

Decoding Sector Valuation Dynamics: Exploring the Nexus of Company Fundamentals, Economic Indicators, and Equity Valuations via Predictive Analytics

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Précis

This study examines the key drivers of equity valuation across various sectors and industries. Equity valuation is a critical metric that captures a company's perceived worth and influences investment decisions, mergers and acquisitions, and risk management strategies. Understanding the primary factors impacting valuation is essential for market participants to make informed choices.

The research seeks to unveil determinants of equity valuation that may have been obscured by traditional linear regression techniques. With modern ensemble machine learning methods, particularly gradient-boosted decision trees, the study aims to leverage non-linear relationships among a diverse set of variables and fluctuations in stock prices, which serves as a proxy for shifts in company valuations.

The analysis employed both linear regression and gradient-boosted decision tree models to explain the variance in monthly stock returns across various sectors within the Global Industry Classification Standard (GICS). The results uncover substantial variations in the factors influencing equity valuation between sectors. Various commodities, economic factors, and company fundamentals emerged as the primary determinants, with their relative importance contingent upon the sector context. Particularly noteworthy is the consistent superiority of gradient-boosted decision tree models over linear regression methods, underscoring the significance of capturing intricate non-linear patterns in financial data analysis.

The identified drivers provide crucial insights that can enhance investors' decision-making, improve valuation modeling practices, and strengthen risk management strategies. By uncovering these pivotal factors, the study aims to guide market participants in navigating the complexities of financial markets with greater foresight.

Future research could explore the incorporation of additional data sources, such as forward guidance from companies, analyst forecasts, and social media sentiment analysis, to further enhance the predictive power of the models. Additionally, investigating industry-specific, sub-industry-specific, and global market dynamics could

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furnish valuable insights into the determinants of equity valuation transcending the context of the United States and broad sector approach.

Overall, this study contributes to a more comprehensive understanding of the dynamic forces shaping equity valuations, empowering investors, analysts, and industry stakeholders to make more informed decisions and refine their valuation methodologies.

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Decoding Sector Valuation Dynamics: Exploring the Nexus of Company Fundamentals, Economic Indicators, and Equity Valuations via Predictive Analytics

The valuation of a company represents a pivotal endeavor in the dynamic landscape of financial markets, serving as a guiding compass for investors and shaping capital allocation decisions. This metric encapsulates a company's perceived worth, reflecting its financial health, growth prospects, and market standing. Understanding the primary drivers of equity valuation is critical for investors to make informed choices regarding stock selection, portfolio management, and risk mitigation strategies. Moreover, in mergers and acquisitions, precise and nuanced company valuations influence negotiations and strategic decisions that can restructure entire industries. As articulated by Koller, Goedhart, Wessels, et al. (2010, p. 3), "value is the defining dimension of measurement in a market economy."

Building upon the groundwork laid by Ely et al. (2007), Liu, Nissim, and Thomas (2002), Khan (2016), and Deng, Easton, and Yeo (2012), this research aims to delve into the drivers of equity valuation within the Global Industry Classification Standard (GICS) sectors. The literature suggests that certain variables may exhibit greater or diminished importance in determining a company's value within industry contexts. Leveraging a similar analytical approach and broad metrics, this study seeks to uncover nuanced elements that significantly impact the valuation of companies within these sectors. To achieve this, modern ensemble machine learning methods were employed to leverage potential relationships not captured through prior linear regression techniques. By incorporating advanced algorithms like gradient-boosted decision trees, this research aims to capture metrics that may have been obscured by intricate patterns and non-linear relationships, thereby providing a more comprehensive understanding of the primary factors driving changes in valuation.

Acknowledging the unique characteristics and complexities inherent in various

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sectors, as emphasized by Li (2021), this research endeavors to offer empirical insights that equip market participants with a deeper comprehension of the factors impacting sector-specific valuations with enhanced accuracy and foresight. By decoding these pivotal drivers, this study also aims to steer risk management and speculative strategies, facilitating the anticipation of potential valuation reactions to shifts in the identified determinants.

Moreover, valuation methodologies like Discounted Cash Flow (DCF) analysis and comparable company analysis heavily hinge on underlying assumptions, profoundly influencing the resulting valuation estimates. Through the identification and prioritization of key drivers that may have been previously overlooked or undervalued, there lies the opportunity to refine and optimize due diligence resource allocation in valuation modeling endeavors.

Methodology

Data Collection

To construct the dataset, historical daily stock prices, quarterly financial statements (10-Q Filings), and earnings call dates were collected for companies contained within the S&P 500, 400, and 600 indices. Stock data and 10-Q financials were sourced from Yahoo Finance, while the respective earnings call dates and times were collected through the Stocktwits API. Various commodity prices, economic indicators, and other market factors were retrieved from Yahoo Finance and the Federal Reserve Economic Data (FRED) database.

The dependent variable is the percentage change in a stock's adjusted closing price from the previous period, representing the change in a company's valuation. Independent variables include the percent change for a diverse set of company fundamentals (e.g. revenue, profitability ratios, cash flows), commodity prices, economic indicators, and other market factors potentially influencing equity valuations, refer to Table A1 in the appendix for a comprehensive list of variables.

A monthly time frame was analyzed, spanning from January 25, 2014, to February 17, 2024, encompassing 525 weeks (approximately 10 years). Percent changes in

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company fundamentals and select economic indicators reported quarterly were calculated based on their last release.

Data Preprocessing

The raw data underwent several preprocessing and analysis steps to handle outliers and missing values.

For the dependent variable, monthly stock returns, the top and bottom 15 values for each sector were explored to identify potential extreme outliers. Observations due to extraordinary events were removed (e.g. GameStop's short squeeze in 2021, failed acquisitions, bankruptcy) as well as improper historical data for IPOs. Further outlier treatment involved Winsorizing returns to within 4-6 interquartile ranges (IQRs) from the median on a per-sector basis.

To address potential autocorrelation stemming from seasonality, new features were incorporated with lagged values spanning 3, 6, or 12 months. The selection of specific lags for each GICS sector was guided by autocorrelation function plots depicting the median percentage change of each company fundamental. This approach mitigates the effects of seasonal patterns in an overall sector's financial metrics.

Missing values for independent variables were imputed with 0, representing no change, when there was no economic data release or earnings call that particular month. The independent variables were then standardized. Potential outliers for the independent variables were identified and removed using the DBSCAN clustering algorithm for each GICS sector (Ester, Kriegel, Sander, Xu, et al., 1996).

Model Development

Both a multivariate linear regression model from the Python library cuML and a gradient-boosted decision tree regression model (LightGBM) were trained for selected¹ GICS sectors/industries to explain the variance in the percentage change in stock prices based on the percentage change in the independent variables (Raschka, Patterson, & Nolet, 2020; Zhang, Si, & Hsieh, 2017).

A 5-fold cross-validation technique was employed to assess the models during both

¹ Refer to Table A2 in the appendix for selected sectors/industries.

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variable selection and hyperparameter tuning stages, aiming to mitigate potential overfitting. These folds were stratified to ensure an equal representation of earnings releases within each fold.

A backward stepwise regression approach was used to address multicollinearity and retain the most important independent variables for each model. Correlated variables were identified using correlation matrices, scatter plots, and Variance Inflation Factor (VIF) analysis. Subsequently, each variable within its group of correlates underwent thorough testing in the model. The variable that contributed to the highest average cross-validated R^2 value among its correlates was retained. After resolving multicollinearity, variables were systematically eliminated from the model to maximize the average cross-validated R^2 , thereby eliminating variables that did not enhance nor contribute to the predictive capability of the model.

Finally, cross-validated hyperparameter tuning was conducted on the linear regression model (Elastic Net) and the gradient-boosted decision tree model (LightGBM).

Model Rationale

The methodology employed in this study leverages regression techniques to uncover the drivers influencing equity valuations by explaining the variance in stock returns. The percentage change in stock prices as the dependent variable provides a direct window into how various financial metrics and economic factors impact a company's perceived market value over time. Regression analysis allows for quantifying the relationships between these independent variables and the fluctuations in stock prices that reflect shifts in valuations. By using advanced machine learning regression models like gradient-boosted decision trees (LightGBM), analysis can flexibly capture complex, non-linear patterns that meaningfully contribute to movement in valuations obscured by traditional linear approaches. The variable selection process retains the most influential drivers while mitigating multicollinearity concerns. Ultimately, uncovering these determinants by explaining stock return variance elucidates the factors driving changes in valuations within each sector's context. This crucial insight allows

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market participants to refine valuation modeling due diligence practices and inform speculative strategies by anticipating potential reactions to changes in identified drivers. Furthermore, it contributes to strengthening risk management protocols through proactive measures that mitigate potential risks associated with fluctuations in the identified determinants.

Analysis and Results

Linear regression models can be interpreted using the coefficients of the standardized independent variables, while gradient-boosted decision tree models can be interpreted using SHAP (SHapley Additive exPlanations) values. SHAP values offer a unified interpretation of models by quantifying the impact of each independent variable on the model's output (Lundberg & Lee, 2017; Mitchell, Frank, & Holmes, 2022). Interpretation is based on the median LightGBM model (model with the median R^2 across 5-fold cross-validation). Utilizing the median model provides a balanced perspective on model performance and explanatory power, alleviating potential overfitting concerns.

Considering the monthly time frame used in the regression analysis, commodities and most economic indicators are expected to carry high importance to models. This is due to the month-to-month variation observed in these variables, which consequently impacts valuations more frequently within the chosen time frame. Company fundamentals and certain economic variables are typically reported on a quarterly basis, potentially diminishing their importance because of their lesser frequency. Therefore, it's essential to keep reporting frequencies in mind while interpreting each primary driver's importance ranking. Variables with less frequent reporting should be weighed accordingly, independent of those exhibiting month-to-month volatility. Refer to Table A1 for a comprehensive list of variables, noting non-monthly reporting frequencies.

Additionally, some economic indicators are not reported in real-time, lagging current economic conditions. As such, these variables should be interpreted as the market's reaction to these economic data releases and its subsequent anticipation of future economic conditions/trends.

Energy Sector

Table 1

Energy Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 40.05% | 37.95% | 4.09% | 29.93% | 40.88% | R^2 | 38.88% |
| Adjusted R^2 | 39.81% | 37.70% | 4.11% | 29.65% | 40.65% | Adjusted R^2 | 38.68% |
| MSE | 1.56% | 1.55% | 0.13% | 1.37% | 1.74% | MSE | 1.53% |
| RMSE | 12.50% | 12.45% | 0.51% | 11.72% | 13.18% | RMSE | 12.39% |
| MAE | 8.92% | 8.90% | 0.21% | 8.60% | 9.24% | MAE | 8.86% |
| F-stat | 151.04 | 157.21 | 19.20 | 136.26 | 190.99 | F-stat | 196.92 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
|---------------------------|--------|--------|--------|--------|--------|------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 51.01% | 50.20% | 2.68% | 45.01% | 52.41% | R^2 | 55.70% |
| Adjusted R^2 | 50.74% | 49.93% | 2.69% | 44.71% | 52.14% | Adjusted R^2 | 55.50% |
| MSE | 1.23% | 1.24% | 0.08% | 1.13% | 1.34% | MSE | 1.11% |
| RMSE | 11.08% | 11.15% | 0.35% | 10.62% | 11.59% | RMSE | 10.55% |
| MAE | 7.84% | 7.82% | 0.16% | 7.55% | 8.04% | MAE | 7.37% |
| F-stat | 161.79 | 164.64 | 12.54 | 149.71 | 187.10 | F-stat | 234.70 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix B for additional model figures and tables.

The Energy Sector was the best-performing sector, both models were statistically significant as measured by the F-statistic. The LightGBM model demonstrated superior performance compared to the linear regression model, exhibiting a median adjusted R^2 of 50.74% versus 39.81%, respectively. The LightGBM model's ability to capture non-linear relationships through gradient-boosted decision trees was more effective in elucidating the variance in stock returns. The LightGBM model surpassed the linear regression model across various metrics including MSE, RMSE, MAE, and F-stat. Top drivers of positive stock returns in the Energy Sector:

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Table 2

Energy Sector: Top Drivers

| Commodities | | Importance Rank | Economic Factor | | Company Fundamentals | |
|-----------------|---------------|-----------------|--|--------------------------|----------------------|---------------------|
| Importance Rank | Commodity | | Importance Rank | Factor | Importance Rank | Metric |
| 1 | Oil ↑ | 2 | | VIX ↓ | 18 | ROA ↑ |
| 3 | Cotton ↑ | 8 | | 3 Month Treasury Yield ↑ | 19 | Operating Revenue ↑ |
| 7 | Natural Gas ↑ | 11 | 10 Year - 2 Year Treasury Yield Spread ↓ | | 22 | Cash Flow to Debt ↑ |
| 9 | Palladium ↓ | 12 | | CPI ↓ | 23 | Efficiency Ratio ↓ |
| | | | | | 24 | Free Cash Flow ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure B3 for the model’s SHAP plot.

Unsurprisingly, commodities take center stage, with oil being the most significant driver and natural gas in the top 10. Given the energy sector’s heavy reliance on oil/gas production and exploration, fluctuations in oil/gas prices directly impact the profitability and valuations of energy companies. Other commodities such as cotton and palladium also play a role, reflecting broader economic conditions and industrial demand. Likely due to its usage in vehicle manufacturing and petroleum refining, the energy sector is sensitive to palladium prices. Increases in palladium prices may impact costs for energy companies and their bottom line.

Key indicators such as market volatility (VIX), interest rates (Treasury yields), and broader macroeconomic metrics like the Consumer Price Index (CPI) exert significant influence. Market volatility can signal economic uncertainty, impacting investor sentiment and stock prices. The sector appears to do well in periods of higher short-term interest rates and low inflation.

Return on Assets (ROA) measures how efficiently a company is utilizing its assets to generate profits. In the energy industry, which requires large investments in exploration, drilling, refineries, and infrastructure, efficient usage of assets is crucial for long-term sustainability and attracting investor capital.

Operating Revenue directly reflects the top-line performance of a company, which is heavily influenced by commodity prices and demand for energy products.

² Median Model: Model with the median R^2 across 5-fold cross-validation.

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Consistently growing operating revenue is a positive signal for valuations.

The cash flow to debt ratio is vital as energy projects often require significant debt financing. A higher cash flow to debt ratio indicates a company's ability to service its debt obligations and maintain financial flexibility. This is especially important during periods of economic uncertainty and low energy price environments.

Efficiency ratio measures how well a company is managing its costs and operating expenses. Energy companies with lower efficiency ratios are better positioned to weather periods of low commodity prices and maintain profitability.

Free cash flow is the cash remaining after a company has paid for its operating expenses and capital expenditures. In the energy sector, where capital expenditures are high, robust free cash flow generation is essential for funding new projects, paying down debt, and driving long-term value.

Overall, the sector values more efficient asset utilization and debt management as well as increasing operating revenue with free cash flow growth.

Materials Sector

Table 3

Materials Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 27.62% | 27.42% | 0.53% | 26.51% | 28.09% | R^2 | 27.81% |
| Adjusted R^2 | 27.39% | 27.18% | 0.53% | 26.27% | 27.86% | Adjusted R^2 | 27.62% |
| MSE | 0.83% | 0.84% | 0.06% | 0.74% | 0.94% | MSE | 0.83% |
| RMSE | 9.09% | 9.14% | 0.35% | 8.62% | 9.72% | RMSE | 9.12% |
| MAE | 6.58% | 6.60% | 0.20% | 6.27% | 6.87% | MAE | 6.58% |
| F-stat | 117.95 | 118.28 | 9.03 | 108.10 | 131.85 | F-stat | 147.62 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |
| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 36.35% | 36.77% | 1.12% | 35.60% | 38.86% | R^2 | 53.80% |
| Adjusted R^2 | 35.97% | 36.39% | 1.13% | 35.22% | 38.50% | Adjusted R^2 | 53.58% |
| MSE | 0.73% | 0.73% | 0.06% | 0.63% | 0.83% | MSE | 0.53% |
| RMSE | 8.52% | 8.53% | 0.37% | 7.95% | 9.09% | RMSE | 7.30% |
| MAE | 6.12% | 6.10% | 0.21% | 5.74% | 6.36% | MAE | 5.15% |
| F-stat | 97.11 | 96.36 | 7.73 | 86.60 | 109.59 | F-stat | 180.76 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix C for additional model figures and tables.

