Research Article

Innovation or Imitation: Empirical Test Based on EPS Global Statistics

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Received 31 May 2022; Accepted 21 July 2022; Published 12 August 2022

Academic Editor: Chun Wei

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Technological progress is an important embodiment of innovation-driven, but also the main determinant of sustained economic development. Technological advances lie in the introduction of technology, learning, imitation, and independent research and development. The introduction of technology to developing countries can accelerate technological progress, reduce the technology gap, and promote sustained and rapid economic development. If the technology gap between developed and developing countries is, in fact, gradually shrinking, then the continual introduction and imitation of new technology can easily lead to "path dependence" and technical bottlenecks in developed countries. This trend may also be unfavorable for the protection of intellectual property rights.

From empirical research and practical observation analysis, only internal technological progress is the only source of long-term economic growth. This has been verified and analyzed by different models constructed by economists. For example, Tang Yong and Fan Xin conducted a quantitative analysis of the influence mechanism and effect of technological progress on economic growth based on specific empirical data. The results showed that every 1% increase in technological progress would increase the economic growth...
rate by 0.347%. The effect of technological progress on economic growth is significantly greater than that of the constant capital, variable capital, and surplus value ratio on economic growth. Ma Wewei remeasured the degree of contribution of China’s technological progress to economic growth by constructing a structural equation model. The calculation results show that in the past two decades, the contribution rate of technological progress to China’s economic growth has generally shown a trend of “fluctuating upward,” and the supply capacity of technology has been continuously improved. It is an important driving force for China’s long-term and stable economic development in the new historical period. Li [1] explored the impact of technological innovation on regional economic development using the geographical weighted regression model (GWR). The results show that the development of technological innovation has a significant positive impact on the regional economy. Local governments need to formulate local innovation development strategies and policies, improve patent quality and transformation paths, increase investment in innovation research and development, and improve the intensity of economic openness. Liu et al. [2] believe that among the specific ways of technological innovation, independent innovation is the main way to promote the improvement of the performance of green growth in China. Technology import from foreign capital and import trade channels can also promote green growth performance, but it is difficult for technology import from technology trade channels to promote green growth performance. Companies must be guided to strengthen independent innovation and the external introduction of green technology, and to fully participate in the positive effect of technological innovation on green growth performance.

Zhang et al. [3] believe that according to different sources of technology, technological innovation is mainly divided into independent innovation and introduction of technology. On the basis of the ABBGH (2005) model, the author constructs a local equilibrium model to reveal that foreign technology import has a lagging promoting effect on the independent innovation activities of local enterprises, and the promoting effect only occurs in the enterprises with relatively lagging innovation ability and some LL industries. Meng and Zhang [4] constructed an econometric model based on the characteristics of sample data and theoretical logic and analyzed that natural resource endowment has a crowding effect on innovation, which is the mode of technological progress, and has an enhancement effect on technology introduction. Innovation is conducive to regional green growth efficiency, while the introduction of technology is not conducive to improving regional green growth efficiency. Yang [5] believes that the two main ways of technological innovation to promote economic growth are the introduction of technology and independent research and development. If only technological imitation could be achieved without independent research and development innovation, the technological gap cannot be narrowed. Based on threshold model analysis and comparison, China’s economic growth from 2001 to 2015 is mainly due to technology import, when there is insufficient protection of intellectual property, technology innovation in the field of market failure is serious, even if the short-term promoting effect on economic growth is relatively obvious, but due to the lack of independent innovation for a long time, it will be conducive to economic growth.

