda)}{\delta+\gamma+\lambda-1}K_{t-2}\right] + \varepsilon_t \tag{16}$$

Error correction coefficient of Eq. (16) is $(1-\delta-\gamma-\lambda)$, and $\lambda > 0$.

The error correction model of corresponding Eq. (7) is:

$$\Delta K_t = \delta\beta_1\gamma\Delta Y_t - (\delta+\gamma-\gamma\lambda-1)\left[K_{t-1} - \frac{\delta\beta_0\gamma(1-\lambda)}{\delta+\gamma-\gamma\lambda-1} - \frac{\delta\beta_1\gamma}{\delta+\gamma-\gamma\lambda-1}Y_{t-1} - \frac{(\delta-1)(1-\gamma+\gamma\lambda)}{\delta+\gamma-\gamma\lambda-1}K_{t-2}\right] + \varepsilon_t' \tag{17}$$

Error correction coefficient of Eq. (17) is $(1+\gamma\lambda-\delta-\gamma)$, and $\lambda < 0$.

For an accurate analysis of the long-term balanced dynamic adjustment of capacity, this paper selects the time-varying parameter model to make an estimation of capacity error correction model, capacity error correction signal equation[8] is:

$$\Delta lk1_t = sg1_t \times \Delta ly1_t + sg2_t \times (lk1_{t-1} - \theta_1 \times ly1_{t-1} - \theta_2 \times lk1_{t-2}) + sg3_t) \tag{18a}$$

State equation:

$$\begin{cases} sg1_t = sg1_{t-1} \\ sg2_t = sg2_{t-1} \\ sg3_t = \theta_3 + \theta_4 \times sg5(-1) + \theta_5 \times sg4(-1) + \tau_t \\ sk4_t = sk3_{t-1} \\ \tau_t \sim N(0,\ e^{\theta_6}) \end{cases} \tag{18b}$$

capacity error correction equation to estimate the result are shown in Eq. (18a′)

$$\begin{aligned} \Delta lk1_t = {} & sg1_t \times \Delta ly1_t + sg2_t \times (lk1_{t-1} - 0.371 \times ly1_{t-1} - 0.447 \times lk1_{t-2}) \\ & + sg3_t\ (2.929)^{***} \quad (-7.04)^{***} \quad (58.32)^{***} \quad (27.43)^{**} \\ & {}^{*} \quad (15.74^{***}) \end{aligned} \tag{18a′}$$

The adjustment of speed fluctuations of steel production capacity during 2004 −2014 are shown in Fig. 5. According to error correction term of adjusting mechanism, when previous capacity is higher than the balanced capacity, it adjusts current period downward in order to achieve the equilibrium state; when the previous capacity is lower than the balanced capacity, it adjusts current period upward gradually close to equilibrium. So in the second quarter of 2005, adjustment parameter is positive, which means the previous period production capacity is a little bit lower, the market increases the production capacity at the speed of nearly 20% upward. The production capacities of the following two consecutive periods are both adjusted downward, the situation of iron and steel market was worsen, the demand growth was down to 0.14 in 2006. And for avoiding the blind investment of manufactures, the government came on the policies to control investment and backward productivity, because of the slowing of sales growth and interference of government, making the speed of adjustment be between 0.6 and 0.9 from 2006 to 2007. Then the global financial

[8] The lag period of each variables in signal equations can be determined after the measurement test of significance.

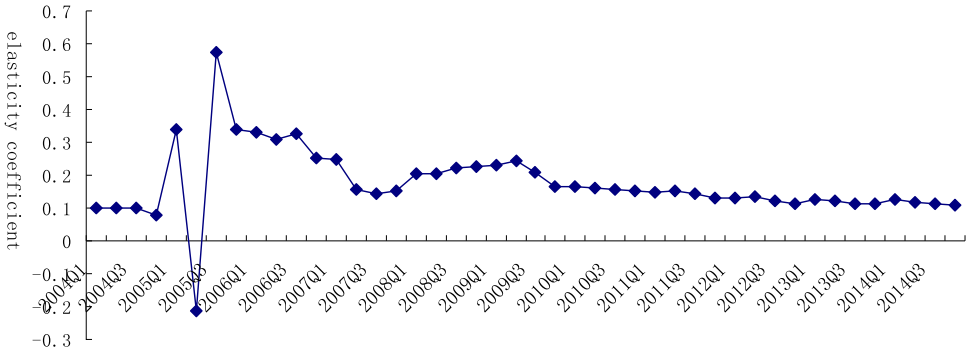

Fig. 3. dynamic effect of demand on capacity (sh1).

