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# Economic Policy and Investment Strategy under Environmental Pressure: An Analytic Approach

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This paper builds the analytic models for economic policy under environmental pressure. It can describe the impact of policy on economic growth. Also, the paper presents the policy models for investment to basic output and innovation, which can be applied to compute the optimal investment rates, and analyze the actual investment effects on economic growth. Further, the paper concludes that, open policies should be the leading one for the traditional industries; closed policies should be implemented at first for the small emerging Industries, which are promising in growth, and open policies are implemented at an opportune moment.

Keywords: Economic growth, environmental pressure, developing policy, optimal investment rate

## Introduction

The economic policies determine the orientations of economic development and the qualities of people living, and influence deeply the growth process. Therefore, the economic policies are forever focused by economists, and the related researches and results are plentiful.

The winner of the Nobel Prize on economy, Prescott (2006) points out, "it is best to choose at each point in time what is best given the current situation and the rules by which policy will be selected in the future", and "before the transformation of macroeconomic policy, what was evaluated was a policy action given the current situation." Fleck (2008) provides a theoretically grounded analysis of a massive policy change, and discusses what conditions cause major policy changes under representative government. Furthermore, the researches about economic policy refer to growth, regional development, finance, and so on:

- Economic policy and growth. Hopenhayn and Muniagurria (1996) indicate that, the lack of persistence in policies is likely to decrease growth. Acs and Szerb (2007) introduce the second Global Entrepreneurship Research Conference, The conference focused on developing a better understanding of the relationships among entrepreneurship, economic growth and public policy, and variations according to the stage of economic development. The meeting thinks that for developed economies, reducing entry regulations, in most cases, will not result in more high-potential startups. Wang (2009) thinks that, the additional foreign borrowing is associated with higher indebtedness and slower economic growth.
- Policy and regional development. Dessant and Smart (1977) present a method of assessing the impact of regional economic policy. Walz (1996) develops a regional growth model with endogenous technological change, and shows that regional policies aiming to support the less-developed region do not only change the location of production but also affect the overall growth performance. Peersman and Smets (2005) find, on average the negative effect of an interest rate tightening on output is significantly greater in recessions than in booms.
- Economic policy and finance. Dressler (2007) assesses the quantitative importance of a change in monetary policy, and a qualitative change in the cyclical behavior of the monetary base. Opiela (2008) finds that banks with partial guarantees have a stronger loan response to monetary policy than banks with full guarantees. Wolnicki (2009) points out, allowing the dollar devaluation has been a short-sighted policy which will have dire consequences on import-dependent economy and the USA's position in the world economy.
- Policy and the related works. Timothy, Steven and Sykes (2009) argue that one country's demographic profile will drive its economic policies in a manner that may seem at odds with the rational behavior of another country. Gerring and Thacker (2009) argue that neoliberal economic policies may improve the human welfare in ways that are independent of their effects on economic performance. Wolf (2010) thinks that a lack of reciprocal trust and commitment affects the policy-making. Konzelmann, Wilkinson,

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Fovargue-Davies and Sankey (2010) study the factors giving rise to the present crisis and to the implications for theory and policy that follow.

To sum up the works above, there are some problems listed as follow:

(i) Based on the opinion of Prescott, how do we choose the policy and determine the time to implement it?

(ii) The introduction from Acs and Szerb does not indicate that, what are the better way to support the high-potential emerging industries and enterprises?

(iii) All the works of Peersman and Smets, Wang, Gerring and Thacker, Wolf, and Konzelmann, et al. do not point out that, how do the policies affect economic recession or growth?

Aiming at the three and some other problems, this paper will, based on advance-retreat course (ARC) theory, builds the analytic models for policy, analyzes the timing and actual effect of implementing an economic policy; presents the policy models taken the investment to basic output and innovation into account, and computes the optimal investing rates, to lay the groundwork for making policy; based on the obtained results, designs the strategies for implementing policies for developed and developing countries.

The key idea of ARC theory is society and economy progress gradually while resolving various problems, in this course, human becomes stronger and stronger in resolving problems, but the problems are more and more complex. That is, the social development and economic growth have to face greater and greater pressure, until a significant change happens. Then the original process ends, and a new process begins. The works about ARC theory and method include: a socio-economic development model under environmental pressure (Dai, Qi & Liang, 2011a) and a monitoring indicator that can provide warnings about economic crises (Dai, Qi & Liang, 2011b). 2.

## The Policy Analysis Models under Environmental Pressure

The main purpose of making and implementing an economic policy is to safeguard economic order and promote economy growth. ARC theory thinks that, the actual economy output (real output for short) is determined by the basic output, endogenous dynamics, exogenous cost and environmental pressure. The basic output is produced by the basic output, which includes capital and labor. And the basic output is regarded as equal to the basic output in the following. The environmental pressure is caused by the lack of resources, ecological disaster, environmental pollution, political instability, wars and so on. While promoting economic growth, the investment to basic output and innovation may result in the risks, and become the economic environmental pressure. The exogenous cost is all the consumption caused by the environmental pressure.

### *The basic ARC model*

Innovation can promote economic growth, but it must take the basic output as a carrier. The literatures (Loeschel, 2002; Smulders, 2005) indicate that, economic innovations are the endogenous factors. Therefore, the endogenous dynamics consists of basic output (and assets for short), economic innovation and technological progress (and innovation for short). We suppose that, the growth rate of endogenous dynamics is decided by the growth rates of basic output and economic innovation, that is $d\sigma/\sigma=d\mu/\mu+dq/q$, or $\sigma=\sigma_0\mu q$, where, $\mu$, $\sigma$ and $q$ represents the basic output, endogenous dynamics and innovation respectively. According to the literature (Dai et al., 2011a), the economic growth model under the environmental pressure is expressed as follows:

$$L = a\mu - \phi + h(a\sigma - \kappa) = \mu\left(a(1+hq) - \frac{v+hwq^{\theta}}{\theta}\mu^{\theta-1}\right) \tag{1}$$

where $L$ is the real output, $\mu$ is the basic output, $\phi=(v/\theta)\mu^{\theta}$ is the exogenous cost, $\sigma=\mu q$ is the endogenous dynamics, and $\kappa=(w/\theta)\sigma^{\theta}$ is the environmental (or exogenous) pressure, $h$ is the increment coefficient, $\theta$ is the environmental pressure index (Dai et al., 2011b), $a$, $v$, $w$ are the constants, $a$, $v$, $w>0$, $\theta>1$.

