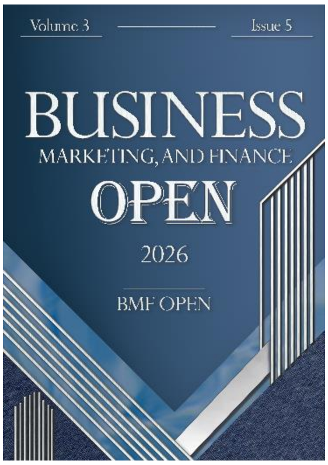
Empirical Analysis of the Impact of Macroeconomic Variables on the Performance of Factor Investment Strategies (Smart Beta) in the Iranian Capital Market



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Abstract: In recent decades, the evolution of financial theories and the development of advanced asset pricing models have paved the way for the emergence of modern investment approaches. Among these, factor investing (smart beta) has emerged as one of the most important approaches, grounded in the identification and exploitation of systematic factors that generate excess returns in financial markets. This approach, which is rooted in the seminal studies of Fama and French (1993, 2015), has today become a core strategy in global asset management. The purpose of the present study is to examine the impact of macroeconomic variables, including economic growth rate, interest rate, and inflation rate, on the performance of five investment factors—size, quality, value, momentum, and low volatility—in the Iranian capital market over the period 2013 to 2024. To this end, the effects of macroeconomic variables on the aforementioned factors were first analyzed using a multivariate regression model. Subsequently, two types of investment portfolios were constructed: an equally weighted five-factor portfolio and an adaptive three-factor portfolio based on the performance of the top three factors in each of the economic regimes of recession, expansion, and stability, and their performances were compared. The findings indicate that macroeconomic variables have a statistically significant impact on the performance of all examined factors, except for the quality factor. Moreover, the results of portfolio performance comparison show that the adaptive three-factor portfolio outperforms the equally weighted five-factor portfolio across all economic regimes. These findings underscore the importance of considering macroeconomic conditions and adopting dynamic approaches in the design of factor-based investment strategies in the Iranian capital market.

Keywords: Factor investing; Macroeconomic variables; Adaptive portfolio; Economic regimes; Iranian capital market.

1. Introduction

Over the past several decades, the evolution of financial economics has fundamentally transformed the way investment strategies are conceptualized, evaluated, and implemented in capital markets. Traditional asset pricing frameworks, most notably the Capital Asset Pricing Model (CAPM), initially emphasized a single source of systematic risk captured by market beta, assuming stable relationships between risk and return across time and economic conditions [1, 2]. While these early models provided an essential foundation for modern portfolio theory, empirical anomalies and persistent deviations from predicted returns gradually revealed their limitations, particularly in environments characterized by macroeconomic instability, structural change, and market heterogeneity [3, 4]. These shortcomings motivated the development of multifactor asset pricing models and, subsequently, the emergence of factor-based investment strategies.

Factor investing represents a systematic approach to portfolio construction that seeks to capture persistent risk premia associated with identifiable characteristics such as size, value, momentum, profitability, and volatility. The seminal work of Fama and French introduced the three-factor model, demonstrating that size and value factors explain a substantial portion of cross-sectional stock returns beyond market risk [5]. This framework was later expanded to incorporate profitability and investment factors, culminating in the five-factor model that further strengthened the empirical foundations of factor-based asset pricing [6]. Parallel research identified additional economically intuitive factors, including momentum [7], low beta [8], and gross profitability [9], reinforcing the view that asset returns are shaped by multiple systematic forces rather than a single market dimension.

As factor investing matured, it transitioned from a purely academic construct into a cornerstone of professional asset management. Large institutional investors increasingly adopted "smart beta" strategies that combine passive implementation with active factor exposure, aiming to improve risk-adjusted returns, transparency, and cost efficiency [10, 11]. However, the growing popularity of factor investing also sparked critical debate regarding factor crowding, instability of factor premia, and the risk of over-reliance on historical averages. Recent contributions emphasize that factor returns are neither constant nor universal, but instead vary across time, markets, and macroeconomic states [12]. This recognition has shifted scholarly attention toward understanding the conditional and regime-dependent behavior of factor strategies.

Macroeconomic conditions play a central role in shaping asset prices and expected returns. Early empirical studies established that variables such as inflation, interest rates, and economic growth contain valuable information about future stock market performance [3]. Subsequent research demonstrated that business cycles influence consumption risk, discount rates, and investor expectations, thereby affecting both the level and volatility of asset returns [1, 13]. These insights underscore the importance of integrating macroeconomic dynamics into asset pricing and portfolio construction, particularly in economies subject to frequent shocks and policy interventions.

The interaction between factor investing and macroeconomic regimes has therefore become an increasingly important research frontier. Empirical evidence suggests that factor premia exhibit pronounced time variation and that their performance is closely linked to the phase of the business cycle. For example, momentum strategies often perform well during expansionary periods but suffer significant reversals during market downturns [7], whereas low-risk or defensive factors tend to provide protection during recessions [8]. Value and size factors have also been shown to respond asymmetrically to changes in interest rates, inflation, and economic growth, reflecting differences in firms' financial structures and sensitivity to discount rate fluctuations [6, 9]. These findings challenge the notion of static factor allocation and motivate the development of adaptive strategies that adjust factor exposures in response to evolving economic conditions.

