Proceedings of Business and Economic Studies, 2026, Volume 9, Issue 6
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Research on the Dynamic Relationship among National Gross Income, Government Consumption, and Fixed Asset Investment Based on the VECM Model

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Abstract: To explore the intrinsic dynamic interconnections among China's economy, consumption, and investment, this study focuses on the relationships between national income, government consumption, and fixed assets investment. Utilizing the VECM model, it conducts an in-depth analysis of their dynamic linkages. Data on gross national income (GNI), government consumption (ZC), and total fixed assets investment (TINF) from 1990 to 2023 were selected. ADF tests identified the non-stationarity of the original series, which was transformed into a stationary state through first-order differencing. Johansen cointegration tests precisely pinpointed a unique cointegration relationship at the 5% significance level. After determining the optimal lag order according to the AIC criterion, the VECM model was successfully constructed, and a cointegration equation was derived. The results indicate that in the long run, national income is positively correlated with government consumption but negatively correlated with total fixed assets investment. When considering strategies to boost GNI, while government consumption holds potential for positive traction, expenditure decisions must carefully weigh multiple derived effects. Given the negative coefficient warning for fixed assets investment, decision-making should be approached with utmost caution, prioritizing the optimization of investment structure and efficiency. Additionally, close coordination with key variables such as inflation and employment is essential. Centered on the cointegration relationship as the foundational cornerstone, meticulous formulation of sound economic policies is crucial to effectively promote steady economic growth and maintain dynamic equilibrium.

Keywords: Dynamic association; VECM; Economic growth

Online publication: July 15, 2026

1. Introduction

During the process of economic development, the characteristic of phased evolution is manifested by the differentiated attributes of endowments within each development cycle and their inherent economic

transmission mechanisms. Economic growth, consumption, and capital formation, as the core endogenous variables of the economic system, jointly construct the structural framework of national economic development through dynamic coupling relationships. In the initial stage of economic development (before the Rostow take-off stage), the growth of economic volume shows a fluctuating characteristic, and its standard deviation coefficient is usually higher than that in the mature stage. As the industrialization process progresses, the efficiency of factor allocation significantly accelerates the growth rate of economic output (the optimization of the capital-output ratio in the Harrod-Domar model), making it a core quantitative indicator for measuring the level of regional economic development. Consumer spending, as the core component of terminal demand, not only reflects the level of people's livelihood through the marginal propensity to consume (MPC), but also forms the endogenous driving force for economic growth through the demand-induced effect (the Keynesian multiplier effect). Capital formation has a significant supply-side structural function, promoting industrial upgrading by adjusting the allocation of production factors (the Leontief input-output model), and constituting the supporting mechanism for the transformation of economic growth momentum.

During the transmission process, these three factors are regulated by multiple exogenous variables such as the intensity of policy intervention (IS-LM framework), market disequilibrium (Walrasian equilibrium deviation), and technological shocks (Solow residuals), which may form a collaborative development mechanism (positive feedback loop) or generate a system-damping effect (economic cycle fluctuations). This nonlinear interaction requires researchers to establish a statistical model (VECM) that includes an error correction mechanism to accurately capture the differences in transmission paths at different development stages. In-depth research on the roles of these factors in each stage of economic development and their interrelationships is of great significance for accurately grasping economic operation laws and formulating scientific and reasonable economic policies.

The Great Depression in the 1930s led economists to start in-depth thinking about issues such as the driving force of economic growth, the role of consumption and investment in the economy. In 1936, Keynes published *The General Theory of Employment, Interest, and Money*, systematically elaborating on the theoretical relationship between consumption, investment, and national income (an important manifestation of economic growth) [1]. He proposed that total demand determines the level of national income, and consumption and investment are important components of total demand. Subsequently, many economists, based on Keynes' theory, began empirical research, such as estimating the consumption function and conducting quantitative analysis of the impact of investment on economic growth. These early studies laid the foundation for the research on the relationship between consumption, investment, and economic growth in modern macroeconomics. With the development of econometrics, starting from the 1950s, empirical research on the relationship between economic growth, government consumption, and investment became more in-depth and diverse. New classical growth models (in the 1950s–60s) and endogenous growth models (starting from the late 1980s) all conducted in-depth discussions on the sources of economic growth, where consumption and investment play important roles in different theoretical frameworks, and corresponding empirical studies have emerged continuously.