Tracy Collins analyzed the dynamic relationship between innovation and imitation at the microlevel using factory-level data in Mexico. The empirical results show that innovation and imitation complement each other in the context of developing countries. Xia [7] and Liu XH analyzed longitudinal firm-level data in the UK and found that imitation plays a mediating role between foreign competition and innovation performance of local firms, and there is an inverted U-shaped relationship between imitation and innovation performance of local firms. The absorptive capacity moderates the mediating effect of imitation and reduces the return on innovation at the moderate imitation level. Lina and Yu [6] use a spatial econometric model to empirically analyze the impact of different modest technological innovation on regional economic development. The empirical results show that there is a significant spatial correlation between technological innovation and regional economic development. In addition, the introduction of technology, imitation innovation, and independent innovation have positive effects on regional economic development, and independent innovation is the most significant. With the upgrade of the industrial structure, the effect of the introduction of technology and imitation innovation on the growth of economic development slowly slows down. Lin et al. [7] analyzed the point of change of the ICT capital structure and its influence mechanism to promote high-quality economic development using intermediary effect and dynamic threshold effect models. The key to balancing high-quality economic development and steady growth lies in optimizing the path of technological progress, especially by imitation innovation to independent innovation transformation. Liang and Yu [6] explain the selection of the path of high-quality industrial development of a country or region from the perspective of an original innovation value network. The analysis shows that the input-output quantitative research shows that there is a significant gap in the input-output ratio of industries driven by different innovation modes, and the input-output efficiency of industrial innovation driven by original innovation is obviously better than that of other industries based on imitative innovation development.

In fact, imitation also has a cost. According to the theory of technology direction of Acemoglu and Zilibotti [8], technological imitation of developed countries by developing countries will damage the comparative advantage of developing countries. A large number of imitation behaviors will make the overall profit space smaller and smaller. In this view, the more imitations there are, the higher the cost of imitation. Therefore, no matter whether from the model of intellectual property protection or technology direction model analysis, it shows that a country or region will not have complete R & D, nor will there be complete imitation. Even developed countries with strong intellectual property rights protection mainly focus on hard technologies related
to new products, quality, and testing, and lack protection for soft technologies such as new production processes and advanced business models. Under the global economic model, developing countries can adopt the corresponding technology strategies according to the actual situation.

We know that knowledge externalities lead to free-riding imitation. If enterprises take the output-input ratio as the optimization objective function, individual companies will reduce the R & D investment internally. And if every company adopts an imitation strategy, market competition will prompt them to improve product quality. Therefore, there is a stable inner point Nash equilibrium between the R & D strategy and the imitation strategy. The existence of this equilibrium is important to explain the steady growth path of many developing countries. Research in this article starts from a broad technical perspective, where research and development not only includes the improvement of new products and quality, but also includes the experiment and adoption of soft technologies such as new processes and new business models. Therefore, the model does not consider the influence of intellectual property protection, but obtains the overall dynamics and replicator dynamics of R & D and imitation through optimizing the investment path of enterprises under a closed economic framework, and studies the equilibrium path through the change of the number of R & D and imitators. In view of the above analysis, we selected data from 54 countries during the time period 1976 to 2013 as our sample. Using empirical research methods and based on the results, we conclude that only when the returns to scale of the R & D group that determines the technological frontier are increasing, there is an evolutionary balance between R & D and imitation, and on this basis, the answer and explanation to practical problems are given.

2. Model Construction

2.1. Model Framework. We begin by assuming the enterprise has a production function in the form of $c$-$d$ as shown in (1). Investment has two directions: fixed capital and production technology (in the broad sense of technology). Where $k_2$ is fixed-capital investment, $a$ and $t$ are output elasticity of both.

$$q = A k_2^a. \tag{1}$$

Here, $A$ is the technical level. There are two ways in this model for an enterprise to acquire the necessary technology for production. One is to invest in R & D, and the other is to invest in imitation. R & D is described here by $\lambda(k_1)$, where $k_1$ is the amount of money invested in R & D and $k_1 + k_2 = k$ is the total amount of capital invested by the enterprise.

It should be noted that human capital is not included in the technology production function used in this article; instead, the influence of human capital on technology production is included in the elasticity of output. $A_0 = f(x)$ is the external environment of R & D and is a function of the number of companies adopting R & D strategy $x$. According to the relationship between the technology of a single enterprise and the overall technology of society in

Romer [9], here $f' > 0$ and $f'' < 0$. The technology when the company adopts the imitation strategy is $A_{im} = (k_1 - c)^\gamma$. According to Aghion et al. [10], $c = \phi(y) > 0$ is the function of $y$, where $c$ is the difficulty of imitation and $y$ represents the number of companies adopting the imitation strategy. The more enterprises are imitated, the lower the overall technical level of the society, and the higher the cost of imitation. Therefore, $\phi' > 0, \phi'' > 0, y$ is the elastic coefficient.