crisis was coming in 2008, the economic environment was worsen. And the adjustment speed was up from the fourth quarter of 2009. To contain the decline in economic growth, the Beijing's stimulus policies had been come on, making the part of excess capacity absorbed, so the adjusting speed was down from 2009. In 2012 the economic environment switched, the adjustment speed has uptrend.

From 2004–2005, the steel industry investment growth speed reaches above 30%, this "rise suddenly and sharply" market causes the attention of relevant departments. In 2006, the steel and iron industry's sales growth slow down, however, the investment on the steel and iron industry did not slow down. In 2008, international financial crisis of the world spreads quickly and soon affects the entity economy of China. In order to prevent the decline in economic growth, the Chinese government used 4 trillions of fiscal funds to support the economic growth, for which most of them were downstream industries steel-demanded. Recovering demand partly digested the previous high production capacity.

In Fig. 3, an asymmetric inertia characteristic of the demand-induced investment, making the production capacity higher than the equilibrium level. Each phase of the adjustment parameters of the production capacity is negative— pulling down production to make it restore to equilibrium, suggesting that the industry stock capacity is always higher than the equilibrium level. However, from the analysis of dynamic effect of the initial investment from Fig. 2, we can find that before the third quarter of 2005, there is a huge capacity supply gap in China's iron and steel industry. The insufficient investment of prior-period will cause retaliatory investment and the inevitable blindness of market regulation itself, shifting the insufficient production capacity into overcapacity than that of equilibrium, and make only downward revisions in follow-up phrases. As the effect of production correction mechanism itself is limited by characteristics of asymmetric inertia of investment, making correction mechanism plays a role only in a limited scope. Once the degree of deviation is too large beyond the regulating threshold of self - amendment mechanism of production capacity, the market is in a state of surplus production. If the market demands are not sharply rebounded significantly, the limited bonding of above investment inertia and capacity correction mechanisms will make industry face de-capacity problem. Market regulation cannot avoid the blindness of oneself; making overcapacity from shortage to higher than that of equilibrium, with the subsequent stage only by downward revisions. The effect of the capacity itself correction mechanism plays a role, and is limited by investment into the characteristics of, more than the capacity of their own fixed threshold (amendment) mechanism adjustment. The market is in a state of overcapacity, if the requirements are not great (Figs. 4 and 5).

The current China's economy is still in the mid-to-late industrialization with a large demand for manufactured goods. As a basis to provide raw materials, the heavy industry's technical characteristics determine that the investment tends to have advanced features. Large and sustained demand growth induces heavy industry investments massively.

4. The influence of asymmetric dynamic effects of the downstream market demand on iron and steel industry

As a big country with backward development, industry structure with heavy industry as the leading objectively forms a large number of steel demand, large scale and continuous robust downstream market demand for iron and steel industry, which shows the effects of complex dynamic characteristics on industry, by the influence of rapid and continuous development of downstream industries. The steel market has expanded sharply. Once the market experiences a reverse concentration trend, the demand-determined dynamic capacity shows asymmetric characteristics: demand growth period triggers investment acceleration and forms a large production capacity; once the demand slows down, it is likely to cause industry capacity retention by high cost, the asymmetric effect of influence is closely related with economic scale and development speed. Influenced by the transmission mechanism among industries, the changes of downstream demand tend to cause asymmetric chain reaction in the upstream industry capacity allocation. Due to multiple downstream industry joint effect of investment, decision-making effect factors of steel are more difficult, complex and changeful as basic raw material industry. Thus deconstructing asymmetric dynamic effects from demand to investment with the continuous high speed growing in greatly emerging economic entities can clarify the dynamic effect of downstream industries' development to capacity in iron and steel industry. The root of the overheated investment and overcapacity of iron and steel industry can be further analyzed.

1. Dynamic test of investment effect of the downstream demand for steel industry based on the time-varying parameter model.

