

Analysis of the Stock Market Fluctuations, Anomalies and Fear Index Using Data-driven Methodologies

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Problem Description and Dataset

Quantifying stock market volatility is fundamental to understanding and forecasting market behavior. Among various volatility metrics, the most widely recognized are realized and implied volatility measures. Realized volatility captures the fluctuations of underlying securities or indices based on historical price changes over predefined periods, whereas implied volatility is a forward-looking indicator that reflects the market's expectations for future uncertainty. The Chicago Board Options Exchange's (CBOE) VIX index stands out as the primary benchmark for implied volatility, often regarded as an estimator of expected equity market turbulence.

In this project, we develop a regression model aimed at predicting the one-step-ahead monthly value of the VIX index. The model relies on publicly available economic and financial information, derived through the application of text mining techniques. A central data source for this purpose is the equity market volatility (EMV) tracker introduced by Baker, Bloom, Davis, and Kost (2019). The EMV index is constructed by counting the daily number of news articles that contain at least one term from each of the following categories: economy or economic; uncertain or uncertainty; and one or more terms relating to equity markets, such as equity price, stock market, or stock price. The articles considered in the EMV's construction are sourced from more than 1000 U.S.-related newspapers, accessed via the Access World News' NewsBank service.

In this study, we focus specifically on the monthly, category-specific EMV uncertainty indexes, with the aim of identifying the economic, financial, and political factors that potentially trigger

regime switches and transitions in stock market behavior. Throughout the project, we apply machine learning and analytical techniques to investigate the underlying forces behind anomalous events in the stock markets. More specifically, we seek to characterize how economic, political, psychological, and behavioral dynamics interplay to influence stock market movements, leveraging a variety of machine learning tools.

The dataset employed spans from January 1990 to December 2022, encompassing monthly values of the VIX index along with the full set of monthly EMV tracker categories. Our objective is twofold: first, to construct a regression model capable of predicting future VIX values, and second, and perhaps more importantly, to use the regression analysis as a means of uncovering the economic, financial, and political variables that influence VIX behavior over time.

To tackle this problem, we employ four different regression methodologies: Ordinary Least Squares (OLS), Ridge Regression, LASSO, and Elastic Net Regression. For each method, we provide a comprehensive evaluation of its performance, discussing strengths and weaknesses such as sensitivity to multicollinearity, feature selection capabilities, and the degree of sparsity introduced by the model.

In addition to modeling the entire period, we recognize that the forces driving market movements often evolve across time, especially at points of significant regime transitions. Therefore, we apply Elastic Nets regression separately to each market segment, as identified through shifts in volatility patterns. This segmented analysis allows us to better characterize the dominant forces influencing stock market dynamics during distinct periods, offering insights into the phenomena responsible for market regime changes and state transitions.

Github: <https://github.com/sepidfs/dtsa-5509>

Abstract

The use of linear models for forecasting market volatility through EMV trackers is viable via Elastic Nets regression. Segment-wise market analysis suggests that turbulent phases are influenced by numerous driving factors, whereas periods of market stability are characterized by fewer contributing elements. Consistently impactful factors include inflation, financial regulation, labor disputes, broad quantitative indicators, and interest rates. While these models show potential in volatility prediction, their accuracy may decline as market dynamics evolve. Furthermore, it's important to consider how investor decisions may be psychologically affected by their exposure to news media.

Introduction

The stock market is a complex and often unpredictable system. For investors, having some foresight into future market behavior would be highly advantageous. Many traders and investors rely on the Chicago Board Options Exchange's VIX index, which measures volatility and market uncertainty, as a tool for gauging anticipated market fluctuations. Developing a forecast for the next month's VIX value would be extremely useful, enabling more informed adjustments to stock market investments based on expected volatility. Although numerous methods exist for predicting the VIX, one approach involves analyzing a range of financial and economic articles published throughout the month to identify prevalent topics. Such analysis may reveal signs of upcoming market turbulence.

In pursuing this goal, we utilize various equity market volatility (EMV) trackers, similar to those employed in 'Policy News and Stock Market Volatility' by Baker, Bloom, Davis, and Kost (2019). Each tracker represents a particular category, with its value partially influenced by the frequency of related articles appearing across different newspapers.

Each tracker measures the frequency of articles that mention both a term related to its specific category and keywords associated with the economy, the stock market, and volatility (Baker, Bloom, Davis, and Kost, 2019). By gathering information from various text-based sources, we can develop a clearer understanding of the topics dominating public discourse during particular periods. To leverage the EMV indices for forecasting the following month's VIX value, we construct multiple linear regression models and evaluate which one best fits the data. The models under consideration include Ordinary Least Squares (OLS), Ridge, LASSO, and Elastic Nets regression. Our objective is to create accurate predictive models that use the text-derived EMV tracker values to anticipate future VIX values, thereby offering a forecast of upcoming market volatility.

Moreover, we have partitioned the dataset into distinct time segments corresponding to major shifts in market volatility, enabling a more detailed analysis of each phase. These divisions, illustrated in the figure below, allow us to explore the potential causes behind market volatility changes. Specifically, we aim to determine whether the EMV values associated with factors presumed to drive these shifts were elevated prior to, or during, periods of heightened volatility.

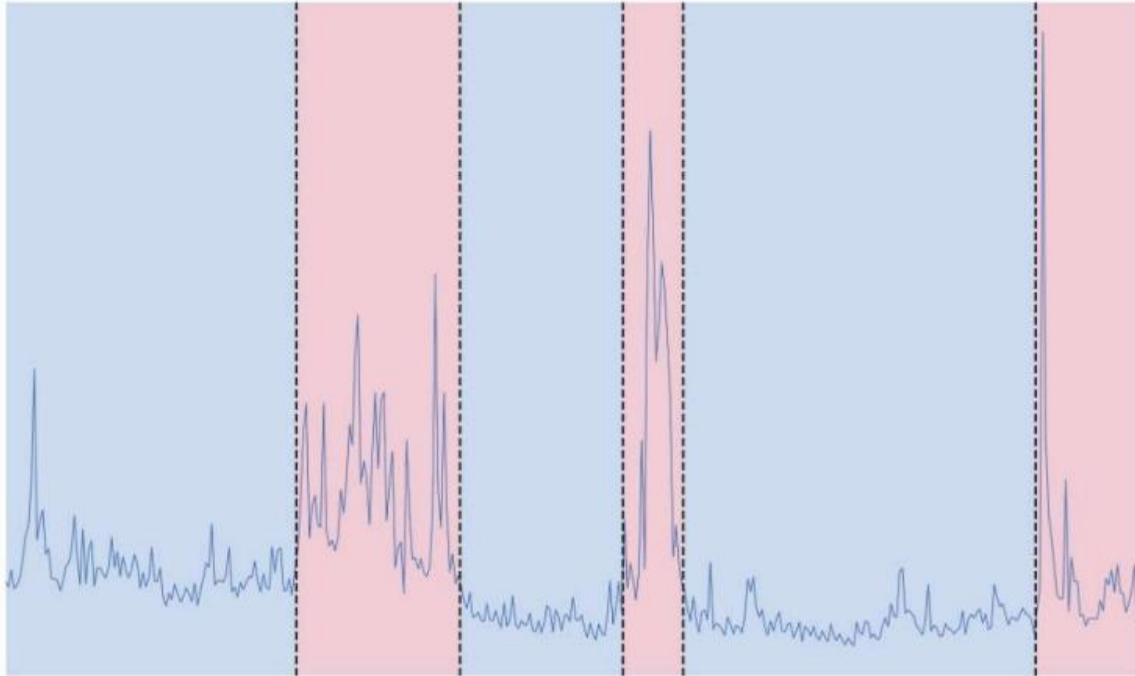


Figure 1: Figure 1: VIX value over time. Pink segments are more volatile, while blue segments are calmer.

In this study, our aim is to validate the effectiveness of linear models in predicting VIX values based on EMV trackers, as well as to investigate which predictors exert the greatest influence on market volatility, both across the entire dataset and within each individual segment.

Explanatory Data Analysis

To gain deeper insight into the relationships between the covariates and the response variable, we computed the Pearson correlation matrix across all variables, excluding the date column. This correlation analysis serves as a preliminary step to identify potential multicollinearity issues and to better understand the associations between the various economic and financial indicators and the future values of the VIX index. The computed correlation matrix reveals several notable patterns that characterize the underlying structure of the dataset.



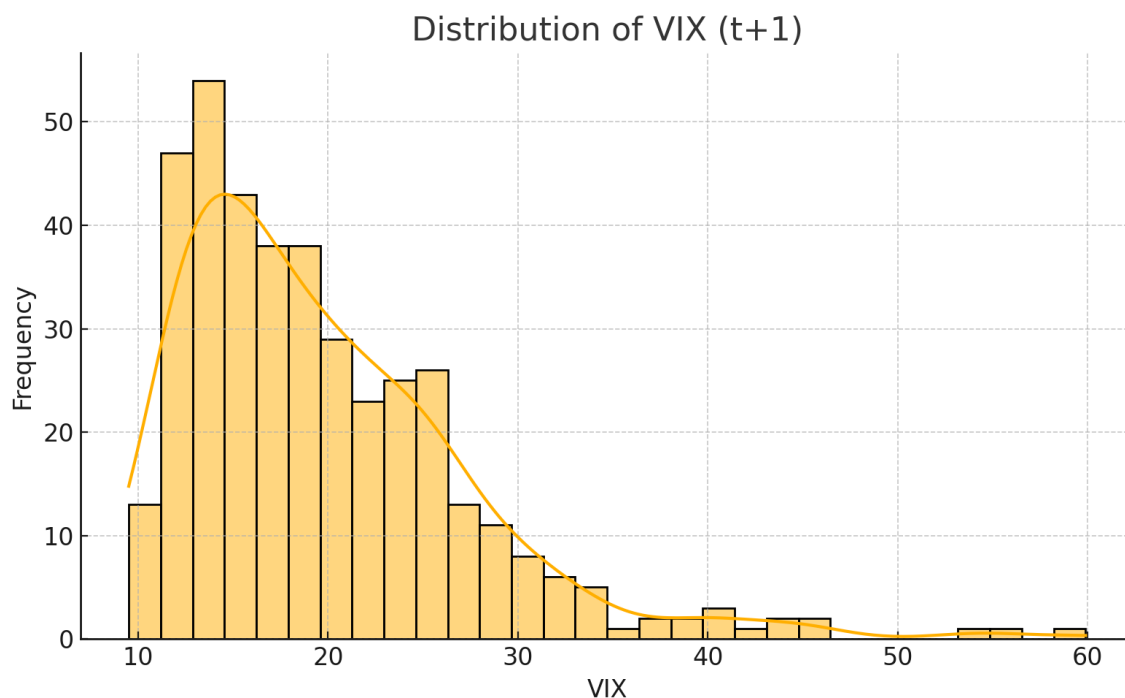
Among the predictors, the EMV index exhibits the strongest positive correlation with the VIX, with a correlation coefficient of approximately 0.885. This finding is consistent with the construction of the EMV tracker, as it is designed to capture economic uncertainty, which is naturally linked to fluctuations in market volatility. Furthermore, other indicators such as the Macroeconomic News and Outlook EMV Tracker, the Political Uncertainty Tracker, and the Financial Regulation EMV Tracker also display substantial positive correlations with the VIX. These relationships suggest that news and events related to economic forecasting, political developments, and financial regulatory changes are closely associated with periods of heightened market volatility. The Commodity

Markets EMV Tracker also demonstrates a moderately strong positive relationship with the VIX, further indicating that uncertainty in commodity markets can transmit to broader financial market instability.