It is assumed in this model that enterprises face perfect competition in both the product and the labor markets. The profits of enterprises in R & D ($\pi_{re}$) and imitation ($\pi_{im}$) can be expressed as follows:

$$\pi_{re} = pf(x)k_1^a - r(k_1 + k_2), \tag{2}$$

$$\pi_{im} = p(k_1 - \phi(y))k_2^a - r(k_1 + k_2), \tag{3}$$

where $p$ is price of the product, $r$ is the interest rate, and all coefficients of elasticity are exogenous variables, while $k$ is investment, $x$ is the number of R & D companies, and $y$ is the number of imitation companies in the time series.

First, enterprises have to face the problem of capital allocation in two directions at each time point. Instantaneous capital allocation can be given as a static optimization process.

$$r/a = k_1/k_2$$

can be obtained from the first-order condition of static optimization in formula (2). The profit function is expressed as

$$\pi_{re} = pf(x)τ^a\left(\frac{k}{\alpha + τ}\right)^{ατ} - rk. \tag{4}$$

When adopting the imitation strategy, $k_1 = γ/α + γk + α/\alpha + γ\phi(y)$, $k_2 = α/α + γ(k - \phi(y))$ can be obtained from the first-order condition of (3). Then, the profit function of imitation is expressed as

$$\pi_{im} = p\left(\frac{γ}{α + γ}\right)^\gamma\left(\frac{α}{α + γ}\right)^{α}(k - \phi(y))^{αγ-1} - rk. \tag{5}$$

As both enterprises that adopt R & D and those that adopt imitation are faced with perfectly competitive product and labor markets, the following formula can be established if formula (4) and formula (5) are used to represent the market clearing conditions:

$$f(x) = \left(\frac{γ/α + γ k - \phi(y)}{(τ/α + τ)\gamma}\right)^{\gamma}. \tag{6}$$

In the formula, all the coefficients and the investment $k$ are greater than zero, so when the market clearing condition is met, there is a reverse relationship between $f, \phi$. At the same time, as $f, \phi$ is a monotonous increasing function and the assumption is surjective, a reverse relationship also exists between the number of R & D companies $x$ and the number of imitation companies $y$, regardless of the assumption that there are only two strategies of R & D and imitation, and regardless of the assumption that the total number of companies is fixed.
2.2. Conditions of Evolutionary Stability and Rate of Technological Progress. As investment \( k \) is a function of time, the long-term return of an enterprise is a functional with \( k \) as the argument, expressed as

\[
U = \int_{t_0}^{t_1} \pi(k) \, dt.
\]

(7)

The changes are divided into

\[
\delta U = \int_{t_0}^{t_1} \pi(k + \delta k) \, dt - \int_{t_0}^{t_1} \pi(k) \, dt = \int_{t_0}^{t_1} \partial \pi \delta k \, dt.
\]

(8)

The optimal investment path requirement \( \delta U = 0 \), and because the change of investment is not zero, the condition \( \partial \pi / \partial k = 0 \) applies. The relationship between this condition and (4) and (5) can be obtained on the optimal investment path \( f, \phi, \) and \( k \):

\[
f(x) = \frac{r}{\rho^x} a^{(1/\alpha + \tau) a^x} (a + \tau)^{a^{x+1}},
\]

(9)

\[
\phi(y) = k - \eta,
\]

(10)

where \( \Phi > 0, \eta > 0 \) is the new parameter. The derivatives of time from both sides of (11) and (12) are

\[
\dot{x} = \frac{(1 - \alpha - \tau) \Phi \dot{k}}{k^{a+\tau} f(x)},
\]

(13)

\[
\dot{y} = \frac{k}{\phi^y y}.
\]

(14)

As both \( f \) and \( \phi \) have a second derivative, let \( 1/f(x) \) be expandable, taking one term \( \omega x \); then, \( \omega > 0 \). The corresponding \( 1/\phi^y \) expanded item \( \theta y \) is \( \theta < 0 \). The linear expansion of (13) and (14) is

\[
\dot{x} = \frac{(1 - \alpha - \tau) \Phi \dot{k}}{k^{a+\tau} f(x)} \omega x,
\]