As basic raw materials, capacity of iron and steel industry is closely related to the development of the downstream industry. Along with the sustained and rapid growth of China's economy, the developments' speed of more and more heavy industries of downstream steel industry are extremely rapid, such as machinery, electronics, large-scale equipment manufacturing, automobile manufacturing and real estate industries, which induces a lot of investment into the steel industry by market demand. Changes in investment demand show the time-varying characteristics by the conducting effect of frequency conversion of the downstream industry market situation. Therefore this paper uses the time-varying parameter model[9] to conduct a dynamic empirical test of investment influenced by the development of downstream industries. Refer to the Gao et al. (2004), Li and Wang (2009), choosing the real estate、transportation, Electrical Machinery And Equipment, general equipment as the downstream industries.

(1) Index design and data collection

[9] The introduction of time-varying parameter is the same as above.

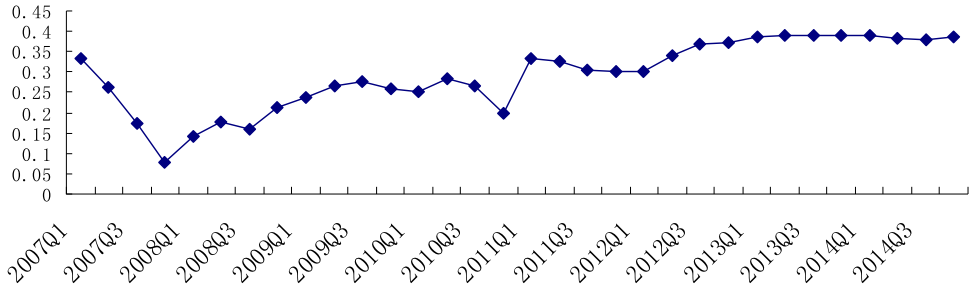

Fig. 4. Dynamic effect of demand on capacity since 2007.

This paper selects data of black metal smelting and rolling processing industry's fixed assets as steel capacity proxy variables, marked lk. Major downstream industries are identified as special equipment manufacturing industry, transportation equipment manufacturing industry, electric machinery and equipment manufacturing industry. we choose the above three industries' main business income data for proxy variables of the development of downstream industries; marked-

$lk_t = sk1 \times lcjt_{t-4} + sk2 \times lcdq_{t-2} + sk3 \times lfc_{t-3} + sk4 \times lczy_{t-3} + sk5$,-

$lk_t = sk1 \times lcjt_{t-4} + sk2 \times lcdq_{t-2} + sk3 \times lfc_{t-3} + sk4 \times lczy_{t-3} + sk5$ and

$lk_t = sk1 \times lcjt_{t-4} + sk2 \times lcdq_{t-2} + sk3 \times lfc_{t-3} + sk4 \times lczy_{t-3} + sk5$ respectively. The data of floor space under construction is selected marked

$lk_t = sk1 \times lcjt_{t-4} + sk2 \times lcdq_{t-2} + sk3 \times lfc_{t-3} + sk4 \times lczy_{t-3} + sk5$ as the proxy variable of the real estate industry to steel demand. The above data first uses price index of investment in fixed assets of 2003 as the base period, because of the PPI deflator processing is made; then to make seasonal adjustment, keeping pure trend components, as measuring proxy variables in the development of various industries. In order to efficiently get rid of the heteroscedasticity of time series data, the sequence data log is conducted to each variable's trend sequence data. Application of time series data modeling needs a stationary test first. If the horizon-level data is non-stationary, co-integration test is needed to see if there is a long-term equilibrium relationship among the data. Logarithmic trend data selected in this paper passes the $lk_t = sk1 \times lcjt_{t-4} + sk2 \times lcdq_{t-2} + sk3 \times lfc_{t-3} + sk4 \times lczy_{t-3} + sk5$ process, and all passes the subsequent co-integration test.[10] Because of effect of variable industries development may cause.

Signal equation and state equation of iron and steel industry affected by the downstream industries are shown in (19a) and (19b).