To formally capture regime-dependent dynamics, researchers have increasingly relied on nonlinear econometric frameworks, particularly Markov-switching models. These models allow for endogenous identification of latent economic regimes and provide a flexible structure for modeling abrupt changes in volatility, mean returns, and factor sensitivities [14]. Applications of regime-switching models in finance have demonstrated their effectiveness in explaining time-varying risk premia, beta dynamics, and conditional asset pricing relationships [15, 16]. By distinguishing between regimes such as recession, stability, and expansion, these models offer a theoretically grounded and empirically robust approach to linking macroeconomic conditions with financial market behavior.

The relevance of regime-based analysis is particularly pronounced in emerging and frontier markets, where structural breaks, policy shifts, and external shocks are more frequent. Iran's capital market provides a compelling case in this regard. Over recent decades, the Iranian economy has experienced substantial macroeconomic volatility driven by inflationary pressures, monetary policy changes, international sanctions, and geopolitical uncertainty. Empirical evidence indicates that inflation and monetary policy exert regime-dependent effects on stock returns in Iran, highlighting the inadequacy of linear models in capturing market dynamics [17]. These conditions raise important questions about the stability and effectiveness of factor-based investment strategies in such environments.

Despite the growing international literature on factor investing and macroeconomic regimes, several gaps remain. First, most empirical studies focus on developed markets, where financial systems are relatively stable and data availability is high. The applicability of established factor models to emerging markets with distinct institutional characteristics remains underexplored. Second, while recent research acknowledges time variation in factor premia, fewer studies explicitly integrate regime identification and factor allocation within a unified empirical framework. Third, existing work often treats macroeconomic variables as exogenous controls rather than as fundamental drivers of regime shifts that shape factor performance over time.

Addressing these gaps requires a comprehensive analytical framework that combines multifactor asset pricing, macroeconomic analysis, and nonlinear regime-switching techniques. Such an approach enables a deeper understanding of how systematic risk factors behave across different economic states and whether adaptive allocation can enhance risk-adjusted performance. Moreover, in economies characterized by high inflation, interest rate volatility, and recurrent shocks, the ability to align investment strategies with macroeconomic regimes is not merely an academic exercise but a practical necessity for asset managers and policymakers.

Beyond technical considerations, behavioral and institutional dimensions also influence investment outcomes. Investor decision-making is subject to cognitive biases such as anchoring, which can amplify mispricing and affect factor returns, particularly during periods of heightened uncertainty [18]. At the same time, broader structural factors, including investment knowledge, social capital, and institutional development, shape the effectiveness of financial strategies and market participation [19]. These elements are especially relevant in emerging markets, where informational frictions and heterogeneous investor sophistication can interact with macroeconomic regimes to produce distinctive return patterns.

Furthermore, global economic integration and cross-border investment flows introduce additional layers of complexity. Infrastructure development, international investment risks, and transnational capital movements can indirectly affect domestic asset prices by altering growth prospects and risk perceptions [20, 21]. Although these factors are often studied in isolation, they collectively underscore the need for a holistic perspective on investment strategy design—one that recognizes the interplay between macroeconomic forces, market structure, and factor dynamics.

In light of these considerations, a regime-aware analysis of factor investing in the Iranian capital market offers both theoretical and practical contributions. From a theoretical standpoint, it extends the factor investing literature by examining the conditional behavior of factor premia within a volatile emerging economy. From a methodological perspective, it integrates multivariate macroeconomic analysis with Markov-switching models to capture nonlinear dynamics and regime transitions. From a practical standpoint, it provides actionable insights for designing adaptive factor portfolios that respond to changing economic conditions, thereby improving risk-adjusted performance in an uncertain environment.

Accordingly, the aim of this study is to empirically examine the impact of macroeconomic variables on the performance of factor-based investment strategies in the Iranian capital market and to design regime-adaptive factor portfolios based on Markov-switching identification of economic cycles.

2. Methodology

From a philosophical perspective, this study is situated within the positivist paradigm and is conducted with the aim of identifying and testing causal relationships between macroeconomic variables and the performance of factor-based investment strategies in the Iranian capital market. In terms of purpose, the present research falls within the category of applied–developmental studies. The primary objective of the study is to generate actionable knowledge in the field of asset management and the design of risk factor–based investment strategies that are capable of adapting to changing economic conditions. At the same time, by extending the factor investing literature within the context of an emerging and highly volatile market, this research contributes to the development of existing theoretical foundations. The findings of the study have direct applicability for asset managers, professional investors, and capital market policymakers.

In terms of nature, the research is descriptive–analytical. In the descriptive phase, the characteristics of the Iranian capital market, the behavior of various investment factors, and the trends of macroeconomic variables are examined in order to provide a clear picture of prevailing conditions. In the analytical phase, causal relationships among variables are tested using multivariate econometric models and regime-switching models. This combined approach enables a deeper understanding of market dynamics and the mechanisms through which macroeconomic variables influence the performance of investment factors.

This study adopts a longitudinal time-series approach and covers the period from March 2013 to March 2025. The selection of this time horizon is justified by its coverage of major economic and political events, including international sanctions, the implementation of the Joint Comprehensive Plan of Action (JCPOA), the withdrawal of the United States from the JCPOA, the outbreak of the COVID-19 pandemic, and severe macroeconomic fluctuations. The extended study period allows for the identification of complete economic cycles and the application of Markov-switching models to distinguish different economic regimes. Moreover, this interval encompasses diverse periods of boom and recession in the capital market, thereby enabling a comprehensive evaluation of factor-based investment strategy performance.

The statistical population of this study includes all firms listed on the Tehran Stock Exchange and Iran Fara Bourse that were active in the main markets (including the First Market, Second Market, and Iran Fara Bourse) during the period from 2013 to 2025. Due to information opacity and the absence of complete and audited financial statements, firms listed on the Base Market were excluded from the study population.