If $\theta=1$, or $v=w=0$, the model (2) or (3) can describes the Cobb-Douglas function and Solow growth model (1956, 1957), including AK model (Romer, 1987; Jones, 1998).

### *The basic policy analysis model*

In general, implementing a policy, will impact directly on the economic environment, and change the environmental pressure. If the basic output and innovation remain unchanged, the exogenous cost and the environmental pressure will change after the policy is implemented, then the basic policy analysis model, based on ARC model (1), is expressed as follows:

$$L = \mu\left(a(1+hq) - \frac{v+hwq^{\theta_p}}{\theta_p}\mu^{\theta_p-1}\right) \tag{2}$$

where $p$ is the policy parameter, the measure of effective degree of the policy. $\theta_p=(1+p)\theta$ ($\theta_p>1$) is the environmental pressure index after the policy is implemented.

In model (2), $p<0$ means $\theta_p<\theta$, and the decreases of exogenous cost and environmental pressure, the policy is called the open or liberal one. The open policy advocates the fair competition, and market readjustment, and is helpful to survival of the fittest industries or enterprises. If $p>0$, means $\theta_p>\theta$, and the increase of exogenous cost and the environmental pressure, the policy is called the closed or protective one. The closed policy is helpful to emerging industries or enterprises in its initial stage, and not to the fair competition and survival of the fittest industries or enterprises in following stage.

***The policy analysis model with the change of basic output***

If implementing a policy with the change of basic output, and the innovation does not change, then the policy analysis model is expressed as follows:

$$L_\mu = \mu_p\left(a(1+hq)-\frac{v+hwq^{\theta_p}}{\theta_p}\mu_p^{\theta_p-1}\right) \tag{3}$$

where $\mu_p=(1+p_\mu)\mu$ is the assets after the policy is implemented, $p_\mu$ is the change rate of assets, $p_\mu>-1$. $p_\mu>0$ means the increase of basic output, and the investment to assets; $p_\mu<0$ means the decrease of assets.

***The policy analysis model with the change of innovations***

If implementing a policy with the change of innovations, and the basic output do not change, then the policy analysis model is as follows:

$$L_q = \mu\left(a(1+hq_p)-\frac{v+hwq_p^{\theta_p}}{\theta_p}\mu^{\theta_p-1}\right) \tag{4}$$

where $q_p=(1+p_q)q$ is the innovations after the policy is carried out, $p_q$ is the change rate of innovations, $p_q>-1$. $p_q>0$ means the increase of the innovations, and the investment to innovations; $p_q<0$ means the decrease of the innovations.

***The policy analysis model with the change of assets and innovations***

Based on ARC model (2), (3) and (4), if implementing a policy with the change of basic output and innovations, then the policy analysis model is as follows.

$$L_z = \mu_p\left(a(1+hq_p)-\frac{v+hwq_p^{\theta_p}}{\theta_p}\mu_p^{\theta_p-1}\right) \tag{5}$$

where, $\mu_p(t)=(1+p_\mu)\mu$, $q_p(t)=(1+p_q)q(t)$, $p_\mu$ is the change rate of basic output, $p_q$ is the change rate of innovations.

## Methods

From the policy analysis models (2), (3), (4) and (5), the analytic method for policy and investment are presented as follow.

***Timing and role analysis on economic policy***

According to ARC model (1) and (2), the impact of a policy on real output is measured as:

$$G(p,t)=L_p-L=\frac{\mu^\theta}{\theta_p}[(1+p)(v+hwq^\theta)-(v+hwq^{\theta_p})\mu^{p\theta}] \tag{6}$$

In equation (6), if $p=0$, $G(0, t)=0$, that is, $L_p$-$L=0$, means the policy is ineffective, or no policy is implemented. If $G(p, t)>0$, that is, $L_p$-$L<0$, means the policy promotes real output to increase. If $G(p, t)<0$, that is, $L_p$-$L<0$, means the policy reduces the real output.

In ARC model (2), when the growth rates of assets and innovation increase, according to ***Appendix A***, there are the $T_p^+>0$ and $T_p^-<0$, they are separately corresponding to the open and closed policy:

- If implementing an open policy, $T_p^+$ is the critical time of the policy. In the period of $(0, T_p^+)$, the real output is smaller than the original one; and in the period of $(T_p^+, +\infty)$, the real output is larger than the original one. This means, the open policy will decrease the real output before the critical time $T_p^+$, and increase the real output after the time $T_p^+$.
- If implementing a closed policy, $T_p^-$ is the critical time of the policy. In the period of $(0, T_p^-)$, the real output is than larger the original one; and in the period of $(T_p^-, +\infty)$, the real output is smaller than

the original one. This means, the closed policy will increase the real output before the critical time $T_p^-$, and decrease the real output after the time $T_p^-$.

***The optimal change rate of basic output under a policy***

According to ARC model (2) and (3), the impact of basic output on real output, under an economic policy, can be measured by expression (7).

$$G_\mu(p, p_\mu, t) = L_\mu - L \tag{7}$$

In expression (7), if $p_\mu$=0, the assets does not change. If $p_\mu \neq 0$, and $G_\mu(p, p_\mu, t) > G_\mu(p,0, t) = G(p, t)$, means the change of assets, based on the policy, will increase the real output. If $G_\mu(p, p_\mu, t) < G_\mu(p,0, t) = G(p, t)$, means the change of assets, under the policy, will decrease the real output.

According to ***Appendix B***, if the change rate of assets is determined by the following expression (8), the real output (3) reaches its maximum value.

$$p_\mu^* = \frac{1}{\mu}\left(\frac{a(1+hq)}{v + hwq^{\theta_p}}\right)^{\frac{1}{\theta_p - 1}} - 1 \tag{8}$$

The expression (8) presents the way to compute the optimal change rate of assets, and indicates that, the optimal change rate is relevant to the current assets, innovation and policy. When the current change rate $p_\mu < p_\mu^*$, real output increases, and real output decreases when $p_\mu > p_\mu^*$. If the optimal change rate is larger than zero, it is the optimal investment rate of assets; and if the optimal change rate is smaller than zero, it is the optimal decreased rate of assets.