(15)

\[
\dot{y} = \dot{k} \theta y.
\]

(16)

Equations (15) and (16) represent the overall dynamics of R & D and imitation. In the system after the two-in-one, if the increment of investment of the two types of enterprises is not less than zero, then \( \alpha + \tau > 1 \), at any point. There are also stable singularities in the system. When \( \alpha + \tau < 1 \), the system has a saddle point path.

At the same time, due to the evolution of \( u(re, \ast) = \dot{x}, \)
\( u(im, \ast) = \dot{y}, \) the replicon dynamics of the two strategies of R & D and imitation become

\[
p_x = (\dot{x} - p_x x - p_y y) p_x,
\]

(17)

\[
p_y = (\dot{y} - p_x x - p_y y) p_y.
\]

(18)

In these formulas, \( p_x \) is the proportion of R & D enterprises and \( p_y \) is the proportion of imitation enterprises. In this system, when \( x = y \), there is a balance point in the system; the proportional relationship is \( p_x = c_1 p_y \) and \( c_1 \) is an arbitrary constant, which is determined by the initial conditions of capital endowment. The equilibrium condition can also be expressed as

\[
\frac{(1 - \alpha - \tau) \Phi}{k^{a+\tau} f(x)} = \frac{1}{\phi(y)}
\]

(19)

The comparative static derivative of \( x \) to \( y \) in this condition is

\[
\frac{\partial x}{\partial y} = \frac{k^{a+\tau} f(x)}{1 - \alpha - \tau} \phi(y)
\]

(20)

As \( f'' < 0, \phi'' > 0 \), the increase in imitation companies will lead to a reduction in R & D companies.

In terms of technological advancement, as the technological frontier is determined by the R & D enterprise, that is, \( A = f(x) k^{\frac{1}{2}} \), on the balanced path:

\[
A = \Phi \left( \frac{\tau}{\alpha + \tau} \right) k^{\frac{1}{1 - \alpha}}
\]

(21)

where \( k \) is the investment of R & D enterprises. After taking the time derivative on both sides,

\[
\dot{A} = \Phi \left( \frac{\tau}{\alpha + \tau} \right)^\tau \left( \frac{1 - \alpha}{k} \right)
\]

(22)

If the total endowment of social capital is set to 1, then \( k \) is expressed as the proportion of R & D capital to total capital. At the same time, the stability condition and (17) can be obtained as \( p_x = e^x/c_2 + c_1 e^x \) where \( c_2 \) is constant (as with \( c_1 \), determined by the initial capital endowment). Then, the technological progress rate on the equilibrium path can be solved as follows:

\[
\dot{A} = \Phi \left( \frac{\tau}{\alpha + \tau} \right)^\tau \left( \frac{1 - \alpha}{(e^x/c_2 + c_1 e^x)^\alpha} \right) k.
\]

(23)

When the output elasticity of fixed-capital enterprises’ fixed capital is less than 1, the social technology progress rate is positive and proportional to the capital growth rate. The greater the investment rate, the faster the technological progress.

3. Empirical Test

The main proposition of this article is that due to the externality of knowledge and the cost of imitation, society will not have the R & D of the whole people and there will be no imitation of the whole people. When there is an increase in the scale of returns for the R & D group, there is stability between R & D and imitation, evolutionary balance. This proposition is now tested by the following process.
3.1. Indicators. First, for the criterion of evolutionary stability, (23) can be assumed to be constant at the time of stability. This ratio actually represents the size of the technological increment caused by capital increments or the elasticity of capital to technology. Index building is
\[ \varepsilon_i = \frac{A_{t+i}/A_i}{(K_{t+1}/K)} \]  
(24)

where \( A \) is the number of patent applications in a certain country in a certain year, and the corresponding \( K \) is the total amount of fixed-capital formation. As this indicator reflects the elasticity of capital to technology, it is important to measure a country’s economic development potential if it is tested to be stable in large samples.

