A Structural Predictive Model for Near-Accurate Market Performance Under Uncertainty: Computational Statistical Evidence from JSE Firms

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Abstract*—This paper presents a structural predictive model to analyse and forecast firm-level market performance in uncertain times, with JSE-listed firms as an empirical case. The paper presents a dual-regime specification in our model to distinguish stable policy conditions from turbulent contexts, which permits estimation without the dependence on a fixed equilibrium. A balanced panel-data set of 10 leading JSE firms over 2016–2025, including firm-level stock returns and prominent macroeconomic variables of interest (inflation, GDP growth, and exchange rate movements), is used for modeling. Our models are estimated using fixed-effects panel regression within a set of interaction terms incorporating disruption periods, including the COVID-19 shock (2020–2021) and prolonged instability (2022–2023). This structural model improves the explanatory power (R^2 = 0.478 compared with 0.319) and reduces the information loss (AIC = 866.8 compared to 880.2) as compared to a traditional model. Furthermore, the impact of the disruption period on returns is significantly negative, whereas GDP and disruptions interaction reveals that during crises, economic growth accounts for less in explaining the market performance. These findings indicate that explicitly modeling disrupted conditions leads to better prediction stability in a volatile environment. It offers a solid framework for analysts, policymakers, and system designers in developing countries, those exposed to changes in policy and shocks from the outside world.

***Keywords*—Structural modeling; market uncertainty; JSE; market performance; computational statistics**

I. Introduction

Market prediction continues to be difficult in times when economic conditions change rapidly, and there are no common patterns to follow. The presence of macroeconomic variables generally assumes stable relationships between them and firm-level performance in the established models. This assumption does not apply in practice, especially in emerging markets where there are frequent policy shifts, external shocks, and structural instability [1], [2]. The COVID-19 pandemic provides a clear example of how market behavior can take a sudden turn. Firms experienced a steep drop in the value of their assets, followed by various fluctuations in growth rates and economic growth across industries and regions. At the same time, exchange rate volatility, supply chain disruptions, and global uncertainty exerted sustained stress on financial systems. In such circumstances, models based on historical relationships struggle to make predictions. This is visible on the Johannesburg Stock Exchange (JSE). Global commodity cycles, currency movements, and the domestic policymaking environment determine firm performance on the JSE. This trend is not static over time, and if firms' performance goes by chance or indeed in the long term at all, it is then that this kind of linkage between macroeconomic indicators and firm-level outcomes weakens further, and the pattern changes with time. As a result, traditional predictive methods fail to retain their reliability whenever the market shifts.

This study addresses any deficiency by providing structural models that track how a market changes as conditions in one direction become totally different from what it was before. The model differentiates between periods when economic relations remain stable and periods when those relationships weaken or end up breaking down. By allowing disparities in economic performance to be covered within one model that captures so many of them, the model increases predictive consistency across different settings, and it also increases overall predictive power by allowing these different results into a single model. The treatment of uncertainty is the heart of this approach.

The model regards uncertainty not as an outside disturbance; instead, it is part of the system, and it modulates the way in which variables interact. This enables the model to replicate firm reactions under stress as opposed to prior relationships having not moved much [7], [8]. Three contributions are presented in this paper. First, it proposes a framework for empirical market analysis that allows changes in conditions within a single predictive framework. Second, it reveals empirical evidence that JSE firms have been making real improvements at a level different from what conventional models can offer. Third, the framework offers us guidelines that can be applied to other emerging markets, where the importance of instability is key to affecting trends.

II. Problem Statement

Financial market prediction systems make the general assumption that the relationship between macro determinants and firm-level performance remains fixed over time. Although under normal times this assumption may hold and therefore be successful, under structural instability, policy changes, and external shocks, it is not valid. Such problems are rife in the emerging sector, for instance, in South Africa, and undermine the trustworthiness of traditional predictive methodologies [1], [2].