So, after implementing a policy, the expression (8) points out the condition, under which the investment to assets promotes real output to grow, and presents the basis for decision-making on investment rate of assets.

***The optimal change rate of innovations under a policy***

According to ARC model (1) and (4), the impact of the innovation change on real output, under an economic policy, can be measured by expression (9).

$$G_q(p, p_q, t) = L_q - L \tag{9}$$

In expression (9), if $p_q \neq 0$, and $G_q(p, p_q, t) > G_q(p,0, t) = G(p, t)$, means the change of innovation, based on the policy, will increase the real output. If $G_q(p, p_q, t) < G_q(p,0, t) = G(p, t)$, means the change of innovation, based on the policy, will decrease the real output.

According to ***Appendix C***, if the change rate of innovations is determined by the following expression (10), the real output (4) reaches its maximum value.

$$p_q^* = \frac{1}{\mu \cdot q}\left(\frac{a}{w}\right)^{\frac{1}{\theta_p - 1}} - 1 \tag{10}$$

The expression (10) presents the way to compute the optimal change rate of innovations, and indicates that, the optimal change rate is relevant to the current assets, innovation and policy. When the current change rate is smaller than the optimal one, real output increases, and real output decreases when the current change rate is smaller than the optimal one. If the optimal change rate is larger than zero, it is the optimal investment rate of innovations; and if the optimal change rate is smaller than zero, it is the optimal decreased rate of innovations.

Under an implemented policy, the expression (10) points out the condition, that the investment to innovations promotes real output to grow, and presents the basis for decision-making on investment rate of innovations.

***The optimal change rates of both assets and innovations under a policy***

According to ARC model (1) and (5), the impact of the changes of both assets and innovations on real output, under an economic policy, can be measured by expression (11).

$$G_z(p, p_\mu, p_q, t) = L_z - L \tag{11}$$

According to ***Appendix D***, if the change rates of both assets and innovations are determined by the following expression (12), the real output (5) reaches its maximum value.

$$\begin{cases} p_\mu^* = \dfrac{1}{\mu}\left(\dfrac{a}{v}\right)^{\frac{1}{\theta_p - 1}} - 1, & p_\mu^* > -1 \\ p_q^* = \dfrac{1}{q}\left(\dfrac{v}{w}\right)^{\frac{1}{\theta_p - 1}} - 1, & p_q^* > -1 \end{cases} \tag{12}$$

The expression (12) presents the way to compute the optimal change rates of both assets and innovations. When both the current change rates of assets and innovations are smaller than those under the optimal state, there are the investment opportunities of assets and innovations, so as to increase the real output.

## Results

In the following conclusions, suppose the growth rates of basic output and innovations are larger than zero, that is, there are the natural growths both in basic output and innovation.

### *The basic function of economic policy*

From the expression (6) and appendix A, the open policy will reduce the real output in the initial stage, the range of decrease will be smaller and smaller, until it disappeared. This indicates that, there is an adaptation of economic production to the policy. After the adaptation phase, open policy will promote the increase of real output. The closed policy increases the real output in the initial stage, and the range of increase will gradually reduce, until it disappeared. This means that, there is a benefited growth at the initial phase of implementing closed policy. After the benefited phase, the closed policy will quicken the decrease of real output. Therefore, we have the conclusion 1.

***Conclusion 1***. The open policy is able to promote economic growth in a long-term, and the closed policy stimulates economic growth only in a shorter time. The further interpretations are:

(i) The open policy will reduce the real output in its infancy; after being adapted by economy and production, it will increase the real output, and promote economic growth in a long-term. If the economic base is weaker, the adaption process will be longer.

(ii) The closed policy is able to promote growth only in its infancy, and its stimulating effect will disappear gradually. After the stimulating effect disappears, the closed policy will stunt and restrain economic growth.

### *The policy and investment to basic output*

From the expression (8) and appendix B, The open policy will cause the environmental pressure to decrease, and prolong the acting time of the investment to basic output. The closed policy will increase the environmental pressure, and shorten the acting time of the investment to basic output. Then the conclusion 2 is obtained.

***Conclusion 2***. Under the open policy, investment to basic output, though there is the adaption process, is able to promote output growth for a longer time. Under the closed policy, increase of basic output promotes output growth only for a shorter time, afterward, real output will decrease faster.

Conclusion 2 indicates**,** the investment to basic output, under the closed policy, stimulates economy to growth only in a shorter time. If hoping economy to grow for a long time, it is important to carry out the open policies.

Also, according to expression (8), the optimal change rate will be descending with time, then have

***Conclusion 3***. As time goes on, the basic output and innovation will be larger and larger in their scale, and the optimal change rate of assets will be smaller and smaller. In the initial stage of implementing a policy, the investment to assets may be larger; and in the latter, the investment rate has to be smaller.

### *The policy and investment to innovations*

From the expression (10) and appendix C, if the optimal change rate of innovation is larger than zero, there is the investment opportunity in innovations, and the optimal change rate will be descending with time. Thus, we have the conclusions for innovation, which are similar to the conclusion 2 and 3. In addition, according to expression (10), the optimal investment rate is related to the current assets and innovations. This implies the conclusion 4 as follows.

***Conclusion 4***. If the optimal change rate of innovations is larger than zero, the optimal investment rate is influenced by the industrial scale and the time of policy implementing, and descending with time.

### *The policy and investment to both assets and innovations*

According to expressions (12) and appendix D, if the growth rates and the optimal change rates of assets and innovations are larger than zero, that is, there are the investment opportunities for assets and innovations, have the conclusion 5 as follows.