While most strong correlations with VIX are positive, a few predictors exhibit negative correlations, although their magnitudes are relatively small. Indicators related to labor markets and real estate markets, for instance, display mild negative associations with VIX movements. These negative relationships may reflect periods of relative economic strength and stability, during which market volatility tends to be lower.

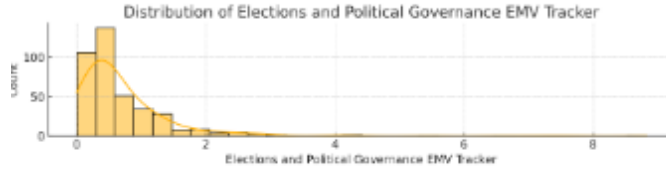
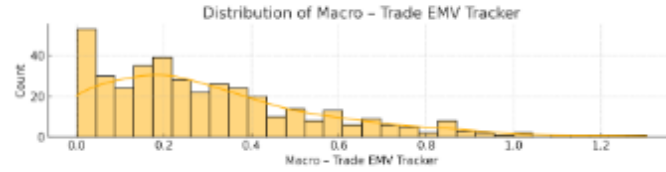
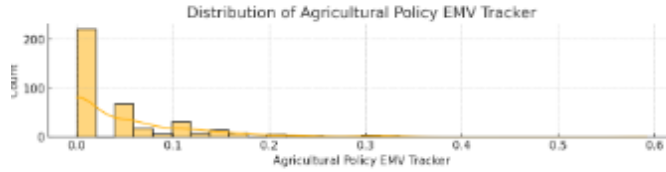
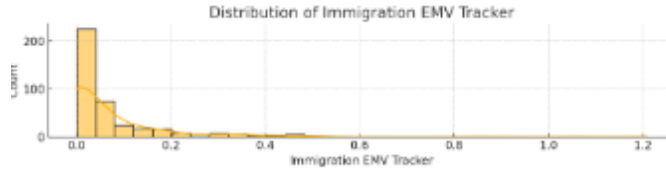
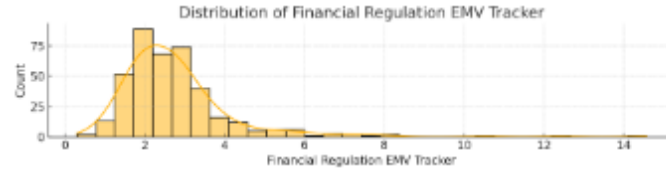
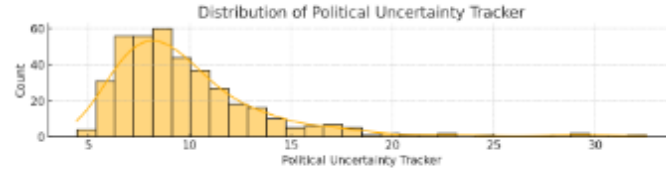
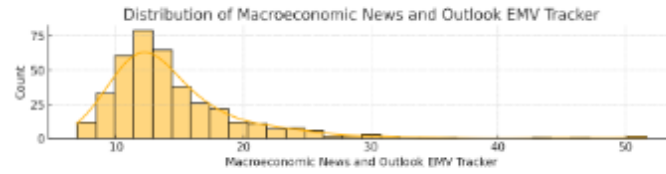
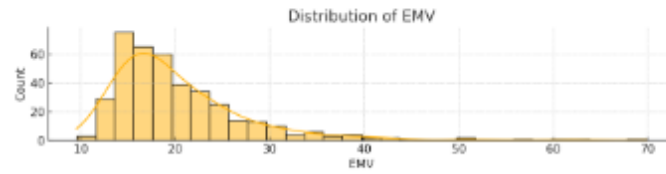
In addition to the relationships between predictors and VIX, the correlation matrix highlights the presence of strong correlations among several predictors themselves. In particular, variables that capture broad economic or policy-related themes, such as EMV, Macroeconomic News, and Political Uncertainty, are highly correlated with each other. This observation is in line with the findings from the variance inflation factor (VIF) analysis, which confirmed the presence of severe multicollinearity in the dataset. Such multicollinearity necessitates the use of shrinkage methods such as Ridge Regression, LASSO, and Elastic Net Regression, as traditional OLS regression would be prone to instability and unreliable coefficient estimates in the presence of highly correlated explanatory variables.

The correlation structure of the dataset thus reinforces the need for careful model selection and regularization when constructing predictive models for the VIX index. The observed patterns also offer early indications of which economic and financial factors may exert the most significant influence on market volatility, a hypothesis that will be further explored through subsequent regression modeling and analysis.



To further investigate the statistical behavior of the response variable and its predictors, we examined the marginal distributions of the VIX index (at time $t+1$) alongside several selected EMV-based covariates. The distribution of the VIX, as shown in Figure 3, is distinctly right-skewed, with a concentration of values in the lower range (between 10 and 25), and a long tail extending toward higher levels of volatility. This skewness reflects the empirical reality of financial markets where episodes of extreme volatility occur relatively infrequently but with substantial magnitude. The mode of the distribution lies well below the mean, underscoring the asymmetry and the presence of occasional volatility spikes, such as those observed during major financial crises or geopolitical shocks.

The covariates selected for distributional analysis include some of the most prominent EMV categories: general EMV, Macroeconomic News and Outlook, Political Uncertainty, Commodity Markets, and Financial Regulation, as well as others such as Immigration, Agricultural Policy, Trade Policy, and Elections and Political Governance. Most of these predictors also exhibit right-skewed distributions, with varying degrees of concentration around lower values and heavier tails. For instance, the distributions of EMV, Macroeconomic News and Outlook, and Political Uncertainty trackers reveal shapes that are qualitatively similar to that of the VIX, indicating that extreme uncertainty events, though rare, are consistently documented across these categories.



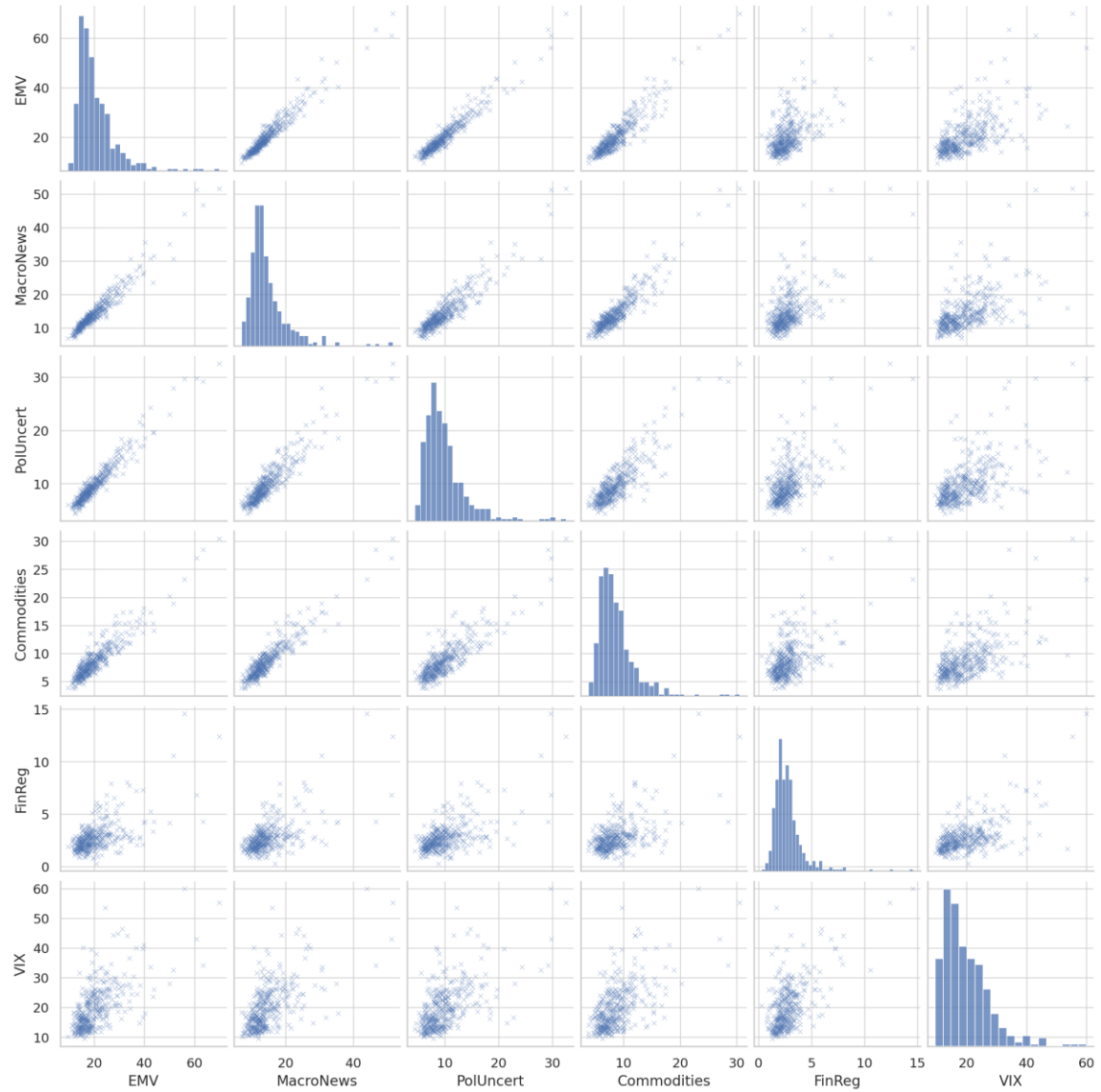
By contrast, certain predictors, particularly those associated with more narrowly defined policy domains—such as the Immigration or Agricultural Policy EMV trackers—exhibit extremely sparse distributions, with the majority of their mass concentrated near zero. These distributions suggest that while such topics are occasionally discussed in the media, they are not frequent enough to contribute a dominant effect unless tied to significant policy events. The Trade Policy and Elections trackers also demonstrate pronounced skewness but with a slightly more dispersed range, reflecting their episodic relevance to financial markets, particularly during periods of geopolitical tension or election cycles.