In the Materials Sector, both models were statistically significant as measured by the F-statistic. The LightGBM model exhibited superior performance compared to the linear regression model, with respective median adjusted R^2 values of 35.97% and 27.39%. The LightGBM model outperformed the linear regression model in terms of R^2 and other metrics, indicating that the relationships captured by the gradient-boosted decision tree model were more effective in explaining the variance in stock returns. Top drivers of positive stock returns in the Materials Sector:

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Table 4

Materials Sector: Top Drivers

| Commodities | | Importance Rank | Economic Factor | Company Fundamentals | |
|-----------------|-------------|-----------------|--|----------------------|-----------------------|
| Importance Rank | Commodity | | | Importance Rank | Metric |
| 2 | Oil ↑ | 1 | VIX ↓ | 7 | Gross Profit Margin ↑ |
| 3 | Soybean ↑ | 10 | Federal Funds Rate ↓ | 11 | Debt Ratio ↓ |
| 4 | Cotton ↑ | 15 | 10 Year - 2 Year Treasury Yield Spread ↓ | 17 | Cash Flow to Debt ↑ |
| 5 | Palladium ↑ | 16 | CPI ↓ | 18 & 22 | EBITDA ↑ |
| | | | | 28 | Free Cash Flow ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure C3 for the model’s SHAP plot.

Commodities take center stage as key drivers for the sector, much like the energy sector. Oil emerges as the most influential commodity. Oil plays a pivotal role as a material input and energy source across various industries within the materials sector. Many commodities move in tandem with oil prices, reflecting broader economic conditions and industrial demand. High soybean and cotton prices are also reflective of high demand for raw materials.

Turning to economic factors, market volatility (VIX) stands out as a significant driver. Heightened market volatility often signals economic uncertainty, which can impact demand for materials and disrupt supply chains, ultimately affecting the sector’s performance.

The Federal Funds Rate and the 10-year to 2-year Treasury yield spread also emerged as influential factors. Changes in interest rates can impact borrowing costs for materials companies, particularly those with substantial debt financing for capital-intensive projects or operations. Decreasing short-term interest rates has a positive impact on the sector, reducing borrowing costs.

The Consumer Price Index (CPI) can impact input costs for materials companies, potentially squeezing profit margins and affecting profitability.

Regarding company fundamentals, the gross profit margin stands out. It is ranked in the top 10 of importance despite its quarterly reporting frequency. Gross profit

² Median Model: Model with the median R^2 across 5-fold cross-validation.

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margin is a key metric that reflects a company's ability to generate profits after accounting for production costs. In the Materials Sector, where capital expenditures can be significant, maintaining healthy gross profit margins is crucial for profitability and long-term sustainability.

Lower debt (debt ratio) and the cash flow to debt ratio are vital metrics, as materials companies often rely on debt financing for capital-intensive projects and operations. A higher cash flow to debt ratio indicates a company's ability to service its debt obligations and maintain financial flexibility, which is essential during economic downturns or periods of low demand.

EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization) is a widely used measure of a company's operating profitability, providing insights into its core business performance without the impact of financing and accounting decisions. In the materials sector, EBITDA is a valuable metric for assessing a company's true earnings power.

In capital-intensive sectors like materials, robust free cash flow generation is essential for funding growth opportunities, paying down debt, and driving long-term value. Overall, the sector values higher profit margins and more efficient debt management with EBITDA and free cash flow growth.

Industrials Sector

Table 5

Industrials Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 26.96% | 25.89% | 1.63% | 23.30% | 27.49% | R^2 | 26.25% |
| Adjusted R^2 | 26.86% | 25.78% | 1.63% | 23.19% | 27.39% | Adjusted R^2 | 26.17% |
| MSE | 0.72% | 0.73% | 0.02% | 0.71% | 0.76% | MSE | 0.73% |
| RMSE | 8.50% | 8.55% | 0.11% | 8.43% | 8.72% | RMSE | 8.53% |
| MAE | 6.11% | 6.14% | 0.07% | 6.07% | 6.23% | MAE | 6.13% |
| F-stat | 247.12 | 250.87 | 6.54 | 244.06 | 261.42 | F-stat | 314.24 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |
| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 38.22% | 37.86% | 1.43% | 35.54% | 39.69% | R^2 | 48.91% |
| Adjusted R^2 | 38.10% | 37.74% | 1.43% | 35.41% | 39.57% | Adjusted R^2 | 48.83% |
| MSE | 0.61% | 0.61% | 0.02% | 0.60% | 0.63% | MSE | 0.50% |
| RMSE | 7.79% | 7.83% | 0.10% | 7.73% | 7.95% | RMSE | 7.10% |
| MAE | 5.43% | 5.48% | 0.08% | 5.41% | 5.62% | MAE | 5.04% |
| F-stat | 293.52 | 292.22 | 4.79 | 285.07 | 298.84 | F-stat | 462.92 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix D for additional model figures and tables.

In the Industrials Sector, both models were statistically significant as measured by the F-statistic. The LightGBM model outperformed the linear regression model across various metrics, with respective median adjusted R^2 values of 38.10% and 26.86%. Top drivers of positive stock returns in the Industrials Sector:

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Table 6

Industrials Sector: Top Drivers

| Commodities | | Economic | | Company Fundamentals | |
|-----------------|---------------|-----------------|--|----------------------|-----------------------|
| Importance Rank | Commodity | Importance Rank | Factor | Importance Rank | Metric |
| 2 | Copper ↑ | 1 | VIX ↓ | 11 | Operating Revenue ↑ |
| 5 | Cotton ↑ | 4 | Federal Funds Rate ↓ | 17 | Gross Profit Margin ↑ |
| 12 | Natural Gas ↑ | 7 | 10 Year - 2 Year Treasury Yield Spread ↓ | 19 | Operating Margin ↑ |
| 15 | Coffee ↑ | 13 | Average Home Price ↓ | 20 | Free Cash Flow ↑ |
| | | 18 | Housing Starts ↑ | 21 | Financing CF to OCF ↓ |
| | | | | 22 | Cash Flow Margin ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure D3 for the model’s SHAP plot.

Commodities significantly impact the sector, with copper, cotton, natural gas, and coffee playing key roles. Copper is essential in construction, manufacturing, and infrastructure projects, serving as an indicator of economic activity and industrial demand. Cotton is a key agricultural output, with higher prices signaling increased demand for textiles and in turn industrial and farming equipment. Coffee is a consumer staple with global demand, reflecting broader economic conditions and industrial activity.

Market volatility (VIX) remains a crucial driver, with lower volatility typically associated with positive stock returns. Heightened market volatility can signal economic uncertainty, impacting investor sentiment and industrial demand.

Interest rates, as measured by the 10-year to 2-year Treasury yield spread and Federal Funds Rate, are highlighted as influential factors. Higher interest rates can impact borrowing costs for industrial companies, particularly those with significant debt financing for capital projects and operations.

Real estate metrics such as average home prices and Housing Starts are primary drivers. Increases in home construction are a boon for the sector, signaling economic growth and demand for construction materials and equipment. Declining home prices are potentially the result of additional home supply, signaling the high demand for new

² Median Model: Model with the median R^2 across 5-fold cross-validation.

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projects. These metrics provide insights into housing market conditions, construction activity, and infrastructure development, which can impact industrial companies' performance.

Key company fundamentals include operating revenue, gross profit margin, and operating margin. These serve as vital indicators of a company's performance and profitability. Maintaining healthy revenue growth and profit margins is essential for industrial companies to drive shareholder value and sustain long-term growth.

Additionally, metrics like free cash flow, cash flow margin, and the financing cash flow to operating cash flow ratio deserve attention. Free cash flow offers insights into a company's financial robustness and capacity to fuel growth endeavors. The cash flow margin delineates the percentage of revenue converted into cash flow, while the financing cash flow to operating cash flow ratio assesses a company's reliance on external financing for its operations, with a diminishing ratio indicating greater self-sufficiency in funding operations. These metrics play a crucial role in evaluating a company's liquidity, financial flexibility, and ability to sustainably generate future cash flows.

Overall, the sector values operating revenue growth, higher profit margins, and more efficient financing operations with free cash flow growth.

Consumer Discretionary Sector

Table 7

Consumer Discretionary Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 25.46% | 24.53% | 1.17% | 22.91% | 25.50% | R^2 | 24.80% |
| Adjusted R^2 | 25.34% | 24.41% | 1.17% | 22.79% | 25.39% | Adjusted R^2 | 24.71% |
| MSE | 1.01% | 1.02% | 0.02% | 1.00% | 1.06% | MSE | 1.02% |
| RMSE | 10.06% | 10.12% | 0.10% | 10.02% | 10.27% | RMSE | 10.10% |
| MAE | 7.44% | 7.47% | 0.06% | 7.39% | 7.58% | MAE | 7.45% |
| F-stat | 209.13 | 210.96 | 6.21 | 204.74 | 222.92 | F-stat | 264.32 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
|---------------------------|--------|--------|--------|--------|--------|------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 38.55% | 38.16% | 1.12% | 36.20% | 39.20% | R^2 | 49.63% |
| Adjusted R^2 | 38.42% | 38.04% | 1.12% | 36.07% | 39.08% | Adjusted R^2 | 49.55% |
| MSE | 0.83% | 0.84% | 0.02% | 0.83% | 0.88% | MSE | 0.68% |
| RMSE | 9.10% | 9.16% | 0.11% | 9.08% | 9.37% | RMSE | 8.27% |
| MAE | 6.65% | 6.67% | 0.10% | 6.57% | 6.85% | MAE | 6.08% |
| F-stat | 291.83 | 293.51 | 3.29 | 291.25 | 300.00 | F-stat | 473.23 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix E for additional model figures and tables.

In the Consumer Discretionary Sector, both models were statistically significant as measured by the F-statistic. The LightGBM model outperformed the linear regression model, with respective median adjusted R^2 values of 38.42% and 25.34%. Top drivers of positive stock returns in the Consumer Discretionary Sector:

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Table 8

Consumer Discretionary Sector: Top Drivers

| Commodities | | Economic | | Company Fundamentals | |
|-----------------|------------|-----------------|-------------------------------------|----------------------|-----------------------|
| Importance Rank | Commodity | Importance Rank | Factor | Importance Rank | Metric |
| 2 | Oil ↑ | 1 | VIX ↓ | 16 | Operating Margin ↑ |
| 3 | Platinum ↑ | 5 | Federal Funds Rate ↓ | 18 | Debt Ratio ↓ |
| 9 | Cotton ↑ | 6 | Housing Starts ↑ | 19 | Gross Profit Margin ↑ |
| | | 10 | CPI ↓ | 20 | EBITDA ↑ |
| | | 12 | Federal Budget Surplus or Deficit ↓ | 23 | Free Cash Flow ↑ |
| | | | | 24 | ROE ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure E3 for the model’s SHAP plot.

Commodities such as oil, platinum, and cotton are significant drivers in the Consumer Discretionary sector. Oil, platinum, and cotton are essential inputs for various consumer goods and services such as apparel, electronics, and automobiles. Higher prices of these commodities may reflect increasing consumer demand.

Market volatility (VIX) remains a crucial driver, with lower volatility typically associated with positive stock returns. Heightened market volatility can signal economic uncertainty, impacting consumer sentiment and discretionary spending.

The sector is sensitive to interest rates, as indicated by the Federal Funds Rate. Lower short-term interest rates can stimulate consumer spending by reducing borrowing costs, benefiting companies in the consumer discretionary sector.

Housing Starts stands out as a key driver with a ranking in the top 5 despite its less frequent reporting frequency. New home builds can indicate consumer confidence and economic growth. Additionally, new homes can boost demand for home-related consumer goods and services such as furniture, appliances, and home improvement products which are included in the sector.

Lower inflation is a positive driver for the sector, as measured by the Consumer Price Index (CPI). Low inflation can boost consumer purchasing power and confidence, leading to increased spending on discretionary items. Higher government spending

² Median Model: Model with the median R^2 across 5-fold cross-validation.

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(Federal Budget Surplus or Deficit), also appears to be a positive driver for the sector as this can stimulate economic growth and consumer spending.

Key company fundamentals such as operating margin, debt ratio, gross profit margin, EBITDA, free cash flow, and return on equity (ROE) are essential indicators of a company's financial health and profitability. Maintaining healthy profit margins, low debt relative to assets, strong returns on equity, EBITDA growth, and robust free cash flow generation are crucial for consumer discretionary companies to drive shareholder value and sustain future growth. Overall, the sector values higher profitability margins, lower debt, and higher returns on equity with EBITDA and free cash flow growth.

Consumer Staples Sector

Table 9

Consumer Staples Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 11.40% | 11.19% | 2.27% | 8.87% | 15.15% | R^2 | 11.93% |
| Adjusted R^2 | 11.11% | 10.89% | 2.28% | 8.56% | 14.87% | Adjusted R^2 | 11.70% |
| MSE | 0.67% | 0.66% | 0.03% | 0.61% | 0.71% | MSE | 0.66% |
| RMSE | 8.19% | 8.15% | 0.20% | 7.82% | 8.41% | RMSE | 8.12% |
| MAE | 5.90% | 5.87% | 0.10% | 5.71% | 5.98% | MAE | 5.85% |
| F-stat | 39.91 | 39.96 | 2.10 | 37.42 | 43.73 | F-stat | 49.52 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
|---------------------------|--------|--------|--------|--------|--------|------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 19.55% | 18.67% | 2.14% | 15.81% | 21.29% | R^2 | 28.10% |
| Adjusted R^2 | 19.13% | 18.24% | 2.15% | 15.37% | 20.87% | Adjusted R^2 | 27.80% |
| MSE | 0.61% | 0.61% | 0.03% | 0.57% | 0.65% | MSE | 0.54% |
| RMSE | 7.83% | 7.80% | 0.18% | 7.53% | 8.09% | RMSE | 7.34% |
| MAE | 5.61% | 5.59% | 0.07% | 5.50% | 5.69% | MAE | 5.28% |
| F-stat | 45.72 | 45.00 | 3.71 | 39.32 | 49.96 | F-stat | 64.92 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix F for additional model figures and tables.

The performance of both models was relatively weak in the Consumer Staples Sector, however, both models were statistically significant as measured by the

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F-statistic. The LightGBM model once again outperformed the linear regression model across various metrics, the median adjusted R^2 values were 19.13% for the LightGBM model and 11.11% for the linear regression model. Poor performance in the sector may be attributed to the wide array of goods and services included in the sector, which includes the production, distribution, and retail of various consumer goods. Top drivers of positive stock returns in the Consumer Staples Sector:

Table 10

Consumer Staples Sector: Top Drivers

| Commodities | | Economic | | Company Fundamentals | |
|-----------------|-------------|-----------------|--|----------------------|------------------------|
| Importance Rank | Commodity | Importance Rank | Factor | Importance Rank | Metric |
| 2 | Platinum ↑ | 1 | VIX ↓ | 5 | Gross Profit Margin ↑ |
| 4 | Oil ↑ | 7 | 10 Year - 2 Year Treasury Yield Spread ↓ | 10 | Free Cash Flow ↑ |
| 6 | Coffee ↓ | 9 | Housing Starts ↑ | 17 | Investment CF to OCF ↓ |
| 8 | Palladium ↓ | 14 | Federal Funds Rate ↓ | 24 | CROA ↑ |
| 12 | Wheat ↑ | | | 25 | Basic EPS ↑ |
| | | | | 26 | Operating Margin ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure F3 for the model’s SHAP plot.