***Conclusion 5***. While the policy changes from closed to open, the optimal investment rate will increase, and the open policy is able to provide the larger growth space for the basic output and innovations. When implementing the policy, in order to get the maximum output, the three following aspects must be paid attention to: (i) The open policy is able to expand the growth range for the basic output and innovations, and the closed policies will restrict and shorten the growth range. (ii) If the current investment rate of the basic output is smaller than the optimal

one, the real output increases, and the same to innovation. If the current investment rate of the basic output is larger than the optimal one, the real output decreases, and so do the innovation. (iii) Both the optimal investment rates decrease with time. Therefore, at the initial stage of economic growth in a cycle, the policy is able to be implemented with more investments. At the latter stage, the policy has to be implemented with fewer investments. So, if implementing a policy with the investment to basic output and/or innovation, the conclusion 5 can be regarded as the basis for decision making.

**Discussion**

In the following discussion, let the basic output and innovations be $\mu=\mu_0 e^{\lambda t}$ and $q=q_0 e^{st}$ separately, and their growth rates are larger than zero, that is, $\lambda>0$ and $s>0$.

***The impacts of policy on economic growth***

Implementing the open policy ($p<0$) or the closed policy ($p>0$), and let $G(p, T_p)=0$ in expression (6), we obtain the policy critical time $T_p$ (>0) by the numerical method. The change processes of real output (1) and (2) are shown in Figure 1.

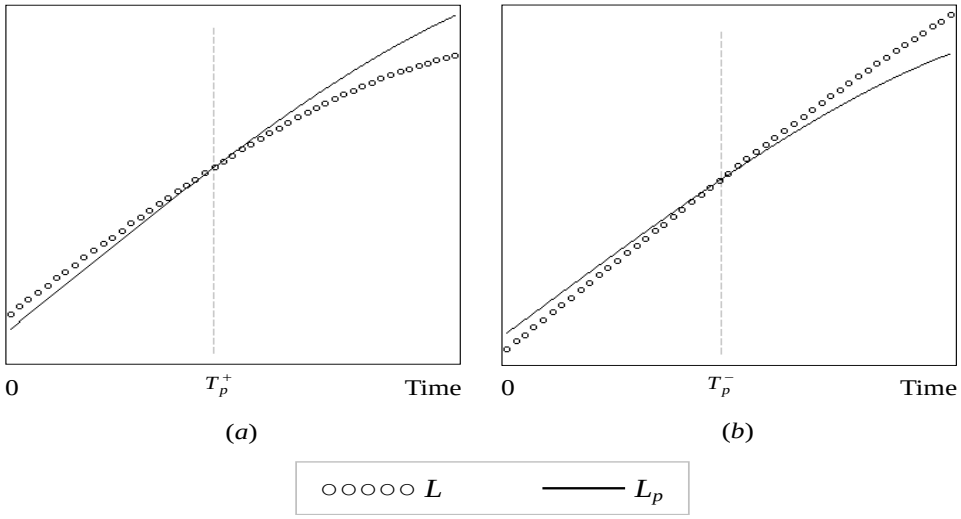



Figure 1. The impacts of policy on economic growth.

**Note**. In figure 1, $L$ is the real output before implementing the policy, and original output for short, $L_p$ is the real output after implementing the policy. (*a*) shows the real output ($L_p$) after implementing the open policy ($p<0$); (*b*) shows the real output ($L_p$) after the closed policy ($p>0$).
In (*a*), the environmental pressure decreases after implementing the open policy, $T_p^+$ is the critical time of the policy, the real output reduces in the period of (0, $T_p^+$), and increases after the critical time. Open policy promotes the long-term output growth after a period of adaptation. In (*b*), the environmental pressure increases after the closed policy, $T_p^-$ is the critical time of the policy, the real output increases in period of (0, $T_p^-$), and decreases after the critical time. Closed policy is disadvantageous to the long-term output growth.

Figure 1(*a*) indicates, after implementing the open policy, real output ($L_p$) is smaller than original output ($L$) in the period of (0, $T_p^+$), that is, the open policy decreases real output in its infancy, but the decrease becomes less and less, until it is disappeared. In the period of ($T_p^+$, $+\infty$), the real output is larger than the original one, the open policy increases the real output. Figure 1(*b*) indicates, after implementing the closed policy, real output is larger than original one in the period of (0, $T_p^-$), the closed policy is able to increase output in its infancy, but the increase becomes less and less, until it is disappeared. In the period of ($T_p^-$, $+\infty$), the real output is less than the original one, the closed policy decreases the real output, and the decrease is quicker in speed.
The discussion on figure 1 supports the conclusion 1. And the following strategy 1 is derived.
***Strategy 1*** (The policy choice strategy for economic development). When implementing the policies, the advisable strategies for economic development are as follow:
● In the period of recession or depression, the closed policy is able to stimulate economy to growth for a

short time. But, in order to keep economic long-term growing, the authorities should abandon the closed policy in good time, and switch from the closed policy to the open one.

● In the period of prosperity or growth, the open policy should be implemented in most cases, though the output may reduce in a short period of time. But, in the long run, the open policy will effectively promote real output to grow.

***The investment to basic output under a policy***

Implementing the open policy ($p$<0) or the closed policy ($p$>0), the change rate of basic output is given as $p_\mu$, $0< p_\mu< p_\mu^*$ in expression (8), means investment to basic output. And let $G_\mu(p, p_\mu, T_\mu)=0$ in expression (7), we obtain $T_\mu$ (>0) by the numerical method. After implementing an open policy, $T_\mu^+ =T_\mu$ is the critical time of investment to assets; after implementing a closed policy, $T_\mu^- =T_\mu$ is the critical time of investment to assets. Then the change processes of real output (1), (2) and (3) are shown in figure 2.