Signal equation:

$$lk_t = sk1 \times lcjt_{t-4} + sk2 \times lcdq_{t-2} + sk3 \times lfc_{t-3} + sk4 \times lczy_{t-3} + sk5 \tag{19a}$$

State equation in recursive form:

$$\begin{cases} sk1_t = sk1_{t-1} \\ sk2_t = sk2_{t-1} \\ sk3_t = sk3_{t-1} \\ sk4_t = sk4_{t-1} \\ sk5_t = \lambda_1 + \lambda_2 \times sk5_{t-1} + \lambda_3 \times sk6_{t-1} + \omega_t \\ sk6_t = sk5_{t-1} \\ \omega_t \sim N(0,\ e^{\lambda_4}) \end{cases} \tag{19b}$$

In the equations, sh1 sh2, sh3 and sh4, sh5 and sh6 respectively stands for induced dynamic elasticity of each point. Sh1 indicates the dynamic induced elasticity of special equipment manufacturing to iron and steel industry investment; Sh2 indicates the dynamic induced elasticity of transportation equipment manufacturing industry to iron and steel industry investment; Sh3 indicates the dynamic induced elasticity of general electric manufacturing industry to iron and steel industry investment; Sh4 indicates the dynamic induced elasticity of real estate industry to iron and steel industry investment. Fig. 6 shows the dynamic induced elasticity by the downstream industries to steel investment at different time points.

The lines describe the dynamic induced elasticity coefficient of development level of variable downstream industries on capacity of steel and iron industry.

2. Downstream asymmetric effect analysis of the iron and steel industry capacity

From Fig. 6, we see that from the first quarter of 2005 to the end of 2014, the impact of special equipment manufacturing industry in the downstream industry on steel capacity with changes in the elasticity of capacity demand between − 0.4~0.37. As it's shown in the effects of time, from 2005 to 2008, the elasticity value fluctuates greatly. In particular, the variable downstream industries except real estate industries, the elasticity of development on the steel and iron industry's capacity is negative due to the government restricted the capacity increasing. Influenced by the international financial crisis, export demand greatly reduces from the end of 2007–2009. The downstream shrunk demand spreads quickly to the steel industry capacity in 2008,

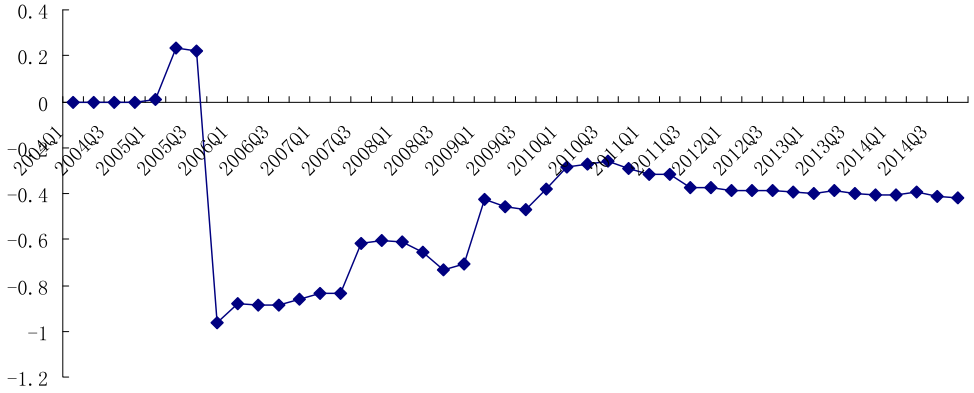

Fig. 5. Adjusting speed to equilibrium of capacity.