At the same time, to compare the stability of each sample, this article uses the average of the significance level of the Q test of the ACF (\( \varepsilon \)) function. The formula is \( p_\varepsilon = (p_1 + p_2 + \cdots + p_\nu)/6 \), where \( p_\varepsilon \) is the \( p \)-value of a sample Q test, and \( i = 1, 2, 3, 4, 5, 6 \), which represents the order of the lag. As the null hypothesis of the Q test is \( p_1 = p_2 = \cdots = p_\nu = 0 \), it can be understood that the larger the \( p_\varepsilon \) value, the better the stability of the sequence.

For the scale remuneration of the developer group, this article uses the product of the scale remuneration \( S \) of a country as a whole and the total value of the listed company as a percentage of gross domestic product (GDP) \( P \). After the scale remuneration is expressed as a \((0, 1)\) variable, the product MSP actually represents the contribution of the listing formula to the increase in scale returns; because the developer group is concentrated in large companies, especially the listing formula, this indicator can be used to approximate the developer group. In the calculation of the scale return \( S \), this article uses the following DEA model:
\[
\begin{align*}
\min \{ \theta - \epsilon (\bar{e}^T s^l + e^T s^r) \} \\
\sum_{j=1}^{n} x_j \lambda_j + \bar{s}^l = \theta x_0, \\
\sum_{j=1}^{n} y_j \lambda_j - s^r = y_0, \\
\lambda_j \geq 0, j = 1, 2, \ldots, n, s^l \geq 0, s^r \geq 0
\end{align*}
\]  
(25)

where \( x \) is the input variable. This article selects the total capital formation and the total population (the reason why the total population is selected is because of the large amount of child labor in most Third World countries). The output variable is only GDP. In the optimal solution of the plan, we use \( \sum \lambda_j > 1, < 1 = 1 \) to judge whether the return to scale is increasing, decreasing, or neither. In order to measure the impact of other factors on stability, this article also adds a public education expenditure variable, PEE.

3.2. Data and Inspection. The data in this article is derived from the EPS data platform, which selects data from 1976 to 2013 in 54 countries around the world as samples. There are 37 observations for each sample and 38 periods for DEA calculations. The results of the ACF function test and the DEA calculation for each \( i \) indicates the country) are shown in Table 1.

As \( p_\varepsilon \) is a probability value, the sequence \( \varepsilon \) is stable at the 5% significance level only at \( p_\varepsilon > 0.05 \). Most of the countries

<table>
<thead>
<tr>
<th>Country</th>
<th>( \varepsilon_\text{value} )</th>
<th>Remuneration</th>
<th>( P ) geometric mean</th>
<th>( \varepsilon_\text{value} )</th>
<th>Remuneration</th>
<th>( P ) geometric mean</th>
<th>( \varepsilon_\text{value} )</th>
<th>Remuneration</th>
<th>( P ) geometric mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>0.4567</td>
<td>drs</td>
<td>0.824</td>
<td>UK</td>
<td>0.1000</td>
<td>—</td>
<td>1.163</td>
<td>USA</td>
<td>0.6483</td>
</tr>
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<td>Japan</td>
<td>0.9388</td>
<td>drs</td>
<td>0.764</td>
<td>Greece</td>
<td>0.0470</td>
<td>—</td>
<td>0.259</td>
<td>Israel</td>
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<tr>
<td>Korea</td>
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<td>drs</td>
<td>0.473</td>
<td>Ireland</td>
<td>0.0303</td>
<td>—</td>
<td>0.490</td>
<td>Malta</td>
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<tr>
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<td>0.8078</td>
<td>irs</td>
<td>0.391</td>
<td>Iceland</td>
<td>0.6663</td>
<td>—</td>
<td>0.375</td>
<td>Algeria</td>
<td>0.8278</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.8752</td>
<td>irs</td>
<td>2.809</td>
<td>Luxembourg</td>
<td>0.1428</td>
<td>—</td>
<td>1.437</td>
<td>Iran</td>
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</tr>
<tr>
<td>Singapore</td>
<td>0.7488</td>
<td>drs</td>
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<td>Netherlands</td>
<td>0.0035</td>
<td>—</td>
<td>0.770</td>
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<td>drs</td>
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<td>Norway</td>
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<td>—</td>
<td>0.363</td>
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<tr>
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<td>—</td>
<td>0.103</td>
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<td>—</td>
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<td>0.166</td>
<td>Bulgaria</td>
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<td>Germany</td>
<td>0.0348</td>
<td>drs</td>
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<td>Turkey</td>
<td>0.0150</td>
<td>—</td>
<td>0.185</td>
<td>Mexico</td>
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<tr>
<td>Denmark</td>
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<td>—</td>
<td>0.467</td>
<td>India</td>
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<td>—</td>
<td>0.359</td>
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<td>Sri Lanka</td>
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<td>Bengal</td>
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<td>0.036</td>
<td>Kenya</td>
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<td>drs</td>
<td>0.534</td>
<td>Canada</td>
<td>0.0517</td>
<td>—</td>
<td>0.821</td>
<td>Tanzania</td>
<td>0.0238</td>
</tr>
</tbody>
</table>