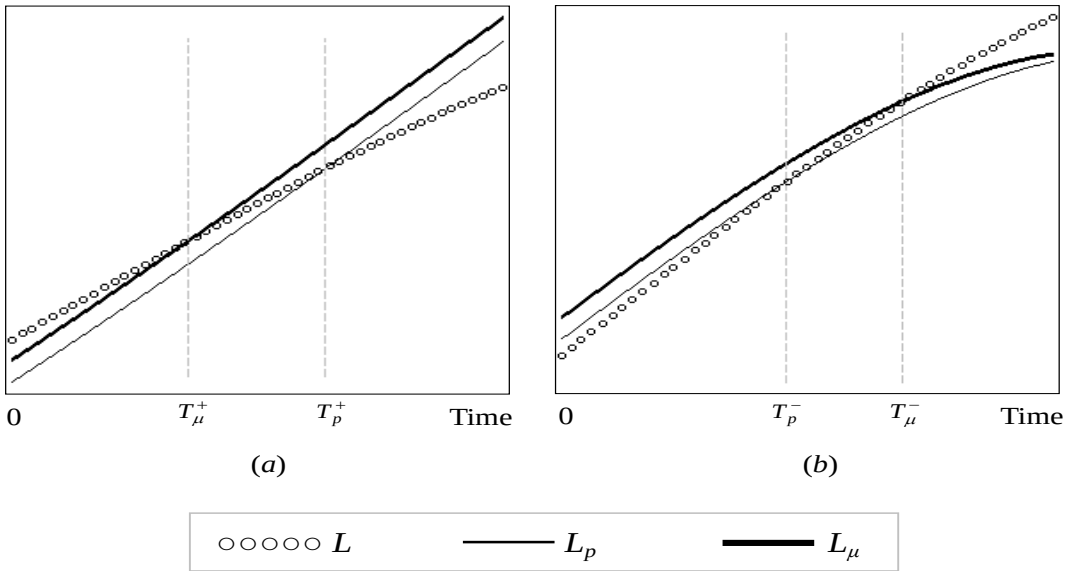



Figure 2 The impacts of investment to assets on economic growth

**Note**. In figure 2, $L$ is the real output before implementing the policy, and original output for short; $L_p$ is the real output after implementing the policy; and $L_\mu$ is the real output after investment to assets under the policy. (*a*) shows the real output after investment to basic output under the open policy ($p$<0). (*b*) shows the real output after investment to basic output under the closed policy ($p$>0). In (*a*), $T_\mu^+$ is the critical time of the investment to assets under the open policy. The real output $L_\mu$ reduces in the period of (0, $T_\mu^+$), and increases after the critical time. In (*b*), $T_\mu^-$ is the critical time of the investment to assets under the closed policy. The real output $L_\mu$ increases in the period of (0, $T_\mu^-$), and decreases quickly after the critical time.

Figure 2 (*a*) indicates, after implementing an open policy, real output (3) is smaller than original output (1) in the period of (0, $T_\mu^+$), and larger than real output (2). Because $T_\mu^+ < T_p^+$ this means the investment to assets increases the real output under the open policy.

Figure 2 (*b*) indicates, after implementing a closed policy, real output (3) is larger than real output (2) in the period of (0, $T_p^-$), and larger than original output (1) in the period of (0, $T_\mu^-$), $T_p^- < T_\mu^-$. This means, under the closed policy, the investment to assets increases the real output for a longer time. But, after the time $T_\mu^-$, the decrease of real output (3) will be quicker than that of real output (2).

Obviously, the discussions on figure 2 support the conclusion 2 and conclusion 3. To sum the conclusion 1, conclusion 2 and conclusion 3, we have the strategy 2 as follows.

***Strategy 2*** (The strategy for policy choice and investment to basic output). Making the decisions for policy and investment to basic output in the industries, the following three basic strategies should be paid to great attention:

(i) The open policy should be implemented to the large and medium industries, in order to reduce the environmental pressure, ensure the continuous efficiency in investment to basic output, and promote the long-term growth.

(ii) The closed policy should be implemented to the small industries, including the investment to the basic output, in order to conserve them in their initial phase. But, the closed policies should be withdrawn before their critical time, and replaced by the open policy, to strengthen their own competition ability.

(iii) If the output of an industry cannot be increased by the investment to basic output, the investment should be decreased, in order to reduce the exogenous cost, and the investment should be increased to other promising and smaller emerging industries.

***The investment to innovations under a policy***

The analysis indicates that, the impact of investment to innovation is similar to basic output. Under the open policy, the time, when investment to innovation makes the real output larger than the original one, is later than the time to basic output; the impact of investment on real output lasts longer than that of basic output. Under the closed policy, the time of investment to innovation being ineffective, is also later than that to basic output. Therefore, we have the strategy 3 as follows.

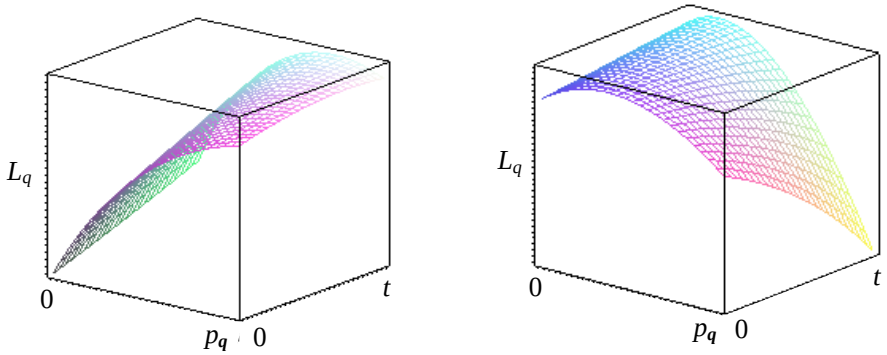
***Strategy 3*** (The strategy for policy choice and investment to innovations). Making the decisions for policy and investment to innovations in the industries, the following three basic strategies should be paid to great attention:

(i) The open policy should be implemented to the large and medium industries, in order to reduce the environmental pressure, ensure the continuous efficiency in investment to innovation, and promote the long-term growth.

(ii) The closed policy should be implemented to the small industries, in order to conserve them in their initial phase. But, the closed policy should be withdrawn before their critical times, and replaced by the open policy, to strengthen their own competition ability.

(iii) If the output of an industry cannot be increased by the investment to innovation, the investment should be decreased, and the investment should be increased to the promising and smaller industries.

In ARC model (4), if the innovation investment rate is $p_q$ (>0), before and after implementing the open or closed policy, the changes in real output are shown in figure 3.