The COVID-19 pandemic laid bare this limitation. During this time, financial markets weakened, became more volatile, and experienced interdependencies affecting the economy. Macroeconomic signals like GDP growth and inflation did not translate into firm-level outcomes and no longer provided predictable and reliable historical information. The pandemic created unprecedented disruptions to global financial systems and economic activity, confirmed in global economic reports, diminishing the traditional predictive nature [3], [4]. Current approaches to resolve the above problem may be volatility measures or scenario analysis, but these approaches do not consider uncertainty as a structural element of the economy. This constrains their capacity to account for altering relationships among variables with respect to varying economic environments. Specifically, they fail to capture periods in which the structural framework of the market breaks down, leading to disruptions in classical macroeconomic transmission mechanisms.

This study fills this gap by formulating a structural predictive model that explicitly adjusts the estimation process for the changing market states. The model identifies stable periods and disrupted periods, based on which the correlation between macro variables and firm performance depends on which of those periods is expected to hold. By including uncertainty in the model rather than treating it only as an external variable, the approach enhances predictive consistency and offers a more accurate representation of how the markets behave in the real marketplace.

III. Literature and Conceptual Framework

A. *Conventional Market Prediction Models*

Historically, econometric forecasting approaches, including autoregressive models, vector autoregression (VAR), and panel data for market prediction, have had the best performance in such a scenario. They are effective when the relations between macroeconomic factors and firm performance are static over time. It has been established, and the foundation of time series analysis and causation work has been proven, that such models represent dynamic interaction across time in relatively stable economic circumstances [9], [10]. But their performance falls flat when the structure of these relationships is changed by structural changes, especially in periods of economic disturbance.

B. *Treatment of Uncertainty in Existing Models*

Most empirical studies introduce uncertainty via volatility indicators or stochastic error terms. Whilst it accepts outcomes as such, it does not take into consideration situations where the structure of the economic system itself undergoes a structural transformation. In times of significant disturbance, the connection between macroeconomic factors and corporate performance becomes unstable, which undermines the predictive validity of models. Literature provides evidence that uncertainty shocks can have a major impact on investment behavior, output, and financial markets, in a manner not easily accounted for through traditional research [11],[12]. Accordingly, accounting for uncertainty as a by-product of the decision-making process weakens these models for explaining uncertainties.

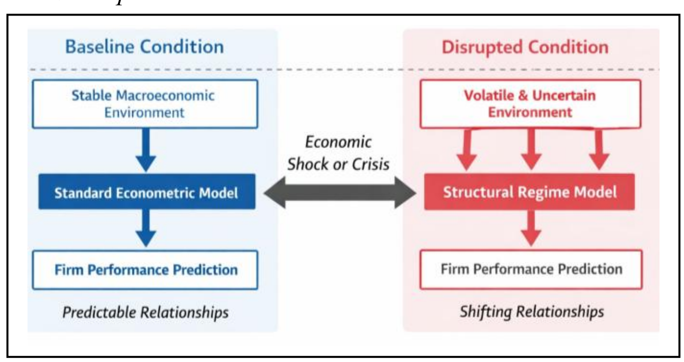
C. *Regime-Based and Alternative Approaches*

To cope with limitations, regime-based models have been proposed in which parameters are not fixed and can vary between economic states. They add new flexibility by modeling differences between high-growth and low-growth environments or stable and unstable conditions [13]. However, they rely on assumptions about transition probabilities that don't always fit with actual changes in the underlying structures of an entity. Scenario-based approaches could represent an alternative, simulating different conditions in the economy, but are typically applicable outside of the estimation framework rather than integrated within the estimation process. As a consequence, they are unable to capture how relationships change within the model [14].

D. *Evidence from Emerging Markets*

In emerging markets, less than optimal or stable economic environments and more vulnerability to external shocks are the main drawbacks of conventional models, more pronounced. Stock market performances are influenced by exchange rate volatility, commodity price movements, and macroeconomic instability in the context of South Africa. In financial markets, it appears that these factors contribute to non-linear responses, and thus, conventional models have difficulty in modeling reliable relationships among the variables [6], [15]. Consequently, predictive models that neglect those dynamics generally become less reliable in times of heightened uncertainty.