Overall, the distributional analysis reinforces the asymmetric nature of both the response and the predictors, a characteristic that must be accounted for in model construction and interpretation. Furthermore, the heterogeneous frequency and tail behavior of the EMV-based predictors suggest that while some economic and political themes persistently influence market sentiment, others only manifest during discrete and event-driven episodes. These structural characteristics provide essential context for both regression modeling and the interpretation of temporal segmentation in subsequent analyses.

To further explore the empirical associations between the VIX index and its most informative predictors, we constructed a matrix of bivariate scatter plots—commonly referred to as a pair plot—between the VIX and five of the EMV trackers exhibiting the highest marginal correlation. These include the general EMV index, the Macroeconomic News and Outlook EMV Tracker, the Political Uncertainty Tracker, the Commodity Markets EMV Tracker, and the Financial Regulation EMV Tracker. For ease of interpretation and visual clarity, shortened labels were adopted for the axes.

The scatter plots reveal pronounced positive associations between the VIX and each of the selected EMV-based predictors. In particular, the relationships with EMV, macroeconomic news, and political uncertainty appear especially linear and tightly clustered, reflecting their shared informational content regarding broader economic sentiment and uncertainty. The plots involving commodity markets and financial regulation also exhibit upward-sloping tendencies, albeit with slightly greater dispersion, suggesting a weaker but still meaningful link to future market volatility. These patterns are complemented by the histograms displayed on the diagonal of the pair plot, all of which confirm the right-skewed nature of the marginal distributions—consistent with the fact that extreme market and policy-related events occur relatively infrequently but with significant magnitude when they do arise.

Pair Plot of VIX and Top Correlated EMV Trackers (Short Labels)



The visual structure of the pair plot reinforces earlier findings from the correlation analysis and distributional diagnostics, validating the inclusion of these predictors in the regression models. Moreover, the discernible positive monotonic relationships suggest that the predictive task may benefit from linear modeling frameworks, provided that multicollinearity is adequately addressed. Together, these observations lend empirical justification to the modeling choices employed in subsequent sections of this study.

Model Specification

For this study, we aim to utilize linear regression models due to their relative ease of interpretation. A linear regression model is generally expressed as

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_j x_{ij} + \varepsilon_i$$

In this formulation, y_i denotes the dependent variable for the i -th observation, while x_{ij} represents the j -th independent variable, or predictor, for that observation. The term β_j corresponds to the coefficient associated with the j -th predictor, with β_0 specifically serving as the intercept term. Lastly, ε_i accounts for the error associated with the i -th observation. This model can be expressed more compactly using matrix notation as $Y = X\beta + \varepsilon$, where Y is a vector containing the dependent variable values, X is the design matrix containing all predictor observations (with the first column consisting of ones to represent the intercept), β is a vector of coefficients, and ε is the vector of error terms.

In the context of our problem, Y consists of VIX values, with the i -th element representing the VIX value for the $(i+1)$ -th month. Each non-intercept column of X corresponds to a different EMV tracker, where the j -th row includes the EMV values for month j . Additionally, the date column is removed from the design matrix as it does not influence the results. This yields 46 predictors in total.

Our primary objective in applying various linear regression models is to estimate the coefficients β to facilitate future predictions. However, before proceeding to model fitting, it is crucial to conduct a preliminary analysis of the data to ensure that the key assumptions underlying linear regression are satisfied.

One important condition to examine is multicollinearity, where two or more predictors are highly linearly related. Linear models require that no perfect multicollinearity exists among the predictors. We check for perfect multicollinearity by calculating the rank of the design matrix, finding it to be 46, which includes the intercept column. Since there are 45 EMV indices in our dataset, this suggests that the matrix is of full rank, indicating no perfect multicollinearity. Despite the absence of perfect multicollinearity, it remains important to assess the degree of multicollinearity present. Due to the high dimensionality of the data, visual inspection through plotting is impractical and unreliable. Instead, we calculate the Variance Inflation Factor (VIF) for each predictor, which measures how much the coefficient of determination increases when the predictor is excluded. Higher VIF values indicate stronger multicollinearity, with a threshold of 10

typically used to flag problematic predictors. The following table lists the EMV indices with VIF values exceeding this threshold:

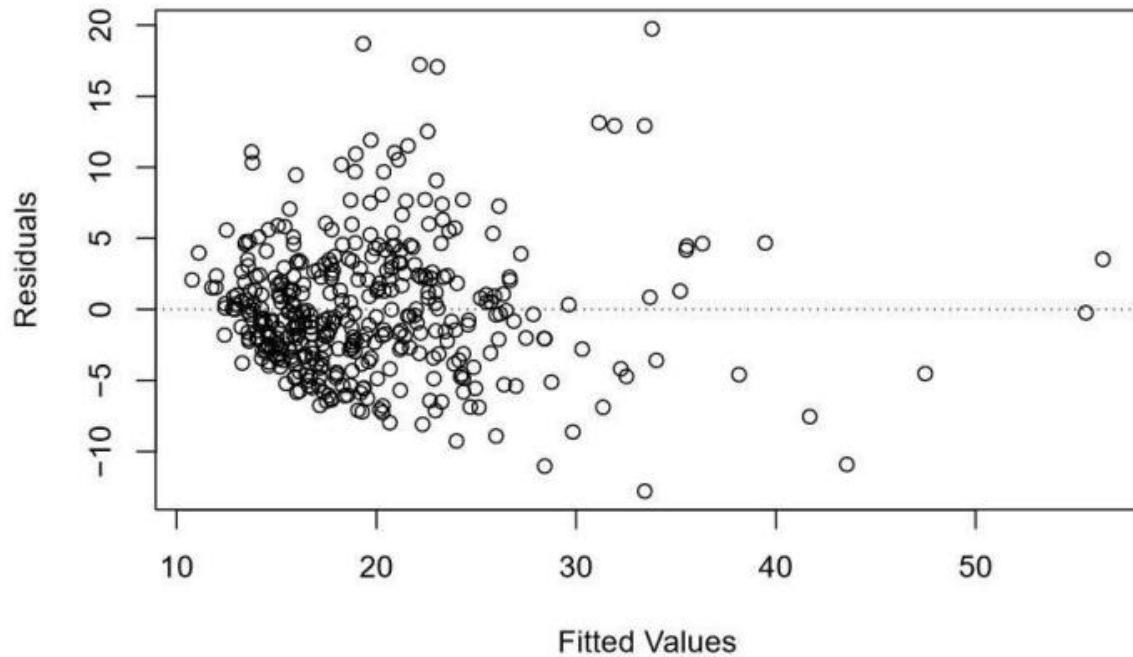
EMV Tracker	VIF
EMV	148.73422
Political Uncertainty Tracker	64.97209
Macroeconomic News and Outlook EMV Tracker	141.73117
Macro – Broad Quantity Indicators EMV Tracker	13.75099
Macro – Labor Markets EMV Tracker	10.76287
Macro – Real Estate Markets EMV Tracker	15.63493
Commodity Markets EMV Tracker	40.83936
Healthcare Matters EMV Tracker	13.55624
Fiscal Policy EMV Tracker	63.15667
Taxes EMV Tracker	28.99129
Monetary Policy EMV Tracker	13.10752
Regulation EMV Tracker	16.01153
Financial Regulation EMV Tracker	12.43745
Healthcare Policy EMV Tracker	11.31716
Petroleum Markets EMV Tracker	10.41846

As shown above, a significant number of our predictors exhibit signs of multicollinearity, with some displaying extremely high VIF values. Even predictors omitted from the table, though not exceeding the threshold of 10, have VIFs approaching it, suggesting potential multicollinearity concerns as well. Therefore, our analysis using VIF confirms that multicollinearity is indeed present in our dataset. Additionally, we must assume that the errors across observations are uncorrelated—an assumption that is challenging to validate rigorously and will thus be maintained throughout the analysis.

Another important set of checks involves ensuring that three key conditions are satisfied: that a linear relationship exists between the predictors and the response variable, that the variances of the error terms are constant (homoscedasticity), and that the mean of the error terms is zero. These assumptions can be assessed using a fitted-residuals plot, which compares the predicted values obtained through Ordinary Least Squares (OLS) regression with the corresponding residuals, where a residual represents the error term.

To verify linearity, we examine whether the plotted points form a relatively flat, horizontal band—specifically, ensuring there is no discernible nonlinear trend. To assess whether the error variances are equal, we check that the spread of the residuals remains consistent across the plot; in particular, we avoid patterns where the magnitude of the residuals expands as we move to the right, which

would resemble a cone shape. Finally, to confirm that the mean of the residuals is zero, we look to see whether the points are generally centered around the horizontal axis at zero.



From the residual plot presented earlier, we observe that the plotted values do not follow any particular trend, supporting the assumption of linearity between predictors and the response variable. Additionally, the absence of a cone-like pattern suggests that the residuals have relatively constant variance across the range of fitted values. Finally, the points appear to be fairly symmetrically distributed around zero, indicating that the mean of the residuals is approximately zero. Together, these observations confirm that the key assumptions for applying linear models are satisfied, reinforcing the suitability of linear regression for this study.

With these conditions validated, we now proceed to implement our different linear regression models. Each linear model aims to estimate the coefficient vector β by minimizing a specific objective function. Ordinary Least Squares (OLS) regression minimizes the objective $\|Y - X\beta\|_2^2$ with respect to β . While OLS assumptions are satisfied, multicollinearity remains a concern that could affect model performance.

The three additional methods we will implement—Ridge, LASSO, and Elastic Nets—belong to the family of shrinkage regression techniques. Given the presence of multicollinearity in our dataset, shrinkage methods help address this issue by pulling the coefficients of highly correlated predictors toward zero or exactly zero, thereby mitigating their influence on predictions.

This is achieved by adding a regularization (Lagrange) term to the OLS objective function. Although this introduces a small amount of bias into the model, it leads to a notable reduction in variance. According to the bias-variance trade-off principle, this can result in lower overall mean squared error (MSE), enhancing the model's predictive capability. Moreover, the added regularization enables these methods to function effectively even in the presence of perfect multicollinearity.

Elastic Nets, Ridge, and LASSO regression all share a similar structure in their objective functions. Following the convention used by the glmnet package (which we will adopt for implementation), we separate the intercept term β_0 from the coefficient vector β . The objective function for Elastic Nets regression is given by

$$\min_{\beta_0, \beta} \frac{1}{N} \sum_{i=1}^N w_i L(y_i, \beta_0 + \beta^T x_i) + \lambda [(1 - \alpha) \|\beta\|_2^2 + \alpha \|\beta\|_1]$$

Here, w_i represents optional weights for emphasizing specific observations, but it will not be used in our analysis. The function $L(\cdot)$ denotes the loss function. The parameters λ and α are hyperparameters that must be determined separately. Ridge and LASSO are special cases of Elastic Nets: when $\alpha=0$, the model reduces to Ridge regression; when $\alpha=1$, it becomes LASSO regression. The parameter α controls the balance between the ℓ_1 (LASSO) and ℓ_2 (Ridge) penalties, while λ dictates the overall strength of regularization. As $\lambda \rightarrow 0$, the model approaches standard OLS. As λ increases, penalization becomes stronger, leading to greater shrinkage of the coefficients toward zero. To determine the optimal hyperparameters, we will perform a separate tuning procedure before final model training.