(*a*) (*b*)

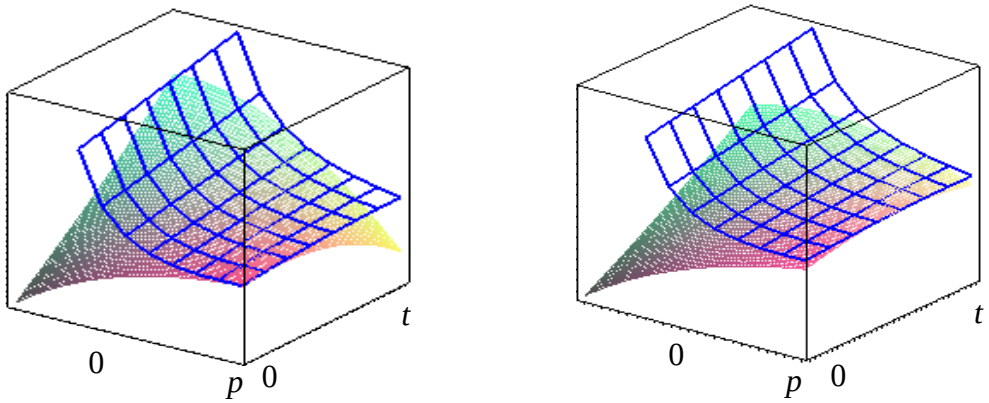
Figure 3 The impacts of investment to innovations on economic growth

**Note**. In figure 3, (*a*) is the results from investment to innovation under the open policy. While the innovation investment rate changes from smaller to larger, the real output changes from smaller to larger. If $p_q$ is smaller, real output increases in higher speed; if $p_q$ is larger, real output increases in lower speed. (*b*) is the results from investment to innovation under the closed policy. While the innovation investment rate changes from smaller to larger, the real output changes from larger to smaller. If $p_q$ is smaller, real output increases with time; if $p_q$ is larger, real output decreases with time.

If basic output do not change, we see from (*a*) in figure 3, implementing an open policy, the real output increases with the increase of innovation growth rate. When the growth rate is smaller, the real output increases in a higher speed with time, and the real output increases in a lower speed if the rate is higher. From (*b*) in figure 3, when implementing a closed policies, the real output decreases with the

increase of innovation growth rate. When the growth rate is smaller, the real output increases with time, and the real output decreases with time if growth rate is larger.

Whether the policies are open or closed, the optimal investment rate in expression (10) keeps the real output in the maximum route, which are shown in figure 4.




(*a*) (*b*)

Figure 4 The impacts of changing innovations on real output in a policy cycle

**Note**. In figure 4, the grids are the maximum output determined by appendix C. While the policy changes from open to closed (from $-p$ to $p$), (*a*) describes the impact of increasing innovation on real output ($p_q$>0). The open policy will promote the sustained output growth. Under closed policy, the real output will decrease after a short increase. (*b*) describes the impact of decreasing innovation on real output ($p_q$<0). The open policy will promote the sustained output growth in a lower speed. The closed policy will decrease the real output after a short increase, but the speed is lower.

In figure 4, (*a*) indicates the impact of increasing innovation on real output ($p_q$>0), (*b*) indicates the impact of decreasing innovation on real output ($p_q$<0). The grids are the maximum outputs determined by the optimal investment rate, and show that, the maximum outputs are higher if the policies are more open, and the maximum outputs are lower if the policies are more closed.

From (*a*) in figure 4, under the open policies, increase of innovation will result in steady growth in the real output, the higher the open degree, the quicker the output growth. under the closed policies, increase of innovation will result in a temporary increase in the real output, then the decrease occurs, and the higher the closed degree, the earlier and quicker the decrease of real output.

We see, comparing (*a*) and (*b*) in figure 4, the decrease of investment to innovation results in a gentler change in real output, and means the less risk in real output. Then, we have the strategy 4.

***Strategy 4*** (The policy for investment to innovation). The basic strategies for investing to innovation are as follow:

(i) If investing to innovations for smaller emerging industries, the radical strategies, with high investment rate, should be carried out, and it is helpful to promote the survival and development of the fittest industries.

(ii) If investing to the innovations for larger traditional industries, the secure strategies, with low investment rate, should be carried out, and it is helpful to avoid the output risk.

(iii) whether the emerging or traditional industries, the optimal investment rate in expression (10) will make the real output maximum. And, the optimal investment rate decreases gradually with time.

***The investment to both assets and innovation under the policy***

According to expression (12) and appendix D, if increasing both assets and innovations in the optimal investment rate, while economic policy changes from open to closed, and the environmental pressure index changes from small to large, the maximum value of real output will change from larger to smaller. This means that, open policy is able to extend the growth range for the basic output and innovations. The discussions support the conclusion 5.

It is worth interpreting that:

(i) In ARC model (3), "basic output changes, and innovation does not change", means the basic output changes around the innovation, the innovation and

technology progress dominate in economic growth, and is called the innovation-dominated. Most emerging high-tech and service industries are innovation-dominated. Therefore, the model (3), conclusion 2, conclusion 3 and strategy 2 are more suitable to emerging high-tech and service industries.
(ii) In ARC model (4), "innovation changes, and basic output does not change", means the innovation changes around the basic output, the basic output dominates in output growth, and is called the assets-dominated. Most traditional industries or enterprises are assets-dominated. Therefore, the model (4), conclusion 4, strategy 3 and strategy 4 are more suitable to traditional industries or enterprises.
(iii) In ARC model (5), both basic output and innovation change, this means there is a balance between them. Therefore, the model (5), expression (12) and conclusion 5 are more suitable to analyze the industries or enterprises balanced in basic output and innovation.

## Applications

In general, international trade policies include the free trade policy and the protective trade policy, they are separately corresponding to open and closed policy in this paper. Applying the policy analysis models, and the conclusions and strategies, we have the following applications to the international trade policy.

### *The strategy for applying free trade policy*

The free trade is a kind of policy behavior, which claims the relaxation or exemption of restrictions on imported commodities and services, and focuses on the fair competition in international market. Free trade policy is aimed to promote the circulation of commodities and services, and advocates the co-prosperity and reciprocity among the countries and zones . But, free trade policy may cause the market monopoly in some commodities and services by developed countries, restrain the economic growth of developing countries.

The developed countries are often good in their economic base. According to conclusion 1 and conclusion 5, free trade policy is helpful to their long-term economic growth, though the real output may reduce at the initial stage of implementing the policy. The length of adaptive phase is able to be computed by appendix A.