E. *Conceptual Framework*



[a] Conceptual framework developed by the authors

Fig. 1. Conceptual Framework

IV. Econometric Framework and Identification Strategy

A. *Structural Representation and Regime Dependence*

The empirical basis for this model is that the correlation between macroeconomic variables and firm-level performance is relative to the visible conditions of the economy. Instead of considering parameter integrity, the model establishes a regime-dependent pattern, and systematic fluctuations in the coefficient response can be observed. This does not rely on latent state processes or on probabilistic switching mechanisms [2], [11]. Structural changes are included in the estimation regime by reference to observable regime indicators. This method ensures that the model can include baseline effects and fluctuations associated with instability, mirroring the non-linear behaviour seen in financial markets under uncertainty [12].

B. *Identification and Inference Under Common Shocks*

Identification is made based on time variability at the macroeconomic variables and on periods of disruption and does not rely purely on cross-sectional variation. As macroeconomic shocks impact all the firms at once, the framework relies on within-sample time variation and regime-dependent sensitivity to separate them. Additional identifying variance can be accounted for by interaction structures that take into account variability in reactions among economic conditions, permitting consistent estimation across common shocks [16]. Assumption of variance under relaxed assumptions is also applied for inferences. The disturbance term is permitted to be heteroskedastic, especially during disturbances when volatility is higher. Sturdy covariance estimates are thus used to make valid statistical inferences as well as to prevent biases induced by non-constant variance [21].

C. *Parameter Stability and Model Contribution*

The framework specifically considers instability of parameter coefficients, so coefficients also vary according to regime. With this, the effect caused by omission of structural breaks in linear specifications is circumvented [2]. The validity of the model is tested by comparing regime-dependent terms' joint significance, which is suggestive of whether, in general, macroeconomic relationships are stable through different time periods. The advantage of this method is its possibility to build structural variance into a linear panel framework that is both interpretable and easy to estimate. Since these regime effects are internalized in the model, the result can represent economic relationship changes automatically without the need for complex non-linear estimation methods, and is thus suitable for empirical investigations in volatile and developing market situations [13].

D. *Specification Diagnostics and Robustness Considerations*

The correct specification of the model and consistency of parameter estimates under such conditions should be important for the validity of the empirical framework, as they relate to violations of classical assumptions. The model is then subjected to specification diagnostics and robustness considerations to mitigate this. The first step in mitigating the risk of omitted variable bias is adding firm-specific fixed effects, which control for unobserved heterogeneity that could be correlated with the regressors. Furthermore, multicollinearity among macroeconomic variables is investigated for coefficient estimates stability and interpretability. The impact of high collinearity, especially concerning interaction terms and standard errors, is often to weaken statistical inference and to produce relatively larger standard errors. Third, heteroskedasticity and possibilities for cross-sectional dependence are clearly acknowledged. Financial panel data tends to be characterized by the clustering of volatility and co-movement among firms in response to systemic shocks. To compensate for this, robust covariance estimators allow for consistent inference when variance assumptions are violated [21]. Lastly, model robustness is evaluated by comparison of different specifications, those that do not have regime-dependent terms. Enhancements in explanatory power and model fit indicate validation of the specification increases when structural interactions are performed. The comparison is used as an indirect check of structural significance, highlighting that regime-dependent effects reflect sufficient variation in the data.

V. Data and Methodology

A. *Data*

This study employed a balanced panel dataset of 10 JSE-listed leading firms covering the period from 2016 to 2025. The sample consists of firms from the sectors: mining, financial services, telecommunications, and energy, ensuring coverage of the market. Annual stock returns in percentage terms measure firm-level performance. Macroeconomic variables are inflation (consumer price index), real GDP growth, and the exchange rate (ZAR/USD). The study selected these variables based on their known capacity to affect financial market performance in global and South African scenarios [6], [15]. The two regime indicators are adopted in order to capture the structural change in the market conditions. The first captures the COVID-19 disruption period (2020–2021), and the second describes a protracted period of disruption (2020–2023) during which uncertainty persisted even as the pandemic receded. These variables allow the model to distinguish between stable and disrupted economic environments.