Training and Diagnostics

We will train our models using the `lm` function in python for OLS regression, and the `ElasticNet` package for implementing Elastic Nets, Ridge, and LASSO regressions. Since our dataset does not include a predefined training and testing split, we will rely on multiple rounds of 5-fold cross-validation to evaluate model performance. We choose repeated cross-validation because traditional cross-validation randomly partitions the dataset into folds, and an unrepresentative fold could lead to a disproportionately large mean squared error (MSE) in that round. By running cross-validation multiple times, we can average the errors across runs, obtaining a more stable and representative measure of model performance.

Once the cross-validation means are calculated for each model, we can compare them to assess predictive accuracy. A lower cross-validation mean suggests that the corresponding model has better predictive capabilities relative to the others. Unlike Elastic Nets, Ridge, and LASSO regression—which require cross-validation to optimize hyperparameters—OLS regression does not necessitate cross-validation for model fitting. For Ridge and LASSO, different values of λ are trialed to find the best-performing model. In contrast, Elastic Nets require tuning over a grid of both α and λ values to ensure that no optimal combination is overlooked.

In addition to the cross-validation mean (cvm), we also consider the coefficient of determination, R^2 , as another evaluation metric. The R^2 value measures how well the model fits the training data, providing insight into whether the model offers a meaningful improvement over random guessing or whether it risks overfitting.

The OLS model is trained using R's `lm` function, allowing us to obtain its coefficients. Repeated 5-fold cross-validation is then manually conducted to assess model accuracy. All model coefficients are provided in the appendix, while the table presented below highlights a selection of coefficients with the largest magnitudes, indicating variables that exert a stronger influence on VIX values.

Table 2: Table 1: Major OLS model Coefficients

EMV Tracker Index	Estimated Coefficient Value
Energy and Environmental Regulation EMV Tracker	3.736002
Labor Disputes EMV Tracker	3.126042
Intellectual Property Matters EMV Tracker	2.937708
Financial Regulation EMV Tracker	1.703597
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	1.394200
Government Spending, Deficits, and Debt EMV Tracker	-1.187397
Litigation Matters EMV Tracker	-1.313388
Macro - Interest Rates EMV Tracker	-1.432616
Macro - Trade EMV Tracker	-2.277171
Other Regulation EMV Tracker	-3.875063
Agricultural Policy EMV Tracker	-7.021830

The Ordinary Least Squares (OLS) model produced a cross-validation mean error of 33.27195 and achieved an R-squared value of 0.6214. Before proceeding with an in-depth analysis of the OLS model, it is useful to establish similar evaluation metrics for the other linear regression models, allowing for direct comparison. The Ridge regression model was trained using the `cv.glmnet` function in R, with the shrinkage parameter (λ) selected via five-fold cross-validation. Specifically, the value of λ that minimized the cross-validation mean was chosen. After determining the optimal λ , we then fit the Ridge regression model using the `glmnet` function with the mixing parameter set to zero. The optimal shrinkage parameter was found to be 1.449649.

All coefficients for the Ridge model are included in the appendix (Table 11). The table presented here highlights the impacts of major predictors. Importantly, for any model trained using the glmnet package, the resulting coefficients are standardized. To assess the real-world influence of each predictor on the VIX, we must de-standardize the coefficients by multiplying them by the standard deviation of their corresponding predictors. This adjustment ensures that we capture the true effect sizes. A similar process will be applied for the LASSO and Elastic Nets models.

Table 3: Table 2: Major Ridge Regression Coefficients Effects

EMV Tracker Index	Covariates Impact
Labor Disputes EMV Tracker	1.1009593
Financial Regulation EMV Tracker	1.0850473
EMV	0.9139619
Macro – Broad Quantity Indicators EMV Tracker	0.8057084
Macro – Inflation EMV Indicator	0.7820702
Macro – Interest Rates EMV Tracker	-1.5170875

The Ridge regression model achieves a cross-validation mean (cvm) of 30.47479 and an R^2 value of 0.5837136. The LASSO regression model is trained using the exact same approach as the Ridge regression model, applying 5-fold cross-validation to determine the optimal value of λ . The optimal λ is found to be $\lambda=0.1334107$. Using this value and setting $\alpha=1$, we then construct the LASSO model with glmnet.

All estimated coefficients for the LASSO model will be presented in the appendix. The table below summarizes the effects of some of the major covariates identified in the LASSO model.

Table 4: Table 3: Major LASSO Regression Coefficients Effects

EMV Tracker Index	Covariates Impact
EMV	2.846473
Macro – Inflation EMV Indicator	1.373332
Financial Regulation EMV Tracker	1.282582
Labor Disputes EMV Tracker	1.275238
Macro – Broad Quantity Indicators EMV Tracker	1.172684
Macro – Interest Rates EMV Tracker	-2.663669

The LASSO regression model has a cross-validation mean (cvm) of 29.87902 and an R^2 of 0.5911187. The Elastic Nets model is trained in a similar manner to the Ridge and LASSO models. However, due to the addition of the hyperparameter α , a grid search technique is required to determine the optimal parameters. Initially, a wide grid is defined, and the search range is progressively refined to better locate the best parameter values.

For this grid search, we utilize the caret package along with glmnet, performing repeated 5-fold cross-validation. The grid search identifies $\alpha=0.9497487$ and $\lambda=0.1432162$ as the optimal hyperparameter values. Using these values, we then construct the Elastic Nets.

The full model's coefficients are listed in the appendix. The table below will present the major impacts of some key covariates within the Elastic Nets model.

Table 5: Table 4: Major Elastic Nets Regression Coefficients Effects

EMV Tracker Index	Covariates Impact
MV	2.810232
Macro - Inflation EMV Indicator	1.347231
Financial Regulation EMV Tracker	1.292099
Labor Disputes EMV Tracker	1.273719
Macro - Broad Quantity Indicators EMV Tracker	1.159040
Macro - Interest Rates EMV Tracker	-2.628084

The Elastic Nets model achieved a cross-validation mean (cvm) of 29.87942 and an R^2 value of 0.5902455. Comparing the cross-validation means across our different models, it is evident that the best-performing models are based on either LASSO regression or Elastic Nets regression. Although the LASSO model has a slightly lower cvm, this difference could stem from the inaccuracy introduced by python package providing only approximate solutions. It would be reasonable to expect that Elastic Nets regression should, at minimum, perform as well as LASSO regression. Longer computation times, or utilizing industrial solvers such as CPLEX to find exact solutions, could help resolve this discrepancy.

Another point worth noting is that the OLS model displays both a higher cross-validation mean and a higher R^2 compared to the other models. This suggests that OLS is overfitting the data, likely due to the presence of multicollinearity, and thus fails to serve as a reliable model for this dataset. While Ridge regression does handle multicollinearity and produces a model comparable to those from LASSO and Elastic Nets, the results from LASSO and Elastic Nets imply that the underlying data structure favors a sparse model—something Ridge regression inherently cannot achieve. Thus, Ridge exhibits higher cvm and R^2 values relative to LASSO and Elastic Nets.

Between LASSO and Elastic Nets, I consider Elastic Nets to be the preferable model, as it flexibly incorporates both ℓ_1 and ℓ_2 regularization. With adequate hyperparameter tuning, Elastic Nets is

capable of performing at least as well as Ridge or LASSO individually. The sparsity observed in our model suggests that, over the long 33-year period analyzed, only a few key forces have played a dominant role in influencing market volatility. From the results presented in Tables 4 and 14, it is evident that factors such as inflation, labor disputes, and financial regulation significantly contribute to market volatility—which aligns with economic intuition. For instance, rising inflation tends to drive up the cost of goods and services, leading consumers to save more and sell off stocks, which in turn pushes stock prices downward. Additionally, heightened inflation may cause greater investor uncertainty, making them more reluctant to participate actively in the stock market.

This increased market volatility and uncertainty make logical sense. Labor disputes, for example, can significantly impact the stock performance of companies, particularly when disputes are prolonged. In some cases, such disputes may disrupt entire supply chains and industries. When industries are halted, revenue generation ceases, leading to declining stock prices and greater volatility. The extent of the impact depends on the scale of the labor disputes.

Financial regulation is often linked to supervisory activities over banks and financial institutions, aimed at ensuring market stability. Therefore, its association with volatility can be understood in this broader context. We also observe a strong association between the EMV tracker and market volatility. This finding aligns with expectations, as articles discussing the economy, the stock market, and volatility tend to be published when the market itself is undergoing turbulent periods.

Another noteworthy observation is the negative relationship between interest rates and the VIX index. This suggests that higher interest rates are correlated with greater market stability. This interpretation is plausible; however, given the range of the data, caution is warranted. During periods of elevated inflation, there are often discussions about increasing interest rates to stabilize the market, which could explain this relationship. Conversely, during recessions, articles may discuss lowering interest rates to stimulate the economy and restore stability.

It is important to recall that the EMV trackers are constructed based on the number of articles containing terms associated with each tracker's specific category. While background knowledge about historical events can help us infer causal relationships, pinpointing the exact drivers behind these associations over a 33-year period is inherently challenging. Moreover, it is important to recognize that the relationships between predictors and the response variable may be bidirectional. For example, changes in interest rates might be a reaction to increased market volatility, not necessarily its cause.

Nonetheless, the main finding from our models is that, over the past 33 years, market volatility has been associated with discussions around labor disputes, inflation, and financial regulation, while it has exhibited a negative association with interest rates. Building on these insights, we will next apply Elastic Nets regression to model the six segments of market behavior identified earlier in Figure 1. By doing so, we aim to conduct a more detailed analysis of each segment to uncover the specific forces driving volatility.

Due to the smaller sample sizes within each segment, we will employ leave-one-out cross-validation for hyperparameter tuning, rather than five-fold cross-validation. However, repeated five-fold cross-validation will still be used to calculate each segment model's cross-validation mean (cvm).

The modeling methodology will be consistent with the approach used for our previous Elastic Nets model. The following tables will present the impacts of covariates on the VIX, while the full set of model coefficients can be found in Tables 15 through 20 in the appendix. Additionally, Table 21 in the appendix summarizes the selected α and λ values for each segment model, as well as the time periods covered, the number of predictors, and the number of observations for each model.

Table 6: Table 5: Segment 1 Major Coefficients Effects

EMV Tracker Index	Covariates Impact
Commodity Markets EMV Tracker	0.9938443
Petroleum Markets EMV Tracker	0.9187881
Labor Regulations EMV Tracker	0.8736603
Trade Policy EMV Tracker	-0.8609633
Macro – Interest Rates EMV Tracker	-0.9533108

The first segment, illustrated in Figure 1, represents a period of relative market stability. As shown in Table 5, most predictors do not exhibit particularly strong effects on market volatility. Additionally, from Table 15 in the appendix, we observe that the model is quite sparse, which may suggest that during stable periods, fewer forces are actively influencing the market.