According to conclusion 2 and conclusion 3, in order to shorten the adaptive phase, at the initial stage of implementing the free trade policy, authorities should make more investment to basic output in emerging industries, or more investment to innovation in traditional industries. As time goes on, the optimal investment rates will become smaller, and the rates can be computed separately by appendix B, appendix C or appendix D.

According to strategy 1, strategy 2 and strategy 3, the developed countries must pay attention to the following strategies.

- The free trade policy should be carried out to the large industries, in order to decrease their environmental pressure. If so, the investment to basic output will promote output growth, and keep the effect for a longer time.
- The protective trade policy should be carried out to the small and promising industries, with investment to their basic output and innovation, in order to conserve them in initial phase, and promote them to develop healthily. But, the protective policy should be ended before the critical time, and replaced by the free policy for the industries, to strengthen their own competition ability, and keep them growing for a long time.
- The investment to innovation could be audacious for small and emerging industries, in order to ensure their development and growth. And the investment to innovation, in large and traditional industries, should be cautious and advance gradually in due order, in order to avoid the output and investment risk.

In the metaphase 1980s, the strategic trade policy is proposed. Its aims are, by export subsidy and setting tariff and other strategic measures, enhancing the country and enterprise in their international competition ability, sharing the monopoly profit of foreign enterprises, and increasing market share. Therefore, the strategic trade policy is a kind of protective trade policy. According to the conclusions and discussions in this paper, the strategic trade policy is not conducive to the long-term economic development. Therefore, the developed countries are unsuitable to adopt the strategic trade policy for a long time. In general, the free trade policy is the leading one for developed countries, and the protective trade policy is the auxiliary one.

### *The strategy for applying protective trade policy*

The protective trade is a kind of policy behavior, which restricts the imported commodities and services, in order to protect domestic economy from foreign competition. In general, protective trade policy is aimed to break the foreign monopoly in commodities and services, promote the domestic economic growth and industrial development, and reduce unemployment and the trade deficit.

The developing countries, especially the poor countries, are often poor in their economic base.

According to conclusion 1 and conclusion 5, protective trade policy is helpful to promote their economic growth in initial phase. But, the growth dynamics, caused by the policy, will disappear in a limited period. The length of the benefited phase can be computed by appendix A.

According to conclusion 2 and conclusion 3, under the protective trade policy, increasing investment to industries will result in quicker output growth in a short time. While the policy becomes weaker in their function, the investment should be reduced gradually. The optimal investment rate can be computed separately by appendix B, appendix C or appendix D.

From conclusion 4, the protective trade policy is able to support some industries in developing countries for a short period. If the protective trade policy is carried out for a long time, the industries development will be restricted. According to strategy 1, strategy 2 and strategy 3, the protective trade policy should be carried out to the smaller and promising industries, and with investment to basic output or/and innovation at the same time. But, the protective policy should be ended before the critical time, and replaced by the free policy for the industries, to strengthen their own competition ability, and keep them growing for a long time. Based on strategy 4, the protected industries should be invested more, in order to promote them to grow and develop quickly. In general, the protective trade policy should be the leading one for developing countries, and the free trade policy is the auxiliary one.

**Summary**

This paper focuses on the impact of the policy on economic growth, and the investment to basic output and innovation after the policy is carried out. The works have been done as follow:

(i) Building the analytic models for economic policies under the environmental pressure. The policy will change the economic environment and its pressure. The open policy decreases the environment pressure and exogenous cost, the closed policy increases the environment pressure and exogenous cost. Based on the ideas, the analytic models for economic policies are built.

(ii) Establishing the policy analysis models taken the investment into account. The investments to basic output and/or innovation will influence the real output. The investment effectiveness, under the open policy, is different from that under the closed policy. These differences are described by the policy analysis models taken the investments into account.

(iii) Presenting the computational formulas of optimal investment rate. At the time of implementing a policy, there may be the investments to basic output, innovation or both basic output and innovation involved. Aiming at the three cases, this paper gives the methods of computing the optimal investment rate. The optimal investment rates present the basis and standards for decision-making on investment rate.

Through the works above, this paper achieves the following valuable conclusions:

(i) Based on the basic analysis policy model, we obtain conclusions as follow:

-The policies could be chosen and combined, to meet the needs of economic growth. According to the functions of policy, and current economic conditions, the open or/and closed one can be chosen or combined, to suit the needs of industries or enterprises growth and development. The approaches for choosing and combining are given in the train of thought.

- There is an adaptive phase for implementing open policy. In the phase, the open policy results in the decrease of real output, and the decrease range becomes smaller and smaller. open policy will promote economic growth after the phase. The length of the phase can be computed by the policy models.

-The closed policy will cause the real output to increase only in a shorter time, and the increase range becomes smaller and smaller, until invalidation of the policy. Hereafter, the closed policy will restrain growth, and decrease output. The length of the time, that the closed policy increases real output, can be computed by the policy models.

(ii) From the policy analysis models taken investment into account, we obtain conclusions as follow:

-Under the open policy, the investment is able to promote output growth further, and shorten the adaptive phase of the policy. The shortened adaptive phase can be computed by the policy model taken the investment into account.

- Under the closed policy, the investment is able to promote output growth in a shorter time. But, when the policy is invalidated or exceeds its critical time, the decrease of the real output will be quicker. The period of validity of investment can be computed by the policy model.

-The investment to innovation is later than that to basic output in the time of increasing real output. But, the effect of investment to innovation lasts longer than that to basic output.

It should be pointed out that, increase of money supply and fiscal expenditures, is helpful to protect the domestic industries and enterprises, and is a protective policy. On the contrary, the equilibrium or a little lack of money supply and fiscal expenditures,

is an open policy, and is helpful to survival of the fittest and fair competition among the industries and/or enterprises. These policies can be analyzed by the methods in this paper.

By the way, a global organization is important, if it is able to instruct and harmonize the economic policies of all the countries in the world, promote the logical open policies to implement all over the world, decrease the global environmental pressure, and promote the world economic growth.

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## Appendix A

The critical time of the policy and its computation.

