

Monetary policy and investment dynamics in Morocco: an econometric analysis of transmission mechanisms and economic growth

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Abstract. The interaction between monetary policy and investment plays a fundamental role in shaping economic stability and growth, particularly in emerging economies. In Morocco, monetary authorities primarily utilize interest rate adjustments to influence macroeconomic conditions and stimulate investment. However, the effectiveness of monetary policy transmission remains a key concern due to financial market constraints, structural rigidities, and external shocks. Understanding the dynamics of this transmission mechanism is crucial for designing policies that foster sustainable economic development. This study employs an econometric approach using a Vector Error Correction Model (VECM) to analyze the long-term and short-term effects of monetary policy on investment, inflation, and economic growth. The dataset comprises quarterly time-series data from 2015 to 2024, covering Morocco's key macroeconomic indicators, including the policy interest rate, investment-to-GDP ratio, inflation, and real GDP growth. The empirical findings reveal two long-term equilibrium relationships, confirming that monetary policy exerts a significant influence on investment and inflation. The error correction mechanism (ECM) suggests that investment reacts more rapidly to monetary shocks, while GDP and inflation adjust gradually. The Impulse Response Functions (IRFs) indicate that an increase in the policy rate initially curbs inflation but dampens investment, highlighting the trade-offs in monetary policy decisions. Additionally, the variance decomposition analysis confirms that inflation is primarily driven by interest rate movements, while investment is more closely linked to GDP fluctuations. These results provide critical insights for policymakers at Bank Al-Maghrib, emphasizing the need for a balanced monetary stance that supports investment without compromising inflation stability. The study also underscores the importance of financial sector deepening to enhance the effectiveness of monetary policy transmission in Morocco.

Keywords: *Monetary policy Investment; Interest rate transmission; Macroeconomic stability; VECM; Inflation; Economic growth; Morocco.*

1. Introduction

The relationship between monetary policy and investment has been a longstanding subject of economic research, particularly in the context of emerging economies. Central banks play a crucial role in regulating financial conditions, influencing investment decisions, and ensuring macroeconomic stability. However, in developing markets such as Morocco, the transmission mechanisms of monetary policy remain complex due to structural rigidities, financial market constraints, and external economic shocks. Despite the growing body of literature on monetary policy transmission in emerging economies, the research problem remains insufficiently clarified in the Moroccan context. In particular, there is no consensus on how monetary policy effectively influences investment dynamics while simultaneously interacting with inflation and economic growth under structural and financial constraints. This leads to the following research question: To what extent does monetary policy, through the interest rate channel, influence investment, inflation, and economic growth in Morocco in both the short run and the long run?

Economic theories provide a foundational understanding of how monetary policy influences investment. The Keynesian framework suggests that lower interest rates stimulate private sector investment by reducing borrowing costs (Mishkin, 1996). On the other hand, the monetarist school, led by Friedman, M. (1970) argues that monetary policy primarily impacts nominal variables rather than real investment in the long run. Emerging economies, including Morocco, face unique challenges in implementing effective monetary policy. Studies have demonstrated that financial frictions, weak credit markets, and limited access to capital hinder the smooth transmission of central bank policies to the real economy (Calvo & Reinhart, 2002). Additionally, the presence of informal sectors and underdeveloped capital markets further complicate monetary interventions (Bowman, et al., 2015). Recent empirical research highlights the heterogeneity of monetary policy effects across emerging markets. Similarly, Beirne and Fernandez (2020) emphasize that developing countries often struggle with weak monetary transmission due to shallow banking systems and high dependency on external financing. Moreover, external shocks, such as U.S. monetary policy changes, have significant spillover effects on emerging economies affecting capital flows, exchange rate stability, and domestic investment levels. In the Moroccan context, Bank Al-Maghrib has undertaken various measures to enhance monetary policy transmission, including the transition toward an inflation-targeting framework and greater exchange rate flexibility (El Ouazzani et al., 2024). However, the effectiveness of the interest rate channel remains limited due to financial sector inefficiencies and constraints in credit allocation, particularly for small and medium-sized enterprises (SMEs). However, existing studies often focus either on inflation dynamics or on specific transmission channels, without addressing the joint interaction between monetary policy, investment, and economic growth within a unified econometric framework. This creates a clear scientific gap, particularly in the Moroccan context, where structural rigidities and financial constraints may alter standard transmission mechanisms. This study is original in that it focuses on the Moroccan economy, which remains underexplored in empirical analyses using advanced multivariate time-series models. Unlike existing studies that examine isolated relationships, this research adopts an integrated framework to simultaneously analyze monetary policy, investment, inflation, and economic growth dynamics. The contribution of this study is threefold. First, it provides new empirical evidence on monetary policy transmission in Morocco using recent quarterly data. Second, it adopts a multivariate framework based on Johansen cointegration and a Vector Error Correction Model (VECM) to jointly analyze long-run equilibrium relationships and short-run dynamics. Third, it offers policy-relevant insights into the trade-offs between inflation control and investment dynamics in an emerging economy context. These contributions are particularly relevant in the context of ongoing monetary policy reforms and financial sector development in Morocco. This study provides an integrated econometric analysis of monetary policy transmission in Morocco by examining the dynamic interactions between interest rates, investment, inflation, and economic growth. By utilizing quarterly time-series data from 2015 to 2024, the research provides a comprehensive analysis of Morocco's monetary policy effectiveness in fostering investment growth. The choice of this period is justified by its relevance in capturing major macroeconomic transformations, including the gradual transition toward exchange rate flexibility, post-2015 monetary reforms, and recent external shocks such as the COVID-19 pandemic and global inflationary pressures. Additionally, the availability of consistent quarterly data ensures the robustness of the econometric analysis. The selection of variables is based on both theoretical and empirical considerations. The policy interest rate represents the main instrument of monetary policy, while inflation and GDP capture macroeconomic stability and economic performance. The investment-to-GDP ratio is used as a proxy for capital formation, reflecting investment dynamics. This set of variables is widely used in the literature to analyze monetary transmission mechanisms. The use of the Johansen cointegration approach is justified by its ability to identify

multiple long-run equilibrium relationships in a multivariate system (Johansen, 1988). Furthermore, the Vector Error Correction Model (VECM) is particularly appropriate when variables are integrated of order one and cointegrated, as it captures both short-term dynamics and long-term adjustments. This methodology is widely recognized as a robust framework for analyzing monetary policy transmission mechanisms. Overall, this study enhances the understanding of monetary transmission mechanisms in emerging economies by providing context-specific and policy-oriented evidence. The remainder of this paper is structured as follows: Section 2 reviews the theoretical and empirical literature, Section 3 presents the data and methodology, Section 4 discusses the empirical findings, Section 5 provides model validation, Section 6 presents forecasts and policy implications, and Section 7 concludes.

2. Theoretical and econometric foundations of monetary policy and investment in the Moroccan context

a. Theoretical framework of monetary policy and investment

The impact of monetary policy on investment is explained through several major economic theories. The Keynesian framework asserts that investment is highly sensitive to interest rates, as a reduction in the policy rate lowers borrowing costs, thereby stimulating private investment (Mishkin, 1996). In contrast, the monetarist perspective argues that monetary policy primarily influences nominal variables and has no significant long-run effect on real investment (Friedman, 1970). In emerging economies such as Morocco, the transmission of monetary policy to investment is often hindered by structural rigidities (Calvo & Reinhart, 2002). The inefficiency of the interest rate channel is frequently observed due to limited financial intermediation and low banking inclusion. Furthermore, the Phillips Curve hypothesis suggests that monetary policy decisions must balance inflation control and economic growth (Gali & Gertler, 1999). Given the underdeveloped financial markets in Morocco, the credit cycle approach is particularly relevant. This approach highlights the importance of credit conditions and financial stability in ensuring the effective transmission of monetary policy measures to investment (El Haddad et al., 2024). In this context, the effectiveness of Moroccan monetary policy depends heavily on the depth and diversification of the banking and financial system.