Among the more impactful predictors, petroleum markets and commodity markets stand out. These two are somewhat correlated, as both reflect changes in oil prices. Given the context of the Gulf War, oil prices were notably elevated during this time, likely contributing to increased volatility.

Commodity-related discussions may also have been amplified by the Asian financial crisis, which may have disrupted the United States' ability to source certain essential resources. Labor disputes and labor regulations, as previously discussed, typically exert upward pressure on market volatility. On the negative side, we recognize that this segment began during a recessionary period. A reduction in interest rates during this time likely contributed to market stabilization, which aligns with the negative coefficient observed for the Macro - Interest Rates EMV Tracker.

Table 7: Table 6: Segment 2 Major Coefficients Effects

EMV Tracker Index	Covariates Impact
Labor Disputes EMV Tracker	1.4465815
Macro – Trade EMV Tracker	0.3785070
Macro – Business Investment and Sentiment EMV Tracker	0.3614140
Fiscal Policy EMV Tracker	0.3451623
Food and Drug Policy EMV Tracker	0.3279611

The second segment, depicted in Figure 1, reflects a highly volatile and chaotic market period. Nevertheless, the model for this segment remains fairly sparse, as shown partially in Table 16. Only a few predictors significantly impact market volatility, with labor disputes being the most prominent factor. Several major events took place during this period, including the United Auto Workers' strike, the Enron scandal, the onset of the War on Terror, and the bursting of the dot-com bubble.

The Enron scandal, a major case of corporate fraud, resulted in substantial layoffs and job losses. In response, new regulatory measures were introduced to prevent similar corporate misconduct in the future. This helps explain the importance of predictors related to energy, environmental, and financial regulations. The collapse of the dot-com bubble saw many technology companies go bankrupt, leading to massive layoffs. This context is reflected in the Macro - Business Investment and Sentiment EMV Tracker, as investor confidence and sentiment toward companies significantly declined. The War on Terror redirected government fiscal priorities toward military spending, which may have introduced uncertainty into financial markets, thus affecting the Fiscal Policy EMV Tracker. While many critical events unfolded during this time, the Elastic Nets model likely zeroed out some correlated predictors, focusing instead on the most distinct influences on market volatility.

Table 8: Table 7: Segment 3 Major Coefficients Effects

EMV Tracker Index	Covariates Impact
Fiscal Policy EMV Tracker	0.7897204
Taxes EMV Tracker	0.6478433
Energy and Environmental Regulation EMV Tracker	0.5428609
Macro – Other Financial Indicators EMV Tracker	0.3415303
Entitlement and Welfare Programs EMV Tracker	-0.3560420

The third segment, like the previous two, also appears to be fairly sparse, as shown in Table 17. According to Figure 1, this period is characterized by relatively low market volatility. One notable carryover from the previous segment is the continued influence of fiscal policy. With the War on Terror persisting through this period, military spending remained high, which may have sustained investor concerns about potential economic impacts.

The influence of the Energy and Environmental Regulation EMV Tracker may be attributed to the passage of the Energy Independence and Security Act of 2007. This legislation marked a significant step in the United States' efforts to combat climate change and reduce its dependence on oil. Consequently, investors in the energy sector—particularly those with interests in oil—might have been uncertain about the future, contributing to some fluctuations in market sentiment.

Another important observation is that the Real Estate Markets EMV Tracker begins to show some impact on market volatility during this segment. Throughout this period, housing prices continued to rise, setting the stage for developments in the next segment.

Table 9: Table 8: Segment 4 Major Coefficients Effects

EMV Tracker Index	Covariates Impact
Intellectual Property Policy EMV Tracker	0.8294355
Government Spending, Deficits, and Debt EMV Tracker	0.7278243
Financial Crises EMV Tracker	0.7205613
Macro – Labor Markets EMV Tracker	0.6688713
Other Regulation EMV Tracker	-1.2066795

This segment, as shown in Figure 1, is characterized by high volatility. Table in the appendix further reveals that numerous forces were simultaneously active during this period. One notable factor is the high value of the Financial Crises EMV Tracker, which makes sense given that this segment corresponds to the 2008 housing crisis. With multiple forces at play—many with similarly strong impacts—it becomes challenging to isolate which factors were the primary drivers of the crisis.

A significant observation is the elevated value of the Intellectual Property Policy EMV Tracker. This might be attributed to many businesses shutting down during this time, with articles discussing the various operations and intellectual property these businesses once managed. The Government-Sponsored Enterprises EMV Tracker likely reflects the troubles faced by mortgage companies that required government support during the crisis. These companies, having engaged in risky lending due to historically low interest rates, ended up repossessing large numbers of houses when borrowers defaulted. As housing inventory flooded the market, prices collapsed, and mortgage companies faced severe financial distress, leading to widespread bankruptcies and massive investor losses, further amplifying market volatility.

Articles categorized under the Government Spending, Deficits, and Debt EMV Tracker may have discussed potential government interventions or the bailouts provided to major corporations during the crisis. The Macro - Labor Markets EMV Tracker also shows a significant impact, reflecting the large-scale job losses that occurred. However, it is important to recognize that the labor market conditions might have been more of a consequence of the overall market volatility rather than a direct cause. Interestingly, the Other Regulation EMV Tracker shows a strong negative relationship with volatility. This could be linked to efforts such as interventions from the Small Business Administration, which aimed to support struggling businesses during the downturn.

Overall, this segment exhibits a highly complex interplay of forces, making detailed interpretation of each EMV Tracker difficult. Moreover, it is important to highlight that, as shown in Appendix, the number of observations in this segment is considerably lower than the number of predictors. This situation is something that Elastic Nets regression handles effectively, unlike LASSO regression, which would struggle as it generally cannot retain more non-zero coefficients than the number of observations. This partially explains why the model for this segment is not particularly sparse.

Table 10: Table 9: Segment 5 Major Coefficients Effects

EMV Tracker Index	Covariates Impact
Macro – Real Estate Markets EMV Tracker	2.7941492
Financial Regulation EMV Tracker	1.2236495
Infectious Disease EMV Tracker	-0.4569264
Immigration EMV Tracker	-0.5461025
Healthcare Matters EMV Tracker	-0.7821957

This fifth segment is by far the longest among all segments analyzed. It also represents a period of significant market stability. As shown in Table 19, this segment is notably sparse, and only a few predictors exhibit meaningful impacts on market volatility. The Real Estate Markets EMV Tracker stands out with the strongest positive influence on volatility. This is likely attributable to the steady and sharp rise in housing prices during this period, pushing housing costs to levels that became unaffordable for a large portion of the population. Such developments could have fueled concerns among real estate investors about the possibility of another housing crisis similar to the one that occurred in 2008.

The Financial Regulation EMV Tracker also has a positive impact. This influence may stem from the enactment of new regulations aimed at preventing a recurrence of the financial crisis. However, the observed increase in volatility associated with financial regulation is somewhat counterintuitive, as one might expect stricter regulations to reassure investors rather than contribute to instability. The negative impact of immigration on market volatility could reflect the stabilizing effect of an expanded labor force, where an influx of workers helped fill job vacancies and sustain economic activity.

A point of uncertainty remains regarding why healthcare matters show a reduction in volatility. It is plausible that topics related to infectious diseases were captured under this tracker. During this period, outbreaks such as Ebola and Zika were discussed in the news, although these events had limited direct impact on the United States economy. Even early mentions of COVID-19 during this time did not significantly affect financial markets. Overall, this segment reflects a highly stable period in the market, supported by new regulatory efforts designed to mitigate the risk of another systemic financial crisis.

Table 11: Table 10: Segment 6 Major Coefficients Effects

EMV Tracker Index	Covariates Impact
Elections and Political Governance EMV Tracker	2.063466
Trade Policy EMV Tracker	2.003698
Energy and Environmental Regulation EMV Tracker	1.372143
National Security Policy EMV Tracker	1.318724
Regulation EMV Tracker	-1.565076
Macro – Other Financial Indicators EMV Tracker	-1.595791
Labor Regulations EMV Tracker	-1.689385

The final segment, depicted in Figure 1, is marked by high market volatility. From this table, we can see that numerous forces are simultaneously at work during this period. One EMV tracker we might have expected to see play a dominant role is the Infectious Disease EMV Tracker, as COVID-19 was heavily believed to be a major contributor to financial instability. However, the correlation between VIX and the Infectious Disease EMV Tracker is actually quite low. Although the initial volatility triggered by COVID-19 was significant, it only lasted around two months, meaning its overall impact on this longer period was minimized. Nonetheless, COVID-19 appears to be indirectly reflected in several other predictors.

One of the most prominent forces here is the Elections and Political Governance EMV Tracker. The 2020 U.S. election was highly controversial and generated considerable uncertainty. Many investors were apprehensive about the election outcome and its potential impact on financial markets, leading to heightened volatility. Trade policy also played a significant role in market volatility, as the United States engaged in trade disputes with China and imposed sanctions on Russia. Disruptions to international trade flows likely contributed to an unstable economic environment.

The deterioration of the economy, exacerbated by the pandemic, led consumers to reduce their spending. This dynamic is captured by indicators related to consumer spending and sentiment. With many people confined to their homes, retail activity and economic engagement dropped sharply, impacting businesses and leading investors to reevaluate their holdings. In terms of national security, it is worth noting that COVID-19 was officially classified as a national security threat during this period. Additionally, the ongoing war in Ukraine, combined with sanctions against Russia, added to market uncertainty and volatility. Thus, while COVID-19 itself caused some volatility, broader national security concerns, including geopolitical conflicts, likely had an even greater influence.

The Food and Drug Policy EMV Tracker's impact may be linked to the efforts of the FDA to approve various COVID-19 vaccines. Initially, delays and regulatory challenges fueled market anxiety. However, once vaccines were approved, COVID-19 cases declined, leading to a decrease in related articles and market uncertainty. An interesting finding is the negative relationship observed with labor regulations. As return-to-work policies and COVID-19 safety measures were put into place, the economy began to stabilize, leading to reduced volatility. This trend is also partially captured in the general Regulation EMV Tracker, where discussions about workplace safety measures and regulations coincided with a calming market. Overall, this chaotic and volatile segment is driven by a highly complex mix of forces. Given the overlapping effects and shifting dynamics, it remains challenging to pinpoint the precise drivers of market volatility during this period.

Discussion and Conclusions

After implementing all regression models using the full dataset, it became clear that the Ordinary Least Squares (OLS) model performed the worst. The best-performing models were between LASSO regression and Elastic Nets regression. Ultimately, we chose to proceed with Elastic Nets, as it offers greater flexibility. Using Elastic Nets, we analyzed the six market segments outlined in Figure 1 to investigate the forces driving shifts in market volatility, leveraging the EMV trackers presented in Baker, Bloom, Davis, and Kost (2019).