When the growth rates of assets and innovation increase, that is $\dot{\mu}/\mu$ >0 and $\dot{q}/q$ >0, If $\mu q$>1, and the root of the equation $G(p, t)$=0 is $t=T_p$ (>0), then $t=T_p$ is the critical time, and

(i) If $p$<0, denotes $T_p^+ = T_p$. When 0<$t$<$T_p^+$, $G(p, t)$<0, and $G(p, t)$>0 when $t$>$T_p^+$.

(ii) If $p$>0, denotes $T_p^- = T_p$. When 0<$t$<$T_p^-$, $G(p, t)$>0, and $G(p, t)$<0 when $t$>$T_p^-$.

**Proof**. In expression (6), denoting $Y = (1+p)(v+wq^{\theta}) - (v+wq^{\theta_p})\mu^{p\theta}$, have

$$dY = -w\theta_p[(q\mu)^{p\theta} - 1]q^{\theta}\frac{dq}{q} - p\theta(v+wq^{\theta_p})\mu^{p\theta}\frac{d\mu}{\mu} \text{ and } \mu q>1$$

(i) When $p$<0, $(q\mu)^{p\theta} - 1$<0, that is $\dot{Y}$ >0 and $Y(t)$ is increasing. Then, $G(p, t)$<$G(p, T_p^+)$ =0 when 0<$t$<$T_p^+$, and $G(p, t)$>$G(p, T_p^+)$=0 when $t$>$T_p^+$.

(ii) When $p$>0, $(q\mu)^{p\theta} - 1$>0, that is $dY$ <0 and $Y$ is decreasing. Then, $G(p, t)$>$G(p, T_p^-)$ =0 when 0<$t$<$T_p^-$, and $G(p, t)$<$G(p, T_p^-)$=0 when $t$>$T_p^-$.

**Note**. $\sigma=\mu q$ is the endogenous dynamics. The condition $\mu q$>1 means, there is enough endogenous dynamics for economic growth. And if $\mu q$<1, means no enough endogenous dynamics. Because the growth rates of assets and innovation increase, the condition $\mu q$>1 will be satisfied after an opportune moment, and the critical times are prolonged. Therefore, the appendix A is always true.

## Appendix B

The optimal change rate of assets.

In ARC model (3), if the innovation does not change, and the optimal change rate of basic output is $p_{\mu}^* = \frac{1}{\mu}\left(\frac{a(1+hq)}{v+hwq^{\theta_p}}\right)^{\frac{1}{\theta_p-1}} - 1$, the maximum value of real output is $L_{\mu}^* = \left(1-\frac{1}{\theta_p}\right)\left(\frac{[a(1+hq)]^{\theta_p}}{v+hwq^{\theta_p}}\right)^{\frac{1}{\theta_p-1}}$.

**Proof**. In expression (7) and model (3), let $\frac{\partial G_{\mu}}{\partial p_{\mu}} = \frac{\partial L_{\mu}}{\partial p_{\mu}} = \mu[a(1+hq) - (v+hwq^{\theta_p})\mu_p^{\theta_p-1}] = 0$, obtain $p_{\mu}^* = \frac{1}{\mu}\left(\frac{a(1+hq)}{v+hwq^{\theta_p}}\right)^{\frac{1}{\theta_p-1}} - 1$. Because of $\frac{\partial^2 L_p}{\partial(p_{\mu})^2} = -\mu^2(v+hwq^{\theta_p})(\theta_p-1)\mu_p^{\theta_p-2}$<0, $p_{\mu}^*$ makes expression (7) and real output (3) maximum, puts $p_{\mu}^*$ into the real output (3), the maximum value is obtained.

## Appendix C

The optimal change rate of innovations.

In ARC model (4), if the basic output do not change, the optimal change rate of innovation is $p_q^* = \frac{1}{\mu \cdot q}\left(\frac{a}{w}\right)^{\frac{1}{\theta_p - 1}} - 1$, and the maximum value of real output is

$$L_q^* = a\left[\mu + h\left(1 - \frac{1}{\theta_p}\right)\left(\frac{a}{w}\right)^{\frac{1}{\theta_p - 1}}\right] - \frac{v\mu^{\theta_p}}{\theta_p}.$$

**Proof**. From expression (9) and model (4), have $\frac{\partial G_q}{\partial p_q} = \frac{\partial L_q}{\partial p_q} = h\mu \cdot q[a - w(\mu \cdot q_p)^{\theta_p - 1}]$, let $\frac{\partial G_q}{\partial p_q}$ =0, obtain $p_q^* = \frac{1}{\mu \cdot q}\left(\frac{a}{w}\right)^{\frac{1}{\theta_p - 1}} - 1$. Because $\frac{\partial^2 L_q}{\partial (p_q)^2} = -hw(\theta_p - 1)(\mu \cdot q)^2 (\mu \cdot q_p)^{\theta_p - 2}$ <0, $p_q^*$ makes expression (9) and real output (4) maximum, puts $p_q^*$ into the real output (8), the maximum value is obtained.

## Appendix D

The optimal change rates of assets and innovations.

From the ARC model (5) and expression (11), let $dG_z = dL_z = 0$, that is,

$$[a(1 + hq_p) - (v + hwq_p^{\theta_p})\mu_p^{\theta_p - 1}]d\mu_p + h\mu_p[a - w(\mu_p q_p)^{\theta_p - 1}]dq_p = 0$$

have

$$\begin{cases} a(1 + hq_p) - [v\mu_p^{\theta_p - 1} + hwq_p(q_p\mu_p)^{\theta_p - 1}] = 0 \\ a - w(\mu_p q_p)^{\theta_p - 1} = 0 \end{cases}$$

Then the optimal change rates are

$$\begin{cases} p_\mu^* = \frac{1}{\mu}\left(\frac{a}{v}\right)^{\frac{1}{\theta_p - 1}} - 1 \\ p_q^* = \frac{1}{q}\left(\frac{v}{w}\right)^{\frac{1}{\theta_p - 1}} - 1 \end{cases}$$

Putting the above $p_\mu^*$ and $p_q^*$ into the ARC model (5), the maximum value of real output is obtained as $L_z^* = a\left(\frac{a}{v}\right)^{\frac{1}{\theta_p - 1}}\left(1 - \frac{1}{\theta_p}\right)\left[1 + h\left(\frac{v}{w}\right)^{\frac{1}{\theta_p - 1}}\right]$.