From the aforementioned population, the final research sample was selected by applying the following screening criteria.

First, industry exclusions were applied. Firms operating in the banking and credit institutions, insurance, investment companies, and holding companies were excluded due to fundamental differences in balance sheet structure, income statements, and the nature of their operations. In addition, firms in the agriculture and farming sector were excluded because of specific accounting conditions and pronounced non-systematic volatility.

Second, fiscal year-end alignment was required. To ensure comparability and consistency in the timing of financial variable calculations, only firms with fiscal years ending in March were included in the final sample. Firms with non-March fiscal year-ends (e.g., September) were excluded.

Third, other general criteria were maintained, including a minimum of three consecutive years of continuous market presence, no trading suspension exceeding six consecutive months, and the availability of complete financial information for the entire study period.

To ensure practical tradability, firms with low liquidity were excluded, and observations exhibiting abnormal price fluctuations not attributable to corporate actions were removed from the dataset. Ultimately, a sample comprising approximately 250 to 300 firms was selected for analysis, providing sufficient statistical power for the construction of factor portfolios and the execution of econometric tests.

The data used in this study include adjusted daily stock price data, firm-level financial information, macroeconomic data, and overall market information. Price and financial data were extracted from trading systems and reputable databases such as TSE Technology, TSE Client software, and BourseView. Macroeconomic data, including economic growth rate, inflation rate, and the risk-free interest rate, were collected from official sources such as the Central Bank of the Islamic Republic of Iran and the Statistical Center of Iran. These data were employed to calculate returns, construct investment factors including size, value, quality, momentum, and low volatility, and model the relationships between investment factors and macroeconomic variables.

The process of data collection and preparation comprised the stages of planning, raw data collection, data cleaning and validation, organization, and final preparation for analysis. Throughout this process, logical, statistical, and consistency checks were applied to identify errors and outliers, thereby ensuring data accuracy, consistency, and reliability. Ultimately, the refined dataset was used to conduct econometric analyses and test the research hypotheses.

Table 1. Research Variables and Their Measurement

Variable Type	Variable Name	Symbol	Definition and Measurement
Dependent	Return on size factor portfolio	RSIZE	Return on the size-based portfolio (Small–Big), constructed by ranking firms according to market capitalization and calculated as the value-weighted average return of constituent stocks. Returns are adjusted for cash dividends and capital increases.
Dependent	Return on value factor portfolio	RVALUE	Return on the value-based portfolio (book-to-market ratio), in which firms are ranked based on this ratio and returns are computed as a value-weighted average.
Dependent	Return on quality factor portfolio	RQUALITY	Return on the portfolio based on firms' profitability quality and financial stability indicators, calculated as the value-weighted average return of constituent stocks.
Dependent	Return on momentum factor portfolio	RMOM	Return on the momentum-based portfolio, constructed by ranking stocks based on past performance and calculating the total portfolio return.
Dependent	Return on low-volatility factor portfolio	RLOWVOL	Return on the portfolio consisting of stocks with lower historical volatility, calculated as a value-weighted average return.
Dependent	Return on equally weighted five-factor portfolio	REQ5F	Simple average return of the five single-factor portfolios (size, value, quality, momentum, and low volatility), representing the traditional factor investing strategy without economic regime adjustment.
Dependent	Return on regime-adaptive portfolio	RADAPT	Return on a portfolio whose factor weights are determined based on the identified economic regime (expansion, recession, stability) and the historical performance of factors within each regime.
Independent	Economic growth rate	GDPG	Quarterly growth rate of real gross domestic product, representing the business cycle conditions and the level of economic activity.

Independent	Interest rate	IR	Weighted average of bank deposit rates and treasury bill yields, representing the opportunity cost of investment and the discount rate for cash flows.
Independent	Inflation rate	INF	Inflation rate calculated based on changes in the Consumer Price Index (CPI), reflecting inflationary pressures in the economy.
Independent (Regime)	Economic expansion regime	DBOOM	Dummy variable derived from the Markov-switching model, indicating periods of economic expansion.
Independent (Regime)	Economic recession regime	DRECESS	Dummy variable derived from the Markov-switching model, indicating periods of economic recession.
Independent (Regime)	Economic stability regime	DSTABLE	Dummy variable derived from the Markov-switching model, indicating periods of relative economic stability.
Control	Market factor	MKT	Excess return of the Tehran Stock Exchange total index over the risk-free rate of return.
Control	Market liquidity	LIQ	Market liquidity index calculated based on the total trading volume and value of the stock market.
Control	Market volatility	VOL	Standard deviation of the Tehran Stock Exchange total index returns as a proxy for overall market risk.
Control	Seasonal variables	SEASON	A set of dummy variables used to control for seasonal effects related to economic activity and corporate reporting.

To empirically examine the impact of macroeconomic variables on the returns of factor-based investment strategies and to design strategies adapted to economic cycles, this study employs a combination of time-series regression models and Markov regime-switching models. The modeling framework is designed to identify both the linear effects of macroeconomic variables on factor portfolio returns and the behavioral heterogeneity of the market across different economic regimes.