b. Econometric approaches to monetary policy analysis

While the theoretical frameworks discussed above provide the conceptual foundation for understanding monetary transmission mechanisms, empirical studies rely on time-series econometric models to assess how these mechanisms operate in practice. Empirical analysis of the relationship between monetary policy and investment relies primarily on time-series econometric models, particularly the Vector Error Correction Model (VECM). This model is widely used to analyze long-term dynamics and short-term adjustments of macroeconomic variables (Benomar & El Haj, 2024). In this context, the co-integration approach developed by Johansen (1988) is widely employed to identify and estimate long-run relationships between investment, interest rates, and economic growth. Other studies have adopted Autoregressive Distributed Lag (ARDL) models to capture the lagged effects of monetary policy on investment, considering external economic shocks and transmission delays. Moreover, the Generalized Method of Moments (GMM) models have been utilized to overcome endogeneity problems, particularly regarding investment decisions influenced by monetary policy and macroeconomic uncertainty. The use of Impulse Response Functions (IRFs) and Variance Decomposition Analysis is essential in assessing the effect of monetary shocks on investment and economic growth. These econometric tools help evaluate the magnitude and persistence of the impact of policy rate changes on investment and economic activity.

c. Monetary policy in Morocco: a historical and empirical perspective

Since the early 2000s, Morocco has gradually adopted an inflation-targeting framework while strengthening the independence of its central bank, Bank Al-Maghrib (BAM). The transition to a more flexible exchange rate regime and the adoption of modern monetary transmission mechanisms have contributed to inflation stabilization and investment growth (El Ouazzani et al., 2024). However, several studies have highlighted the limitations of the interest rate channel in Morocco. The weak transmission of policy rate changes to borrowing costs for firms and households limits the direct impact of monetary decisions on investment. As a result, Bank Al-Maghrib has sought to diversify its instruments, particularly by strengthening the role of credit expansion and facilitating access to financing for small and medium-sized enterprises (SMEs). Recent research has also emphasized the importance of the exchange rate in monetary policy transmission in Morocco. Other studies found that the stability of the Moroccan dirham plays a crucial role in attracting foreign investments and managing capital flows. Simultaneously, infrastructure investments and financial market liberalization have progressively enhanced the effectiveness of monetary policy. The evolution of outstanding bank credit is thus a key indicator for understanding the impact of monetary policy on investment and growth.

d. International comparisons and lessons for Morocco

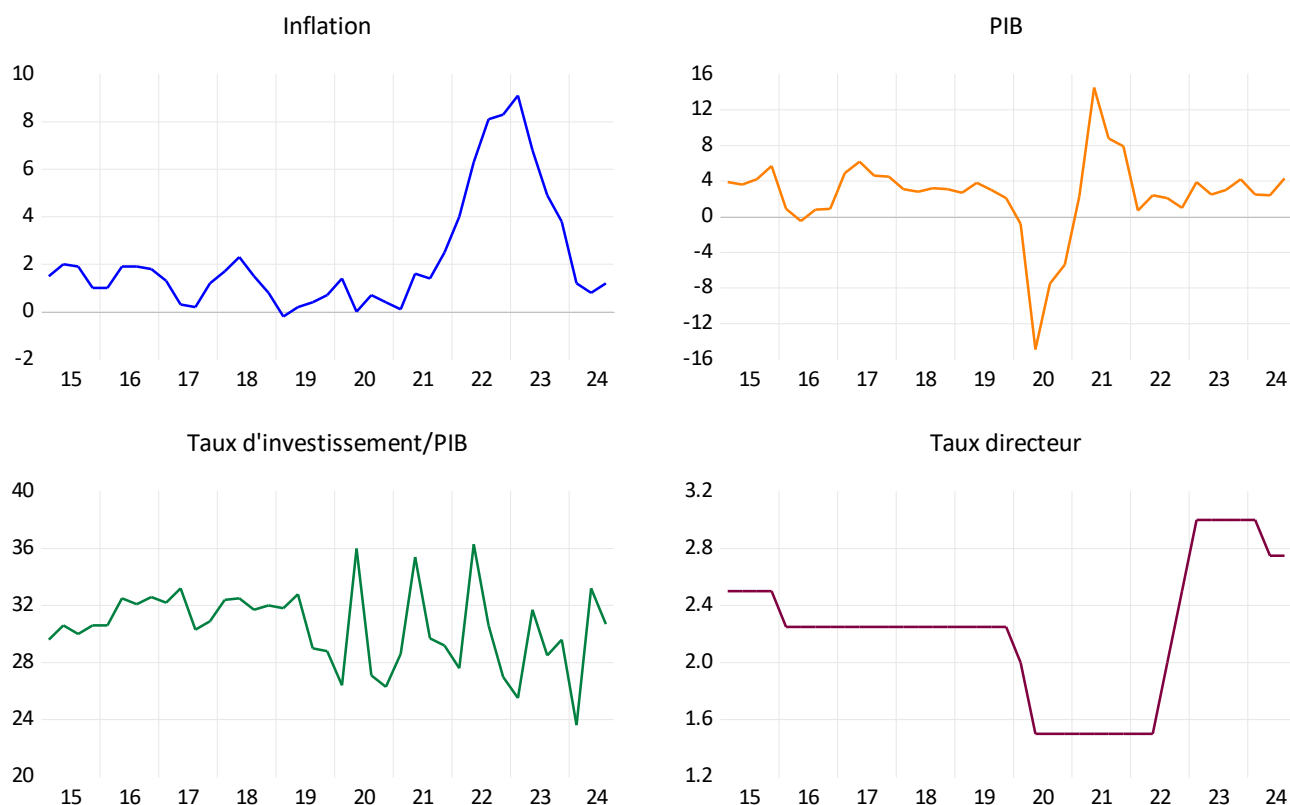
Morocco's monetary policy and investment framework can be better understood through comparisons with other emerging economies. A study on North Africa emphasized that the credibility of monetary institutions is crucial for ensuring effective transmission of monetary decisions to the real economy. In Asia, China's monetary policy relies on a combination of strict banking regulations and direct market interventions, offering insights into the importance of coordination between monetary policy and financial regulation. Furthermore, economic reforms in Brazil demonstrate that financial market openness and transparent monetary policy rules enhance macroeconomic stability and investment. For Morocco, these international experiences suggest the need to strengthen central bank independence and improve monetary transmission channels by developing the bond market and diversifying corporate financing sources. Overall, the existing literature highlights the importance of monetary policy in influencing inflation and investment dynamics, particularly in emerging economies. However, prior studies often focus either on inflation outcomes or on specific transmission channels, with limited attention to the joint long-run and short-run interactions between monetary policy, investment, and economic growth within a unified econometric framework. This study contributes to the literature by providing an integrated analysis of monetary policy transmission in Morocco, simultaneously examining inflation, investment, and GDP dynamics within a Vector Error Correction Model. By focusing on a recent period and incorporating both long-run equilibrium relationships and short-run adjustment dynamics, the paper extends existing empirical findings and offers context-specific insights relevant to emerging economies with evolving monetary frameworks.

3. Empirical design

a. Indicators and data sources

The dataset used in this study spans from 2015Q1 to 2024Q4 and includes Morocco's key macroeconomic indicators. All data collected are quarterly time series from 2015 to 2024, totaling 39 observations.

Figure 1. Inflation rate (INF), Real GDP Growth rate (GDP), Investment-to-GDP ratio (INV), Policy interest rate (IR) - 2015Q1 to 2024Q4



Source: HCP & Bank Al-Maghrib. Elaborated by the authors, EViews 12 output.