B. *Model Specification*

The empirical analysis starts with a baseline panel model, which treats macroeconomic variables as stable predictors of firm performance. This is specified as:

$$Return_{it} = \alpha + \beta_1 Inflation_t + \beta_2 GDP_t + \beta_3 FX_t + \mu_i + \epsilon_{it} \quad (1)$$

The model is expanded to include a disruption regime and interaction term to accommodate structural changes. The structural formulation is stated as:

$$\begin{aligned} Return_{it} = \alpha + \beta_1 Inflation_t + \beta_2 GDP_t + \beta_3 FX_t + \beta_4 D_t \\ + \beta_5 (GDP_t \times D_t) + \mu_i + \epsilon_{it} \end{aligned} \quad (2)$$

In this formulation, (D_t) represents the disruption period, and the interaction term explains how the effect of GDP growth changes under disrupted conditions. This allows the model to capture shifts in macroeconomic transmission during times of instability.

C. *Estimation Strategy*

The fixed-effects panel estimate of the model, controlling for firm-specific characteristics that are unobserved, can determine its predictive power. Such variations include differences in firm size, sector exposure, and operational structure [16]. A Hausman test is also used to suggest the preference for fixed effects over random effects. Firm-specific effects are associated with the explanatory variables and justify the use of fixed-effects estimation as a consistent parameter estimation method [17], [18].

D. Diagnostic Testing

Different diagnostic measures are performed to guarantee model reliability. We also conduct a stationarity test by applying the Augmented Dickey-Fuller (ADF) test on all the variables to check that they are stationary at levels [19]. This confirms the validity of the regression without differencing. Multicollinearity is measured by the Variance Inflation Factor (VIF). As expected, all variance values are considered acceptable, and therefore, there is no strong link between explanatory variables [20]. Heteroskedasticity is established by the Breusch-Pagan test. The results prove heteroskedasticity, and robust standard errors are therefore chosen to rectify it [21].

VI. Results

A. Descriptive Statistics

Table I presents the summary statistics for the variables in the analysis. A large divergence in firm-level returns can be seen from the sample for the stable versus the disordered market.

TABLE I. DESCRIPTIVE STATISTICS

Descriptive Statistics				
Variable	***Mean***	***Std. Dev***	***Min***	***Max***
Return (%)	12.4	18.6	-35.2	52.1
Inflation (%)	4.8	1.5	3.2	7.1
GDP Growth (%)	1.9	2.8	-6.4	4.3
Exchange Rate	15.2	2.3	12.5	19.1

B. Correlation Analysis

Table II reports the correlation matrix. The results show that returns are positively associated with GDP growth and negatively associated with inflation and exchange rate depreciation.

TABLE II. CORRELATION MATRIX

Correlation Matrix				
	Return	***Inflation***	***GDP***	***FX***
Return	1.00			
Inflation	-0.21	1.00		
GDP	0.34	-0.18	1.00	
FX	-0.29	0.42	-0.25	1.00

C. Model Estimation Results

Table III presents the results of the baseline and structural models in this context. The structural model includes the disruption variable and the interaction terms, allowing the relationship between GPD and those of the returns to vary across conditions.

TABLE III. PANEL REGRESSION RESULTS

Panel Regression Results		
Variable	**Baseline**	**Structural**
Inflation	-0.92**	-1.24**
GDP Growth	2.15***	2.87***
Exchange Rate	-0.74**	-0.98**
Disruption	—	-5.62***
GDP × Disruption	—	-1.45**
R^2	0.319	0.478
Adjusted R^2	0.172	0.324
AIC	880.2	866.8

*a. Robust standard errors are applied. **, ** indicate significance at the 1% and 5% levels, respectively.

In this context, as evidenced above, the structural model shows a clear improvement over the baseline model. The increase in R^2 indicates stronger explanatory power, while a lower AIC indicates a better model fit.