Multivariate Time-Series Regression Model

To analyze the impact of macroeconomic variables on factor portfolio returns, a multivariate time-series regression model is employed. This model enables the simultaneous examination of changes in economic growth, interest rates, and inflation alongside control variables. The general form of the model is specified as follows:

$$R_{p,t} = \alpha + \beta_1 \Delta Growth_t + \beta_2 \Delta Interest_t + \beta_3 \Delta Inflation_t + \beta_4 R_{m,t} + \beta_5 Liquidity_t + \beta_6 Volatility_t + \sum \gamma_i Seasonal_i + \varepsilon_t$$

where $R_{p,t}$ denotes the return on the factor portfolio at time t, $\Delta Growth_t$ represents changes in the economic growth rate, $\Delta Interest_t$ denotes changes in the interest rate, $\Delta Inflation_t$ denotes changes in the inflation rate, $R_{m,t}$ is the excess market return, and the remaining variables are control variables.

This model is estimated separately for the five single-factor portfolios (size, value, quality, momentum, and low volatility) as well as for the equally weighted five-factor portfolio, allowing for a comparison of the sensitivity of different factors to macroeconomic variables.

Given the potential simultaneity between stock returns and macroeconomic variables, appropriate lags of the explanatory macroeconomic variables are incorporated into the model. In addition, Granger causality tests are conducted to examine the direction of causal relationships among variables. To avoid spurious regression, unit root tests are performed on all variables, and in cases of non-stationarity, differencing or cointegration approaches are applied.

To further examine the impact of macroeconomic variables on factor portfolio returns, a three-variable linear regression is estimated as follows:

$$R_{p,t} = \alpha + \beta_1 \Delta GDP_t + \beta_2 \Delta Interest_t + \beta_3 \Delta Inflation_t + \varepsilon_t$$

where:

• $R_{p,t}$is the quarterly return of portfolio $p$in quarter t. Quarterly returns are calculated for six portfolios (five single-factor portfolios plus the equally weighted five-factor portfolio) from July 2013 to December 2024, comprising a total of 46 quarters.

• ΔGDP_t, $\Delta Interest_t$, and $\Delta Inflation_t$denote changes in quarterly economic growth, the interest rate, and point-to-point inflation, respectively.

To control for the effects of severe economic shocks, an economic shock dummy variable is added to the model.

To ensure that the regression results are not unduly influenced by major economic shocks (such as intensified international sanctions or the COVID-19 pandemic), a dummy variable labeled Economic Shock is incorporated into the model. This variable takes the value of 1 for quarters affected by such events (as specified in the corresponding table) and 0 otherwise.

$$R_{p,t} = \alpha + \beta_1 \Delta GDP_t + \beta_2 \Delta Interest_t + \beta_3 \Delta Inflation_t + \beta_4 D\_Shock_t + \varepsilon_t$$

For each portfolio, the regression model is estimated twice: once without the shock variable and once with the shock variable. Comparing the coefficients and significance levels of the macroeconomic variables across these two specifications allows for an assessment of the impact of economic shocks and provides evidence on the robustness of the results.

Markov-Switching Autoregressive Model (MS-AR)

To identify different economic regimes, a Markov-switching autoregressive model is employed. This model enables the detection of structural changes in the data-generating process and the separation of periods of recession, stability, and expansion. The baseline variable for regime identification is the quarterly economic growth rate, which is recognized in the literature as the primary indicator of business cycles. The general form of the MS-AR model is specified as follows:

$$\Delta Growth\_t = \mu(S\_t) + \varphi_1(S\_t)\Delta Growth\_\{t-1\} + \varphi_2(S\_t)\Delta Growth\_\{t-2\} + \ldots + \varphi\_p(S\_t)\Delta Growth\_\{t-p\} + \varepsilon\_t$$

where S_t denotes the state (regime) variable, which takes the values 1, 2, or 3, corresponding to recession, stability, and expansion, respectively. μ(S_t) represents the regime-dependent mean, and φ_i(S_t) are the regime-dependent autoregressive coefficients.

The transition probabilities between regimes are determined by the Markov transition matrix:

P = $[p_{11} p_{12} p_{13};\ p_{21} p_{22} p_{23};\ p_{31} p_{32} p_{33}]$

where p_{ij} denotes the probability of transitioning from regime i to regime j. The sum of each row of this matrix equals one.

Estimation of this model is conducted using the Maximum Likelihood method. The Expectation–Maximization (EM) algorithm is applied to solve the associated complex optimization problem. This procedure consists of two iterative steps: the expectation step, in which the posterior probabilities of the regimes are computed, and the maximization step, in which the model parameters are updated.

To enhance the accuracy of regime identification, quarterly real gross domestic product data covering the period from 2000 to 2024 are utilized. Due to changes in the base year of the national accounts, all data are converted to constant prices of 2021 to obtain a continuous and comparable time series.

Historical Performance Analysis of Factors across Economic Regimes

After identifying economic regimes, the historical performance of each investment factor within each regime is calculated. For each factor and each regime, indicators including mean return, standard deviation, Sharpe ratio, maximum drawdown, and the probability of positive returns are computed. These indicators form the basis for evaluating factor efficiency and risk under different economic conditions and play a key role in determining factor weights in regime-adaptive strategies.

Factor Weight Optimization Model

To determine the optimal factor weights in each economic regime, three approaches are employed. In the simplest approach, the weight of each factor is set proportional to its historical mean return in the corresponding regime. In a more advanced approach, mean–variance optimization is used to maximize the portfolio Sharpe ratio. The objective function in this method is defined as:

$$\text{Max } w'\mu / \sqrt{(w'\Sigma w)}$$

where w is the vector of factor weights, μ is the vector of expected factor returns, and Σ is the covariance matrix of factor returns. This optimization is subject to constraints such as the sum of weights equaling one and the prohibition of short selling.

The third approach adopts a Bayesian framework in which parameter uncertainty is explicitly incorporated. This method is particularly useful when data are limited or uncertainty is high. In this approach, prior distributions are specified for the parameters, and posterior distributions are derived using observed data.