Overall, we observed that during longer time periods and periods characterized by low market volatility, only a sparse set of predictors were active. In contrast, periods with high volatility exhibited a much larger number of active predictors. Across the entire 33-year dataset, labor disputes consistently emerged as a factor contributing to market volatility. However, within individual segments, identifying the precise causes behind transitions between stable and volatile markets proved difficult, largely because volatile periods introduce many new forces simultaneously.

In some instances, lingering investor fears from previous market shocks could be observed, but clear predictive signals about future volatility were rare. Although the models demonstrated some predictive capability, they are inherently limited: if events occur that have no historical precedent in the dataset, the model's predictions may not be accurate. Additionally, as the forces influencing the market change over time, the model's predictive ability could degrade, further emphasizing the need for caution when interpreting results.

Another important consideration is that the analysis is based solely on information derived from newspaper articles. This introduces two major limitations:

1. Investor behavior may be influenced—or even manipulated—by the content they read, leading to spikes in market volatility unrelated to fundamental economic conditions.
2. The mention of a topic in the news does not imply causality; it may merely coincide with market movements rather than drive them.

Overall, our findings indicate that specific EMV trackers do not consistently act as early signals before significant volatility events occur. The EMV trackers most associated with increased volatility were general EMV mentions, inflation, financial regulation, and labor disputes. In contrast, Broad Quantity Indicators and interest rates also had a strong effect, but with a negative relationship to volatility.

While it is feasible to build predictive models based on these EMV trackers, caution must be exercised: the underlying drivers of market volatility could shift over time, potentially rendering the models ineffective if substantial structural changes occur in the market environment.

Appendix

Table 12: Table 11: OLS Coefficients

EMV Tracker Index	Estimated Coefficient Value
Intercept	9.0137716
EMV	0.2505429
Political Uncertainty Tracker	0.5442050
Infectious Disease EMV Tracker	0.1557817
Macroeconomic News and Outlook EMV Tracker	0.3309704
Macro – Broad Quantity Indicators EMV Tracker	0.5291921
Macro – Inflation EMV Indicator	1.0381235
Macro – Interest Rates EMV Tracker	-1.4326161
Macro – Other Financial Indicators EMV Tracker	-0.4441254
Macro – Labor Markets EMV Tracker	0.1309951
Macro – Real Estate Markets EMV Tracker	-0.1212193
Macro – Trade EMV Tracker	-2.2771710
Macro – Business Investment and Sentiment EMV Tracker	0.9453553
Macro – Consumer Spending and Sentiment EMV Tracker	-0.0191938
Commodity Markets EMV Tracker	-0.1284838
Financial Crises EMV Tracker	0.1040023
Exchange Rates EMV Tracker	0.3519622
Healthcare Matters EMV Tracker	-1.0416954
Litigation Matters EMV Tracker	-1.3133877
Competition Matters EMV Tracker	0.1070083
Labor Disputes EMV Tracker	3.1260420
Intellectual Property Matters EMV Tracker	2.9377081
Fiscal Policy EMV Tracker	0.4774321
Taxes EMV Tracker	-0.7741529
Government Spending, Deficits, and Debt EMV Tracker	-1.1873973
Entitlement and Welfare Programs EMV Tracker	0.4385135
Monetary Policy EMV Tracker	-0.4900204
Regulation EMV Tracker	-1.0451376
Financial Regulation EMV Tracker	1.7035966
Competition Policy EMV Tracker	0.8504119
Intellectual Property Policy EMV Tracker	-0.9071066
Labor Regulations EMV Tracker	0.3534593
Immigration EMV Tracker	-1.0527068
Energy and Environmental Regulation EMV Tracker	3.7360017
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	1.3941996
Housing and Land Management EMV Tracker	0.0145704
Other Regulation EMV Tracker	-3.8750634
National Security Policy EMV Tracker	-0.0786699
Government-Sponsored Enterprises EMV Tracker	0.5403092
Trade Policy EMV Tracker	-0.5401497
Healthcare Policy EMV Tracker	-0.0393875
Food and Drug Policy EMV Tracker	0.9942116
Transportation, Infrastructure, and Public Utilities EMV Tracker	-0.4812107
Elections and Political Governance EMV Tracker	-0.0045465
Agricultural Policy EMV Tracker	-7.0218296
Petroleum Markets EMV Tracker	-0.0844342

Table 13: Table 12: Ridge Regression Coefficients and Covariate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	8.3892742	-
EMV	0.1168835	0.9139619
Political Uncertainty Tracker	0.1575113	0.6237483
Infectious Disease EMV Tracker	0.1265590	0.7147437
Macroeconomic News and Outlook EMV Tracker	0.0916693	0.5374
Macro – Broad Quantity Indicators EMV Tracker	0.2254033	0.8057084
Macro – Inflation EMV Indicator	0.3289921	0.7820702
Macro – Interest Rates EMV Tracker	-0.5730166	-1.517087
Macro – Other Financial Indicators EMV Tracker	-0.0728545	-0.0354326
Macro – Labor Markets EMV Tracker	0.2038385	0.5143364
Macro – Real Estate Markets EMV Tracker	0.0115783	0.04163317
Macro – Trade EMV Tracker	-1.7424625	-0.4449586
Macro – Business Investment and Sentiment EMV Tracker	0.1062473	0.04064767
Macro – Consumer Spending and Sentiment EMV Tracker	0.2260912	0.311027
Commodity Markets EMV Tracker	0.1285675	0.4348431
Financial Crises EMV Tracker	0.0368157	0.09711845
Exchange Rates EMV Tracker	0.0357459	0.01863444
Healthcare Matters EMV Tracker	-0.2848064	-0.2384173
Litigation Matters EMV Tracker	-0.8209306	-0.3570219
Competition Matters EMV Tracker	0.3384456	0.1486681
Labor Disputes EMV Tracker	2.2088889	1.100959
Intellectual Property Matters EMV Tracker	1.8087122	0.5806956
Fiscal Policy EMV Tracker	0.0408824	0.1280493
Taxes EMV Tracker	-0.0418832	-0.1027737
Government Spending, Deficits, and Debt EMV Tracker	-0.4620092	-0.7866009
Entitlement and Welfare Programs EMV Tracker	0.4891669	0.5686874
Monetary Policy EMV Tracker	-0.1871808	-0.6264286
Regulation EMV Tracker	0.1592651	0.329657
Financial Regulation EMV Tracker	0.7392620	1.085047
Competition Policy EMV Tracker	0.8143812	0.3054754
Intellectual Property Policy EMV Tracker	0.8596814	0.03683187
Labor Regulations EMV Tracker	-0.5557652	-0.1685324
Immigration EMV Tracker	-2.2427639	-0.2974921
Energy and Environmental Regulation EMV Tracker	2.9585764	0.6320945
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	-0.4056496	-0.1166185
Housing and Land Management EMV Tracker	0.1616262	0.04126555
Other Regulation EMV Tracker	-1.7610749	-0.3340327
National Security Policy EMV Tracker	0.0741392	0.1954439
Government-Sponsored Enterprises EMV Tracker	0.4910377	0.5502808
Trade Policy EMV Tracker	-0.4951682	-0.6149753
Healthcare Policy EMV Tracker	-0.5325297	-0.3157969
Food and Drug Policy EMV Tracker	0.6523059	0.1453662
Transportation, Infrastructure, and Public Utilities EMV Tracker	0.4216264	0.07226596
Elections and Political Governance EMV Tracker	-0.2212486	-0.2147847
Agricultural Policy EMV Tracker	-5.1892690	-0.3776065
Petroleum Markets EMV Tracker	-0.0046645	-0.01101946

Table 14: Table 13: LASSO Regression Coefficients and Covariate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	8.3470147	-
EMV	0.3640259	2.846473
Political Uncertainty Tracker	0.0000000	0
Infectious Disease EMV Tracker	0.1041012	0.5879129
Macroeconomic News and Outlook EMV Tracker	0.0000000	0
Macro – Broad Quantity Indicators EMV Tracker	0.3280675	1.172684
Macro – Inflation EMV Indicator	0.5777170	1.373332
Macro – Interest Rates EMV Tracker	-1.0060900	-2.663669
Macro – Other Financial Indicators EMV Tracker	0.0000000	0
Macro – Labor Markets EMV Tracker	0.0580598	0.1464997
Macro – Real Estate Markets EMV Tracker	0.0000000	0
Macro – Trade EMV Tracker	-1.3137146	-0.3354727
Macro – Business Investment and Sentiment EMV Tracker	0.0000000	0
Macro – Consumer Spending and Sentiment EMV Tracker	0.1295041	0.178155
Commodity Markets EMV Tracker	0.0000000	0
Financial Crises EMV Tracker	0.0000000	0
Exchange Rates EMV Tracker	0.0000000	0
Healthcare Matters EMV Tracker	0.0000000	0
Litigation Matters EMV Tracker	-0.6413273	-0.2789126
Competition Matters EMV Tracker	0.0000000	0
Labor Disputes EMV Tracker	2.5585494	1.275238
Intellectual Property Matters EMV Tracker	1.6231730	0.5211273
Fiscal Policy EMV Tracker	0.0000000	0
Taxes EMV Tracker	0.0000000	0
Government Spending, Deficits, and Debt EMV Tracker	-0.4859927	-0.8274344
Entitlement and Welfare Programs EMV Tracker	0.2830654	0.3290814
Monetary Policy EMV Tracker	-0.0318642	-0.1066382
Regulation EMV Tracker	0.0000000	0
Financial Regulation EMV Tracker	0.8738463	1.282582
Competition Policy EMV Tracker	0.6579075	0.2467819
Intellectual Property Policy EMV Tracker	0.0000000	0
Labor Regulations EMV Tracker	0.0000000	0
Immigration EMV Tracker	-2.1257554	-0.2819715
Energy and Environmental Regulation EMV Tracker	2.3882730	0.5102502
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	0.0000000	0
Housing and Land Management EMV Tracker	0.0000000	0
Other Regulation EMV Tracker	-1.1916950	-0.2260353
National Security Policy EMV Tracker	0.0202035	0.05325993
Government-Sponsored Enterprises EMV Tracker	0.3318357	0.3718713
Trade Policy EMV Tracker	-0.3812210	-0.4734583
Healthcare Policy EMV Tracker	-0.4151695	-0.2462008
Food and Drug Policy EMV Tracker	0.0000000	0
Transportation, Infrastructure, and Public Utilities EMV Tracker	0.0000000	0
Elections and Political Governance EMV Tracker	-0.0667829	-0.06483185
Agricultural Policy EMV Tracker	-4.0899464	-0.2976123
Petroleum Markets EMV Tracker	0.0000000	0