Table 1. Description of variables and data sources

Variables	Abbreviation	Description	Sources
Inflation Rate	(INF)	The rate at which the general level of prices for goods and services rises, expressed as a year-over-year percentage change in the Consumer Price Index (CPI). Inflation reflects the purchasing power of money over time.	High Commission for Planning (HCP)
Real GDP Growth Rate	(GDP)	The percentage change in real Gross Domestic Product (GDP) from one quarter to another, adjusted for inflation. It measures the overall economic activity and output within the country.	High Commission for Planning (HCP)
Investment-to-GDP Ratio	(INV)	The ratio of gross fixed capital formation (GFCF) to GDP, indicating the share of total economic output allocated to investment in capital assets such as infrastructure, machinery, and equipment. It serves as a proxy for capital accumulation and long-term economic growth potential.	High Commission for Planning (HCP)
Policy Interest Rate	(IR)	The central bank's benchmark interest rate, which influences borrowing costs and monetary conditions. This rate is a key instrument of monetary policy used to regulate inflation, investment, and economic stability.	Bank Al-Maghrib (BAM)

These variables are essential for analyzing the interaction between monetary policy and investment. The data sources include the High Commission for Planning (HCP) of Morocco for inflation and GDP, and Bank Al-Maghrib (BAM) for the policy interest rate and investment-to-GDP ratio. The following table presents the descriptive statistics of the macroeconomic variables used in this study:

Table 2. Descriptive statistics of key variables

Statistic	(INF)	(GDP)	(INV)	(IR)
Mean	2,210	2,500	30,490	2,220
Median	1,400	3,000	30,600	2,250
Maximum	9,100	14,500	36,300	3,000
Minimum	- 0,200	- 14,900	23,600	1,500
Std. Dev.	2,420	4,490	2,770	0,480
Skewness	1,630	-1,340	- 0,180	- 0,130
Kurtosis	4,590	8,560	3,070	2,260
Jarque-Bera	21,290	61,910	0,210	1,000
Probability	-	-	0,900	0,610
Sum	86,000	97,400	1 189,200	86,500
Sum Sq. Dev.	222,340	767,570	292,570	8,770

Source: compiled by the authors on the basis of results obtained from Eviews Software.

The results indicate that inflation has a mean value of 2.21%, with a maximum of 9.1% and a minimum of -0.2%, reflecting significant fluctuations over the period. GDP growth rate shows a negative skewness, implying that there have been more instances of low growth or recessionary periods. The policy interest rate is relatively stable, with a standard deviation of 0.48, suggesting that Bank Al-Maghrib has pursued a relatively steady monetary policy. The Jarque-Bera test for normality indicates that GDP and inflation deviate from normal distribution, while investment and interest rates appear more normally distributed. The descriptive analysis highlights the variability in macroeconomic indicators and provides a basis for further econometric analysis to understand the transmission mechanism of monetary policy to investment in Morocco.

b. Econometric framework and pre-estimation procedures

i. Stationarity and unit root tests

The stationarity of the variables was assessed using the Augmented Dickey-Fuller (ADF) test to ensure appropriate time-series properties. The ADF test is based on the following regression equation:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum \delta_i \Delta Y_{t-i} + \epsilon_t \quad (1)$$

Where

- Y_t is the variable of interest,
- $\Delta Y_t = Y_t - Y_{t-1}$ represents the first difference,
- α is a constant,
- βt captures a time trend,
- γ is the coefficient for the unit root test,
- δ_i are lag coefficients,
- ϵ_t is a white noise error term

In our study we will apply the ADF test, which is based on the following assumptions:

- H_0 (Null Hypothesis): The variable has a unit root (non-stationary)
- H_1 (Alternative Hypothesis): The variable is stationary (no unit root).

The results are summarized as follows:

Table 3. Stationarity and unit root tests

Variables	ADF t-Statistic (Level)	p-Value (Level)	Conclusion (Level)	ADF t-Statistic (1st Diff.)	p-Value (1st Diff.)	Conclusion (1st Diff.)
(INF)	0.7045	0.9902	Non-stationary	-4.1035	0.0034	Stationary
(GDP)	-3.0220	0.1398	Non-stationary with a trend	-5.9868	0.0001	Stationary
(IR)	-2.0159	0.2790	Non-stationary	-3.2988	0.0221	Stationary
(INV)	-4.0291	0.0177	Stationary with a linear trend	Not applicable	Not applicable	Not applicable

Source: Elaborated by the authors.

The stationarity analysis indicates that inflation (INF), GDP growth rate (GDP), and the policy interest rate (IR) are non-stationary at their levels but become stationary after first differencing, confirming that they are integrated of order one $I(1)$. Conversely, the investment-to-GDP ratio (INV) is stationary at its level, indicating that it is integrated of order zero $I(0)$. These results justify the inclusion of these variables in the VECM framework for further analysis.

ii. Co-integration testing: Johansen's Approach (Trace & Maximum Eigenvalue Tests)

The Johansen co-integration test was employed to determine the presence of long-term equilibrium relationships among the variables Johansen, S. (1988). The results of the two approaches, Trace Test and Maximum Eigenvalue Test, are summarized as follows:

Table 4. Trace test results

Null Hypothesis (H_0)	Trace Statistic (λ trace)	Critical Value (5%)	p-Value	Decision
No co-integration ($r=0$)	76.11754	47.85613	0.0000	Reject H_0 : Co-integration exists
At most 1 co-integration ($r=1$)	37.76403	29.79707	0.0049	Reject H_0 Co-integration exists
At most 2 co-integrations ($r=2$)	11.89866	15.49471	0.1619	Do not reject H_0: No additional co-integration

Source: calculated by the authors

The Trace Test indicates the presence of two co-integrating equations at the 5% significance level.

Table 5. Maximum Eigenvalue test results:

Null Hypothesis (H0)	Max-Eigen Statistic (λ_{max})	Critical Value (5%)	p-Value	Decision
No co-integration (r=0)	38.35351	27.58434	0.0014	Reject H0: Co-integration exists
At most 1 co-integration (r=1)	25.86537	21.13162	0.0100	Reject H0 Co-integration exists
At most 2 co-integrations (r=2)	8.440437	14.26460	0.3357	Do not reject H0: No additional co-integration

Source: calculated by the authors

The Max Eigenvalue Test also identifies two co-integrating equations at the 5% significance level.

4. VECM Model Specification and Results

The VECM is specified to capture both short-term dynamics and long-term equilibrium relationships. The general form of the model is:

$$\Delta Y_t = \alpha \beta' Y_{t-1} + \sum_{i=1}^k \Gamma_i \Delta Y_{t-i} + \mu + \epsilon_t \quad (2)$$

Where:

- Y_t : Vector of endogenous variables [INF, GDP, INV, IR],
- α : Adjustment coefficients indicating the speed of adjustment,
- β' : Co-integrating vectors representing long-term relationships,
- Γ_i : Coefficients for lagged differences,
- μ : Deterministic components (constant or trend),
- ϵ_t : White noise error term.

The results of the Johansen co-integration test indicate the presence of two significant co-integrating relationships among the variables (r=2). This implies the existence of a long-term equilibrium relationship between inflation, GDP, the investment-to-GDP ratio, and the policy interest rate.

a. Long-term relationships (Co-integrating equations)

The co-integrating coefficients highlight the long-term equilibrium relationships among the variables:

First Co-Integrating Equation (normalized by inflation):

$$INF + 24.45 \times INV - 345.94 \times IR + C = 0 \quad (3)$$

- Policy Interest Rate (-345.94): An increase in the policy interest rate significantly reduces inflation in the long-term equilibrium. This finding aligns with economic theory, where restrictive monetary policy lowers inflation by curbing aggregate demand.
- Investment-to-GDP Ratio (+24.45): An increase in the investment-to-GDP ratio raises inflation, potentially due to heightened demand pressures in the presence of supply constraints.

Second Co-Integrating Equation (normalized by GDP):

$$GDP - 47.97 \times INV + 680.17 \times IR + C = 0 \quad (4)$$

- Policy Interest Rate (+680.17): A higher policy interest rate is associated with increased GDP in the long-term equilibrium. This positive long-run association should be interpreted as a conditional equilibrium relationship rather than a direct causal effect and may reflect the stabilizing role of monetary policy in maintaining macroeconomic credibility and anchoring inflation expectations in the Moroccan context.
- Investment-to-GDP Ratio (-47.97): An increase in the investment-to-GDP ratio leads to a decrease in GDP in equilibrium. This might indicate inefficient overinvestment or resource misallocation.

b. Short-Term Adjustments (Error Correction Terms)

The error correction coefficients (α) reflect the speed at which each variable adjusts to restore long-term equilibrium following a shock. The analysis covers each dependent variable, along with insights into the lagged effects of variables in the system. Additionally, the R^2 values provide an understanding of the explanatory power for each equation.