Source of data: EPS data platform. *The EPS data platform integrates various data resources on a large scale, forming a global database of global economy, macroeconomics, trade, economic development, regional development, industrial operation, and enterprise data. It contains 50 databases and has more than 250,000 statistical indicators. The time series, the total amount of data reached 4 billion. The EPS database has become the source of research data for core journals such as China Industrial Economy, Industrial Economics Research, Macroeconomic Research, World Economy, and Management World.
in the table are stable in ε; only a few underlined countries are not stable. Most of these unstable countries are European, and the unstable sequence ε may be related to the free flow of elements between EU member states.

For the column of scale return, drs indicates that the scale returns are decremented, and its indicates that the scale returns are increasing, which means that the scale returns are unchanged.

To test the impact of the scale of the R & D group on stability, the results of the linear regression of the explanatory variables are shown in Table 2.

Table 2 shows the results estimated by the OLS method, where S is a dummy variable. When a country’s return to scale increases, the value is 1 and the other value is 0. The t-test value is in parentheses. In regression 1 and regression 2, neither S nor PP was significant. Only in the regression 3, the interaction terms of the two were significant. This result confirms the objectivity of the theoretical model in this article. There is an evolutionary balance between R & D and imitation when the scale of returns for R & D-type groups that determine the frontiers of technology increases.

**4. Conclusion**

This article finds that due to the existence of imitation cost, there is a stable internal point Nash equilibrium between R & D strategy and model strategy. The ratio between the two depends on the scale of remuneration of R & D enterprises. Social technological progress depends on the proportional relationship between the output elasticity of input and development and the output elasticity of production. As the rate of technological progress is directly proportional to the rate of capital growth, more and more investment is needed to develop new technologies, making the scale of returns for R & D-type companies more apparent, and society will continue to make technological advances. The protection of intellectual property rights increases the cost of imitation, while ensuring the scale of the R & D-type enterprises, so that the number of R & D enterprises can gradually increase. For developing countries with fully competitive product markets and labor markets, due to the balance between R & D and imitation, if there is no inflow of products and technologies, then capital inflows will inherently drive local R & D activities.

The main conclusions of this article can explain economic problems based on endogenous growth. First, we answer the question of stable growth. Why, for example, does a country’s GDP growth rate remain constant for a long period of time? According to the classical theory, this is determined by the base of a country’s total economic volume. The model of this article shows that this is determined by technological growth through stable R & D and imitation activities. Due to the balance between R & D and imitation, the rate of technological progress and capital growth increased in proportion to each other. Second, we address a question about the middle-income trap: Why can some countries enter the high-income stage across the middle-income trap, while others cannot? The equilibrium path and saddle point path of this article can explain this phenomenon. Although the human capital variable is not included in this study, the elastic coefficient determined and influenced by it is the main indicator to determine the equilibrium path and the saddle point path. Additionally, the index constructed in this document is of practical importance for evaluating the growth potential of a country [11].

**Data Availability**

The data used to support the findings of this study have been deposited in the EPS Global statistical database.

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

**References**