In this study, to ensure the validity of the econometric results, a set of standard statistical tests was conducted prior to model estimation using the Python programming environment. Stationarity of variables was examined using the Augmented Dickey–Fuller and Phillips–Perron tests, and in the presence of unit roots, differencing or cointegration methods were applied. Residual normality was assessed using the Jarque–Bera and Shapiro–Wilk tests, homoskedasticity was evaluated using the Breusch–Pagan and White tests, and the absence of autocorrelation was examined using the Durbin–Watson, Breusch–Godfrey, and Ljung–Box tests; where necessary, robust estimators were employed. Validation of the Markov-switching model was performed using the Hansen and Garcia tests, information criteria including AIC, BIC, and HQ to determine the optimal number of regimes, as well as tests of parameter stability and regime classification quality. The performance of investment strategies was compared using t-tests and Wilcoxon tests, stochastic dominance tests, and the Reality Check and Superior Predictive Ability (SPA) tests. Finally, the robustness of the results was examined through sensitivity analysis, subsample analysis, bootstrap methods, and out-of-sample tests in the Python programming environment to ensure the generalizability and predictive power of the models.

3. Findings and Results

The descriptive statistics presented in Table 2 indicate that the examined sample provides an adequate representation of the structure of the Iranian capital market in terms of industry composition and firm size. The high concentration of market capitalization in capital-intensive industries such as petrochemicals and basic metals, alongside the widespread presence of smaller firms in other industries, reflects the structural heterogeneity of the market. This characteristic provides an appropriate setting for testing size and value factors.

Table 2. Descriptive Statistics of the Sample, Macroeconomic Variables, and Market Returns

Variable Category	Variable / Group	Mean	Standard Deviation	Minimum	Maximum	Key Remark
Industry composition	Number of firms	–	–	–	–	273 firms from 10 industries
	Largest industry	–	–	–	–	Petrochemicals (21.2% of firms, 28.3% of market capitalization)
Firm size	Q1 (largest)	812.4	–	185.2	4,285.7	68.5% of market capitalization
	Q5 (smallest)	7.3	–	2.1	13.1	1.4% of market capitalization

Macroeconomic (quarterly)	Economic growth (%)	2.34	5.87	−12.4	14.2	High volatility, non-normal
	Interest rate (%)	18.75	4.32	11.2	29.8	Relatively stable
	Inflation rate (%)	26.89	11.45	7.8	52.3	Severe volatility
Market returns (monthly)	Market index return (%)	1.87	12.43	−32.5	42.8	High return, high risk
	Risk-free return (%)	1.42	0.38	0.8	2.3	Very low volatility
	Market excess return (%)	0.45	12.41	−33.2	41.5	Sharpe = 0.036

The firm size distribution indicates a strong concentration of market capitalization in the largest firm quintile, such that the largest 20% of firms account for approximately 68.5% of total market capitalization. This pattern, which is a salient feature of emerging markets, underscores the importance of examining factor strategies and dynamic weighting schemes.

At the macroeconomic level, a positive but highly volatile average economic growth rate, together with high interest and inflation rates, reflects the unstable macroeconomic environment of Iran during the study period. The rejection of normality for economic growth and the wide range of inflation fluctuations indicate the presence of frequent economic shocks and regime shifts, thereby justifying the use of regime-based approaches in the design of investment strategies.

Finally, the analysis of market returns shows that although the Iranian stock market generated positive nominal returns during the study period, high volatility and a low Sharpe ratio imply that risk-adjusted returns were not particularly attractive. This finding highlights the necessity of employing factor-based strategies adapted to macroeconomic conditions in order to improve risk-adjusted performance.

Table 3. Regression Results of the Impact of Macroeconomic Variables on Factor Returns

Factor	Economic Growth	Interest Rate	Inflation Rate	Economic Shock	R^2	Most Significant Effects (5% level)
Size (SMB)	+0.18*	−0.24*	+0.09	−2.15	0.34	Growth (+), Interest (−)
Value (HML)	−0.15	+0.32*	−0.12	−3.78*	0.29	Interest (+), Shock (−)
Quality (QLT)	+0.05	−0.08	+0.03	−1.24	0.11	None (insignificant)
Momentum (MOM)	+0.25*	−0.37*	+0.15*	−4.23*	0.48	Growth (+), Interest (−), Inflation (+), Shock (−)
Low Volatility (LVOL)	−0.09	+0.18	−0.04	+2.15*	0.22	Shock (+)
Equally weighted five-factor portfolio	+0.05	−0.04	+0.02	−1.38	0.09	None (insignificant)

Significance levels are reported at $p < 0.05$.

The panel analysis in Table 3 indicates that macroeconomic variables exert heterogeneous effects on the behavior of investment factors, with the magnitude and direction of these effects depending on factor-specific characteristics. The momentum and size factors exhibit the highest sensitivity to economic fluctuations. For the size factor (SMB), economic growth has a significant positive effect, while interest rates have a significant negative effect, indicating greater flexibility of small firms during economic expansions and their high sensitivity to financing costs. In contrast, value factors (HML) perform better in high interest rate environments but are more vulnerable to economic shocks, suggesting lower dependence of value stocks on discount rates and a stronger adverse impact of crisis conditions on their performance. The quality factor (QLT) appears largely independent of economic developments and, due to intrinsic characteristics such as financial stability and competitive strength, represents a defensive and stable option for investors. By contrast, the momentum factor (MOM) shows the greatest sensitivity to macroeconomic variables, with positive effects during expansionary and inflationary periods and pronounced negative effects during crises, reflecting the distinctive behavioral dynamics of the Iranian stock market. The low-volatility factor (LVOL) acts as a safe haven during economic downturns, with positive shocks contributing to its performance. Finally, the equally weighted five-factor portfolio, despite its relative insensitivity to macroeconomic variables, exhibits an R^2 of 0.09, indicating that factor diversification can mitigate the systematic effects of economic conditions and serve as a suitable tool for risk-averse investment strategies.