Table 6. Error correction coefficients for each dependent variable

Dependent Variable	Error Correction Term (α)	Interpretation	Significance (t-stat)
Inflation (D(INFLATION))	0.17770	Positive adjustment towards equilibrium, but adjustment is slow.	Weak significance (t=1.32).
GDP (D(GDP))	-0.6462	Negative adjustment towards equilibrium, limited in impact.	Not significant (t-stat not significant).
Investment-to-GDP Ratio (D(INVESTMENT))	1.1745	Strong positive adjustment towards equilibrium, indicating a fast response.	Strong significance (t=3.01).
Policy Interest Rate (D(INTEREST RATE))	0.02910	Weak positive adjustment towards equilibrium.	Moderate significance (t=1.98).

Source: Elaborated by the authors.

Table 7. Lagged effects of variables

Lagged variable	Dependent variable	Coefficient	Interpretation	Significance (t-stat)
Inflation D (INFLATION (-2))	Policy Interest Rate (D(INTEREST RATE))	-0.5757	Past variations in inflation negatively influence the policy rate.	Significant (t=-2.34).
GDP D (GDP (-4))	Policy Interest Rate (D(INTEREST RATE))	-0.0187	Lagged GDP has a negative effect on the policy rate.	Significant (t=-3.80).
Investment D (INVESTMENT (-1))	Investment-to-GDP Ratio (D(INVESTMENT))	-1.1703	Investment dynamics show strong inertia, where past investment negatively affects current levels.	Highly significant (t=-4.44).
Policy Interest Rate D (INTEREST RATE (-1))	Policy Interest Rate (D(INTEREST RATE))	0.78360	Lagged policy rate has a significant positive effect on itself, reflecting persistence in monetary policy.	Highly significant (t=3.64)

Source: Elaborated by the authors.

Table 8. Explanatory power of the system

Dependent variable	R ²	Explanatory power
Inflation (D(INFLATION))	0.8273	Strong explanatory power.
GDP (D(GDP))	0.7405	Moderate explanatory power.
Investment-to-GDP Ratio (D(INVESTMENT))	0.9007	Very strong explanatory power.
Policy Interest Rate (D(INTEREST RATE))	0.9232	Excellent explanatory power.

Source: Elaborated by the authors.

The analysis of short-term adjustments highlights the dynamic responses of macroeconomic variables to deviations from equilibrium. Investment exhibits the strongest and fastest adjustment, reflecting its sensitivity to economic shocks, while the policy interest rate shows significant persistence in the short run. Inflation and GDP adjust more gradually, demonstrating the complexity of their dynamics, with the model's high explanatory power affirming its robustness in capturing these relationships.

c. Impulse response functions (IRFs)

To analyze the dynamic impact of monetary policy on investment, inflation, and economic growth, Impulse Response Functions (IRFs) were computed. These functions track the response of each variable to a one-standard-deviation shock in the policy interest rate, providing insights into the transmission mechanisms of monetary policy.

Response of inflation to a policy interest rate shock: Initially, inflation reacts negatively to an increase in the policy rate. The response reaches its lowest point (approximately -6) after about five periods before gradually returning toward zero. A higher policy rate reduces inflation initially, which aligns with restrictive monetary policies aimed at curbing aggregate demand. However, the effect dissipates over time, and inflation eventually reverts to equilibrium.

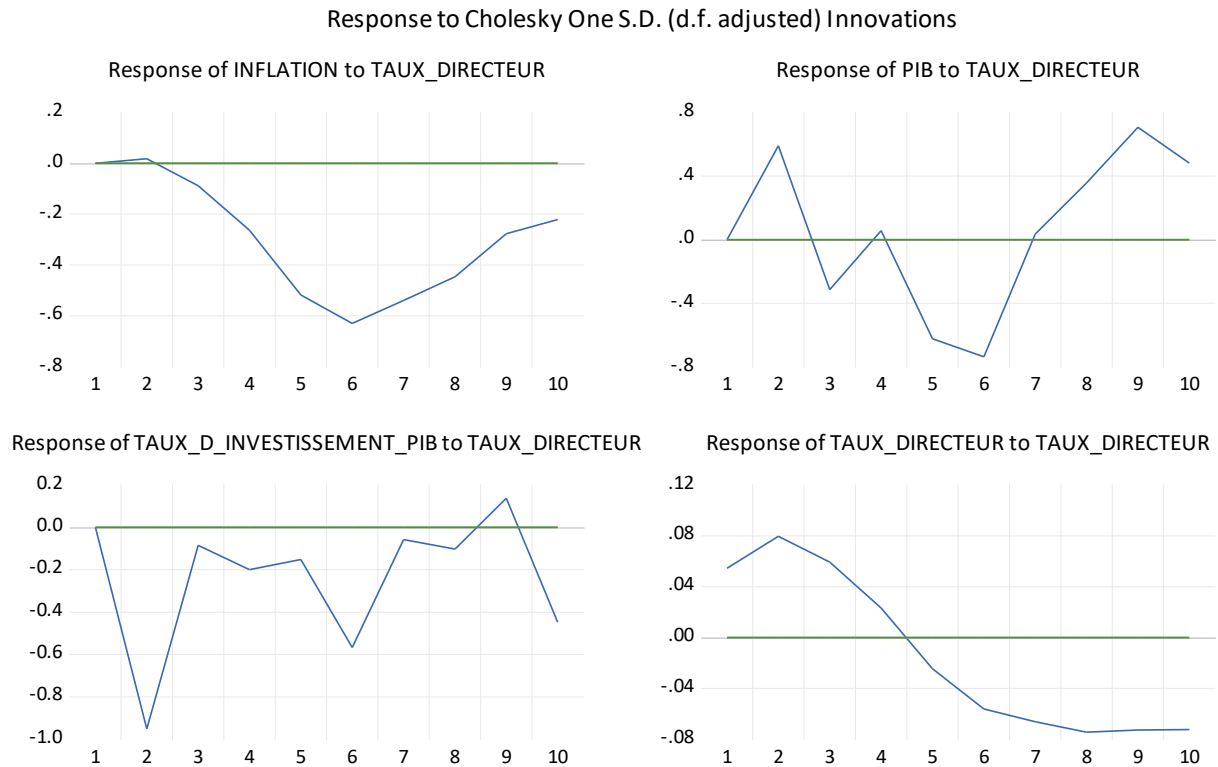
Response of GDP to a policy interest rate shock: GDP initially increases in the first two periods but subsequently declines before fluctuating. The oscillations progressively diminish, suggesting a return to equilibrium after approximately ten periods. An increase in the policy interest rate may initially stabilize the economy but exerts a negative impact on economic growth in the medium term by reducing investment and consumption. These fluctuations reflect dynamic adjustments before GDP stabilizes at a new equilibrium level.

Response of the investment-to-GDP Ratio to a policy interest rate shock: The investment-to-GDP ratio experiences an immediate and significant decline following the shock. It begins to recover gradually after two periods, with fluctuations before converging toward zero. A higher policy interest rate directly reduces investment, as borrowing costs increase. The oscillations indicate temporary adjustments before the system stabilizes investment at a new equilibrium level.

Response of the policy interest rate to itself: The policy interest rate exhibits a strong autocorrelation, reacting positively to its own shock and reaching a peak within two periods. It then declines rapidly, stabilizing near zero. This behavior reflects the persistence of monetary policy adjustments, where an initial shock propagates in the short term before its effect gradually dissipates.