Table 15: Table 14: Elastic Nets Regression Coefficients and Co-
variate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	8.3534859	-
EMV	0.3593912	2.810232
Political Uncertainty Tracker	0.0000000	0
Infectious Disease EMV Tracker	0.1041248	0.5880461
Macroeconomic News and Outlook EMV Tracker	0.0000000	0
Macro – Broad Quantity Indicators EMV Tracker	0.3242507	1.15904
Macro – Inflation EMV Indicator	0.5667373	1.347231
Macro – Interest Rates EMV Tracker	-0.9926495	-2.628084
Macro – Other Financial Indicators EMV Tracker	0.0000000	0
Macro – Labor Markets EMV Tracker	0.0602094	0.1519237
Macro – Real Estate Markets EMV Tracker	0.0000000	0
Macro – Trade EMV Tracker	-1.2952421	-0.3307556
Macro – Business Investment and Sentiment EMV Tracker	0.0000000	0
Macro – Consumer Spending and Sentiment EMV Tracker	0.1285183	0.1767989
Commodity Markets EMV Tracker	0.0000000	0
Financial Crises EMV Tracker	0.0000000	0
Exchange Rates EMV Tracker	0.0000000	0
Healthcare Matters EMV Tracker	0.0000000	0
Litigation Matters EMV Tracker	-0.6226658	-0.2707968
Competition Matters EMV Tracker	0.0000000	0
Labor Disputes EMV Tracker	2.5555025	1.273719
Intellectual Property Matters EMV Tracker	1.6039283	0.5149487
Fiscal Policy EMV Tracker	0.0000000	0
Taxes EMV Tracker	0.0000000	0
Government Spending, Deficits, and Debt EMV Tracker	-0.4799531	-0.8171516
Entitlement and Welfare Programs EMV Tracker	0.2731435	0.3175465
Monetary Policy EMV Tracker	-0.0253615	-0.08487611
Regulation EMV Tracker	0.0000000	0
Financial Regulation EMV Tracker	0.8803304	1.292099
Competition Policy EMV Tracker	0.6516272	0.2444262
Intellectual Property Policy EMV Tracker	0.0000000	0
Labor Regulations EMV Tracker	0.0000000	0
Immigration EMV Tracker	-2.1539567	-0.2857123
Energy and Environmental Regulation EMV Tracker	2.3658359	0.5054566
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	0.0000000	0
Housing and Land Management EMV Tracker	0.0000000	0
Other Regulation EMV Tracker	-1.1507870	-0.2182761
National Security Policy EMV Tracker	0.0204353	0.05387106
Government-Sponsored Enterprises EMV Tracker	0.3340966	0.374405
Trade Policy EMV Tracker	-0.3811290	-0.473344
Healthcare Policy EMV Tracker	-0.3890834	-0.2307314
Food and Drug Policy EMV Tracker	0.0000000	0
Transportation, Infrastructure, and Public Utilities EMV Tracker	0.0000000	0
Elections and Political Governance EMV Tracker	-0.0676906	-0.06571296
Agricultural Policy EMV Tracker	-4.0449231	-0.2943361
Petroleum Markets EMV Tracker	0.0000000	0

Table 16: Table 15: Segment 1 Coefficients and Covariate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	10.4235178	-
EMV	0.0361489	0.1461809
Political Uncertainty Tracker	0.0000000	0
Infectious Disease EMV Tracker	-0.0599577	-0.02145762
Macroeconomic News and Outlook EMV Tracker	0.0000000	0
Macro – Broad Quantity Indicators EMV Tracker	0.0000000	0
Macro – Inflation EMV Indicator	0.0000000	0
Macro – Interest Rates EMV Tracker	-0.4875524	-0.9533108
Macro – Other Financial Indicators EMV Tracker	0.6581073	0.1690989
Macro – Labor Markets EMV Tracker	0.0000000	0
Macro – Real Estate Markets EMV Tracker	0.4320973	0.5171883
Macro – Trade EMV Tracker	-1.2824819	-0.3084173
Macro – Business Investment and Sentiment EMV Tracker	0.0000000	0
Macro – Consumer Spending and Sentiment EMV Tracker	0.0000000	0
Commodity Markets EMV Tracker	0.4810729	0.9938443
Financial Crises EMV Tracker	0.0000000	0
Exchange Rates EMV Tracker	0.0000000	0
Healthcare Matters EMV Tracker	-0.8429454	-0.3997108
Litigation Matters EMV Tracker	-1.4815644	-0.4467887
Competition Matters EMV Tracker	-0.0507161	-0.01629952
Labor Disputes EMV Tracker	1.5408670	0.6421527
Intellectual Property Matters EMV Tracker	0.0000000	0
Fiscal Policy EMV Tracker	0.0000000	0
Taxes EMV Tracker	0.0000000	0
Government Spending, Deficits, and Debt EMV Tracker	-0.3574625	-0.2565121
Entitlement and Welfare Programs EMV Tracker	0.0000000	0
Monetary Policy EMV Tracker	0.0000000	0
Regulation EMV Tracker	0.0000000	0
Financial Regulation EMV Tracker	1.1839543	0.7248692
Competition Policy EMV Tracker	0.0000000	0
Intellectual Property Policy EMV Tracker	0.0000000	0
Labor Regulations EMV Tracker	3.5392604	0.8736603
Immigration EMV Tracker	0.0000000	0
Energy and Environmental Regulation EMV Tracker	0.7166571	0.1177595
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	0.0000000	0
Housing and Land Management EMV Tracker	0.0000000	0
Other Regulation EMV Tracker	0.0000000	0
National Security Policy EMV Tracker	0.0000000	0
Government-Sponsored Enterprises EMV Tracker	-1.3161209	-0.2994093
Trade Policy EMV Tracker	-1.5377512	-0.8609633
Healthcare Policy EMV Tracker	0.8347171	0.2449132
Food and Drug Policy EMV Tracker	0.0000000	0
Transportation, Infrastructure, and Public Utilities EMV Tracker	0.0000000	0
Elections and Political Governance EMV Tracker	-0.1320098	-0.06486954
Agricultural Policy EMV Tracker	0.0000000	0
Petroleum Markets EMV Tracker	0.5745701	0.9187881

Table 17: Table 16: Segment 2 Coefficients and Covariate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	19.1258551	-
EMV	0.0000000	0
Political Uncertainty Tracker	0.0000000	0
Infectious Disease EMV Tracker	0.0000000	0
Macroeconomic News and Outlook EMV Tracker	0.0000000	0
Macro – Broad Quantity Indicators EMV Tracker	0.0000000	0
Macro – Inflation EMV Indicator	0.0000000	0
Macro – Interest Rates EMV Tracker	0.0000000	0
Macro – Other Financial Indicators EMV Tracker	0.0000000	0
Macro – Labor Markets EMV Tracker	0.0000000	0
Macro – Real Estate Markets EMV Tracker	0.0000000	0
Macro – Trade EMV Tracker	1.3301002	0.378507
Macro – Business Investment and Sentiment EMV Tracker	0.9244531	0.361414
Macro – Consumer Spending and Sentiment EMV Tracker	0.0000000	0
Commodity Markets EMV Tracker	0.0000000	0
Financial Crises EMV Tracker	0.0000000	0
Exchange Rates EMV Tracker	0.0000000	0
Healthcare Matters EMV Tracker	0.0000000	0
Litigation Matters EMV Tracker	0.0000000	0
Competition Matters EMV Tracker	0.0000000	0
Labor Disputes EMV Tracker	2.0868079	1.446581
Intellectual Property Matters EMV Tracker	0.0000000	0
Fiscal Policy EMV Tracker	0.1149013	0.3451623
Taxes EMV Tracker	0.0737311	0.197924
Government Spending, Deficits, and Debt EMV Tracker	0.0000000	0
Entitlement and Welfare Programs EMV Tracker	0.0000000	0
Monetary Policy EMV Tracker	0.0000000	0
Regulation EMV Tracker	0.0000000	0
Financial Regulation EMV Tracker	0.0769449	0.1092145
Competition Policy EMV Tracker	0.0000000	0
Intellectual Property Policy EMV Tracker	0.0000000	0
Labor Regulations EMV Tracker	0.0000000	0
Immigration EMV Tracker	0.0000000	0
Energy and Environmental Regulation EMV Tracker	0.2676021	0.05063167
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	0.0000000	0
Housing and Land Management EMV Tracker	0.1722705	0.0163993
Other Regulation EMV Tracker	1.1425054	0.1757825
National Security Policy EMV Tracker	0.0000000	0
Government-Sponsored Enterprises EMV Tracker	0.0000000	0
Trade Policy EMV Tracker	0.0326569	0.01089403
Healthcare Policy EMV Tracker	0.0000000	0
Food and Drug Policy EMV Tracker	1.5958340	0.3279611
Transportation, Infrastructure, and Public Utilities EMV Tracker	0.0000000	0
Elections and Political Governance EMV Tracker	0.0000000	0
Agricultural Policy EMV Tracker	0.0000000	0
Petroleum Markets EMV Tracker	0.0000000	0

Table 18: Table 17: Segment 3 Coefficients and Covariate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	8.9688996	-
EMV	0.0000000	0
Political Uncertainty Tracker	0.0000000	0
Infectious Disease EMV Tracker	0.0000000	0
Macroeconomic News and Outlook EMV Tracker	0.0000000	0
Macro – Broad Quantity Indicators EMV Tracker	0.0000000	0
Macro – Inflation EMV Indicator	0.0000000	0
Macro – Interest Rates EMV Tracker	0.0000000	0
Macro – Other Financial Indicators EMV Tracker	0.5316467	0.3415304
Macro – Labor Markets EMV Tracker	0.0000000	0
Macro – Real Estate Markets EMV Tracker	0.0510097	0.2411613
Macro – Trade EMV Tracker	-1.1059124	-0.2652397
Macro – Business Investment and Sentiment EMV Tracker	0.0000000	0
Macro – Consumer Spending and Sentiment EMV Tracker	0.0000000	0
Commodity Markets EMV Tracker	0.0000000	0
Financial Crises EMV Tracker	0.0000000	0
Exchange Rates EMV Tracker	0.0000000	0
Healthcare Matters EMV Tracker	0.0000000	0
Litigation Matters EMV Tracker	0.0000000	0
Competition Matters EMV Tracker	0.0000000	0
Labor Disputes EMV Tracker	0.3557342	0.1102033
Intellectual Property Matters EMV Tracker	0.0000000	0
Fiscal Policy EMV Tracker	0.5892997	0.7897205
Taxes EMV Tracker	0.5239818	0.6478433
Government Spending, Deficits, and Debt EMV Tracker	0.0000000	0
Entitlement and Welfare Programs EMV Tracker	-0.5259889	-0.356042
Monetary Policy EMV Tracker	0.0000000	0
Regulation EMV Tracker	0.0000000	0
Financial Regulation EMV Tracker	0.0000000	0
Competition Policy EMV Tracker	0.0000000	0
Intellectual Property Policy EMV Tracker	0.0000000	0
Labor Regulations EMV Tracker	0.0000000	0
Immigration EMV Tracker	0.0000000	0
Energy and Environmental Regulation EMV Tracker	4.1237144	0.5428609
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	0.0000000	0
Housing and Land Management EMV Tracker	0.0000000	0
Other Regulation EMV Tracker	2.0081891	0.2566959
National Security Policy EMV Tracker	0.0000000	0
Government-Sponsored Enterprises EMV Tracker	0.0000000	0
Trade Policy EMV Tracker	0.0000000	0
Healthcare Policy EMV Tracker	-0.1960155	-0.04325635
Food and Drug Policy EMV Tracker	0.0000000	0
Transportation, Infrastructure, and Public Utilities EMV Tracker	0.0000000	0
Elections and Political Governance EMV Tracker	-0.1491215	-0.05864181
Agricultural Policy EMV Tracker	0.0000000	0
Petroleum Markets EMV Tracker	0.0000000	0