D. Interpretation of Results

a) Inflation and Market Performance: The research findings indicate that inflation has a significantly negative impact on firm-level returns. This result is also in tune with well-established theories that argue that increasing inflation increases production costs, reduces real consumer demand, and induces financial market uncertainty [22], [23]. In South Africa, the result is to have inflationary pressures that come with tighter monetary policy (and interest-rate adjustments) that are used as an impetus to increase the capital cost and reduce the firm's liquidity. That in turn means higher inflation reduces not only firm profitability but also investor confidence, ultimately decreasing stock returns [5].

b) Economic Growth and Firm Performance: The positive and significant coefficient on GDP growth confirms that economic expansion supports firm-level performance under stable conditions. This aligns with the broader literature, where economic growth is associated with higher corporate earnings, improved business conditions, and stronger investor sentiment [24], [25]. However, this relationship must be interpreted within the broader context of changing economic conditions, as the strength of this link is not constant over time.

c) Exchange Rate Dynamics: For the exchange rate variable, a negative and statistically significant relationship is indicated, such that currency depreciation creates downward pressure on stock returns. This is especially essential in emerging markets, such as South Africa, where firms tend to depend on the exchange-rate fluctuations from imports, exports, and foreign capital flows. A weakening domestic currency raises input costs, lowers margins, introduces uncertainty in cross-border transactions, and negatively impacts the value of firms in trade and hence the valuation of companies [6], [26]. Such effects are stronger in times of economic turmoil when exchange rates are higher in volatility.

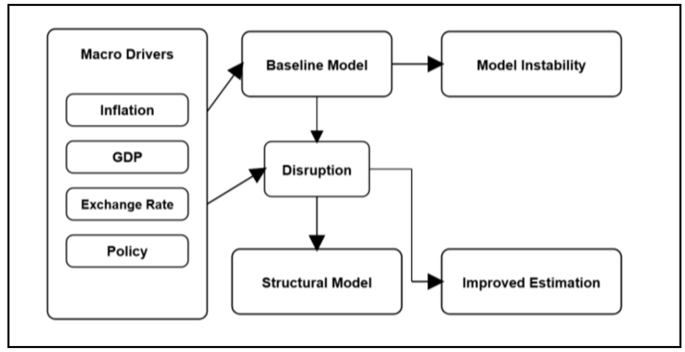
*d) Impact of Disruption (COVID-19 and Beyond))*The variable of disruption is negative and highly significant, demonstrating that systemic shocks cause a big negative impact on market performance. The COVID-19 crisis constitutes a prime example of such a shock, with the global market going through a very steep slide in value and its fluctuations as well as investor sentiment [3], [27]. The enduring impact of this effect beyond the short-term crisis indicates that market recovery is slowly underway under uncertain conditions. This underlines the need to overtly consider disruption in the analysis of market behavior.

e) Weakening of Macroeconomic Transmission During Disruption: GDP growth versus disruption shows that under stress, there are fundamental changes in economic dynamics. The fact that growth has a negative coefficient tells us that the effects of stimulus during times of disturbance weaken. The strong negative coefficient indicates this weakening effect. This implies that while macroeconomic indicators benefit the economy, even when macroeconomic indicators start improving, they do not perform effectively to affect firm performance. Such a finding is in keeping with uncertainty shocks literature, which suggests that firms tend to delay investment and expansion decisions in the face of high uncertainty [11], [12]. Consequently, economic improvement does not lead to improved demand in the market.

f) Structural Shift in Market Behavior: Findings reveal that relationships between the macroeconomic variables and the firm cannot be considered to be fixed to stabilize over time. Rather, they dynamically fluctuate from one market to another, relative to current market conditions. But during those steady periods, the traditional relationships are relatively strong, and there are powerful signals from other macroeconomic variables in market movement. These relationships decay when the world is going through such events, and additional variables like unknowns, uncertainty, and perceptions of risk, along with the attitude of the market, are taking over [28], [29]. This lends credence to modeling structures that can change, not the constant.

g) Model Performance and Empirical Strength: The improvement in model performance, as reflected in higher R^2 and lower AIC values, confirms that incorporating disruption into the model enhances explanatory power. This indicates that the structural model provides a better fit to the data and captures market dynamics more effectively than the baseline model. These findings are consistent with prior research showing that models incorporating regime changes and non-linear dynamics outperform conventional linear models in volatile environments [13].

h) Implications for Market Modeling: The findings in this study were used to develop a framework as illustrated in fig. 2 and shows that market performance largely depends on macroeconomic variables. In times of uncertainty, stable relationship models do not hold. The structural framework thus incorporates disruption directly into the model, ensuring a much less biased but more accurate analysis of firm-level performance. Such an approach is especially pertinent for emerging economies, which are characterized by more volatility and are often hit by shocks.