Figure 2 illustrates the impulse response functions derived from the VECM, showing the dynamic reactions of inflation, GDP, investment, and the policy interest rate to a monetary policy shock.

Figure 2. Impulse response functions (IRFs)



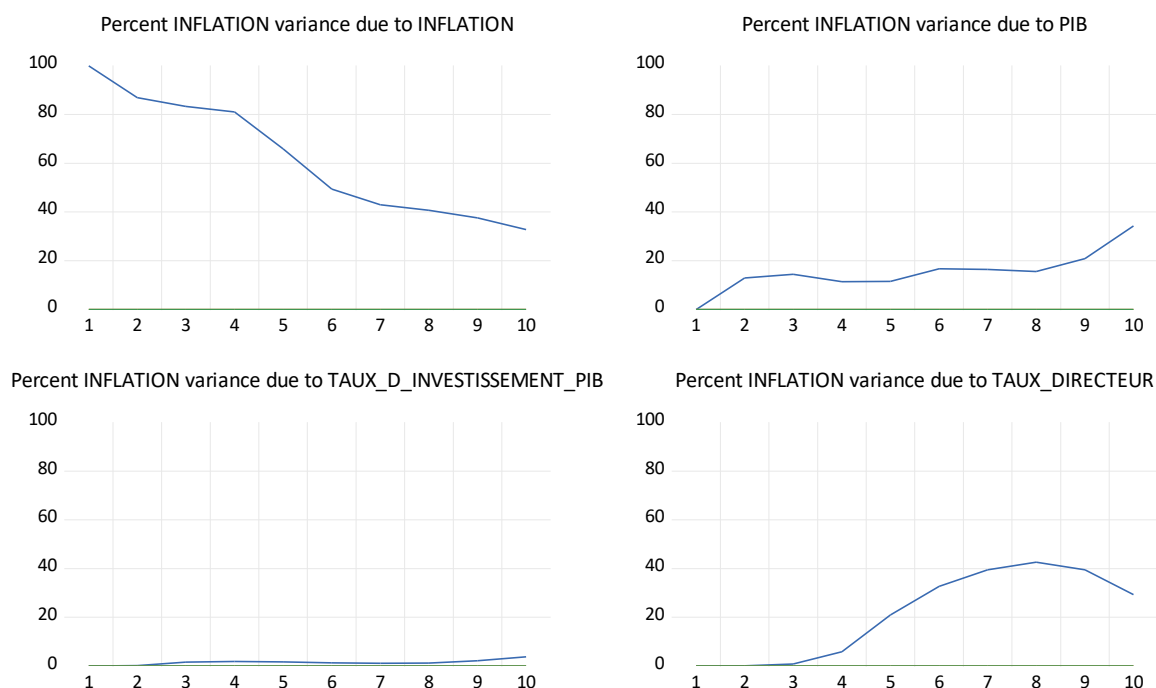
Charts created by the authors, Eviews 12 output.

The impulse response functions illustrate the dynamic responses of inflation, investment, GDP, and the policy interest rate following a monetary policy shock.

d. Variance Decomposition Analysis

Variance decomposition quantifies the contribution of each variable to the forecast error variance of others. This analysis provides insights into the relative influence of monetary policy shocks. Figures 3 to 6 present the variance decomposition results, highlighting the relative contribution of monetary and real variables to the forecast error variance of each macroeconomic indicator.

Figure 3. Variance decomposition of inflation



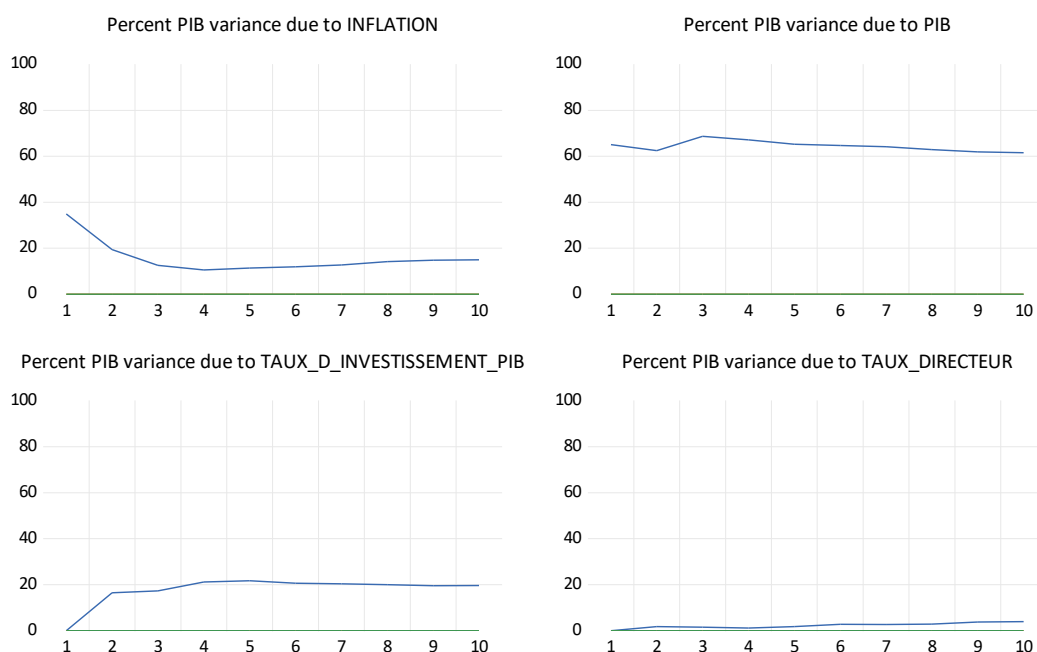
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The variance decomposition analysis reveals that in the short term, inflation is primarily influenced by its own past variations, accounting for nearly 100% of its fluctuations. However, over time, this self-influence diminishes, dropping to less than 20% in the long run.

Meanwhile, the contribution of GDP increases progressively, reaching approximately 30% in the long term, indicating an indirect but growing correlation between economic growth and inflationary pressures.

The investment-to-GDP ratio plays a marginal role, contributing around 5% to inflation's variance, suggesting that investment shocks have a relatively limited direct impact on price levels. In contrast, the policy interest rate emerges as a significant determinant, explaining nearly 50% of inflation's long-run variance. The variance decomposition results indicate that the policy interest rate accounts for a substantial share of inflation variability in the long run.

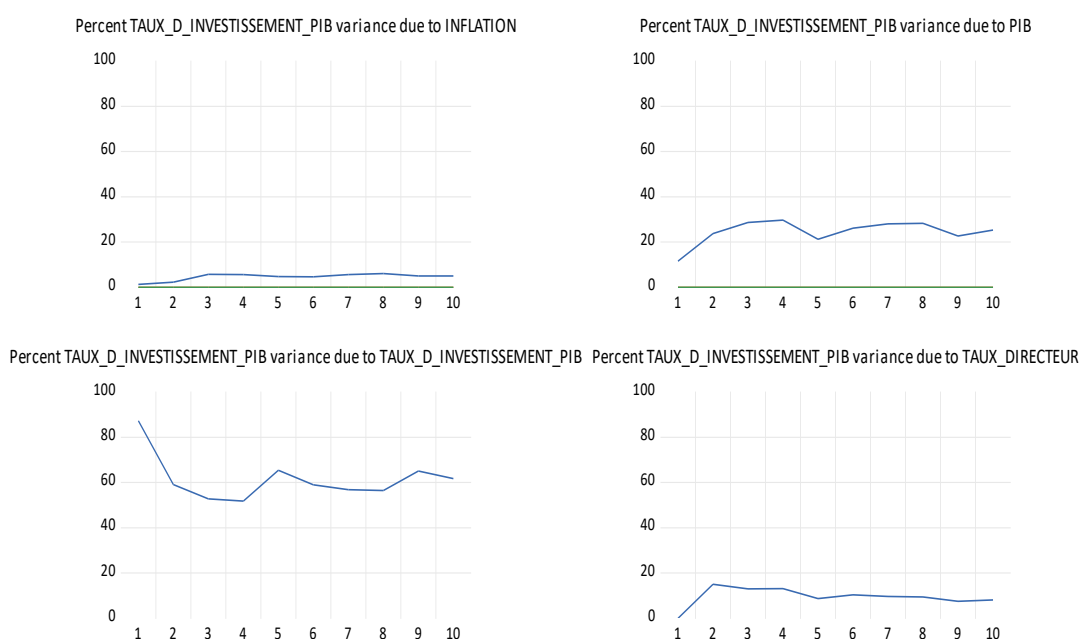
Figure 4. Variance decomposition of GDP



Charts created by the authors, Eviews 12 output.