Table 19: Table 18: Segment 4 Coefficients and Covariate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	16.6958559	-
EMV	0.0332201	0.4249861
Political Uncertainty Tracker	0.0557121	0.368336
Infectious Disease EMV Tracker	-0.6782326	-0.2051314
Macroeconomic News and Outlook EMV Tracker	0.0339929	0.3351366
Macro – Broad Quantity Indicators EMV Tracker	0.0639281	0.3435414
Macro – Inflation EMV Indicator	-0.0406567	-0.1031194
Macro – Interest Rates EMV Tracker	-0.0283466	-0.07932659
Macro – Other Financial Indicators EMV Tracker	-0.0063911	-0.006134194
Macro – Labor Markets EMV Tracker	0.2624691	0.6688713
Macro – Real Estate Markets EMV Tracker	0.0177012	0.1249655
Macro – Trade EMV Tracker	-0.7315386	-0.09966756
Macro – Business Investment and Sentiment EMV Tracker	-2.0086837	-0.2396792
Macro – Consumer Spending and Sentiment EMV Tracker	-0.3588106	-0.4872287
Commodity Markets EMV Tracker	0.0307910	0.1742207
Financial Crises EMV Tracker	0.1282306	0.7205613
Exchange Rates EMV Tracker	1.9194053	0.3237946
Healthcare Matters EMV Tracker	0.9484277	0.624972
Litigation Matters EMV Tracker	-0.9201121	-0.4105782
Competition Matters EMV Tracker	0.0000000	0
Labor Disputes EMV Tracker	0.0000000	0
Intellectual Property Matters EMV Tracker	2.8780970	0.6541057
Fiscal Policy EMV Tracker	0.1210883	0.5632099
Taxes EMV Tracker	0.1288044	0.5179032
Government Spending, Deficits, and Debt EMV Tracker	0.8423188	0.7278243
Entitlement and Welfare Programs EMV Tracker	0.3788096	0.4283164
Monetary Policy EMV Tracker	-0.0210032	-0.112636
Regulation EMV Tracker	0.1288952	0.5529652
Financial Regulation EMV Tracker	0.2006832	0.6286099
Competition Policy EMV Tracker	2.4085575	0.4864708
Intellectual Property Policy EMV Tracker	20.0091300	0.8294355
Labor Regulations EMV Tracker	3.9229599	0.6012645
Immigration EMV Tracker	7.2679362	0.4322184
Energy and Environmental Regulation EMV Tracker	0.0000000	0
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	-1.2283405	-0.3141996
Housing and Land Management EMV Tracker	-0.1444109	-0.05891887
Other Regulation EMV Tracker	-7.9929718	-1.20668
National Security Policy EMV Tracker	0.2086257	0.4037783
Government-Sponsored Enterprises EMV Tracker	0.1828796	0.6463472
Trade Policy EMV Tracker	1.4720823	0.5413318
Healthcare Policy EMV Tracker	1.2259967	0.6488463
Food and Drug Policy EMV Tracker	-1.3820969	-0.3184247
Transportation, Infrastructure, and Public Utilities EMV Tracker	3.1412965	0.4424306
Elections and Political Governance EMV Tracker	-0.8325578	-0.3956314
Agricultural Policy EMV Tracker	-3.6151967	-0.2181263
Petroleum Markets EMV Tracker	0.0104685	0.04080169

Table 20: Table 19: Segment 5 Coefficients and Covariate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	7.8941741	-
EMV	0.0000000	0
Political Uncertainty Tracker	0.0000000	0
Infectious Disease EMV Tracker	-0.9842815	-0.4797382
Macroeconomic News and Outlook EMV Tracker	0.0000000	0
Macro – Broad Quantity Indicators EMV Tracker	0.0000000	0
Macro – Inflation EMV Indicator	0.0000000	0
Macro – Interest Rates EMV Tracker	0.0000000	0
Macro – Other Financial Indicators EMV Tracker	1.1413327	0.3268158
Macro – Labor Markets EMV Tracker	0.0802118	0.1766886
Macro – Real Estate Markets EMV Tracker	1.1444246	2.489317
Macro – Trade EMV Tracker	2.5572178	0.4394318
Macro – Business Investment and Sentiment EMV Tracker	0.0000000	0
Macro – Consumer Spending and Sentiment EMV Tracker	0.0000000	0
Commodity Markets EMV Tracker	0.0269493	0.08526772
Financial Crises EMV Tracker	0.0000000	0
Exchange Rates EMV Tracker	0.0000000	0
Healthcare Matters EMV Tracker	-1.3627095	-0.9385549
Litigation Matters EMV Tracker	-0.4690841	-0.170327
Competition Matters EMV Tracker	1.2066044	0.3426759
Labor Disputes EMV Tracker	0.3834807	0.1530342
Intellectual Property Matters EMV Tracker	1.0524063	0.3833727
Fiscal Policy EMV Tracker	0.0000000	0
Taxes EMV Tracker	0.0000000	0
Government Spending, Deficits, and Debt EMV Tracker	0.0000000	0
Entitlement and Welfare Programs EMV Tracker	0.3840205	0.3352
Monetary Policy EMV Tracker	-0.0768478	-0.2472547
Regulation EMV Tracker	0.0000000	0
Financial Regulation EMV Tracker	1.0574192	1.293809
Competition Policy EMV Tracker	0.0000000	0
Intellectual Property Policy EMV Tracker	5.5068939	0.229896
Labor Regulations EMV Tracker	-0.4072803	-0.1010344
Immigration EMV Tracker	-2.8748571	-0.5300843
Energy and Environmental Regulation EMV Tracker	0.0414063	0.009847212
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	0.0000000	0
Housing and Land Management EMV Tracker	-0.9773843	-0.2158699
Other Regulation EMV Tracker	0.0000000	0
National Security Policy EMV Tracker	-0.0389495	-0.07435977
Government-Sponsored Enterprises EMV Tracker	0.0000000	0
Trade Policy EMV Tracker	0.0000000	0
Healthcare Policy EMV Tracker	0.0000000	0
Food and Drug Policy EMV Tracker	0.0000000	0
Transportation, Infrastructure, and Public Utilities EMV Tracker	0.0000000	0
Elections and Political Governance EMV Tracker	-0.2212524	-0.3040811
Agricultural Policy EMV Tracker	-4.4158904	-0.3787924
Petroleum Markets EMV Tracker	0.1962964	0.4367709

Table 21: Table 20: Segment 6 Coefficients and Covariate Impacts

EMV Tracker Index	Estimated Coefficient Value	Covariates Impact
Intercept	27.4750497	-
EMV	-0.0051862	-0.04742582
Political Uncertainty Tracker	0.0698402	0.3066624
Infectious Disease EMV Tracker	0.0000000	0
Macroeconomic News and Outlook EMV Tracker	0.0000000	0
Macro – Broad Quantity Indicators EMV Tracker	0.1214995	0.5631137
Macro – Inflation EMV Indicator	0.0949144	0.326368
Macro – Interest Rates EMV Tracker	-0.1530777	-0.4364634
Macro – Other Financial Indicators EMV Tracker	-3.3319376	-1.595791
Macro – Labor Markets EMV Tracker	0.0000000	0
Macro – Real Estate Markets EMV Tracker	-0.2761479	-0.713292
Macro – Trade EMV Tracker	-4.8255514	-0.5116623
Macro – Business Investment and Sentiment EMV Tracker	0.8235920	0.2760488
Macro – Consumer Spending and Sentiment EMV Tracker	0.8203324	1.036839
Commodity Markets EMV Tracker	0.2401318	0.9883181
Financial Crises EMV Tracker	-0.1208062	-0.4072711
Exchange Rates EMV Tracker	8.8100703	1.230289
Healthcare Matters EMV Tracker	-0.0642314	-0.1105822
Litigation Matters EMV Tracker	0.7793308	0.4955218
Competition Matters EMV Tracker	0.6295502	0.2812919
Labor Disputes EMV Tracker	-1.2922820	-0.5574275
Intellectual Property Matters EMV Tracker	3.3050181	1.010468
Fiscal Policy EMV Tracker	-0.3147787	-1.051857
Taxes EMV Tracker	-0.5422111	-1.267635
Government Spending, Deficits, and Debt EMV Tracker	-0.3935855	-0.3543308
Entitlement and Welfare Programs EMV Tracker	0.0000000	0
Monetary Policy EMV Tracker	-0.1031407	-0.3549442
Regulation EMV Tracker	-0.7834055	-1.565076
Financial Regulation EMV Tracker	-0.1112103	-0.1205599
Competition Policy EMV Tracker	2.0274491	0.3754997
Intellectual Property Policy EMV Tracker	0.0000000	0
Labor Regulations EMV Tracker	-3.1179000	-1.689385
Immigration EMV Tracker	2.8804397	0.5804444
Energy and Environmental Regulation EMV Tracker	4.4311842	1.372143
Lawsuit and Tort Reform, Supreme Court Decisions EMV Tracker	-1.9745682	-0.9905371
Housing and Land Management EMV Tracker	1.0537727	0.4501639
Other Regulation EMV Tracker	1.4006922	0.6521427
National Security Policy EMV Tracker	0.3802921	1.318724
Government-Sponsored Enterprises EMV Tracker	-0.2459140	-0.1141028
Trade Policy EMV Tracker	3.6729701	2.003698
Healthcare Policy EMV Tracker	-0.4102151	-0.46728
Food and Drug Policy EMV Tracker	2.4130997	1.059783
Transportation, Infrastructure, and Public Utilities EMV Tracker	0.6525376	0.1561535
Elections and Political Governance EMV Tracker	2.3052185	2.063466
Agricultural Policy EMV Tracker	3.2920855	0.3699987
Petroleum Markets EMV Tracker	0.0312298	0.09181569

Table 22: Table 21: Information About the Models and each Segment

Time Period	Alpha	Lambda	Number of Observations	Number of Predictors
1990-01 to 1998-06	0.3165829	0.5728643	102	45
1998-07 to 2003-03	0.2613060	2.4371860	57	45
2003-04 to 2007-12	0.3819095	0.9447236	57	45
2008-01 to 2009-09	0.0050251	18.9949700	21	45
2009-10 to 2019-12	0.9447236	0.1809045	123	45
2020-01 to 2022-11	0.0150754	1.9597990	35	45