[b] Framework developed by the authors

Fig. 2. Disruption-Adjusted Market Modelling Framework

VII. Discussion and Implications

A. *Market Behavior Under Uncertainty*

According to the results presented, models that assume a stable economic relationship are unable to adequately predict market performance. During disruptive event scenarios, like the COVID-19 shock, the performance of a firm decreases sharply, where firm returns deteriorate dramatically, and returns' traditional drivers weaken. This points to a change in market information processing, as uncertainty, risk perception, and exogenous factors start to take precedence over classical macroeconomic signals [11], [28]. Therefore, models based solely on historical relationships cannot maintain prediction consistency. The results support the notion that market behavior varies as the overall state of the economy changes. In steady state conditions, variables such as GDP growth and inflation are expected to behave in similar ways, acting accordingly and giving evidence of a firm's performance. Yet, in times of instability, those links fray, and market reactions become less well-defined.

B. *Implications of Financial Modeling*

The empirical findings indicate that integration of disruptions directly into the model increases the explanatory power and overall ability of the model. We use a structural model for capturing these differences in relationships between variables: one is used without separate models for those periods. This offers a better consistency and practicality in the prediction of the market. For analysts, this indicates that models should be elastic, responsive to shifting economic conditions, not deterministically fixed, including interaction terms or regime-based variables, which enables models to adjust to changing environments, improving their reliability during periods of uncertainty.

C. *Implications for Policy and Investment Decisions*

There are policy and investment implications for policymakers. The weakening of the relationship between growth in GDP and firm performance during disruption periods is of vital interest to policymakers. This implies that better macroeconomic statistics do not necessarily lead to a stronger market recovery when uncertainty is on the rise. Policymakers, therefore, must think about the stability and confidence in supporting the financial markets, rather than the number of growth indicators alone. For investors, they are a reminder to recalibrate expectations in an environment of disruption. "When markets are off, established measures are not going to do much for us. Instead: more investment in risk management, diversification, and forward-looking strategic analysis incorporating uncertainty and structural change [29].

D. Implications for Policy and Investment Decisions

The framework developed in this study is particularly relevant for emerging markets, where economic conditions are often volatile and subject to external shocks. In such environments, market performance is influenced not only by domestic factors but also by global events, exchange rate movements, and policy uncertainty.

By explicitly modelling these conditions, the structural approach provides a more realistic representation of how markets operate. This makes it a useful tool for both researchers and practitioners working in similar contexts, where stability cannot be assumed, and adaptability is essential.

VIII. Conclusion

This study develops a structural predictive model that takes into account changing market conditions when looking at firm-level performance. From empirical data on listed firms in the Johannesburg Stock Exchange, the study reports that the influence macroeconomic factors have on the performance of firms is not constant, but also is dependent on variations regarding economic conditions. The results demonstrate that such instability, for instance, the COVID-19 shock, has adverse effects on firm performance and weakens the size of the positive effects of the macroeconomic fundamentals such as GDP growth. The findings confirm that static models based on traditional historical correlations are ineffective in turbulent situations. For analysis and prediction, adopting a more structural approach with changing conditions allows for a more dependable framework. This study's contribution is the synthesis of stable and disrupted conditions into a single model. As a practical asset to understanding market behavior in the presence of uncertainty, it should be applied to the future for various financial modeling and emerging market analysis studies, too.

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References

[1] R. F. Engle, "Dynamic conditional correlation: A simple class of multivariate GARCH models," *Journal of Business & Economic Statistics*, vol. 20, no. 3, pp. 339–350, 2002.

[2] J. D. Hamilton, "A new approach to the economic analysis of nonstationary time series and the business cycle," *Econometrica*, vol. 57, no. 2, pp. 357–384, 1989.

[3] International Monetary Fund, *World Economic Outlook: The Great Lockdown*. Washington, DC: IMF, 2020.

[4] World Bank, *Global Economic Prospects*. Washington, DC: World Bank, 2021.