The variance decomposition of GDP indicates that its own past values remain the dominant source of variation over time, though their influence gradually decreases, stabilizing at around 50% in the long run. This high degree of self-influence aligns with the persistent nature of economic growth, where past economic performance significantly shapes future output. Inflation plays a relatively minor role in explaining GDP fluctuations, contributing approximately 10% to its variance, suggesting that inflationary shocks have a limited direct impact on economic growth. Meanwhile, the investment-to-GDP ratio emerges as a key determinant, accounting for about 30% of GDP's variance in the long term. This underscores the structural relationship between investment and economic expansion, reaffirming the importance of capital accumulation in sustaining growth. The policy interest rate, while marginal in its overall contribution, still accounts for around 10% of GDP's long-run variance, reflecting a moderate but observable impact of monetary policy on economic activity. These findings suggest that while investment remains a crucial driver of GDP dynamics, monetary policy adjustments also play a role, albeit to a lesser extent.

Figure 5. Variance decomposition of the investment-to-GDP ratio



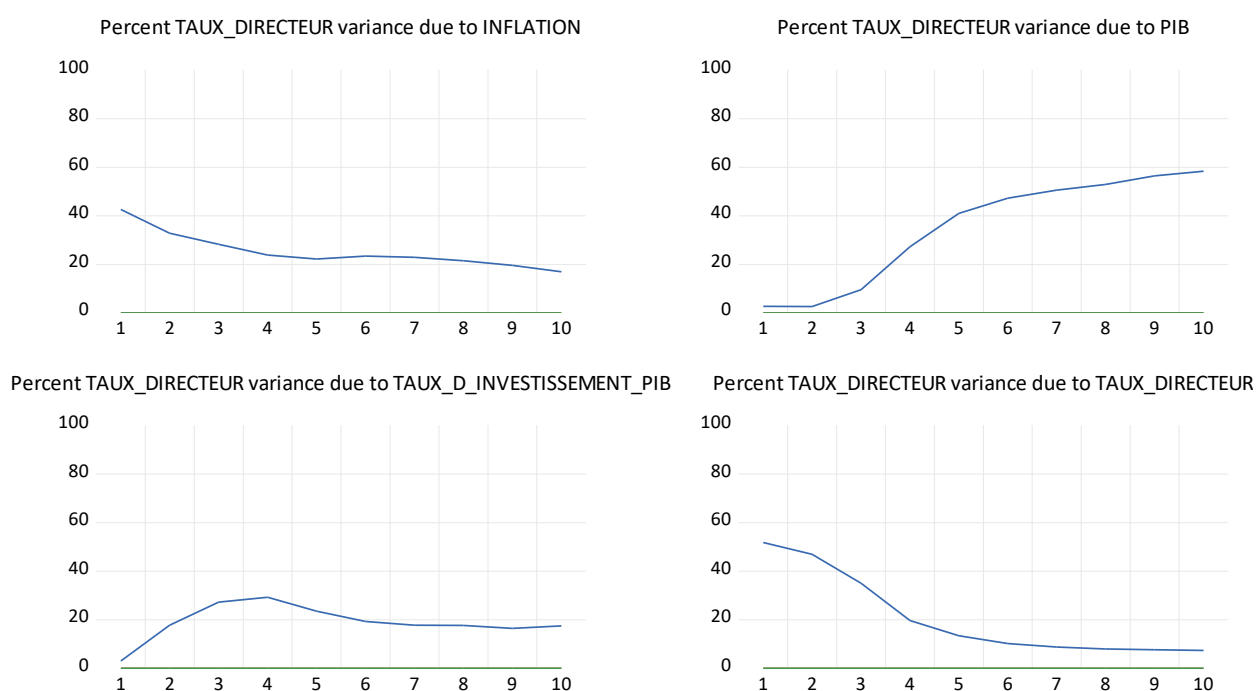
Charts created by the authors, Eviews 12 output.

The variance decomposition analysis reveals that, in the short term, the investment-to-GDP ratio is predominantly influenced by its own past values, with its variance accounting for nearly 100% of its fluctuations initially. Over time, this self-influence gradually declines, stabilizing around 60% in the long run. This strong inertia highlights the persistent nature of investment decisions, which are often guided by long-term planning and structural economic factors. As time progresses, the impact of GDP on investment variance becomes increasingly significant, contributing approximately 30% in the long term. This reinforces the notion that investment activity is closely linked to economic growth, as higher GDP levels typically drive greater investment through increased business confidence and capital accumulation.

Meanwhile, the combined influence of inflation and the policy interest rate remains marginal, accounting for only about 10% of the total variance.

This suggests that while macroeconomic policies do play a role in shaping investment dynamics, structural economic factors and growth trajectories exert a more substantial influence over the long run.

Figure 6. Variance decomposition of the policy interest rate



Charts created by the authors, Eviews 12 output.

In the short term, the variance of the policy interest rate is primarily self-determined, with its own past values explaining nearly all its fluctuations. This reflects the autonomous nature of monetary policy, where short-term adjustments are influenced by central bank decisions rather than external economic factors. However, as time progresses, this self-influence diminishes significantly, accounting for only about 20% of the variance in the long run.

Over time, the impact of GDP on the policy interest rate variance becomes increasingly dominant, surpassing 60% in the long term. This suggests that monetary policy adjustments are largely reactive to economic growth, with central banks modifying interest rates in response to macroeconomic conditions. Meanwhile, the combined influence of inflation and the investment-to-GDP ratio remains marginal, accounting for around 10% of the variance. This indicates that while inflation and investment play a role in shaping monetary policy, economic growth remains the primary driver of long-term interest rate fluctuations.

The analysis of variance decomposition provides key insights into the long-term dynamics of macroeconomic variables and their interactions with monetary policy. Inflation is predominantly influenced by the policy interest rate in the long run, reinforcing the crucial role of monetary policy in controlling price stability. This finding aligns with economic theory, where central banks adjust interest rates to regulate inflationary pressures.

GDP remains largely self-determined, demonstrating its inherent persistence. However, investment plays a significant role in shaping long-term economic growth, confirming the structural link between capital accumulation and GDP expansion. Similarly, the investment-to-GDP ratio exhibits strong inertia in the short term but becomes increasingly correlated with GDP over time, highlighting the cyclical nature of investment in response to economic growth dynamics.