Table 4. Summary of Economic Regime Identification Results Using the Markov-Switching Model

Number of Regimes	Log-Likelihood	AIC	BIC	HQ	Regimes	Key Parameters
2 regimes	−128.45	264.9	273.2	268.1	Recession, Stability	–
3 regimes	−121.78	257.6	270.4	262.9	Recession, Stability, Expansion	Optimal model
4 regimes	−119.23	258.5	276.9	266.0	–	–

Table 5. Summary of Economic Regime Identification Results Using the Markov-Switching Model

Number of Regimes	Log-Likelihood	AIC	BIC	HQ	Regimes	Key Parameters
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3 regimes	−121.78	257.6	270.4	262.9	Recession, Stability, Expansion	Optimal model
4 regimes	−119.23	258.5	276.9	266.0	–	–

Table 6. Estimated Parameters for the Three-Regime Model

Parameter	Recession (Regime 1)	Stability (Regime 2)	Expansion (Regime 3)
Mean (μ)	−4.28	1.85	7.63
Standard deviation (σ)	3.12	2.45	4.08
Persistence probability	0.75	0.82	0.68
Average duration	4.0 quarters	5.6 quarters	3.1 quarters

Table 7. Transition Probability Matrix Between Economic Regimes

From Regime	To Recession	To Stability	To Expansion
Recession	0.75	0.20	0.05
Stability	0.12	0.82	0.06
Expansion	0.15	0.17	0.68

The results obtained from applying the Markov-switching model to identify economic regimes in Iran indicate that the behavior of economic growth is significantly nonlinear and can be explained within distinct regimes. A comparison of models with two, three, and four regimes based on the AIC, BIC, and HQ information criteria shows that the three-regime model provides the best balance between statistical fit and model complexity. Specifically, this model yields the lowest AIC and HQ values and an optimal BIC relative to competing specifications. This finding confirms that the dynamics of Iran's economic growth cannot be adequately explained by a purely linear or two-state structure, and that the presence of an intermediate regime between recession and expansion is statistically and economically necessary.

Estimation of the three-regime model parameters demonstrates that the regimes are clearly differentiated in terms of mean growth, risk, and persistence. The recession regime is characterized by a negative average quarterly growth rate of −4.28 percent, reflecting periods of severe economic contraction, while its relatively high volatility captures the heightened uncertainty prevailing during such episodes. By contrast, the stability regime exhibits a positive but moderate average growth rate of 1.85 percent and represents the dominant state of the Iranian economy over the study period. With the lowest standard deviation and the highest persistence probability (0.82), this regime is the most stable economic state. The expansion regime is identified by a high average quarterly growth rate of 7.63 percent; however, despite its strong performance, it is associated with higher volatility and a lower persistence probability, indicating that episodes of rapid economic growth in Iran are typically short-lived and unstable.

Analysis of the regime transition matrix provides important insights into the dynamics of business cycles. The high probability of remaining within each regime, particularly the stability regime, indicates structural stickiness in the Iranian economy, meaning that changes in macroeconomic states tend to occur gradually rather than abruptly. Moreover, the very low probability of a direct transition from recession to expansion (0.05) suggests that exits from recession generally proceed through the stability regime, and that direct jumps to expansion are rare. This pattern is highly consistent with the historical evidence of Iran's economy, where gradual recoveries have typically replaced rapid growth surges. Overall, the results of the Markov-switching model indicate that the Iranian economy has predominantly remained in a state of stability, with recession and expansion regimes appearing intermittently and transitorily. This finding provides an important analytical foundation for examining the performance of investment factors and for designing investment strategies adapted to economic cycles.

4. Discussion and Conclusion

The empirical results of this study provide robust evidence that macroeconomic variables and economic regimes play a decisive role in shaping the performance of factor-based investment strategies in the Iranian capital market. The regression findings demonstrate that factor returns are not homogeneous in their response to economic growth, interest rates, inflation, and large-scale shocks, thereby rejecting the assumption of time-invariant factor premia that underlies many static asset pricing models. This result is consistent with the broader asset pricing literature, which emphasizes that expected returns and factor loadings are conditional on the state of the economy rather than fixed parameters [1, 2]. The relatively low explanatory power of linear models for some factors, combined with their improved performance once regime dynamics are incorporated, highlights the importance of nonlinear and state-dependent approaches in emerging markets.

The strong sensitivity of the size factor to macroeconomic conditions aligns with theoretical expectations and prior empirical findings. Small firms typically exhibit greater financial constraints, higher leverage sensitivity, and stronger dependence on domestic demand, making their returns more responsive to changes in economic growth and interest rates. The positive relationship between economic growth and size-factor performance observed in this study supports the notion that small-cap stocks benefit disproportionately from expansionary phases, when credit conditions improve and growth opportunities expand [6]. Conversely, the negative impact of rising interest rates on the size factor reflects increased financing costs and heightened default risk for smaller firms, a mechanism widely documented in factor investing research [10, 11]. In the context of Iran's capital market, where access to external financing is often constrained, these effects appear to be amplified.