Many commodities are essential inputs for various consumer goods, including food, beverages, and household products. Changes in commodity prices can be suggestive of demand and impact production costs as well as profit margins for consumer staples companies.

Market volatility (VIX) remains a crucial driver, with lower volatility typically associated with positive stock returns. Heightened market volatility can signal economic uncertainty and tempered expectations of economic growth. Declining short-term interest rates (Federal Funds Rate) can stimulate consumer borrowing and spending, benefiting the sector.

Increased Housing Starts can boost demand for consumer staples products. Housing Starts is also an indicator of economic growth and consumer confidence, which can drive demand for consumer staples.

² Median Model: Model with the median R^2 across 5-fold cross-validation.

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Higher profit margins, as indicated by gross profit margin and operating margin, are drivers of higher valuations in the sector. Companies with higher profit margins can generate more revenue from each dollar of sales, leading to expectations of higher profitability in the future. Cash flow growth as measured by free cash flow, efficient usage of cash in financing operations (financing cash flow to operating cash flow ratio), and a more efficient cash return on assets (CROA) are primary drivers. EPS growth is another key metric for the sector.

Health Care Sector

Table 11

Health Care Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 11.24% | 10.51% | 1.21% | 9.00% | 11.91% | R^2 | 10.85% |
| Adjusted R^2 | 11.09% | 10.35% | 1.22% | 8.85% | 11.76% | Adjusted R^2 | 10.73% |
| MSE | 1.13% | 1.13% | 0.03% | 1.09% | 1.17% | MSE | 1.12% |
| RMSE | 10.62% | 10.62% | 0.14% | 10.44% | 10.83% | RMSE | 10.61% |
| MAE | 7.49% | 7.51% | 0.09% | 7.38% | 7.65% | MAE | 7.49% |
| F-stat | 72.00 | 70.33 | 3.89 | 64.09 | 74.19 | F-stat | 87.08 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |
| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 19.59% | 19.95% | 1.34% | 17.92% | 21.95% | R^2 | 23.37% |
| Adjusted R^2 | 19.38% | 19.74% | 1.34% | 17.71% | 21.75% | Adjusted R^2 | 23.22% |
| MSE | 1.00% | 1.01% | 0.04% | 0.96% | 1.07% | MSE | 0.97% |
| RMSE | 9.98% | 10.05% | 0.19% | 9.79% | 10.35% | RMSE | 9.83% |
| MAE | 6.98% | 7.03% | 0.11% | 6.93% | 7.23% | MAE | 6.88% |
| F-stat | 82.73 | 81.19 | 3.70 | 75.31 | 85.42 | F-stat | 107.22 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix G for additional model figures and tables.

Much like the Consumer Staples Sector, the Health Care Sector had relatively weak performance in both models, however, both models were statistically significant as measured by the F-statistic. The residual plots (Figure G1) and RMSE reveal even worse performance in the sector compared to consumer staples despite similar R^2 values.

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The LightGBM model outperformed the linear regression model with median adjusted R^2 values of 19.38% and 11.09%, respectively. The sector includes a wide range of companies, from pharmaceutical/biotech firms to medical device manufacturers and healthcare providers, which may contribute to the difficulty in predicting returns. Much of the sector is potentially driven by regulatory changes, drug approvals, and healthcare policies that are not captured in the dataset. Top drivers of positive stock returns in the Health Care Sector:

Table 12

Health Care Sector: Top Drivers

| Commodities | | Economic | | Company Fundamentals | |
|-----------------|-----------|-----------------|---|----------------------|-----------------------|
| Importance Rank | Commodity | Importance Rank | Factor | Importance Rank | Metric |
| 2 | Copper ↑ | 1 | VIX ↓ | 11 | Operating Margin ↑ |
| 4 | Oil ↑ | 6 | Federal Funds Rate ↓ | 12 | Total Revenue ↑ |
| 7 | Sugar ↓ | 13 | BAA - AAA Corporate Bond Yield Spread ↓ | 15 | Gross Profit Margin ↑ |
| 9 | Wheat ↑ | | | 19 | Debt Ratio ↓ |
| | | | | 23 | ROA ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure G3 for the model’s SHAP plot.

Commodities such as copper, oil, sugar, and wheat are drivers in the sector with copper and oil used in medical devices and equipment.

Market volatility (VIX) remains a crucial driver, with lower volatility typically associated with positive stock returns. Heightened market volatility can signal economic uncertainty and impact investor sentiment. Lower short-term interest rates and a stronger corporate environment as indicated by the declining BAA to AAA corporate bond yield spread, appear to benefit the sector.

Higher profit margins, revenue growth, lower debt, and higher returns on assets are key drivers for the sector.

² Median Model: Model with the median R^2 across 5-fold cross-validation.

Financial Services Industry Group

Table 13

Financial Services Industry Group: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 27.92% | 28.13% | 1.49% | 25.72% | 29.89% | R^2 | 28.79% |
| Adjusted R^2 | 27.61% | 27.83% | 1.49% | 25.41% | 29.60% | Adjusted R^2 | 28.55% |
| MSE | 0.63% | 0.63% | 0.05% | 0.56% | 0.70% | MSE | 0.63% |
| RMSE | 7.93% | 7.95% | 0.31% | 7.51% | 8.36% | RMSE | 7.93% |
| MAE | 5.86% | 5.87% | 0.17% | 5.63% | 6.12% | MAE | 5.85% |
| F-stat | 97.43 | 96.08 | 6.86 | 87.80 | 106.23 | F-stat | 120.01 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
|---------------------------|--------|--------|--------|--------|--------|------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R2 | 41.50% | 41.62% | 2.03% | 38.55% | 44.95% | R^2 | 46.26% |
| Adjusted R2 | 41.21% | 41.33% | 2.04% | 38.25% | 44.69% | Adjusted R^2 | 46.05% |
| MSE | 0.52% | 0.51% | 0.04% | 0.46% | 0.57% | MSE | 0.47% |
| RMSE | 7.21% | 7.17% | 0.25% | 6.76% | 7.52% | RMSE | 6.89% |
| MAE | 5.17% | 5.17% | 0.16% | 4.90% | 5.40% | MAE | 4.97% |
| F-stat | 141.34 | 139.60 | 10.25 | 121.89 | 152.28 | F-stat | 190.31 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix H for additional model figures and tables.

Banking and insurance industry groups were omitted from the analysis of the Financials Sector due to a lack of data. LightGBM model outperformed the linear regression model with median adjusted R^2 values of 41.21% and 27.61%, respectively with both statistically significant. Top drivers of positive stock returns in the Financial Services Industry Group:

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Table 14

Financial Services Industry Group: Top Drivers

| Commodities | | Economic | | Company Fundamentals | |
|-----------------|------------|-----------------|------------------|----------------------|---------------------|
| Importance Rank | Commodity | Importance Rank | Factor | Importance Rank | Metric |
| 2 | Oil ↑ | 1 | VIX ↓ | 16 | Free Cash Flow ↑ |
| 3 | Aluminum ↑ | 5 | CPI ↓ | 17 | Operating Margin ↑ |
| 4 | Cotton ↑ | 14 | Housing Starts ↑ | 22 | Capex ↑ |
| | | | | 23 | Operating Revenue ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure H3 for the model’s SHAP plot.

Commodities such as oil, aluminum, and cotton are significant drivers in the Financial Services Industry Group. Increases in commodity prices can indicate economic growth, resulting in higher demand for financial services.

Market volatility (VIX) remains a crucial driver, with lower volatility typically associated with positive stock returns. Heightened market volatility can signal economic uncertainty, impacting investor sentiment and financial markets. Lower inflation, as measured by the Consumer Price Index (CPI), can boost purchasing power, leading to increased spending and investment in financial services. Housing Starts can indicate economic growth and consumer confidence, which can drive demand for financial services.

Free cash flow growth, higher profit margins, investments in projects (capital expenditures), and operating revenue are key drivers in the sector. Free cash flow growth is essential for financial services companies to fund operations, invest in growth opportunities, and return capital to shareholders. Higher profit margins and operating revenue indicate strong financial performance and inform anticipation of future growth. Capital expenditures reflect investments within the company, signaling potential growth, expansion, and innovation.

² Median Model: Model with the median R^2 across 5-fold cross-validation.

Information Technology Sector

Table 15

Information Technology Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 20.52% | 20.35% | 1.32% | 18.45% | 22.37% | R^2 | 20.61% |
| Adjusted R^2 | 20.36% | 20.19% | 1.32% | 18.28% | 22.22% | Adjusted R^2 | 20.48% |
| MSE | 0.94% | 0.94% | 0.04% | 0.87% | 0.97% | MSE | 0.93% |
| RMSE | 9.72% | 9.67% | 0.19% | 9.34% | 9.87% | RMSE | 9.66% |
| MAE | 7.11% | 7.10% | 0.14% | 6.87% | 7.28% | MAE | 7.09% |
| F-stat | 127.46 | 127.94 | 3.61 | 123.28 | 133.19 | F-stat | 159.73 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
|---------------------------|--------|--------|--------|--------|--------|------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 33.87% | 34.14% | 1.11% | 32.62% | 36.00% | R^2 | 39.49% |
| Adjusted R^2 | 33.67% | 33.95% | 1.11% | 32.43% | 35.82% | Adjusted R^2 | 39.35% |
| MSE | 0.79% | 0.77% | 0.03% | 0.72% | 0.80% | MSE | 0.71% |
| RMSE | 8.89% | 8.80% | 0.17% | 8.48% | 8.95% | RMSE | 8.43% |
| MAE | 6.40% | 6.32% | 0.12% | 6.12% | 6.42% | MAE | 6.09% |
| F-stat | 154.21 | 152.42 | 6.91 | 139.35 | 160.01 | F-stat | 210.29 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix I for additional model figures and tables.

For the Information Technology sector, both models were statistically significant as measured by the F-statistic. The LightGBM model outperformed the linear regression model with median adjusted R^2 values of 33.67% and 20.36%, respectively. Top drivers of positive stock returns in the Information Technology Sector:

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Table 16

Information Technology Sector: Top Drivers

| Commodities | | Economic | | Company Fundamentals | |
|-----------------|------------|-----------------|---|----------------------|-----------------------|
| Importance Rank | Commodity | Importance Rank | Factor | Importance Rank | Metric |
| 1 | Oil ↑ | 6 | BAA - AAA Corporate Bond Yield Spread ↑ | 13 | Free Cash Flow ↑ |
| 2 | Platinum ↑ | 12 | Housing Starts ↑ | 18 | ROE ↑ |
| 9 | Aluminum ↑ | 22 | Federal Funds Rate ↓ | 19 | R&D to Revenue ↓ |
| | | | | 20 | Operating Margin ↑ |
| | | | | 21 | Gross Profit Margin ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure I3 for the model’s SHAP plot.

Commodities such as oil, platinum, and aluminum are drivers of the Information Technology sector. Rising commodity prices can indicate economic growth resulting in increased demand for technology products and services.

Intriguingly, overall market volatility (VIX) was not identified as a significant driver by the LightGBM model. The sector is sensitive to interest rate changes, as indicated by the BAA to AAA corporate bond yield spread and Federal Funds Rate. Increased Housing Starts can also boost demand for technology products and services as an indicator of economic growth and consumer confidence.

Key metrics encompass the growth in free cash flow, return on equity (ROE), and profit margins. Notably, a reduction in research and development expenditure relative to revenue (R&D to Revenue) serves as a detrimental factor for the sector. This decline could dampen prospects for innovation and product development, critical components for technology companies to sustain a competitive advantage.

² Median Model: Model with the median R^2 across 5-fold cross-validation.

Communication Services Sector

Table 17

Communication Services Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 19.77% | 18.96% | 2.19% | 14.65% | 20.77% | R^2 | 19.85% |
| Adjusted R^2 | 19.20% | 18.39% | 2.21% | 14.05% | 20.21% | Adjusted R^2 | 19.40% |
| MSE | 0.89% | 0.89% | 0.02% | 0.87% | 0.92% | MSE | 0.88% |
| RMSE | 9.42% | 9.45% | 0.08% | 9.34% | 9.59% | RMSE | 9.40% |
| MAE | 6.78% | 6.76% | 0.06% | 6.66% | 6.82% | MAE | 6.73% |
| F-stat | 33.49 | 34.05 | 1.31 | 32.54 | 35.69 | F-stat | 42.62 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
|---------------------------|--------|--------|--------|--------|--------|------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 25.84% | 23.80% | 3.48% | 17.24% | 26.49% | R^2 | 36.65% |
| Adjusted R^2 | 25.15% | 23.09% | 3.52% | 16.46% | 25.80% | Adjusted R^2 | 36.17% |
| MSE | 0.82% | 0.84% | 0.02% | 0.82% | 0.88% | MSE | 0.70% |
| RMSE | 9.08% | 9.16% | 0.14% | 9.03% | 9.37% | RMSE | 8.36% |
| MAE | 6.49% | 6.49% | 0.08% | 6.40% | 6.60% | MAE | 5.97% |
| F-stat | 30.52 | 30.61 | 1.25 | 28.76 | 32.64 | F-stat | 49.11 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix J for additional model figures and tables.

The Communications Services Sector had somewhat weak performance in both models, however, with statistical significance as measured by the F-statistic. The LightGBM model outperformed the linear regression model with median adjusted R^2 values of 25.15% and 19.20%, respectively. This sector had the closest performance between the two models compared to other sectors. The relatively poor performance in the sector may be attributed to the diverse range of companies within the sector, including telecommunications, advertising, broadcast, cable, and entertainment companies. Top drivers of positive stock returns in the Communication Services Sector:

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Table 18

Communication Services Sector: Top Drivers

| Commodities | | Economic | | | Company Fundamentals | |
|-----------------|------------|-----------------|--|--|----------------------|---------------------|
| Importance Rank | Commodity | Importance Rank | Factor | | Importance Rank | Metric |
| 1 | Oil ↑ | 3 | 30 Year - 15 Year Mortgage Rate Spread ↑ | | 12 | Free Cash Flow ↑ |
| 2 | Silver ↑ | 4 | CPI ↓ | | 17 | Efficiency Ratio ↓ |
| 7 | Cotton ↑ | 9 | Housing Starts ↑ | | 18 | Operating Ratio ↑ |
| 8 | Aluminum ↑ | | | | 21 | EBIT ↑ |
| | | | | | 22 | Net Profit Margin ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure J3 for the model’s SHAP plot.

Commodities such as oil, silver, cotton, and aluminum are drivers in the Communication Services sector. Rising commodity prices can indicate economic growth resulting in increased demand for communication services.

Interest rate changes, as indicated by the 30-year to 15-year mortgage rate spread, are drivers in the Communication Services sector. Increased Housing Starts can boost demand for communication services as an indicator of economic growth and consumer confidence.

Metrics such as free cash flow, efficiency ratio, profit margins, and EBIT were identified as primary drivers of valuations in communication services companies. Free cash flow growth, more efficient operations, and higher profitability ratios with EBIT growth are expected to drive valuations.

² Median Model: Model with the median R^2 across 5-fold cross-validation.