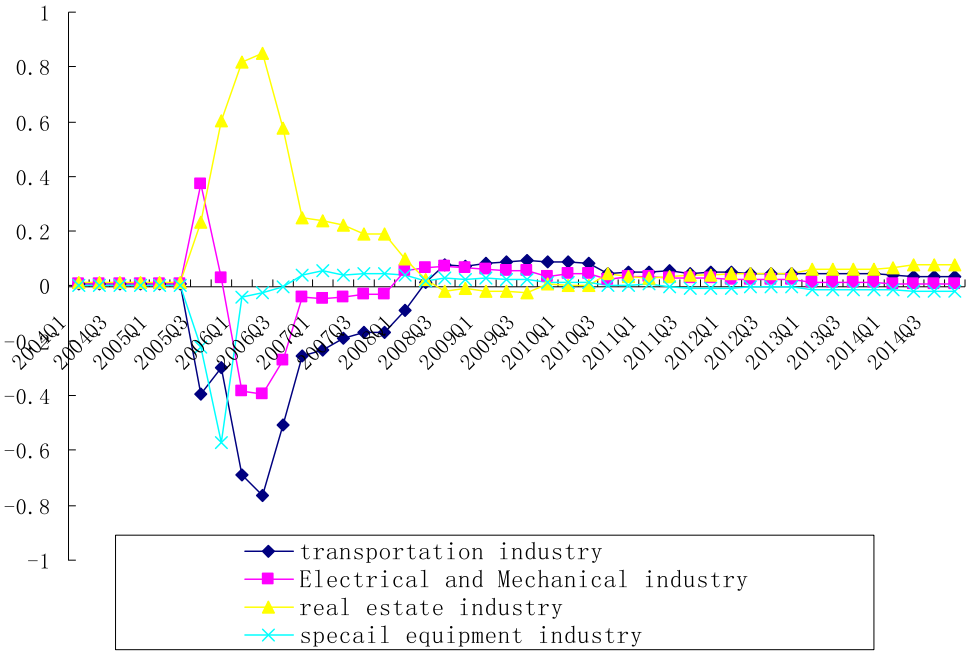

Fig. 6. The induced dynamic elasticity of downstream industries to steel industry's investment.

the year-on-year growth of newly started buildings only was 2.3% in 2008, what is more, the price of commercial residential buildings dropped by half in 2008. the elasticity of real state industry on capacity only was between −0.02 and 0.01 from third quarter of 2008 to second quarter of 2010, and after 2008, the elasticity of the iron and steel industry development on the steel and iron capacity was small To prevent rapid economic decline, the Chinese government issued a series of industrial policies to stable market since 2009, that government spent more on infrastructure investment, such as the highway and high-speed rail. The investment growth rate of transportation industry experienced 48.2% in 2009. The mass investment on transportation industry enhanced the manufacturers' expectation of the steel and iron industry development. From Fig. 6, The capacity of the iron and steel industry, from third quarter of 2008 to second quarter of 2010, elasticity of the transportation industry on capacity was about 0.1. After 2012, the Chinese economic environment worsen, the development of downstream industry such as mechanical and electrical industry、 general equipment industry and transportation industry does not have signally induced effect.

These industries use steel as one of main materials, whose sustainable development will inevitably has a huge impact on steel industry increase in production capacity. Releasing the reform dividend can make social public demand and consumption demand gradually upgrade. Infrastructure construction is the necessity of economic and social development that can make the whole social welfare level improved. By the influence of infrastructure construction, demand for steel industry further induces the large amount of investment, which is the endogenous mechanism of investment growth. With high economic growth, Chinese residents' income level has significantly changed, making all kinds of consumer durables consumption choices quickly shift from luxury to normal goods. In recent years, the performance of the automobile consumption market is quite obvious; low-and-medium-grade cars have gradually entered the most urban families, which first caused the investment and capacity expansion of auto industry. As large groups of consumers on steel, the development automobile consumption market will definitely promote the iron and steel market to expand production capacity. Although the development of automobile manufacturing industry has a huge driving effect, it hasn't produced a big asymmetric effect by investment and capacity withdrawal , therefore it is one-sided to regard it as push hands.

5. Conclusion and revelation

This paper takes the iron and steel industry as an example to conduct a systematical study on the mechanism of investment adjustment and capacity allocation by the market from the theoretical and empirical perspectives. It reveals that there is a notable asymmetric dynamic mechanism between the market mechanism's adjustments to the steel industry investment and capacity expansion in systolic periods from a multidimensional perspective. It studied the dynamic effects of capacity allocation of China's steel industry affected by the downstream industries' demand. Important conclusions are obtained as follows:

1. By the influence of market demand, there is elastic characterization of asymmetric adjustment mechanism demand during two phases of production capacity's formation and withdrawing.