The value factor exhibits a distinct pattern, performing relatively better in high interest rate environments while remaining vulnerable to severe economic shocks. This finding is consistent with the interpretation that value stocks, often characterized by lower growth expectations and higher tangible asset backing, are less sensitive to changes in discount rates than growth stocks, but are more exposed to downturns that directly impair cash flows and balance sheets [5, 9]. Previous studies have documented that value premia tend to fluctuate across business cycles, sometimes disappearing or reversing during crisis periods, particularly in economies experiencing structural instability [12]. The Iranian evidence corroborates this conditional behavior and underscores the limitations of relying on value strategies without accounting for macroeconomic regimes.

One of the most notable findings of this study is the relative insulation of the quality factor from macroeconomic fluctuations. The absence of statistically significant relationships between macroeconomic variables and quality-factor returns suggests that firms with strong profitability, stable earnings, and sound financial structures offer defensive characteristics across different economic states. This result is consistent with the gross profitability premium documented in international markets, where high-quality firms demonstrate resilience during downturns and maintain more stable performance over time [9]. In an environment marked by high inflation and policy uncertainty, such as Iran, the defensive nature of quality stocks becomes particularly valuable, reinforcing their role as a stabilizing component in diversified portfolios [10].

The momentum factor displays the highest degree of macroeconomic sensitivity, exhibiting positive exposure during periods of economic expansion and inflation, and pronounced vulnerability during crises and negative shocks. This asymmetric behavior reflects the well-documented procyclical nature of momentum strategies, which tend to thrive in trending markets but suffer sharp reversals when regimes shift abruptly [7]. The Iranian market's pronounced behavioral dynamics, combined with episodic policy and external shocks, appear to intensify momentum crashes, thereby increasing the importance of regime awareness when implementing momentum-based strategies. These findings align with recent critiques of factor investing that emphasize the risks of crowded and regime-dependent factors [12].

The low-volatility factor's positive response to economic shocks supports its characterization as a defensive or "safe-haven" strategy. During periods of heightened uncertainty, investors tend to rebalance toward lower-risk assets, driving relative outperformance of low-volatility stocks [8]. The Iranian evidence suggests that this mechanism operates even in less developed markets, reinforcing the universality of defensive factor behavior across different institutional settings. However, the moderate explanatory power of macroeconomic variables for this factor also indicates that its performance is influenced by additional market-specific dynamics, such as liquidity conditions and investor risk aversion.

A central contribution of this study lies in the regime-switching analysis of economic growth. The identification of three distinct regimes—recession, stability, and expansion—provides strong evidence that Iran's macroeconomic dynamics are inherently nonlinear. The superiority of the three-regime Markov-switching model over simpler alternatives confirms that a binary classification of economic states is insufficient to capture the complexity of business cycles in volatile economies [14]. The dominance of the stability regime, coupled with the short-lived nature of expansionary phases, is consistent with historical patterns of Iran's economy, where structural rigidities and external constraints limit the sustainability of rapid growth episodes [17].

The regime-dependent performance analysis further demonstrates that adaptive factor allocation strategies consistently outperform static, equally weighted factor portfolios across all economic states. This finding directly supports the growing body of literature advocating for conditional and dynamic factor investing approaches [10, 11]. By adjusting factor weights based on historical performance within each regime, adaptive portfolios are better positioned to exploit favorable conditions while mitigating downside risk during adverse periods. This result also resonates with studies showing that time-varying risk premia and factor loadings are central to understanding asset returns [2, 16].

From a broader perspective, the results underscore the importance of integrating macroeconomic analysis into portfolio construction, particularly in emerging markets subject to frequent shocks and policy shifts. The Iranian capital market's sensitivity to inflation, interest rates, and growth volatility mirrors findings from other developing economies, where macroeconomic instability significantly influences asset pricing dynamics [3, 13]. Moreover, behavioral and institutional factors—such as anchoring effects and disparities in investment knowledge—may further amplify regime-dependent patterns by affecting investor reactions to macroeconomic news [18, 19]. Although these dimensions are not directly modeled in this study, the empirical results are consistent with a framework in which economic regimes, investor behavior, and factor dynamics interact to shape market outcomes.

Finally, the findings have implications beyond the domestic context. In an increasingly interconnected global economy, macroeconomic regimes influenced by infrastructure development, international investment risks, and transnational capital flows can indirectly affect domestic factor performance [20, 21]. The Iranian case illustrates how local macroeconomic instability can condition factor returns in ways that differ from developed markets, thereby contributing to the ongoing debate on the generalizability of factor investing principles across countries and institutional environments [12]. Overall, the results provide strong empirical support for regime-aware, adaptive factor investing as a superior approach to portfolio management in volatile emerging markets.

Despite its contributions, this study is subject to several limitations. First, the analysis relies on historical data from a single emerging market, which may limit the generalizability of the findings to other countries with different institutional, regulatory, and macroeconomic characteristics. Second, the construction of factor portfolios depends on available financial data, which may be affected by reporting quality and survivorship biases. Third, while the Markov-switching framework captures nonlinear regime dynamics, it remains a reduced-form approach that does not explicitly model the structural causes of regime transitions. Finally, transaction costs, market frictions, and short-selling constraints are not fully incorporated, which may affect the real-world implementability of the proposed strategies.

Future research could extend this framework in several directions. Comparative cross-country studies could assess whether regime-dependent factor behavior observed in Iran holds in other emerging and frontier markets. Incorporating additional macro-financial variables, such as exchange rates or fiscal indicators, may provide a more comprehensive view of regime dynamics. Advanced machine learning and nonlinear modeling techniques could also be employed to improve regime detection and factor allocation. Furthermore, integrating behavioral measures or investor sentiment indicators could enhance understanding of how psychological factors interact with macroeconomic regimes to influence factor returns.