Utilities Sector

Table 19*Utilities Sector: Model Statistics*

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 23.17% | 22.38% | 2.84% | 19.11% | 26.66% | R^2 | 23.40% |
| Adjusted R^2 | 22.77% | 21.98% | 2.85% | 18.69% | 26.27% | Adjusted R^2 | 23.08% |
| MSE | 0.29% | 0.30% | 0.02% | 0.27% | 0.32% | MSE | 0.29% |
| RMSE | 5.37% | 5.43% | 0.17% | 5.24% | 5.64% | RMSE | 5.40% |
| MAE | 4.05% | 4.10% | 0.09% | 4.00% | 4.25% | MAE | 4.08% |
| F-stat | 57.47 | 57.40 | 4.86 | 51.27 | 65.06 | F-stat | 71.39 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
|---------------------------|--------|--------|--------|--------|--------|------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 45.36% | 45.25% | 3.39% | 39.63% | 49.11% | R^2 | 51.91% |
| Adjusted R^2 | 44.84% | 44.74% | 3.42% | 39.06% | 48.63% | Adjusted R^2 | 51.55% |
| MSE | 0.20% | 0.21% | 0.02% | 0.19% | 0.24% | MSE | 0.18% |
| RMSE | 4.51% | 4.56% | 0.24% | 4.31% | 4.87% | RMSE | 4.28% |
| MAE | 3.11% | 3.20% | 0.12% | 3.10% | 3.39% | MAE | 2.98% |
| F-stat | 86.99 | 83.76 | 7.39 | 72.94 | 91.00 | F-stat | 122.36 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix K for additional model figures and tables.

The Utilities Sector was one of the best-performing sectors, the LightGBM model outperformed the linear model with median adjusted R^2 values of 44.84% and 22.77%, respectively. Top drivers of positive stock returns in the Utilities Sector:

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Table 20

Utilities Sector: Top Drivers

| Commodities | | Economic | | Company Fundamentals | |
|-----------------|-------------|-----------------|--------------------------|----------------------|-----------------------|
| Importance Rank | Commodity | Importance Rank | Factor | Importance Rank | Metric |
| 11 | Wheat ↑ | 1 | VIX ↓ | 21 | Free Cash Flow ↑ |
| 18 | Palladium ↓ | 3 | 3 Month Treasury Yield ↓ | 22 & 29 | Efficiency Ratio ↓ |
| | | 9 | Real GDP ↑ | 24 | Financing CF to OCF ↓ |
| | | 10 | Federal Funds Rate ↓ | 25 | Current Ratio ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure K3 for the model’s SHAP plot.

Commodities such as wheat and palladium are drivers in the Utilities sector.

Rising wheat prices can indicate economic growth and increased demand for utility services. Palladium is an important input for emissions control systems, higher prices could potentially lead to higher costs for utility companies.

Market volatility (VIX) is a crucial driver, with lower volatility typically associated with positive stock returns. Heightened market volatility can signal economic uncertainty and impact investor sentiment. The sector is sensitive to interest rate changes, as indicated by the 3-Month Treasury Yield and the Federal Funds Rate. Lower interest rates can reduce borrowing costs for utility companies, leading to higher valuations.

Key metrics include free cash flow, efficiency ratio, financing cash flow to operating cash flow, and current ratio. A declining financing cash flow to operating cash flow ratio can indicate further self-sufficiency in financing operations and growth. Overall, the sector is driven by more efficient operations, self-sufficiency in financing, and strong liquidity positions with free cash flow growth.

² Median Model: Model with the median R^2 across 5-fold cross-validation.

Real Estate Sector

Table 21

Real Estate Sector: Model Statistics

| (a) Linear: Cross-Validated | | | | | | (b) Linear: Full Dataset | |
|-----------------------------|--------|--------|--------|--------|--------|--------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 29.45% | 30.48% | 2.14% | 27.71% | 33.58% | R^2 | 31.09% |
| Adjusted R^2 | 29.28% | 30.32% | 2.14% | 27.54% | 33.42% | Adjusted R^2 | 30.96% |
| MSE | 0.49% | 0.49% | 0.02% | 0.46% | 0.51% | MSE | 0.49% |
| RMSE | 7.03% | 7.01% | 0.11% | 6.81% | 7.12% | RMSE | 6.99% |
| MAE | 5.09% | 5.14% | 0.10% | 5.02% | 5.33% | MAE | 5.12% |
| F-stat | 192.05 | 191.69 | 6.07 | 181.57 | 198.80 | F-stat | 240.70 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

| (c) LGBM: Cross-Validated | | | | | | (d) LGBM: Full Dataset | |
|---------------------------|--------|--------|--------|--------|--------|------------------------|--------|
| | Median | Mean | STD | Min | Max | | Score |
| R^2 | 49.49% | 49.48% | 2.19% | 46.01% | 52.29% | R^2 | 57.93% |
| Adjusted R^2 | 49.26% | 49.25% | 2.20% | 45.77% | 52.08% | Adjusted R^2 | 57.78% |
| MSE | 0.36% | 0.36% | 0.01% | 0.34% | 0.37% | MSE | 0.30% |
| RMSE | 6.02% | 5.97% | 0.09% | 5.82% | 6.07% | RMSE | 5.46% |
| MAE | 4.18% | 4.21% | 0.07% | 4.12% | 4.32% | MAE | 3.80% |
| F-stat | 217.23 | 217.65 | 3.91 | 211.74 | 223.79 | F-stat | 336.55 |
| P>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | P>F | 0.0000 |

Refer to Appendix L for additional model figures and tables.

The Real Estate Sector was one of the best-performing sectors, with the LightGBM model outperforming the linear model with median adjusted R^2 values of 49.26% and 29.28%, respectively. The LightGBM model performed exceptionally well in the sector compared to the linear regression model relative to other sectors. Top drivers of positive stock returns in the Real Estate Sector:

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Table 22

Real Estate Sector: Top Drivers

| Commodities | | Economic | | Company Fundamentals | |
|-----------------|-----------|-----------------|----------------------|----------------------|-----------------------|
| Importance Rank | Commodity | Importance Rank | Factor | Importance Rank | Metric |
| 2 | Silver ↑ | 1 | VIX ↓ | 16 | Operating Margin ↑ |
| 10 | Oil ↑ | 3 | Unemployment Rate ↓ | 17 | Capex ↓ |
| | | 4 | Federal Funds Rate ↓ | 18 | Total Revenue ↑ |
| | | 6 | CPI ↓ | 20 & 29 | Gross Profit Margin ↑ |
| | | | | 22 | EBITDA ↑ |

Note: ↑ denotes that higher variable values are associated with positive returns (i.e. “higher is better”), ↓ denotes that lower variable values are associated with positive returns (i.e. “lower is better”).

Drivers based on the median LightGBM model’s² SHAP values. Ambiguous relationships were omitted, see Figure L3 for the model’s SHAP plot.

Commodities such as silver and oil are drivers in the sector. Rising commodity prices can indicate economic growth resulting in increased confidence and demand for real estate.

Market volatility (VIX) is a crucial driver, with lower volatility typically associated with positive stock returns. Heightened market volatility can signal economic uncertainty and impact investor sentiment in real estate. The sector is sensitive to interest rate changes, as indicated by the Federal Funds Rate. Lower short-term interest rates can reduce borrowing costs for real estate companies, leading to higher valuations. Low inflation and a declining unemployment rate are positive drivers for the sector, as they indicate a healthy economic environment with increased consumer purchasing power and confidence.

Key financial metrics include profitability ratios, capital expenditures, revenue, and EBITDA. Capital expenditures are indicative of investments in growth opportunities and expansion. Overall, the sector values higher profitability margins, revenue growth, investments in projects, and EBITDA growth.

Limitations

While this study contributes valuable insights into the drivers of equity valuations, its limitations should be acknowledged. The study’s findings are based on historical

² Median Model: Model with the median R^2 across 5-fold cross-validation.

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data and may not fully capture the dynamic nature of financial markets over time. What has driven valuations in the past may not necessarily hold in the future, as market conditions and investor sentiment are subject to change.

The study's focus on the S&P 500, 400, and 600 indices may limit the generalizability of the findings to markets outside of the United States. Future research could explore the drivers of equity valuations in global markets to provide a more comprehensive understanding of the factors influencing valuations within specific regions. Additionally, certain industry groups, industries, and sub-industries were underrepresented in the dataset due to the holdings of the S&P indices and availability of data. Future research could provide a more granular analysis, providing insights into the drivers of equity valuations within specific industries and sub-industries.

The models do not account for news events outside of the dataset, such as geopolitical events, regulatory changes, and technological advancements, which can significantly impact equity valuations. Analyst forecasts and price targets as well as forward guidance from companies were also not included in the analysis. These could provide additional insights into market expectations and their impact on equity valuations.

Both regression models commonly suffered from heteroscedasticity for returns exceeding approximately $\pm 20\%$ and a skewed distribution of residuals beyond ± 2 standard deviations. The models were less robust in predicting extreme returns, however, this is to be expected given the absence of news events and potential earnings surprises in the dataset that may cause large price movements. Future research could explore alternative techniques and additional data sources to improve model robustness.

Conclusion

In essence, this research has delved into the fundamental determinants of equity valuation spanning various GICS sectors. Gradient-boosted decision tree models consistently outperformed linear regression approaches, demonstrating the importance of leveraging flexible, non-linear patterns in financial regression analysis. Notably, the analysis revealed that the drivers of equity valuations varied across sectors, emphasizing

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the need for a tailored, sector-specific approach to valuation. Intriguingly, Net Income did not emerge as a primary driver across sectors, and EPS featured in a single sector. Rather, free cash flow emerged as a pivotal driver in 9 out of 11 sectors, underscoring its profound significance as a fundamental metric in equity valuation. While expected due to its utilization in DCF models, this finding accentuates the criticality of cash flow generation and precise forecasting in ascertaining a company's worth. A profitability ratio also emerged as a key metric in 9 out of 11 sectors, highlighting its relevance in assessing future growth prospects and financial health.

The identified drivers provide crucial insights that can enhance investors' decision-making processes, improve valuation modeling practices, and strengthen risk management strategies. Armed with a deeper understanding of the pivotal factors influencing sector-specific valuations, market participants can make more informed choices regarding stock selection, portfolio management, and strategic positioning in mergers and acquisitions. Furthermore, the insights gleaned from this study can serve as a compass for researchers and practitioners, aiding them in refining valuation methodologies such as Discounted Cash Flow (DCF) and comparable company analyses. This refinement may entail scrutinizing underlying assumptions and strategically prioritizing the most influential variables. Overall, this research contributes to a more comprehensive understanding of the dynamics influencing equity valuations, providing investors, analysts, and industry stakeholders with enhanced tools to navigate the intricate terrain of financial markets with heightened foresight and confidence.

Future Research

As noted in the limitations section, model performance may be further enhanced by incorporating additional data sources such as forward guidance from companies, analyst forecasts, and price targets to provide a more comprehensive view of market expectations and their impact on equity valuations. Additional sources could include social media sentiment analysis and natural language processing to capture market sentiment, news events, and investor behavior. Incorporating these factors should enhance the predictive power of the models and provide a more nuanced understanding

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of the drivers of equity valuations as events are “priced in.”

Given the broad scope of the study, future research could explore industry-specific and sub-industry-specific drivers to provide more granular insights into the factors influencing valuations. This could assist investors in tailoring their investment strategies within specific industries and sub-industries.

Additionally, there may be differing findings in markets outside of the United States stock market, warranting further research into the drivers of equity valuations in global markets. This could provide valuable insights for investors with international portfolios and help identify regional factors influencing valuations.

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Appendix A

Table A1*Independent Variables*

| Company Fundamentals %Δ QoQ | Economic Indicators %Δ | Commodities %Δ |
|-----------------------------|--|----------------|
| Total Revenue | Federal Funds Rate | Gold |
| Operating Revenue | 3 Month Treasury Yield | Silver |
| Net Income | 10 Year - 2 Year Treasury Yield Spread | Copper |
| Basic EPS | BAA - AAA Corporate Bond Yield Spread | Aluminum |
| EBITDA | In(Volatility Index) ^a | Platinum |
| EBIT | 30 Year - 15 Year Mortgage Rate Spread | Palladium |
| Current Ratio | CPI (Consumer Price Index for All Urban Consumers: All Items in U.S. City Average) | Oil |
| Quick Ratio | Unemployment Rate | Natural Gas |
| Gross Profit Margin | Federal Budget Surplus or Deficit | Corn |
| Net Profit Margin | Housing Starts (New Privately-Owned Housing Units Started: Total Units) | Soybean |
| Cash Flow Margin | Real GDP ^b | Coffee |
| Operating Margin | Average Home Price (Average Sales Price of Houses Sold for the United States) ^b | Sugar |
| ROA | | Cotton |
| CROA | | Wheat |
| ROE | | |
| Efficiency Ratio | | |
| Inventory Turnover | | |
| Debt to Equity | | |
| Debt Ratio | | |
| Interest Coverage | | |
| Cash Flow to Debt | | |
| Assets to Equity | | |
| R&D to Revenue | | |
| Investment CF to OCF | | |
| Financing CF to OCF | | |
| Free Cash Flow | | |
| Capex | | |
| BV per Share | | |
| Tangible BV per Share | | |

^a Note: Natural Log %Δ^b QoQ %Δ**Table A2***Selected Sectors: Global Industry Classification Standard (GICS)*

| | |
|--|---------|
| Energy Sector | (p. 15) |
| Materials Sector | (p. 18) |
| Industrials Sector | (p. 21) |
| Consumer Discretionary Sector | (p. 24) |
| Consumer Staples Sector | (p. 26) |
| Health Care Sector | (p. 28) |
| Financial Services Industry Group ³ | (p. 30) |
| Information Technology Sector | (p. 32) |
| Communication Services Sector | (p. 34) |
| Utilities Sector | (p. 36) |
| Real Estate Sector | (p. 38) |

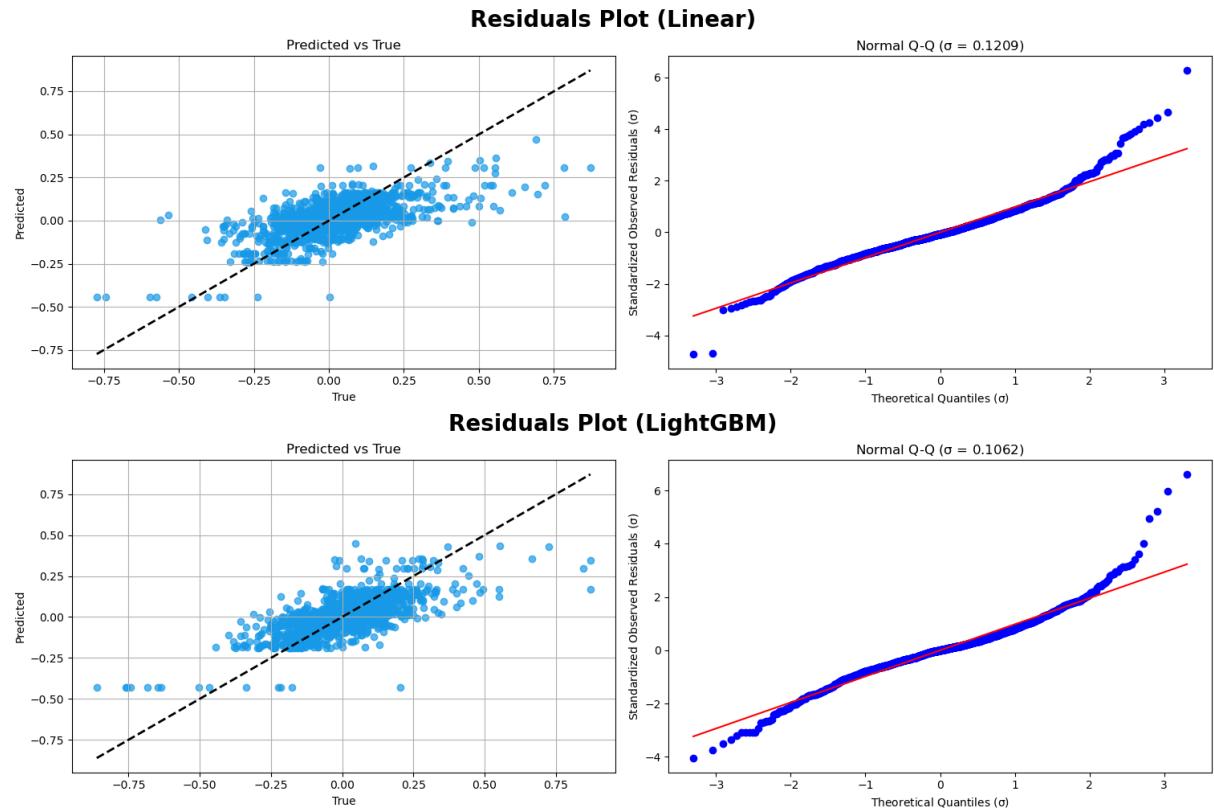
³ Bank and Insurance Industry Groups omitted due to lack of data.