   During the sample period, the investment completes the transformation from acceleration to deceleration in the form of asymmetry by the direct inducement of demand for steel investment; the elasticity value is between 0.05 ~ 1.9, with effect differing 40 times. Demand-caused periodic motion asymmetric inertia investment itself is the first stage of the capacity's asymmetric adjustment; There is difference in dynamic demand elasticity of investment, capacity demand elasticity in third quarter of 2005 appeared the maximum negative value (−0.23), and then rapidly arised, and in the subsequent two phases of the first quarter 2006 reached positive maxima (0.58), then became stable near about 0.15. It shows that a capacity gap can cause production capacity to increase quickly, subjected to withdrawing cost which buried the excess risks in production capacity.
2. Dynamic demand determined asymmetric characteristics of its correction mechanism

Capacity error correction model based on time-varying parameter estimated results shows that capacity adjustment parameters appears positive maximum (0.22). After a period of smoothing, it enters into negative adjustment and subsequently is stable with the adjustment

[10] Considering the limited space, data stationarity test and cointegration test result are not listed in the text, but available upon request.

speed at an average 0.427. The alternating dynamic of positive and negative symbol of adjusted parameters show that steel market capacity gap sparked "retaliation" investment into the steel market, then production capacity is quickly created and appears positive deviation from equilibrium subsequently. After a period of smoothing, capacity adjustment parameters are always negative and downward adjustment capacity is conducted to make them reverse to the equilibrium level. Capacity's correction mechanisms play a limited role influenced by asymmetric inertia mechanism of investment itself, overcapacity exceeds the adjustable threshold value scope of capacity correction mechanism. Market can not return to equilibrium by correction mechanism itself. Instead, it is more and more away from equilibrium, then the industry is facing the difficult problem of how to dissolve the overcapacity.

The above conclusion also means that when market plays a decisive role in the allocation of resources, mechanism design of investment and the dynamic capacity regulation policy should be conducted, which can not only be applicable to the steel industry itself, but also is applicable for those heavy industries that frequently transform the dynamic demand into the high-speed development.

When market continues experiencing the dynamic disequilibrium of supply and demand, it is difficult to achieve investment consensus based on realizing expected equilibrium need with market as the main body. Although the government's regulation policies based on industry growth capacity unilaterally has a great impact on industry's investment, it has little effect on controlling the level of consistent production capacity. Since the 21st century, development of China's gigantic economic entity has braved the wind and waves, demand of raw materials is far from expected and the strong induction of high return of investment is the endogenous impetus of heavy investment. Expansion urge of each round identified by market will surely propel the next round of further expansion. Under the situation of this economic operation, induction of the driving ahead without considering the consequences investment policy asymmetric effect is enlarged, indicating the blindness of the market's adjustment in some degree. Industry demand determined by associated inter - mechanism as the endogenous mechanism of investment becomes to attract large amount of investment when continuing-demand grows. But demand slows down, becoming the root of excessive production. The effect of the endogenous mechanism is closely related to stages of economic development, economic size and scale, the growth speed and other related factors. Outside intervention is difficult and not supposed to be too much. Therefore it is difficult to control the pulse of frequently conversed economic operation with supply gap. What's more, the choice of time, direction, strength of regulation and control tools which aim at preventing the economic from ups and downs development become more difficult, so it is hard to work.

In the sustained and rapid growing process of China's gigantic economic entity, the market dynamic demand frequently switches. After the entrance of pre-investment induced by demand growth, the trailing effect of investment activities becomes obvious as investment inertia is difficult to inhibit or the cost is high,. Hysteresis of capacity makes the originally rational investment decisions a blindness expansion in the formation of capacity. This economic dynamics make it more difficult for market entities to grasp the law of market economy, so that "trial and error" cost goes beyond the ordinary level. Some similar situations also occur in other several markets. So the market needs effective industrial policy, early warning and other assistance to reduce the cost of "learning". According to the fact that China's high-speed economic growth is switching into regular-speed operation, it is urgent for relevant government departments to objectively grasp the uniqueness of China's market operation law, catching the opportunity of comprehensive de-capacity in this round and to explore to build a more perfect warning mechanism in investment and production capacity in the new round of mechanism design. Through being helpful in building "market learning curve" as much as possible, the learning process for market entities could be shortened. Effective policy is based on full grasp of the uniqueness the market operation mechanism, through the private sector and the government department strategic cooperative interaction. It includes, on the one hand, finding the information that restricts the validity of market; on the other hand, collecting market reaction caused by relevant policies, which requires policy enforcement departments to have the continuous learning and innovation ability. Therefore, how to achieve dynamic adjustment of policy through positive interaction between the government and market, making it better service to the market is our main research topics for the future study.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.resourpol.2016.10.011.

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