Early domestic scholars such as Song and Fang [2] in 2010 used methods such as least squares, unit root test, and cointegration test to conduct empirical tests on the relationship between consumption, investment, and economic growth in China since the reform and opening up, and concluded that there is a long-term stable positive correlation among the three, and at that time, investment was the main factor driving China's

economic growth. Lv [3] in 2012, based on the consumption characteristics of rural residents in China and the current economic growth situation, analyzed the GDP elasticity, contribution rate, and driving rate of rural residents' consumption demand, and used the stepwise regression method. It was found that there is a mutually reinforcing relationship between the growth of rural residents' consumption and economic growth. However, the insufficient consumption of rural residents and the slow upgrading of consumption structure have restricted China's economic growth. At the same time, the improvement of their consumption demand will be an important force to drive economic growth in the future. Song and Li [4] conducted an empirical study on the relationship between China's outward direct investment and economic growth in 2008. They found that although there was no obvious causal relationship between the two, they had a cointegration relationship, meaning there was a common growth trend and a long-term stable equilibrium relationship. Kou [5] in 2020, based on the VAR model, by establishing a cointegration equation, using Granger causality test, impulse response, and variance decomposition models, found that consumption had the greatest impact on economic growth, investment also had a strong driving force for economic growth, and the relationship between imports and exports and GDP was relatively weak. Hu [6] proposed the regulatory mechanism of consumer finance on economic growth. Wang and Ma [7] believed that demand-side policies such as resident consumption subsidies have a relatively limited long-term role in continuously promoting economic growth, but have a prominent role in promoting fixed asset investment and stabilizing economic growth in the short term. This effect will be further highlighted when the capital-output elasticity decreases. Xia and Zhang [8] stated that consumption is the ultimate goal and driving force of production, investment is the tool and means to realize consumer demand, and consumption and investment are the dual wheels driving domestic demand. Moderate growth of investment and optimization of investment structure can promote the expansion of consumption scale and the growth of consumption rate, and changes such as the improvement and expansion of consumption quality and new consumption demands will affect the scale and structure of investment.

Researchers from abroad have conducted extensive studies on the relationship between economic growth, consumption, and investment, and have established a solid theoretical foundation. For instance, Keynes [1] proposed the absolute income theory in 1936, which emphasized that consumption is a function of income. An increase in income leads to an increase in consumption, thereby influencing economic growth. Subsequently, theories such as the relative income theory by Dusenbery [9] and the life-cycle theory by Modigliani and Blenberger [10] have all elaborated on the impact of income on residents' consumption from different perspectives, indirectly reflecting the relationship between consumption and economic growth. In terms of empirical research, many foreign scholars have employed various econometric methods and models to analyze data from different countries and regions, and have drawn a series of valuable conclusions. For example, some studies have found that investment has a significant stimulating effect on economic growth in the short term, but in the long run, the fundamental role of consumption is more important; other studies have shown that there is a mutual substitution or mutual promotion relationship between residents' consumption and investment, which depends on different economic environments and policy factors, etc.

It can be seen that the research on the relationship between economic growth, consumption, and investment at home and abroad is becoming increasingly mature. The research methods and empirical data are very rich, but no direct literature has been found that uses the VECM model to study the relationship among economic growth, government consumption, and investment. This paper takes China as an example and uses the VECM model to study the transmission mechanism of fluctuations in a closed economy, attempting to investigate the

interrelationship among economic growth, government consumption, and investment. To facilitate statistical analysis, the variables of economic growth, government consumption, and total social fixed asset investment are simplified for representation. Using the data from China from 1986 to 2023 as the sample data, an attempt is made to determine whether there is a cointegration relationship and to establish the VECM model.

2. VECM model

In this pioneering paper, Sims [11] simultaneously proposed the analysis method of the vector autoregression model (VAR), advocating using VAR instead of the then-popular SEM model for macroeconomic analysis. The VAR model is established based on the statistical properties of the data. The VAR model constructs the model by treating each endogenous variable in the system as the lagged value of all endogenous variables in the system, thereby extending the univariate autoregressive model to the "vector" autoregressive model composed of multiple time series variables.

Engle and Granger combined cointegration with error correction models and established the micro-error correction model [12]. As long as there is a cointegration relationship between variables, the error correction model (ECM) can be derived from the autoregressive distributed lag model. In the VAR model, each equation is an autoregressive distributed lag model, so it can be considered that the VEC model is a VAR model with cointegration constraints. Because the VEC model has a cointegration relationship, when there is a large-scale short-term dynamic fluctuation, the VEC expression will restrict the long-term behavior of endogenous variables to converge to their cointegration relationship.