Appendix B

Energy Sector

Figure B1

Energy Sector: Residuals Plots (Median Model)

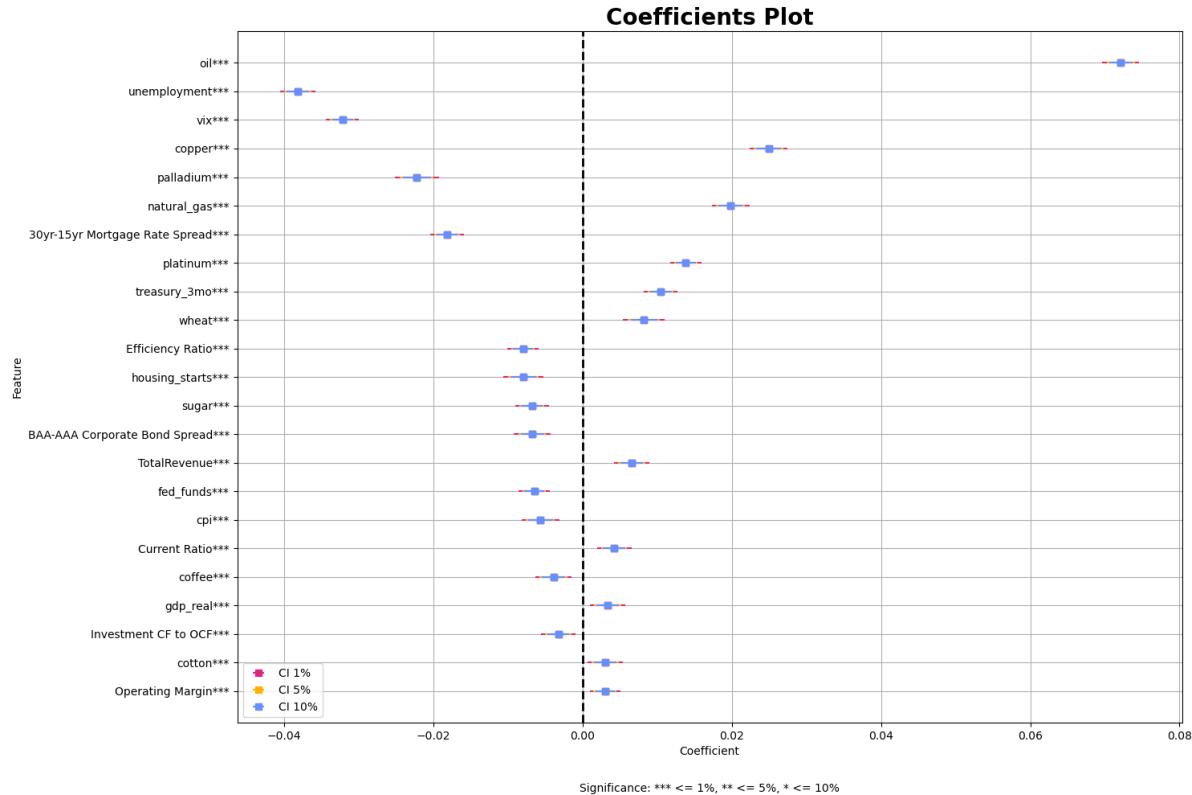


Median Model: Model with the median R^2 across 5-fold cross-validation.

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Figure B2

Energy Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table B1 for coefficient statistics.

Table B1

Energy Sector: Linear Regression Coefficient Statistics (Median Model)

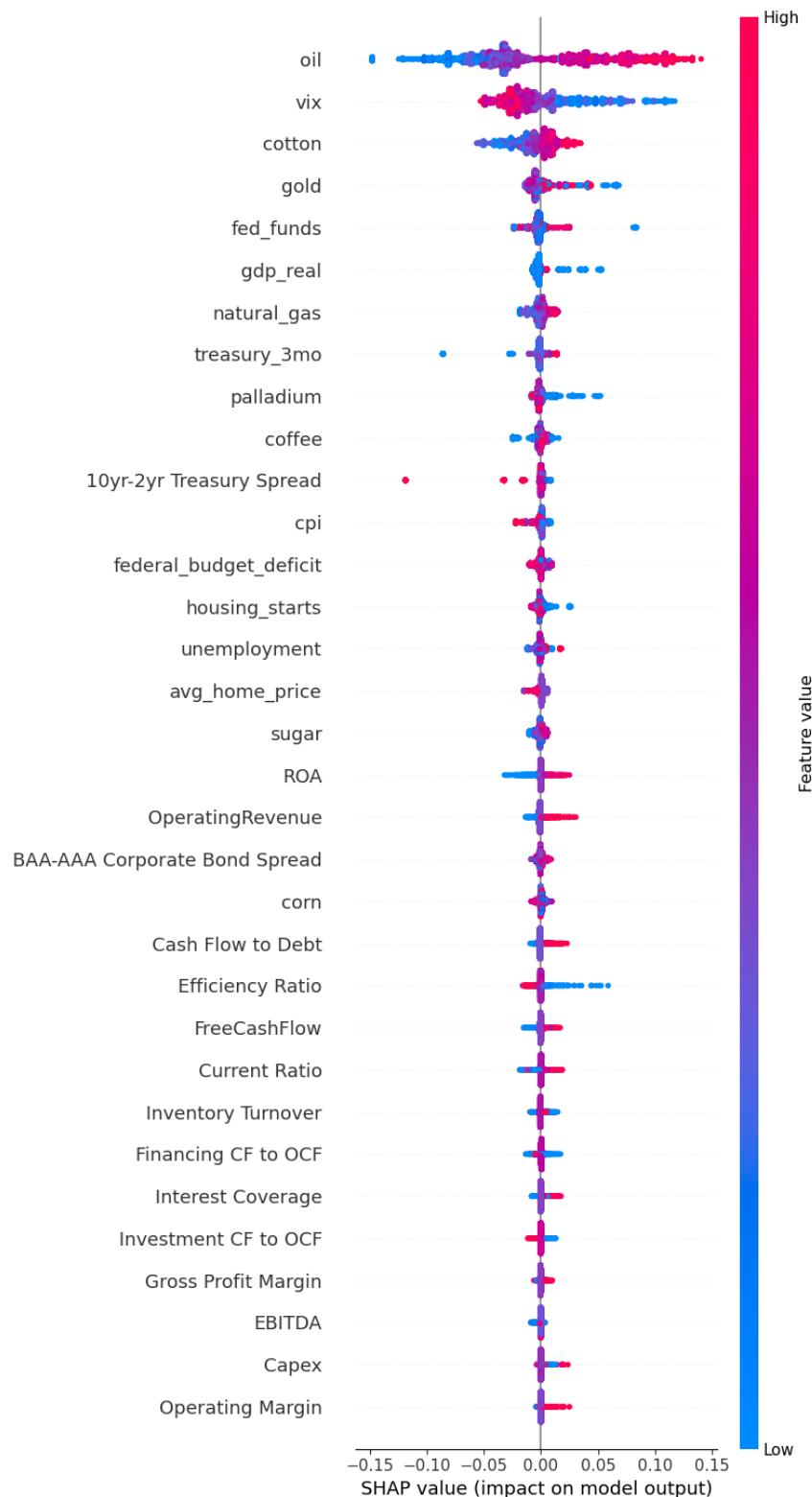
| | Coef | Std Err | t | P > t | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|--------------------------------|-----------|----------|-----------|--------------|----------|----------|----------|----------|----------|----------|
| oil | 0.072119 | 0.000959 | 75.208093 | 0.000000e+00 | 1.645118 | 0.001578 | 1.960375 | 0.001880 | 2.576681 | 0.002471 |
| unemployment | -0.038168 | 0.000917 | 41.626649 | 0.000000e+00 | 1.645118 | 0.001508 | 1.960375 | 0.001798 | 2.576681 | 0.002363 |
| vix | -0.032191 | 0.000848 | 37.942988 | 0.000000e+00 | 1.645118 | 0.001396 | 1.960375 | 0.001663 | 2.576681 | 0.002186 |
| copper | 0.024927 | 0.000993 | 25.098230 | 0.000000e+00 | 1.645118 | 0.001634 | 1.960375 | 0.001947 | 2.576681 | 0.002559 |
| palladium | -0.022238 | 0.001153 | 19.290435 | 0.000000e+00 | 1.645118 | 0.001897 | 1.960375 | 0.002260 | 2.576681 | 0.002970 |
| natural_gas | 0.019830 | 0.000987 | 20.097302 | 0.000000e+00 | 1.645118 | 0.001623 | 1.960375 | 0.001934 | 2.576681 | 0.002542 |
| 30yr-15yr Mortgage Rate Spread | -0.018138 | 0.000871 | 20.832268 | 0.000000e+00 | 1.645118 | 0.001432 | 1.960375 | 0.001707 | 2.576681 | 0.002243 |
| platinum | 0.013830 | 0.000801 | 17.274325 | 0.000000e+00 | 1.645118 | 0.001317 | 1.960375 | 0.001570 | 2.576681 | 0.002063 |
| treasury_3mo | 0.010473 | 0.000869 | 12.051312 | 0.000000e+00 | 1.645118 | 0.001430 | 1.960375 | 0.001704 | 2.576681 | 0.002239 |
| wheat | 0.008210 | 0.001091 | 7.527143 | 5.995204e-14 | 1.645118 | 0.001794 | 1.960375 | 0.002138 | 2.576681 | 0.002811 |
| Efficiency Ratio | -0.008001 | 0.000815 | 9.814769 | 0.000000e+00 | 1.645118 | 0.001341 | 1.960375 | 0.001598 | 2.576681 | 0.002100 |
| housing_starts | -0.007948 | 0.001028 | 7.733571 | 1.221245e-14 | 1.645118 | 0.001691 | 1.960375 | 0.002015 | 2.576681 | 0.002648 |
| sugar | -0.006813 | 0.000875 | 7.786004 | 8.215650e-15 | 1.645118 | 0.001440 | 1.960375 | 0.001715 | 2.576681 | 0.002255 |
| BAA-AAA Corporate Bond Spread | -0.006754 | 0.000951 | 7.104753 | 1.350919e-12 | 1.645118 | 0.001564 | 1.960375 | 0.001864 | 2.576681 | 0.002449 |
| TotalRevenue | 0.006591 | 0.000926 | 7.119706 | 1.213252e-12 | 1.645118 | 0.001523 | 1.960375 | 0.001815 | 2.576681 | 0.002385 |
| fed_funds | -0.006479 | 0.000801 | 8.083756 | 8.881784e-16 | 1.645118 | 0.001318 | 1.960375 | 0.001571 | 2.576681 | 0.002065 |
| cpi | -0.005645 | 0.000991 | 5.698187 | 1.270725e-08 | 1.645118 | 0.001630 | 1.960375 | 0.001942 | 2.576681 | 0.002553 |
| Current Ratio | 0.004219 | 0.000896 | 4.708409 | 2.554940e-06 | 1.645118 | 0.001474 | 1.960375 | 0.001757 | 2.576681 | 0.002309 |
| coffee | -0.003903 | 0.000948 | 4.116240 | 3.904693e-05 | 1.645118 | 0.001560 | 1.960375 | 0.001859 | 2.576681 | 0.002443 |
| gdp_real | 0.003357 | 0.000928 | 3.618484 | 2.988685e-04 | 1.645118 | 0.001526 | 1.960375 | 0.001819 | 2.576681 | 0.002390 |
| Investment CF to OCF | -0.003262 | 0.000905 | 3.603657 | 3.164137e-04 | 1.645118 | 0.001489 | 1.960375 | 0.001775 | 2.576681 | 0.002333 |
| cotton | 0.003010 | 0.000920 | 3.271215 | 1.077149e-03 | 1.645118 | 0.001514 | 1.960375 | 0.001804 | 2.576681 | 0.002371 |
| Operating Margin | 0.003001 | 0.000795 | 3.773926 | 1.623090e-04 | 1.645118 | 0.001308 | 1.960375 | 0.001559 | 2.576681 | 0.002049 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure B3

Energy Sector: LightGBM SHAP Beeswarm Plot (Median Model)



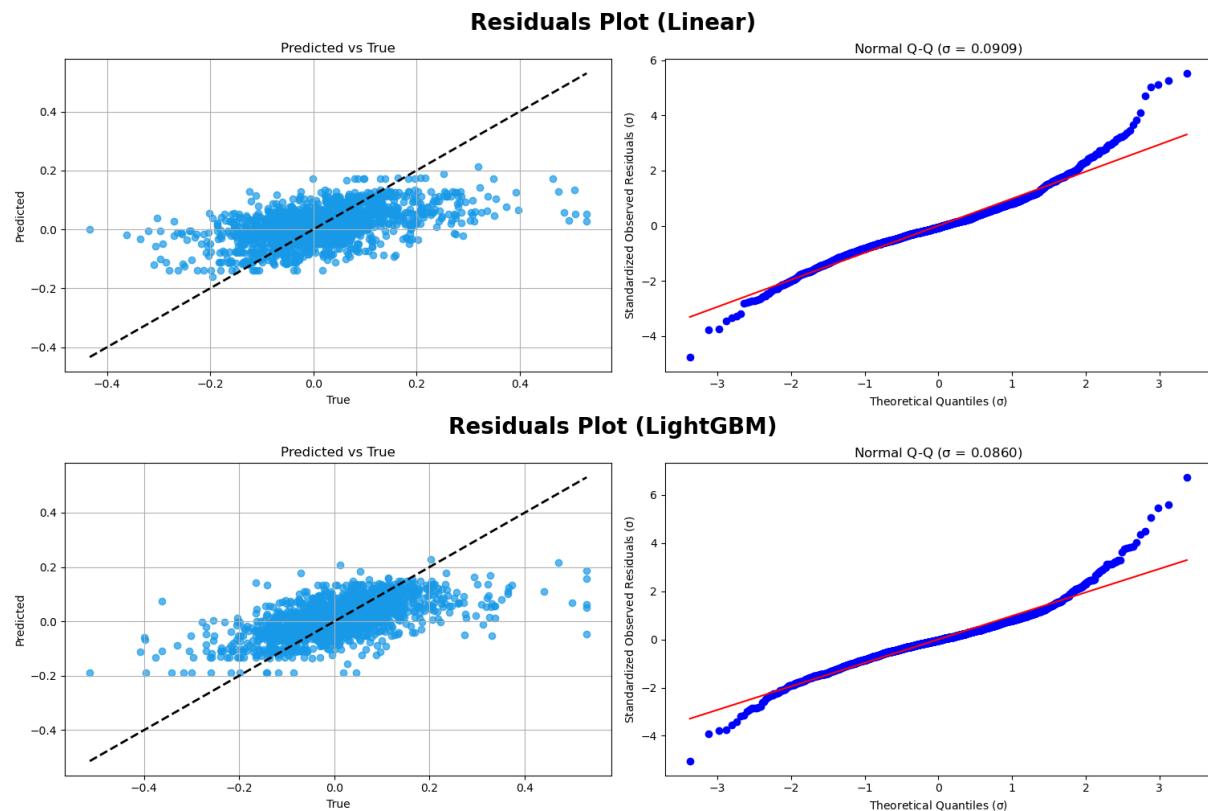
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix C