[5] South African Reserve Bank, *Quarterly Bulletin*, various issues, 2016–2025.

[6] B. N. Ndlovu and S. Moyo, "Exchange rate volatility and stock market performance in South Africa," *Investment Analysts Journal*, vol. 47, no. 2, pp. 85–98, 2018.

[7] F. H. Knight, *Risk, Uncertainty, and Profit*. Boston, MA: Houghton Mifflin, 1921.

[8] J. E. Stiglitz, "Information and the change in the paradigm in economics," *American Economic Review*, vol. 92, no. 3, pp. 460–501, 2002.

[9] C. W. J. Granger, "Investigating causal relations by econometric models and cross-spectral methods," *Econometrica*, vol. 37, no. 3, pp. 424–438, 1969.

[10] H. Lütkepohl, *New Introduction to Multiple Time Series Analysis*. Berlin, Germany: Springer, 2005.

[11] N. Bloom, "The impact of uncertainty shocks," *Econometrica*, vol. 77, no. 3, pp. 623–685, 2009.

[12] S. R. Baker, N. Bloom, and S. J. Davis, "Measuring economic policy uncertainty," *Quarterly Journal of Economics*, vol. 131, no. 4, pp. 1593–1636, 2016.

[13] J. D. Hamilton, "Regime switching models," in *Handbook of Econometrics*, vol. 4, Amsterdam, Netherlands: Elsevier, 1994, pp. 308–327.

[14] P. Glasserman and B. Young, "How likely is contagion in financial networks?" *Journal of Banking & Finance*, vol. 50, pp. 383–399, 2015.

[15] A. Gupta and R. Inglesi-Lotz, "The relationship between macroeconomic variables and stock returns in South Africa," *Economic Modelling*, vol. 52, pp. 52–61, 2016.

[16] B. H. Baltagi, *Econometric Analysis of Panel Data*, 5th ed. Chichester, UK: Wiley, 2013.

[17] J. M. Wooldridge, *Introductory Econometrics: A Modern Approach*, 6th ed. Boston, MA: Cengage, 2016.

[18] J. A. Hausman, "Specification tests in econometrics," *Econometrica*, vol. 46, no. 6, pp. 1251–1271, 1978.

[19] D. A. Dickey and W. A. Fuller, "Distribution of the estimators for autoregressive time series with a unit root," *Journal of the American Statistical Association*, vol. 74, no. 366, pp. 427–431, 1979.

[20] R. M. O'Brien, "A caution regarding rules of thumb for variance inflation factors," *Quality & Quantity*, vol. 41, no. 5, pp. 673–690, 2007.

[21] T. S. Breusch and A. R. Pagan, "A simple test for heteroskedasticity and random coefficient variation," *Econometrica*, vol. 47, no. 5, pp. 1287–1294, 1979.

[22] M. Feldstein, "Inflation and the stock market," *American Economic Review*, vol. 70, no. 5, pp. 839–847, 1980.

[23] E. F. Fama, "Stock returns, real activity, inflation, and money," *American Economic Review*, vol. 71, no. 4, pp. 545–565, 1981.

[24] J. Y. Campbell and R. J. Shiller, "Valuation ratios and the long-run stock market outlook," *Journal of Portfolio Management*, vol. 24, no. 2, pp. 11–26, 1998.

[25] R. Levine and S. Zervos, "Stock markets, banks, and economic growth," *American Economic Review*, vol. 88, no. 3, pp. 537–558, 1998.

[26] K. M. Dominguez and L. L. Tesar, "Exchange rate exposure," *Journal of International Economics*, vol. 68, no. 1, pp. 188–218, 2006.

[27] OECD, *Global Financial Markets and COVID-19*. Paris, France: OECD, 2020.

[28] G. Bekaert, M. Hoerova, and M. Lo Duca, "Risk, uncertainty and monetary policy," *Journal of Monetary Economics*, vol. 60, no. 7, pp. 771–788, 2013.

[29] L. Pastor and P. Veronesi, "Political uncertainty and risk premia," *Journal of Financial Economics*, vol. 110, no. 3, pp. 520–545, 2013.