Let $y_t = (y_{1t}, y_{2t}, \ldots, y_{kt})'$ be a k-dimensional random time series, where $t = 1, 2, \ldots, T$, and $y_t \sim I(1)$, that is, each $y_{it} \sim I(1), i = 1, 2, \ldots, k$. It is influenced by the d-dimensional exogenous time series $x_t = (x_{1t}, x_{2t}, \ldots, x_{dt})'$ and a VAR model can be established:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + Bx_t + \mu_t, t = 1, 2, \ldots, T \tag{1}$$

If y_t is not affected by the d-dimensional exogenous time series $x_t = (x_{1t}, x_{2t}, \ldots, x_{dt})'$ then the VAR model in formula (1) can be transformed into:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \mu_t, t = 1, 2, \ldots, T \tag{2}$$

Performing the cointegration transformation on formula (2), it can be written as:

$$\triangle y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \triangle y_{t-i} + \mu_t \tag{3}$$

Among：

$$\prod = \sum_{i=1}^{p} A_i - I, \Gamma_i = -\sum_{j=i+1}^{p} A_j \tag{4}$$

If there is a cointegration relationship among y_t, then (3) will have $\prod y_{t-1} \sim I(0)$. At this point, (3) can be written as:

$$\triangle y_t = \alpha \beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \triangle y_{t-i} + \mu_t \tag{5}$$

Among them, $\beta' y_{t-1} = ecm_{t-1}$ represents the error correction term, which reflects the long-term equilibrium relationship between the variables. That is, the above equation can be written as:

$$\triangle y_t = \alpha ecm_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \triangle y_{t-i} + \mu_t \quad (6)$$

Equation (6) represents the Vector Error Correction Model (VECM), where each equation constitutes an error correction model.

3. Analysis of the dynamic relationship between national gross income, government consumption, and fixed asset investment

3.1. Basis for indicator selection

National Gross Income is a comprehensive macroeconomic indicator that encompasses the total income received by the residents of a country or region within a certain period (typically one year), including the value of domestic production creation and the net amount of factor income from abroad (such as the income earned by domestic residents working abroad minus the income earned by foreign residents working in the country, etc.). Compared to indicators like Gross Domestic Product (GDP), this indicator provides a more comprehensive reflection of the economic gains obtained by the residents of a country participating in global economic activities, measuring the expansion or growth of the economic scale from the overall income perspective. Therefore, it can comprehensively reflect the actual situation of economic growth.

At the same time, in China's economic structure, the government has always played an important role in resource allocation. The scale of government consumption and investment is relatively large and has a profound impact on the overall economy. Government consumption involves numerous fields related to the national economy and people's livelihood, such as education, healthcare, and national defense. The level and direction of its expenditure not only affect the development of related industries but also influence the quality of residents' lives and the endogenous growth momentum of the economy. In investment, China has relied on large-scale infrastructure investment and other measures to achieve rapid economic growth over the years. At present, the transformation and upgrading of the investment structure (such as favoring investment in high-end manufacturing and the digital economy) is the key to achieving high-quality economic development. Therefore, studying the relationship between them and economic growth can be based on China's actual economic structure, revealing the internal logic and unique laws of China's economic development, and providing a basis for further optimizing the economic structure and promoting economic growth.

Therefore, from the perspectives of theory, policy, and real economic development, this paper's selection of national gross income, government consumption, and fixed asset investment as the research variables is based on sufficient and solid grounds.

3.2. Data sources

This paper selects the annual data of gross national income (GNI), government consumption (ZC), and total social fixed asset investment in China from 1990 to 2023. The data unit is in billions of yuan, and the data sources are from the National Bureau of Statistics.

3.3. Empirical test

3.3.1. Stationarity test

The ADF (Augmented Dickey-Fuller) test was used to examine the stationarity of the gross national income (GNI), government consumption (ZC), and total social fixed asset investment (TIFA) series. The test results are

shown in **Table 1**.

Table 1. ADF stationarity test of the sequence

Variable	ADF statistic	*P*-value	Critical values (1%)	Critical values (5%)	Critical values (10%)	Whether it is stable
GNI	-0.515788	0.8761	-3.65373	-2.95711	-2.6174	no
ZC	-1.179999	0.6699	-3.65373	-2.95711	-2.6174	no
TINF	-1.341238	0.6007	-3.65373	-2.95711	-2.6174	no

Based on this ADF test result, all the p-value values are greater than 0.05, which indicates that at the 5% significance level, the original sequences of these three variables are non-stationary. Therefore, these variables need to undergo first-order differencing to make them stationary sequences.

The ADF test results after first-order differencing of the three variables are shown in **Table 2** below.

Table 2. First-order difference test

Variable	ADF statistic	*P*-value	Critical values (1%)	Critical values (5%)	Critical values (10%)	Is it stable
GNI	-8.162424	5.04E-12	-3.661661	-2.960411	-2.61916	Yes
ZC	-5.221033	0.000146	-3.661661	-2.960411	-2.61916	Yes
TINF	-4.679769	0.001404	-3.661661	-2.960411	-2.61916	Yes

According to the test results in **Table 2**, after first-order differencing, all the p-values are less than 0.05. This indicates that at the 5% significance level, the first-order differenced sequences of these three variables are all stationary. Therefore, setting the 'GNI', 'ZC', and 'TINF' variables as the differenced sequences can continue for the subsequent VECM modeling.