Materials Sector

Figure C1

Materials Sector: Residuals Plots (Median Model)

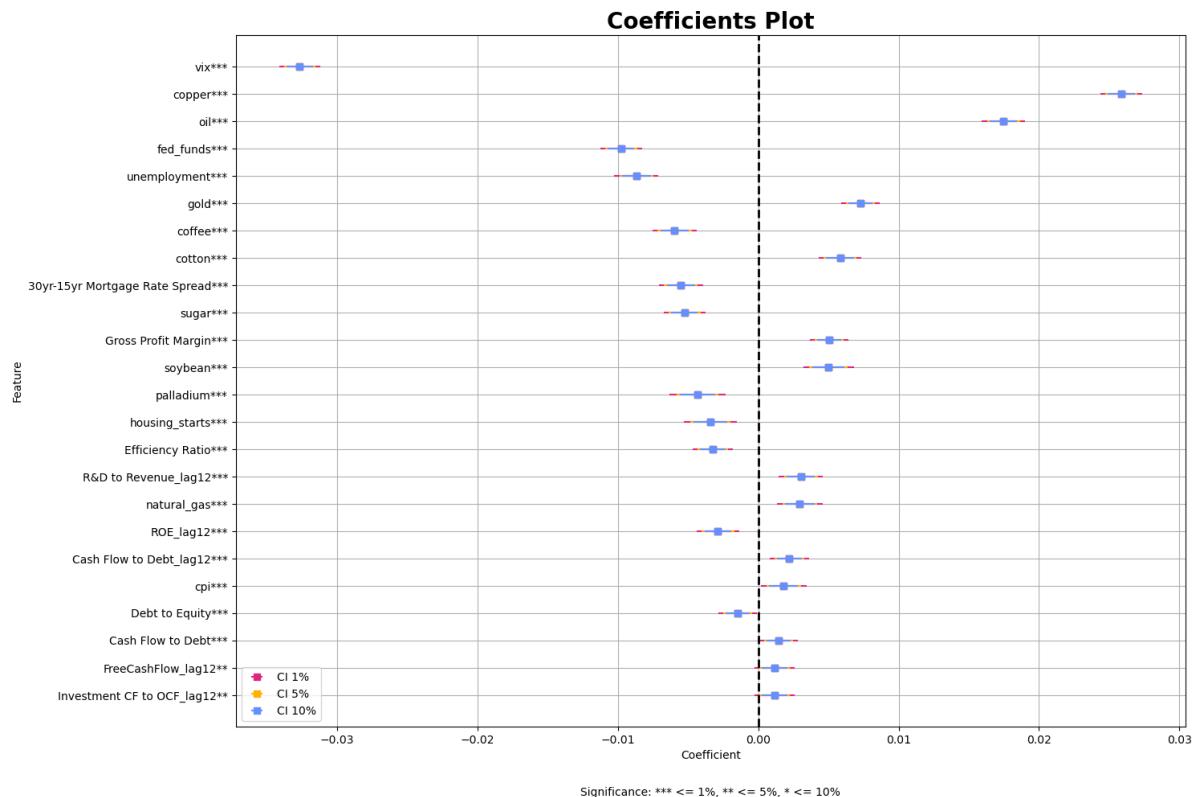


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure C2

Materials Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table C1 for coefficient statistics.

DECODING SECTOR VALUATION DYNAMICS

Table C1

Materials Sector: Linear Regression Coefficient Statistics (Median Model)

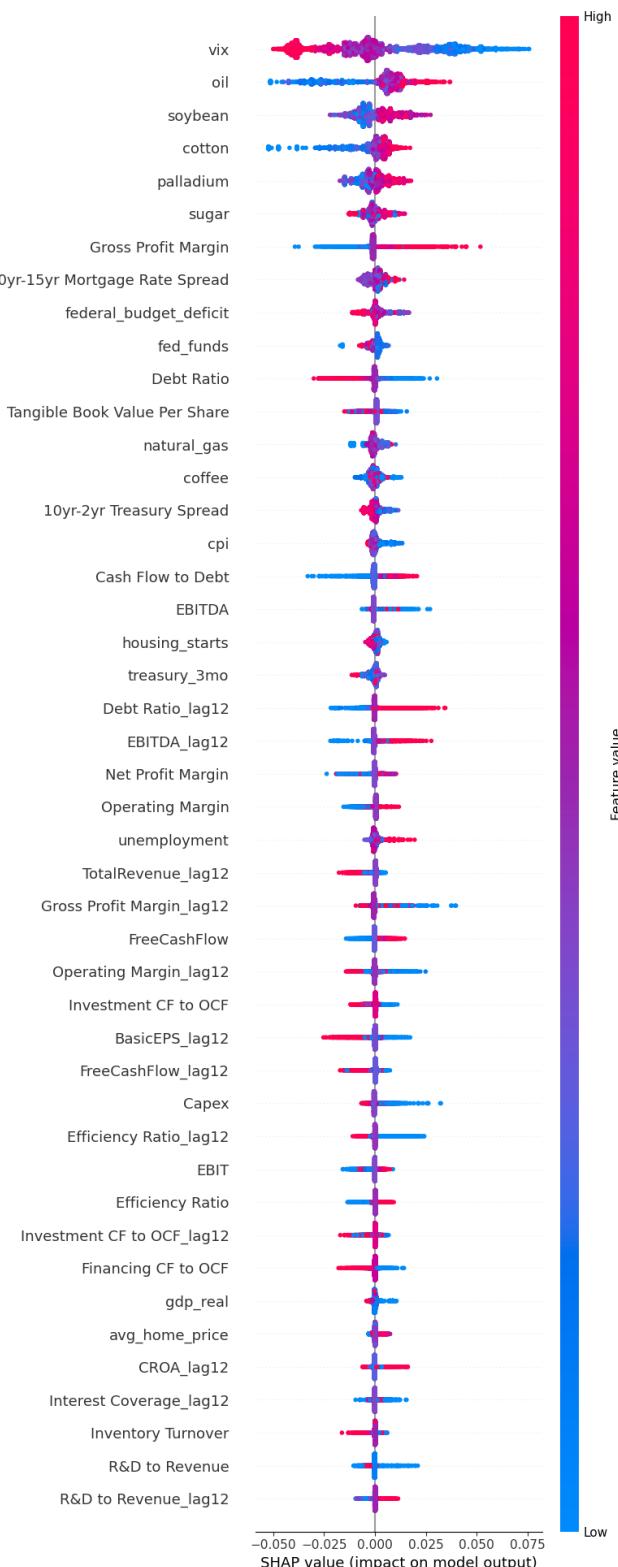
| | Coef | Std Err | —t— | P>—t— | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|--------------------------------|-----------|----------|-----------|--------------|----------|----------|----------|----------|----------|----------|
| vix | -0.032670 | 0.000573 | 56.996400 | 0.000000e+00 | 1.645059 | 0.000943 | 1.960284 | 0.001124 | 2.576493 | 0.001477 |
| copper | 0.025858 | 0.000585 | 44.215908 | 0.000000e+00 | 1.645059 | 0.000962 | 1.960284 | 0.001146 | 2.576493 | 0.001507 |
| oil | 0.017464 | 0.000598 | 29.209475 | 0.000000e+00 | 1.645059 | 0.000984 | 1.960284 | 0.001172 | 2.576493 | 0.001540 |
| fed_funds | -0.009781 | 0.000579 | 16.883030 | 0.000000e+00 | 1.645059 | 0.000953 | 1.960284 | 0.001136 | 2.576493 | 0.001493 |
| unemployment | -0.008679 | 0.000610 | 14.216847 | 0.000000e+00 | 1.645059 | 0.001004 | 1.960284 | 0.001197 | 2.576493 | 0.001573 |
| gold | 0.007280 | 0.000531 | 13.711729 | 0.000000e+00 | 1.645059 | 0.000873 | 1.960284 | 0.001041 | 2.576493 | 0.001368 |
| coffee | -0.005962 | 0.000615 | 9.701652 | 0.000000e+00 | 1.645059 | 0.001011 | 1.960284 | 0.001205 | 2.576493 | 0.001583 |
| cotton | 0.005821 | 0.000597 | 9.753867 | 0.000000e+00 | 1.645059 | 0.000982 | 1.960284 | 0.001170 | 2.576493 | 0.001538 |
| 30yr-15yr Mortgage Rate Spread | -0.005526 | 0.000610 | 9.058539 | 0.000000e+00 | 1.645059 | 0.001004 | 1.960284 | 0.001196 | 2.576493 | 0.001572 |
| sugar | -0.005263 | 0.000581 | 9.057284 | 0.000000e+00 | 1.645059 | 0.000956 | 1.960284 | 0.001139 | 2.576493 | 0.001497 |
| Gross Profit Margin | 0.005062 | 0.000528 | 9.584668 | 0.000000e+00 | 1.645059 | 0.000869 | 1.960284 | 0.001035 | 2.576493 | 0.001361 |
| soybean | 0.005005 | 0.000703 | 7.120071 | 1.179945e-12 | 1.645059 | 0.001156 | 1.960284 | 0.001378 | 2.576493 | 0.001811 |
| palladium | -0.004328 | 0.000770 | 5.618760 | 1.993136e-08 | 1.645059 | 0.001267 | 1.960284 | 0.001510 | 2.576493 | 0.001984 |
| housing_starts | -0.003411 | 0.000731 | 4.665576 | 3.131570e-06 | 1.645059 | 0.001203 | 1.960284 | 0.001433 | 2.576493 | 0.001884 |
| Efficiency Ratio | -0.003247 | 0.000555 | 5.852369 | 5.052831e-09 | 1.645059 | 0.000913 | 1.960284 | 0.001088 | 2.576493 | 0.001430 |
| R&D to Revenue_lag12 | 0.003039 | 0.000611 | 4.972157 | 6.770024e-07 | 1.645059 | 0.001005 | 1.960284 | 0.001198 | 2.576493 | 0.001575 |
| natural_gas | 0.002953 | 0.000632 | 4.674761 | 2.995025e-06 | 1.645059 | 0.001039 | 1.960284 | 0.001238 | 2.576493 | 0.001628 |
| ROE_lag12 | -0.002872 | 0.000585 | 4.908044 | 9.395480e-07 | 1.645059 | 0.000963 | 1.960284 | 0.001147 | 2.576493 | 0.001508 |
| Cash Flow to Debt_lag12 | 0.002202 | 0.000540 | 4.076020 | 4.629209e-05 | 1.645059 | 0.000889 | 1.960284 | 0.001059 | 2.576493 | 0.001392 |
| cpi | 0.001802 | 0.000630 | 2.861777 | 4.224539e-03 | 1.645059 | 0.001036 | 1.960284 | 0.001235 | 2.576493 | 0.001623 |
| Debt to Equity | -0.001483 | 0.000531 | 2.795954 | 5.188001e-03 | 1.645059 | 0.000873 | 1.960284 | 0.001040 | 2.576493 | 0.001367 |
| Cash Flow to Debt | 0.001444 | 0.000533 | 2.711264 | 6.718174e-03 | 1.645059 | 0.000876 | 1.960284 | 0.001044 | 2.576493 | 0.001372 |
| FreeCashFlow_lag12 | 0.001177 | 0.000559 | 2.107441 | 3.511292e-02 | 1.645059 | 0.000919 | 1.960284 | 0.001095 | 2.576493 | 0.001439 |
| Investment CF to OCF_lag12 | 0.001176 | 0.000552 | 2.130153 | 3.319185e-02 | 1.645059 | 0.000908 | 1.960284 | 0.001082 | 2.576493 | 0.001422 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure C3

Materials Sector: LightGBM SHAP Beeswarm Plot (Median Model)



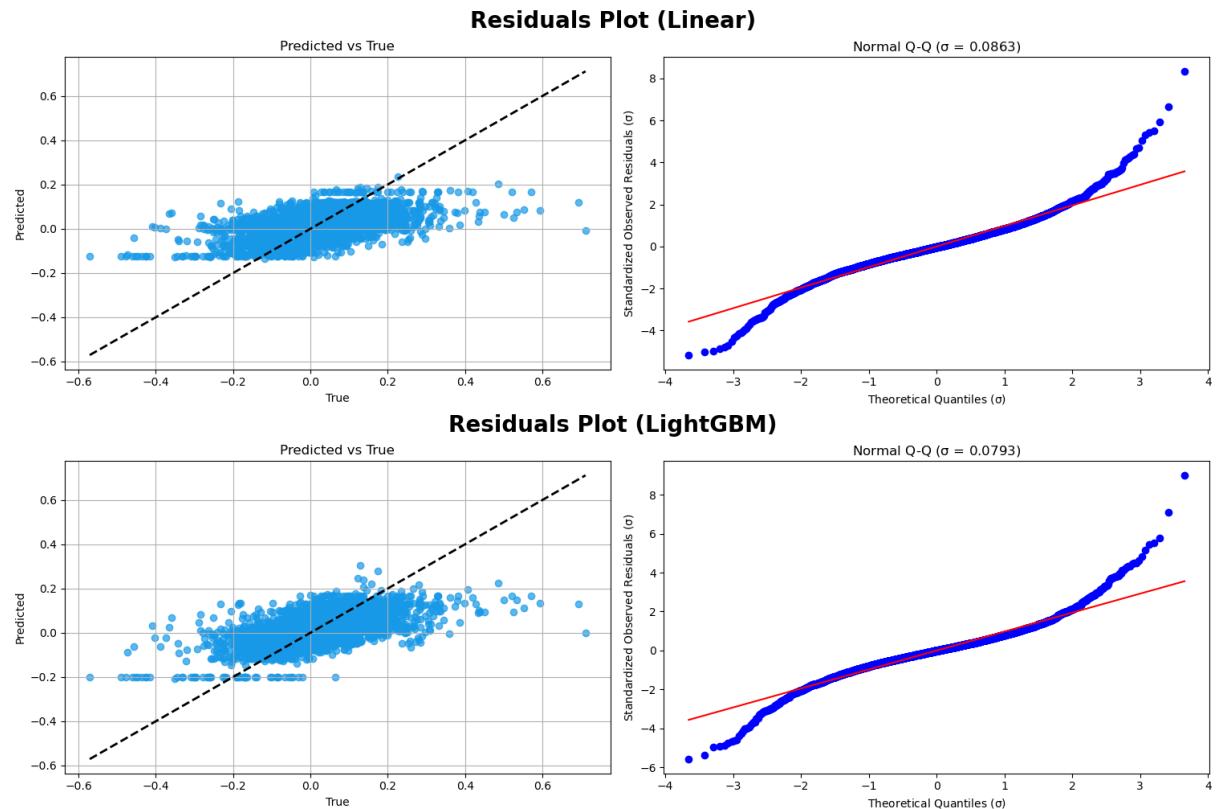
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix D

Industrials Sector

Figure D1

Industrials Sector: Residuals Plots (Median Model)