Finally, the policy interest rate is mainly driven by GDP shocks in the long term, suggesting that monetary authorities adopt a reactive approach in setting interest rates. This reflects a

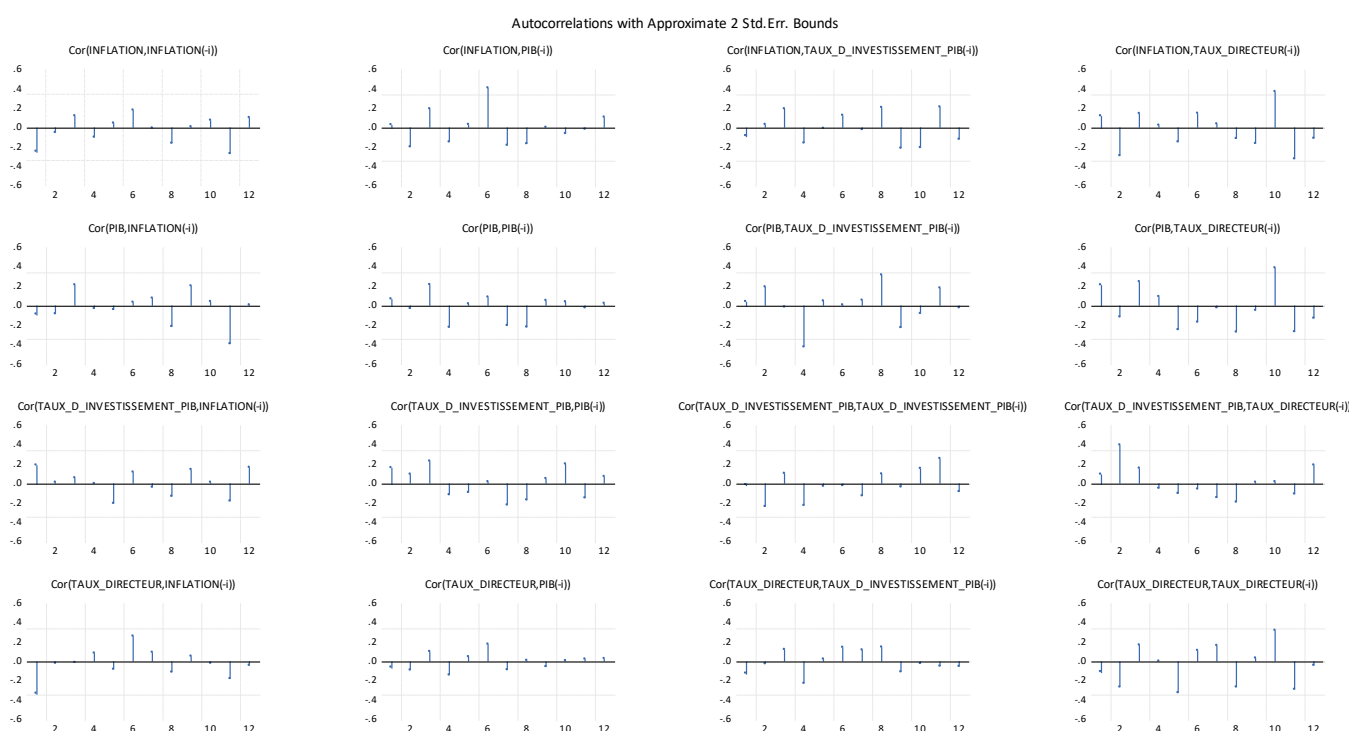
systematic response where central banks adjust their policies based on macroeconomic conditions, particularly in reaction to economic growth trends. These findings confirm the expected transmission mechanisms of monetary policy and their varying degrees of influence across different economic indicators.

5. Model validation

To ensure the robustness and reliability of the Vector Error Correction Model (VECM), a series of diagnostic tests were conducted. These tests assess key statistical properties, including residual autocorrelation, normality, and model stability.

a. Residual Autocorrelation: Tested using the Breusch-Godfrey LM test.

Figure 7. Residual Autocorrelation Test



Charts created by the authors, Eviews 12 output.

The presence of autocorrelation in the residuals was examined using the Breusch-Godfrey LM test. The results indicate no significant serial correlation, confirming that the model adequately captures the underlying data structure without omitted dynamic dependencies.

b. Normality of Residuals: Evaluated using the Jarque-Bera test

The normality of the residuals was evaluated using the Jarque-Bera, skewness and kurtosis tests.

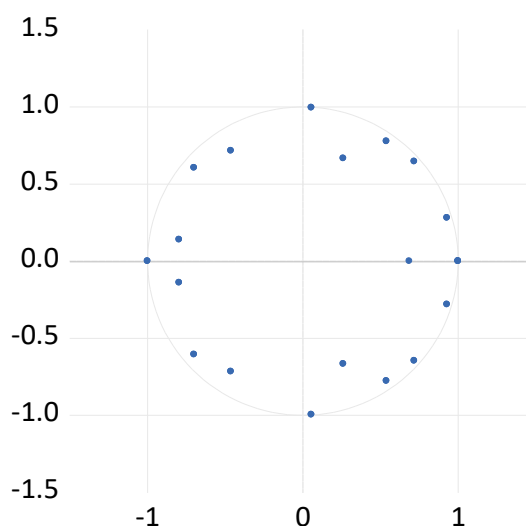
- **Skewness Test:** Individual components exhibit skewness values close to zero (e.g., -0.0326 for component 1), indicating a relatively symmetric distribution. The associated p-values are high (e.g., 0.938), implying that the normality assumption cannot be rejected.
- **Kurtosis Test:** The kurtosis values are close to 3 across all components, which aligns with the expectations of a normal distribution. The p-values remain above 0.5, further supporting the normality assumption.

- Jarque-Bera Test: The joint p-value of 0.9536 confirms that the residuals follow a multivariate normal distribution, ensuring the statistical validity of the model.

c. Stability of the Model

The stability of the VECM was assessed by examining the eigenvalues of the companion matrix, ensuring that all roots lie within the unit circle.

Figure 8. Inverse Roots of AR Characteristic Polynomial



Charts created by the authors, Eviews 12 output.

Characteristic polynomial roots analysis:

- The presence of 02-unit roots (eigenvalues equal to 1) confirms the existence of two co-integrating relationships in the model, consistent with previous co-integration tests.
- All other eigenvalues have a modulus strictly less than 1, indicating a dynamically stable system.

Interpretation:

- The model satisfies the stability condition, ensuring that the estimated relationships remain reliable over time.
- The unit roots reflect the presence of long-term equilibrium relationships, while the other eigenvalues being inside the unit circle confirm that the system exhibits stable convergence toward equilibrium after a shock.

These diagnostic results validate the robustness of the VECM, confirming that it appropriately captures the dynamic relationships among the variables while maintaining statistical consistency.

6. Macroeconomic forecast analysis based on the VECM Model (2024-2026)

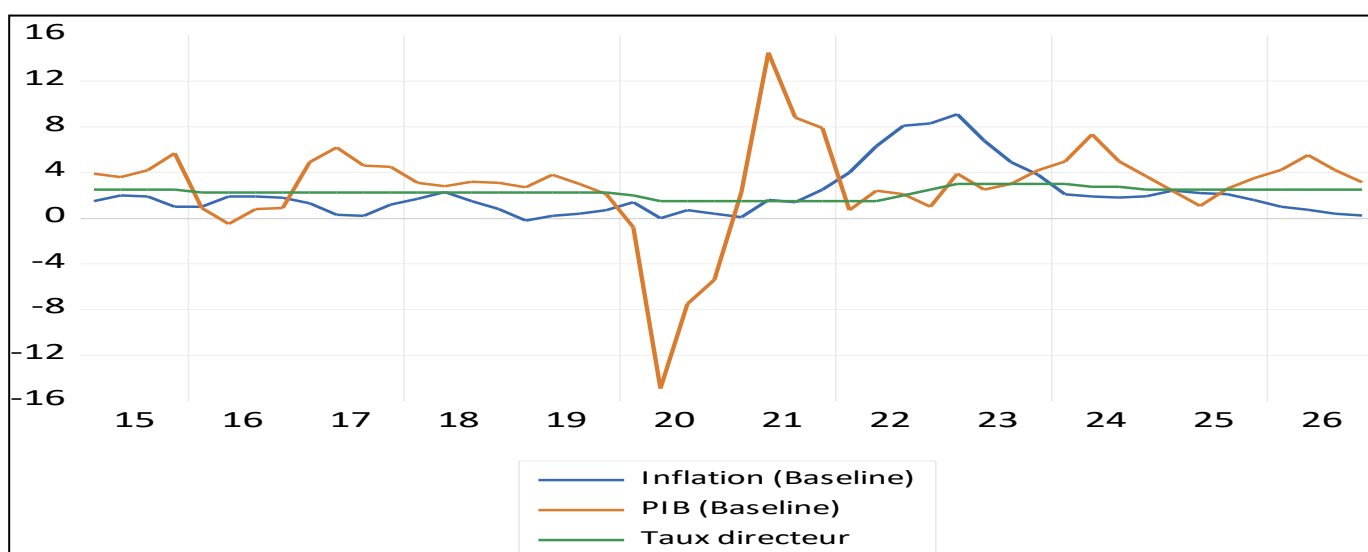
Building on the econometric results presented in Sections 4 and 5, this section discusses the macroeconomic interpretation and policy implications of the findings, with particular emphasis on monetary policy effectiveness and investment dynamics in Morocco. The forecast results from the VECM model provide crucial insights into the anticipated macroeconomic trends in terms of inflation dynamics, monetary policy stance, economic growth, and investment behavior over the period 2024-2026. The interplay between these variables highlights the

transmission mechanisms of monetary policy and the structural factors shaping the economy's trajectory.