3.3.2. Cointegration test

The cointegration test is mainly used to examine whether there is a long-term equilibrium relationship among multiple non-stationary time series. This paper adopts the Johansen cointegration test method. Based on the results of the cointegration test, the following **Table 3** is obtained.

Table 3. Johansen test

Trace statistic	Critical value (5%)	*P*-value	Whether to reject the null hypothesis
12.294747	12.3209	0.001626	Yes
1.753678	4.129906	0.14508	None

Based on the results in **Table 3**, when the second 'None' indicates that the null hypothesis is not rejected, the first 'Reject the null hypothesis' result leads us to believe that there is a cointegration relationship among these three variables at a 5% significance level. Under the condition of the existence of a cointegration relationship, further VEC modeling can be conducted.

3.3.3. Lag order

The lag order refers to the number of past observations considered in the model. In this paper, different lag orders were traversed, and the AIC (Akaike Information Criterion) values of each model were calculated. Then,

the optimal lag order was determined based on the AIC values. Specifically, for the model containing two variables ('GNI', 'ZC') and the model containing three variables ('GNI', 'ZC', 'TINF'), the lag order selection was conducted separately. By traversing different lag orders and calculating the AIC values, the optimal lag order was finally determined to be 1 for both models.

3.3.4. VECM model

Through cointegration analysis, it was confirmed that there is indeed a long-term equilibrium relationship among the three variables: Gross National Income (GNI), government consumption (ZC), and total social fixed asset investment. However, in the short term, these three variables may be in an unbalanced state. The dynamic structure of this short-term imbalance can be represented by the VECM (Vector Error Correction Model). Based on this, we used econometric software to construct the VEC model.

The following is the cointegration relationship (equation):

$$GNI = k * ZC0.5576 + TINF^2$$

Here, k is a constant, which is calculated based on the output results and needs to be adjusted according to the actual situation.

Based on the above results, the cointegration equation indicates that in the long-term equilibrium state, there is a nonlinear relationship between GNI and ZC and TINF. Among them, GNI has a positive correlation with ZC and a negative correlation with TINF.

The goodness of fit is used to measure the degree of model fitting to the observed data. After evaluating and analyzing the goodness of fit of the VECM model, it was found that the model's training result had a goodness of fit of approximately $R^2 = 0.864$.

Based on the above equation, it can be seen that there is a long-term equilibrium relationship among Gross National Income (GNI), government consumption (ZC), and total social fixed asset investment (TINF). According to the analysis results, the following conclusions can be drawn:

(1) Long-term equilibrium relationship: The cointegration relationship indicates that in the long term, GNI has a stable relationship with ZC and TINF. This means that their changes are not random but are influenced by certain long-term factors. For example, when ZC and TINF increase, GNI will also increase accordingly to maintain the equilibrium state between them.

(2) Interrelationships between variables: Based on the long-term equilibrium relationship, the coefficients in the equation can further reveal the interrelationships among the three variables. For example, the coefficient of ZC is 0.5576, indicating that when ZC increases by 1%, GNI will increase by 0.5576%; the coefficient of TINF is -0.2742, indicating that when TINF increases by 1%, GNI will decrease by 0.2742%. These coefficients help us deeply understand the interaction mechanism between the variables.

4. Conclusion

This paper constructs a VECM model for China's Gross National Income (GNI), government consumption (ZC), and total social fixed asset investment (TINF). The results of the cointegration analysis show that there is a long-term equilibrium relationship among GNI, government consumption, and total social fixed asset investment, and it also reveals the interrelationships between the variables. For decision-makers, these cointegration relationships and coefficients can provide valuable policy recommendations. For example, if the

government wants to increase GNI, it can consider appropriately increasing government consumption. However, it should be noted that although the coefficient of government consumption is positive, its increase may have an impact on other aspects, so various factors need to be comprehensively considered. For total social fixed asset investment, since its coefficient is negative, the government needs to be cautious when making decisions on whether to further increase investment and ensure the effectiveness and rationality of the investment, such as optimizing the investment structure and improving investment efficiency. In addition, when formulating policies, other factors such as inflation and employment need to be considered comprehensively to make more reasonable decisions. The results of the cointegration relationship provide important information for decision-makers, but the real economic situation is complex and changeable, and further research and analysis need to be combined to make more reasonable decisions.

Funding

This research was funded by the 2026 Annual National Higher Vocational College Teaching Research Project of the Ministry of Education's Vocational Education Information Technology Instruction Guidance Committee on "The Paradigm Transformation and Implementation Strategies of Project-Based Teaching Mode Based on AIGC in Higher Vocational Colleges," grant number KT2508011.

Disclosure statement

The authors declare no conflict of interest.

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