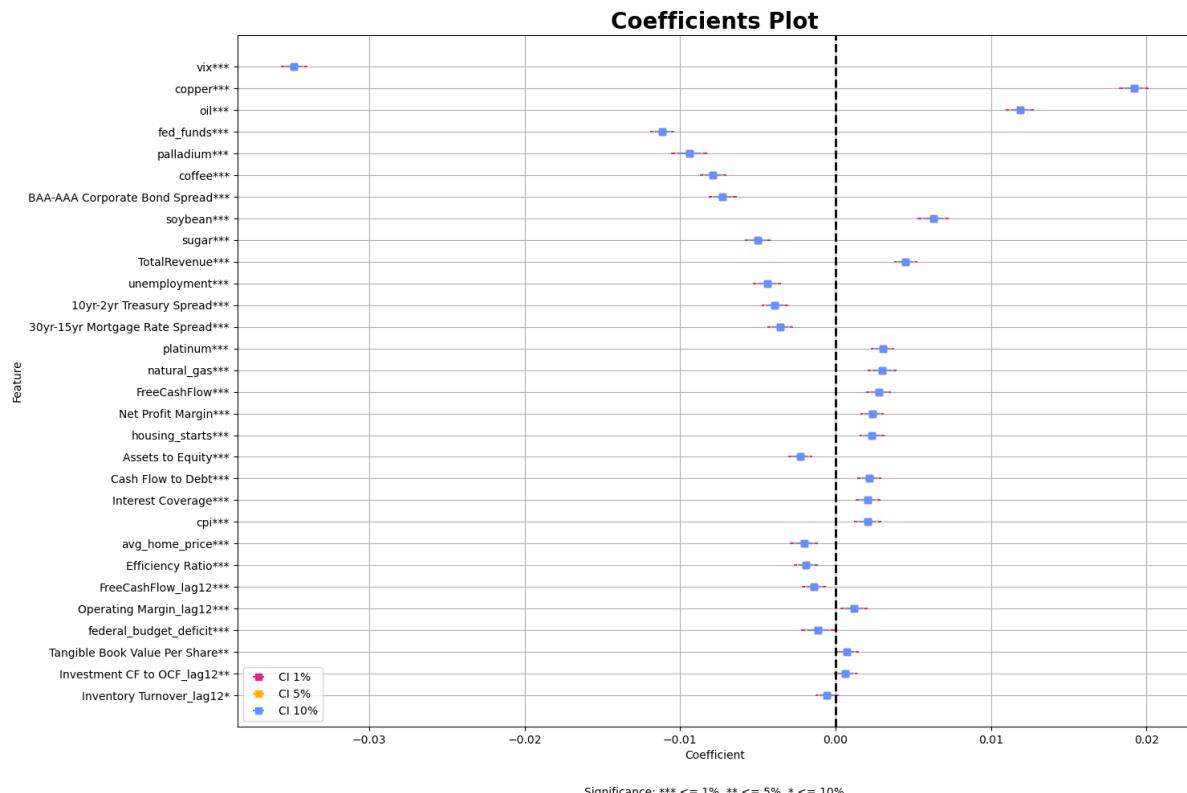


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure D2

Industrials Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table D1 for coefficient statistics.

DECODING SECTOR VALUATION DYNAMICS

Table D1

Industrials Sector: Linear Regression Coefficient Statistics (Median Model)

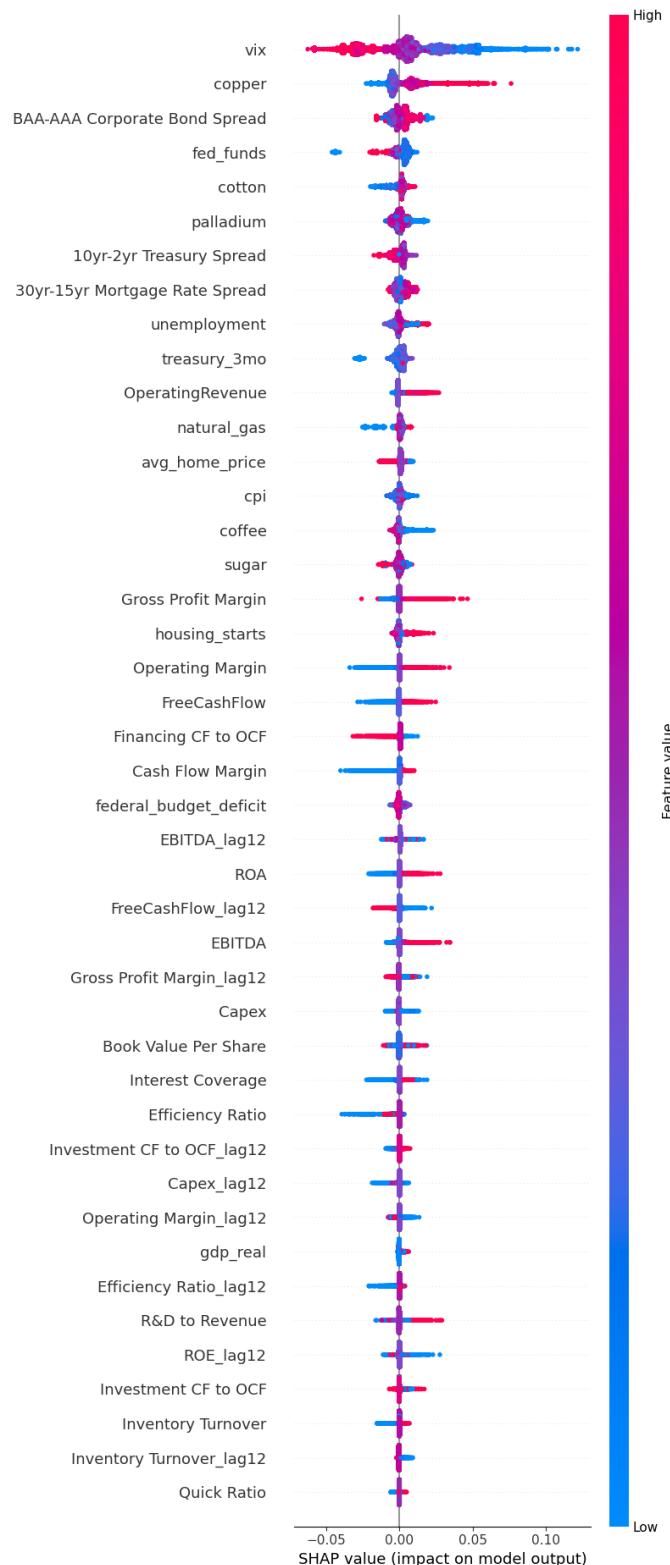
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|--------------------------------|-----------|----------|------------|--------------|----------|----------|----------|----------|---------|----------|
| vix | -0.034846 | 0.000329 | 106.018560 | 0.000000e+00 | 1.644925 | 0.000541 | 1.960075 | 0.000644 | 2.57606 | 0.000847 |
| copper | 0.019193 | 0.000369 | 52.046263 | 0.000000e+00 | 1.644925 | 0.000607 | 1.960075 | 0.000723 | 2.57606 | 0.000950 |
| oil | 0.011864 | 0.000348 | 34.066534 | 0.000000e+00 | 1.644925 | 0.000573 | 1.960075 | 0.000683 | 2.57606 | 0.000897 |
| fed_funds | -0.011140 | 0.000297 | 37.461731 | 0.000000e+00 | 1.644925 | 0.000489 | 1.960075 | 0.000583 | 2.57606 | 0.000766 |
| palladium | -0.009409 | 0.000457 | 20.568201 | 0.000000e+00 | 1.644925 | 0.000753 | 1.960075 | 0.000897 | 2.57606 | 0.001178 |
| coffee | -0.007888 | 0.000331 | 23.803426 | 0.000000e+00 | 1.644925 | 0.000545 | 1.960075 | 0.000649 | 2.57606 | 0.000854 |
| BAA-AAA Corporate Bond Spread | -0.007262 | 0.000349 | 20.835321 | 0.000000e+00 | 1.644925 | 0.000573 | 1.960075 | 0.000683 | 2.57606 | 0.000898 |
| soybean | 0.006290 | 0.000391 | 16.091937 | 0.000000e+00 | 1.644925 | 0.000643 | 1.960075 | 0.000766 | 2.57606 | 0.001007 |
| sugar | -0.004996 | 0.000324 | 15.440495 | 0.000000e+00 | 1.644925 | 0.000532 | 1.960075 | 0.000634 | 2.57606 | 0.000833 |
| TotalRevenue | 0.004519 | 0.000297 | 15.226676 | 0.000000e+00 | 1.644925 | 0.000488 | 1.960075 | 0.000582 | 2.57606 | 0.000765 |
| unemployment | -0.004401 | 0.000347 | 12.694730 | 0.000000e+00 | 1.644925 | 0.000570 | 1.960075 | 0.000680 | 2.57606 | 0.000893 |
| 10yr-2yr Treasury Spread | -0.003907 | 0.000335 | 11.664282 | 0.000000e+00 | 1.644925 | 0.000551 | 1.960075 | 0.000657 | 2.57606 | 0.000863 |
| 30yr-15yr Mortgage Rate Spread | -0.003557 | 0.000311 | 11.424984 | 0.000000e+00 | 1.644925 | 0.000512 | 1.960075 | 0.000610 | 2.57606 | 0.000802 |
| platinum | 0.003034 | 0.000296 | 10.258112 | 0.000000e+00 | 1.644925 | 0.000487 | 1.960075 | 0.000580 | 2.57606 | 0.000762 |
| natural_gas | 0.003008 | 0.000366 | 8.207762 | 2.220446e-16 | 1.644925 | 0.000603 | 1.960075 | 0.000718 | 2.57606 | 0.000944 |
| FreeCashFlow | 0.002785 | 0.000310 | 8.998133 | 0.000000e+00 | 1.644925 | 0.000509 | 1.960075 | 0.000607 | 2.57606 | 0.000797 |
| Net Profit Margin | 0.002364 | 0.000296 | 7.986280 | 1.332268e-15 | 1.644925 | 0.000487 | 1.960075 | 0.000580 | 2.57606 | 0.000763 |
| housing_starts | 0.002353 | 0.000316 | 7.434627 | 1.088019e-13 | 1.644925 | 0.000521 | 1.960075 | 0.000620 | 2.57606 | 0.000815 |
| Assets to Equity | -0.002263 | 0.000304 | 7.441755 | 1.032507e-13 | 1.644925 | 0.000500 | 1.960075 | 0.000596 | 2.57606 | 0.000783 |
| Cash Flow to Debt | 0.002186 | 0.000301 | 7.260160 | 3.999023e-13 | 1.644925 | 0.000495 | 1.960075 | 0.000590 | 2.57606 | 0.000776 |
| Interest Coverage | 0.002087 | 0.000308 | 6.765546 | 1.362443e-11 | 1.644925 | 0.000507 | 1.960075 | 0.000605 | 2.57606 | 0.000794 |
| cpi | 0.002055 | 0.000338 | 6.078365 | 1.234732e-09 | 1.644925 | 0.000556 | 1.960075 | 0.000663 | 2.57606 | 0.000871 |
| avg_home_price | -0.002009 | 0.000351 | 5.724932 | 1.048624e-08 | 1.644925 | 0.000577 | 1.960075 | 0.000688 | 2.57606 | 0.000904 |
| Efficiency Ratio | -0.001906 | 0.000295 | 6.455851 | 1.099263e-10 | 1.644925 | 0.000486 | 1.960075 | 0.000579 | 2.57606 | 0.000761 |
| FreeCashFlow_lag12 | -0.001386 | 0.000296 | 4.685847 | 2.805226e-06 | 1.644925 | 0.000487 | 1.960075 | 0.000580 | 2.57606 | 0.000762 |
| Operating Margin_lag12 | 0.001204 | 0.000345 | 3.488170 | 4.873168e-04 | 1.644925 | 0.000568 | 1.960075 | 0.000676 | 2.57606 | 0.000889 |
| federal_budget_deficit | -0.001121 | 0.000421 | 2.661149 | 7.793264e-03 | 1.644925 | 0.000693 | 1.960075 | 0.000826 | 2.57606 | 0.001085 |
| Tangible Book Value Per Share | 0.000727 | 0.000297 | 2.444289 | 1.452182e-02 | 1.644925 | 0.000489 | 1.960075 | 0.000583 | 2.57606 | 0.000766 |
| Investment CF to OCF_lag12 | 0.000645 | 0.000296 | 2.181907 | 2.912728e-02 | 1.644925 | 0.000486 | 1.960075 | 0.000579 | 2.57606 | 0.000761 |
| Inventory Turnover_lag12 | -0.000537 | 0.000296 | 1.817309 | 6.918377e-02 | 1.644925 | 0.000486 | 1.960075 | 0.000579 | 2.57606 | 0.000761 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure D3

Industrials Sector: LightGBM SHAP Beeswarm Plot (Median Model)



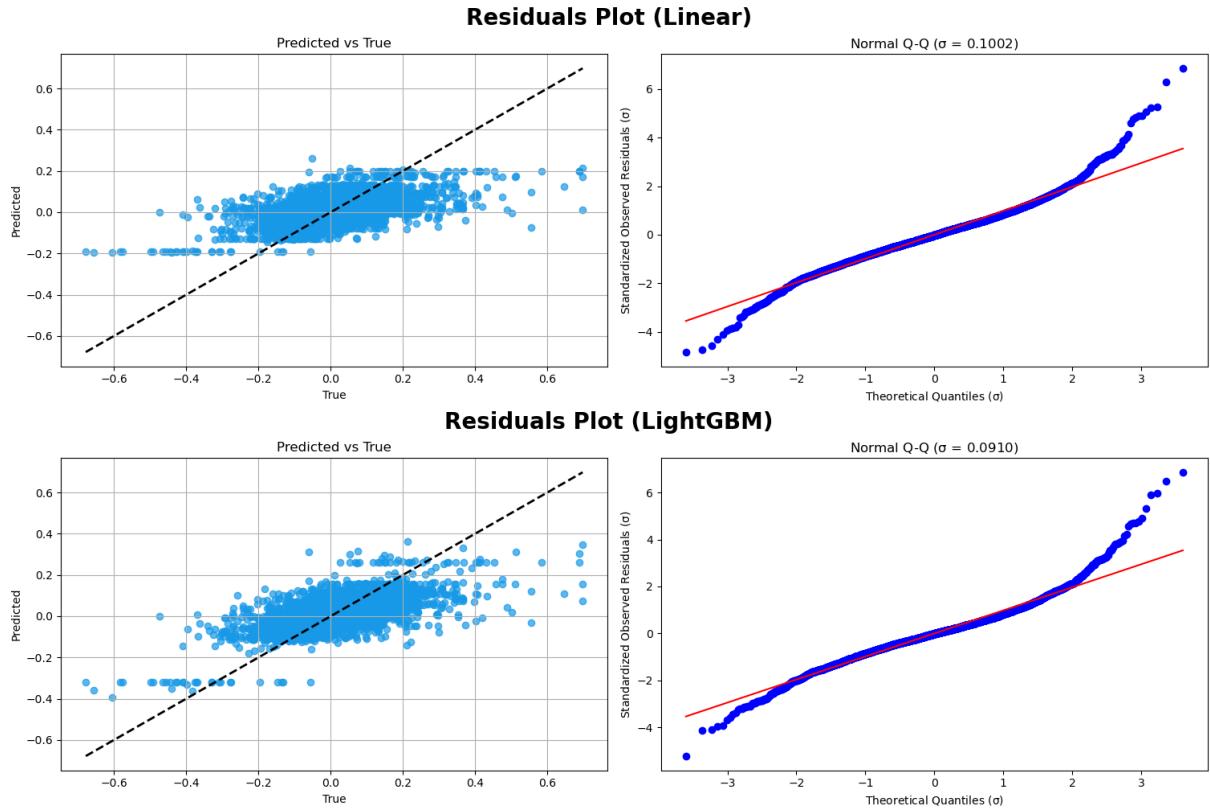
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix E

Consumer Discretionary Sector

Figure E1

Consumer Discretionary Sector: Residuals Plots (Median Model)