Table 9. Macroeconomic forecast analysis based on the VECM Model (2024-2026)

Year-Quarter	Inflation %	Policy Interest Rate (%)	GDP Growth Rate (%)	Investment-to-GDP Ratio (%)
2024:1	2,09	3,00	4,96	26,58
2024:2	1,90	2,75	7,34	31,82
2024:3	1,81	2,75	4,99	30,18
2024:4	1,91	2,50	3,68	32,44
2025:1	2,42	2,50	2,37	28,07
2025:2	2,20	2,50	1,07	33,54
2025:3	2,10	2,50	2,58	31,38
2025:4	1,58	2,50	3,51	33,32
2026:1	1,01	2,50	4,22	28,67
2026:2	0,74	2,50	5,53	33,00
2026:3	0,40	2,50	4,22	31,10
2026:4	0,24	2,50	3,15	34,05

Figure 9. Macroeconomic Forecast Analysis Based on the VECM Model (2024-2026)



Source: Elaborate by the authors

a. Inflation dynamics and monetary policy adjustments

The VECM forecasts suggest a gradual decline in inflation over the period 2024–2026, reflecting the delayed effects of previous monetary tightening and well-anchored inflation expectations. While this disinflationary trend supports price stability, it also highlights the need for careful monitoring to avoid potential deflationary risks.

b. Interest rate policy and its stabilization role

The forecasted stabilization of the policy interest rate at around 2.5% suggests that monetary authorities have reached a broadly neutral stance. This reflects a balanced macroeconomic

environment in which inflation is contained without exerting excessive pressure on economic activity.

c. GDP Growth: cyclical adjustments and structural factors

GDP growth projections display cyclical fluctuations, combining short-term adjustments with longer-term mean reversion. These dynamics reflect the interaction between monetary conditions, investment behavior, and structural factors shaping Morocco's economic performance.

d. Investment behavior and the cost of capital

Investment follows a cyclical pattern, responding negatively to periods of monetary tightening and recovering as interest rates stabilize. This behavior confirms the sensitivity of capital formation to financing conditions, while also highlighting the role of macroeconomic stability in supporting investment over the medium term.

e. Policy implications and strategic considerations

The empirical results highlight the central role of monetary policy in shaping inflation dynamics and investment behavior in Morocco. Both impulse response functions and variance decomposition analysis indicate that inflation is particularly sensitive to changes in the policy interest rate, especially in the medium to long run. This confirms that the interest rate channel remains an effective instrument for price stabilization, provided that monetary policy actions remain credible and predictable.

Investment responds strongly and immediately to monetary policy shocks, underscoring the trade-off faced by monetary authorities between inflation control and investment stimulation. Higher interest rates tend to dampen capital formation by increasing financing costs, particularly in the short run. However, the gradual recovery of investment following monetary stabilization suggests that macroeconomic credibility and financial stability can partially mitigate the adverse effects of tighter monetary conditions. This highlights the importance of adopting a balanced monetary stance that avoids excessive tightening while preserving macroeconomic stability.

The impact of monetary policy on economic growth appears more moderate and indirect. While short-term stabilization effects may occur, the long-run influence of interest rate adjustments on GDP remains limited compared to the role of real and structural factors. This suggests that monetary policy alone may be insufficient to sustain long-term growth and should be complemented by fiscal measures, structural reforms, and policies aimed at improving productivity, credit access, and financial market development.

Finally, the findings emphasize the importance of policy coordination and financial deepening. Strengthening banking intermediation, expanding alternative financing instruments, and enhancing coordination between monetary and fiscal authorities are essential to ensure that monetary policy actions effectively translate into sustained investment growth and long-term economic development.

7. Conclusion

This study has provided an in-depth econometric and economic analysis of the monetary policy transmission mechanism in Morocco, focusing on the dynamic interactions between the policy interest rate, inflation, investment, and GDP growth. By employing a Vector Error Correction Model (VECM), we successfully captured both short-term adjustments and long-term equilibrium relationships, offering empirical insights into how monetary policy interventions

shape macroeconomic variables over time. The findings of this study contribute to both economic theory and policy formulation in several ways.

First, the co-integration analysis confirms the existence of two long-term equilibrium relationships, highlighting the fundamental role of the policy interest rate in inflation stabilization and the investment-to-GDP ratio in economic expansion. This aligns with the Monetary Transmission Mechanism (MTM) theories proposed by Mishkin (1996) and Taylor (1993), which emphasize the impact of monetary policy on price stability and economic activity.

Second, the short-run error correction results indicate that investment adjusts rapidly to economic shocks, whereas GDP converges more gradually toward its long-run equilibrium. This finding is consistent with the New Keynesian Phillips Curve framework proposed by Gali and Gertler (1999), which suggests that monetary policy exerts strong short-term effects on inflation and investment, but more limited direct effects on real output over the long run. Moreover, these results are also in line with the Real Business Cycle (RBC) theory advanced by Kydland and Prescott (1982), which argues that output fluctuations are primarily driven by real productivity shocks rather than monetary policy interventions.

Third, the impulse response functions (IRFs) and variance decomposition analysis confirm that monetary policy shocks significantly influence inflation and investment, while GDP remains largely self-determined over time. The forecasting results for 2024-2026 suggest a sustained decline in inflation, a stabilization of interest rates, and moderate GDP growth oscillations, with investment exhibiting a cyclical adjustment pattern. From a technical econometric perspective, this study has demonstrated the robustness of the VECM framework through rigorous pre-estimation diagnostics, including stationarity testing (ADF test), co-integration testing (Johansen's method), and post-estimation diagnostic checks (Jarque-Bera normality test, Breusch-Godfrey LM autocorrelation test, and characteristic polynomial stability analysis). The significance of the error correction terms (ECTs) and the explanatory power of the system (high R^2 values across equations) confirm the reliability of our results. Moreover, by incorporating Impulse Response Functions (IRFs) and Variance Decomposition (VD) analyses, we provided a deeper structural understanding of the monetary policy transmission mechanism, consistent with recent empirical studies on emerging economies. The findings of this study offer critical policy recommendations for Bank Al-Maghrib and economic policymakers:

- monetary policy efficiency and inflation control: the strong long-term inverse relationship between the policy interest rate and inflation confirms that Morocco's inflation-targeting framework is effective. However, the risk of excessive disinflation (as forecasted beyond 2025) suggests that policymakers should remain vigilant to avoid deflationary pressures.
- investment sustainability and growth strategy: given the high sensitivity of investment to monetary shocks, a balanced approach to interest rate management is required. The cyclical nature of investment, as observed in the forecasted trends, underscores the need for fiscal policy measures (e.g., investment tax incentives, infrastructure financing) to complement monetary interventions.
- structural constraints and financial deepening: the limited impact of monetary policy on GDP growth suggests that structural constraints, such as credit accessibility and capital market development, play a more significant role in shaping economic activity. This finding is consistent with the conclusions of El Haddad et al. (2024), who emphasize the importance of financial inclusion and financial system deepening for enhancing economic stability in Morocco.

- exchange rate stability and monetary policy coordination: given the growing integration of Morocco into global financial markets, maintaining a stable exchange rate regime will be critical in supporting foreign investment and minimizing external shocks.

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