For practitioners, the results highlight the importance of moving beyond static factor allocations toward dynamic, regime-aware investment strategies. Asset managers should regularly monitor macroeconomic indicators and adjust factor exposures in line with prevailing economic conditions. Emphasizing defensive factors during periods of instability and reallocating toward procyclical factors during expansions can improve risk-adjusted performance. Policymakers and market institutions may also benefit from these insights by promoting transparency, data quality, and financial education to support more informed and resilient investment decision-making in volatile economic environments.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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References

[1] J. Y. Campbell, "Asset prices, consumption, and the business cycle," in *Handbook of Macroeconomics*, vol. 1, J. B. Taylor and M. Woodford Eds.: Elsevier, 1999, pp. 1231-1303.
[2] T. Adrian and F. Franzoni, "Learning about beta: Time-varying factor loadings, expected returns, and the conditional CAPM," *Journal of Empirical Finance,* vol. 16, no. 4, pp. 537-556, 2009, doi: 10.1016/j.jempfin.2009.02.003.
[3] N. F. Chen, R. Roll, and S. A. Ross, "Economic forces and the stock market," *Journal of Business,* vol. 59, no. 3, pp. 383-403, 1986, doi: 10.1086/296344.
[4] M. Boldrin, L. J. Christiano, and J. D. Fisher, "Habit persistence, asset returns, and the business cycle," *Econometrica,* vol. 69, no. 6, pp. 1635-1674, 2001, doi: 10.21034/sr.280.
[5] E. F. Fama and K. R. French, "Common risk factors in the returns on stocks and bonds," *Journal of Financial Economics,* vol. 33, no. 1, pp. 3-56, 1993, doi: 10.1016/0304-405X(93)90023-5.
[6] E. F. Fama and K. R. French, "A five-factor asset pricing model," *Journal of Financial Economics,* vol. 116, no. 1, pp. 1-22, 2015, doi: 10.1016/j.jfineco.2014.10.010.
[7] N. Jegadeesh and S. Titman, "Returns to buying winners and selling losers: Implications for stock market efficiency," *Journal of Finance,* vol. 48, no. 1, pp. 65-91, 1993, doi: 10.1111/j.1540-6261.1993.tb04702.x.
[8] A. Frazzini and L. H. Pedersen, "Betting against beta," *Journal of Financial Economics,* vol. 111, no. 1, pp. 1-25, 2014, doi: 10.1016/j.jfineco.2013.10.005.
[9] R. Novy-Marx, "The other side of value: The gross profitability premium," *Journal of Financial Economics,* vol. 108, no. 1, pp. 1-28, 2013, doi: 10.1016/j.jfineco.2013.01.003.
[10] A. Ang, *Asset management: A systematic approach to factor investing*. Oxford University Press, 2021.
[11] J. Bender, R. Briand, D. Melas, and R. Subramanian, *Foundations of factor investing*, 2 ed. MSCI Research, 2022.
[12] R. D. Arnott, C. R. Harvey, V. Kalesnik, and J. T. Linnainmaa, "Rehabilitating factor investing," *Journal of Portfolio Management,* vol. 49, no. 5, pp. 10-31, 2023.
[13] F. M. Bandi, S. E. Chaudhuri, A. W. Lo, and A. Tamoni, "Business-cycle consumption risk and asset prices," *Journal of Econometrics,* vol. 222, no. 1, pp. 354-375, 2021.
[14] M. Guidolin, "Markov switching models in empirical finance," *Advances in Econometrics,* vol. 27, pp. 1-86, 2011, doi: 10.1108/S0731-9053(2011)000027B004.
[15] C. Aloui and D. K. Nguyen, "Regime switching affine processes with applications to finance," *Finance and Stochastics,* vol. 24, no. 2, pp. 309-345, 2014, doi: 10.1007/s00780-020-00419-2.
[16] L. Wang, Y. Zhou, J. Guo, M. Qi, and N. Wang, "A Markov regime switching model for asset pricing and ambiguity measurement of the stock market," *Neurocomputing,* vol. 435, pp. 283-294, 2021, doi: 10.1016/j.neucom.2020.12.103.
[17] S. Aghababaei and A. Feghhi, "Inflation, monetary policy, and stock returns in Iran: A regime-switching approach," *Iranian Economic Review,* vol. 26, no. 4, pp. 735-760, 2022, doi: 10.22059/ier.2022.332145.1007740.
[18] Z. Zhong, "The Impact of Anchoring Effect on Financial Investment Decisions and Coping Strategies," *Advances in Economics Management and Political Sciences,* vol. 164, no. 1, pp. 50-55, 2025, doi: 10.54254/2754-1169/2025.20718.
[19] H. Zamaniyan, R. Farhadi, and A. Rezaeiyan, "The Role of Genetic Capital and Social Capital in the Development of Investment Knowledge," *Journal of Investment Knowledge,* vol. 14, no. 2, p. Summer, 2025.

[20] L. Zhao, Q. Li, and J. M. Chen, "How does infrastructure investment boost tourism development?," *Tourism Economics*, 2025, doi: 10.1177/13548166251315789.
[21] W. Yizhou, "Intellectual Property Risks of Transnational Corporate Investment," *Advances in Economics Management and Political Sciences*, vol. 181, no. 1, pp. 183-188, 2025, doi: 10.54254/2754-1169/2025.23261.