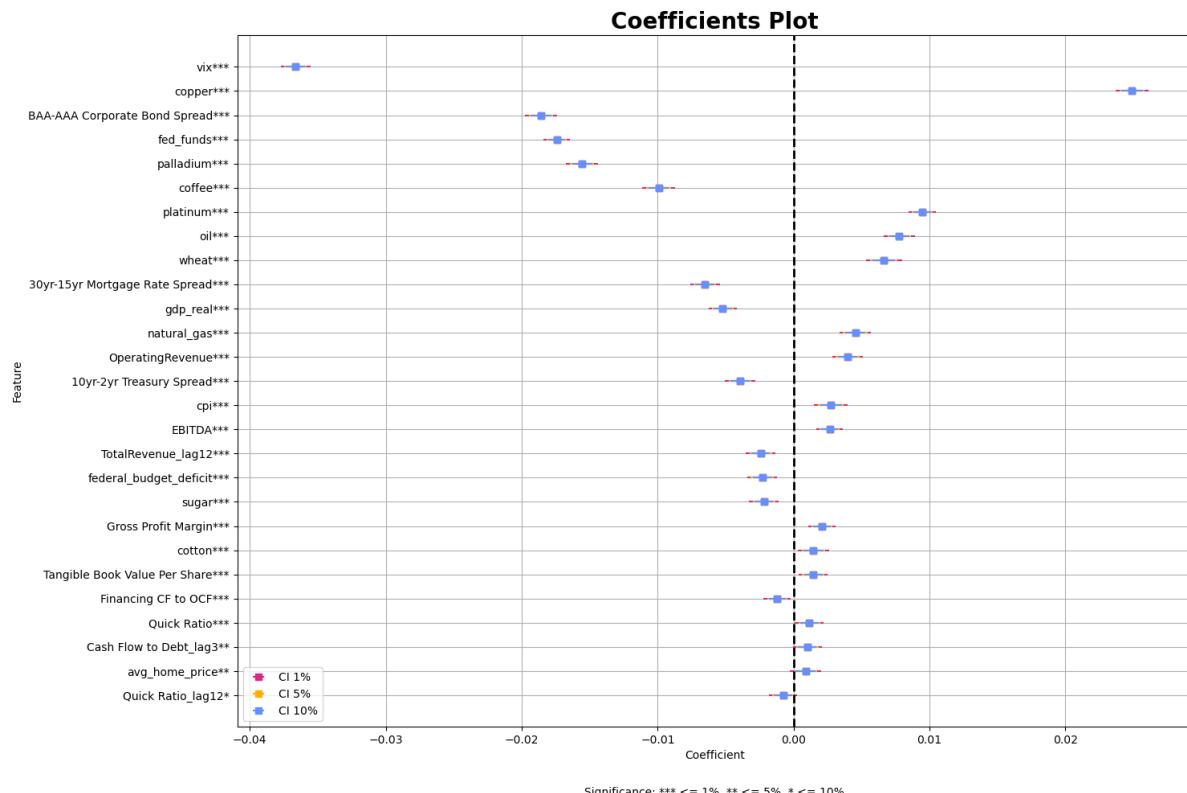


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure E2

Consumer Discretionary Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table E1 for coefficient statistics.

DECODING SECTOR VALUATION DYNAMICS

Table E1

Consumer Discretionary Sector: Linear Regression Coefficient Statistics (Median Model)

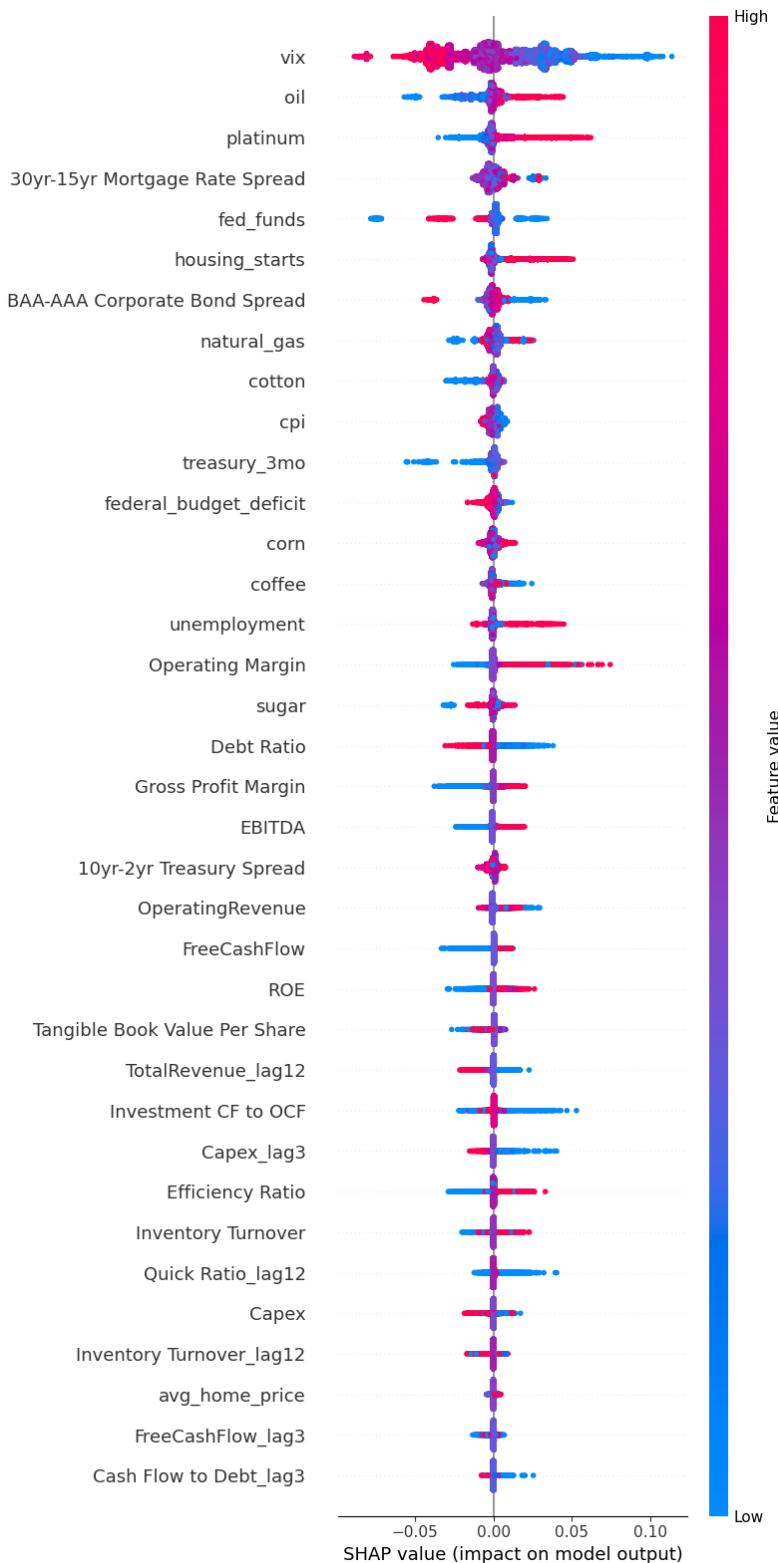
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|--------------------------------|-----------|----------|-----------|--------------|----------|----------|---------|----------|----------|----------|
| vix | -0.036635 | 0.000424 | 86.440573 | 0.000000e+00 | 1.644941 | 0.000697 | 1.9601 | 0.000831 | 2.576111 | 0.001092 |
| copper | 0.024899 | 0.000470 | 52.938871 | 0.000000e+00 | 1.644941 | 0.000774 | 1.9601 | 0.000922 | 2.576111 | 0.001212 |
| BAA-AAA Corporate Bond Spread | -0.018579 | 0.000460 | 40.385533 | 0.000000e+00 | 1.644941 | 0.000757 | 1.9601 | 0.000902 | 2.576111 | 0.001185 |
| fed_funds | -0.017417 | 0.000380 | 45.854122 | 0.000000e+00 | 1.644941 | 0.000625 | 1.9601 | 0.000745 | 2.576111 | 0.000978 |
| palladium | -0.015554 | 0.000457 | 34.044705 | 0.000000e+00 | 1.644941 | 0.000752 | 1.9601 | 0.000896 | 2.576111 | 0.001177 |
| coffee | -0.009929 | 0.000463 | 21.429828 | 0.000000e+00 | 1.644941 | 0.000762 | 1.9601 | 0.000908 | 2.576111 | 0.001194 |
| platinum | 0.009462 | 0.000380 | 24.921168 | 0.000000e+00 | 1.644941 | 0.000625 | 1.9601 | 0.000744 | 2.576111 | 0.000978 |
| oil | 0.007781 | 0.000450 | 17.307491 | 0.000000e+00 | 1.644941 | 0.000739 | 1.9601 | 0.000881 | 2.576111 | 0.001158 |
| wheat | 0.006644 | 0.000511 | 13.001764 | 0.000000e+00 | 1.644941 | 0.000841 | 1.9601 | 0.001002 | 2.576111 | 0.001316 |
| 30yr-15yr Mortgage Rate Spread | -0.006523 | 0.000427 | 15.270926 | 0.000000e+00 | 1.644941 | 0.000703 | 1.9601 | 0.000837 | 2.576111 | 0.001100 |
| gdp_real | -0.005216 | 0.000408 | 12.788159 | 0.000000e+00 | 1.644941 | 0.000671 | 1.9601 | 0.000800 | 2.576111 | 0.001051 |
| natural_gas | 0.004537 | 0.000455 | 9.973165 | 0.000000e+00 | 1.644941 | 0.000748 | 1.9601 | 0.000892 | 2.576111 | 0.001172 |
| OperatingRevenue | 0.003975 | 0.000441 | 9.016396 | 0.000000e+00 | 1.644941 | 0.000725 | 1.9601 | 0.000864 | 2.576111 | 0.001136 |
| 10yr-2yr Treasury Spread | -0.003938 | 0.000435 | 9.054217 | 0.000000e+00 | 1.644941 | 0.000715 | 1.9601 | 0.000852 | 2.576111 | 0.001120 |
| cpi | 0.002755 | 0.000482 | 5.710593 | 1.144138e-08 | 1.644941 | 0.000793 | 1.9601 | 0.000945 | 2.576111 | 0.001243 |
| EBITDA | 0.002656 | 0.000379 | 7.005869 | 2.543965e-12 | 1.644941 | 0.000624 | 1.9601 | 0.000743 | 2.576111 | 0.000977 |
| TotalRevenue_lag12 | -0.002418 | 0.000420 | 5.763009 | 8.402000e-09 | 1.644941 | 0.000690 | 1.9601 | 0.000822 | 2.576111 | 0.001081 |
| federal_budget_deficit | -0.002303 | 0.000428 | 5.374393 | 7.782676e-08 | 1.644941 | 0.000705 | 1.9601 | 0.000840 | 2.576111 | 0.001104 |
| sugar | -0.002189 | 0.000419 | 5.227128 | 1.741459e-07 | 1.644941 | 0.000689 | 1.9601 | 0.000821 | 2.576111 | 0.001079 |
| Gross Profit Margin | 0.002064 | 0.000389 | 5.302414 | 1.156726e-07 | 1.644941 | 0.000640 | 1.9601 | 0.000763 | 2.576111 | 0.001003 |
| cotton | 0.001460 | 0.000441 | 3.306838 | 9.454603e-04 | 1.644941 | 0.000726 | 1.9601 | 0.000865 | 2.576111 | 0.001137 |
| Tangible Book Value Per Share | 0.001438 | 0.000412 | 3.488258 | 4.873751e-04 | 1.644941 | 0.000678 | 1.9601 | 0.000808 | 2.576111 | 0.001062 |
| Financing CF to OCF | -0.001200 | 0.000388 | 3.096405 | 1.961931e-03 | 1.644941 | 0.000638 | 1.9601 | 0.000760 | 2.576111 | 0.000998 |
| Quick Ratio | 0.001161 | 0.000411 | 2.825982 | 4.718944e-03 | 1.644941 | 0.000676 | 1.9601 | 0.000805 | 2.576111 | 0.001058 |
| Cash Flow to Debt_lag3 | 0.001013 | 0.000412 | 2.462366 | 1.381196e-02 | 1.644941 | 0.000677 | 1.9601 | 0.000807 | 2.576111 | 0.001060 |
| avg_home_price | 0.000883 | 0.000440 | 2.008264 | 4.463060e-02 | 1.644941 | 0.000723 | 1.9601 | 0.000862 | 2.576111 | 0.001133 |
| Quick Ratio_lag12 | -0.000775 | 0.000399 | 1.943996 | 5.191197e-02 | 1.644941 | 0.000656 | 1.9601 | 0.000782 | 2.576111 | 0.001028 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure E3

Consumer Discretionary Sector: LightGBM SHAP Beeswarm Plot (Median Model)



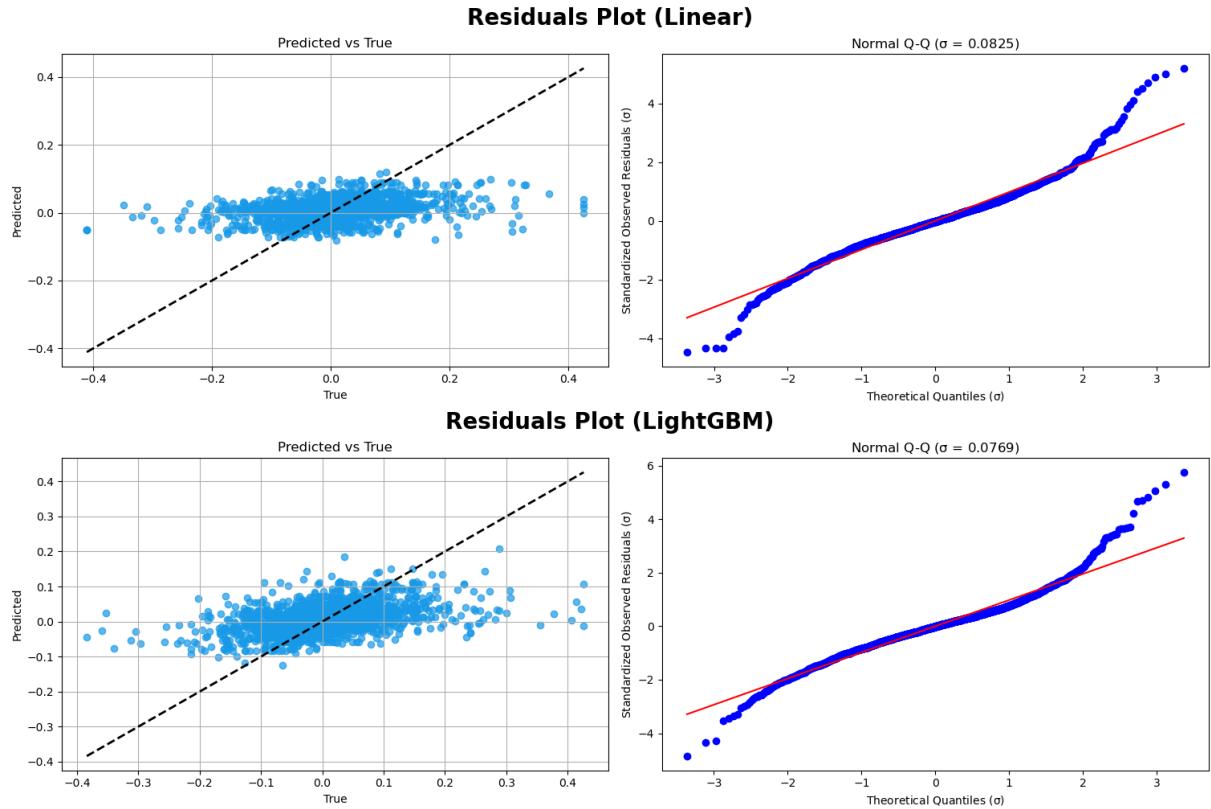
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix F

Consumer Staples Sector

Figure F1

Consumer Staples Sector: Residuals Plots (Median Model)

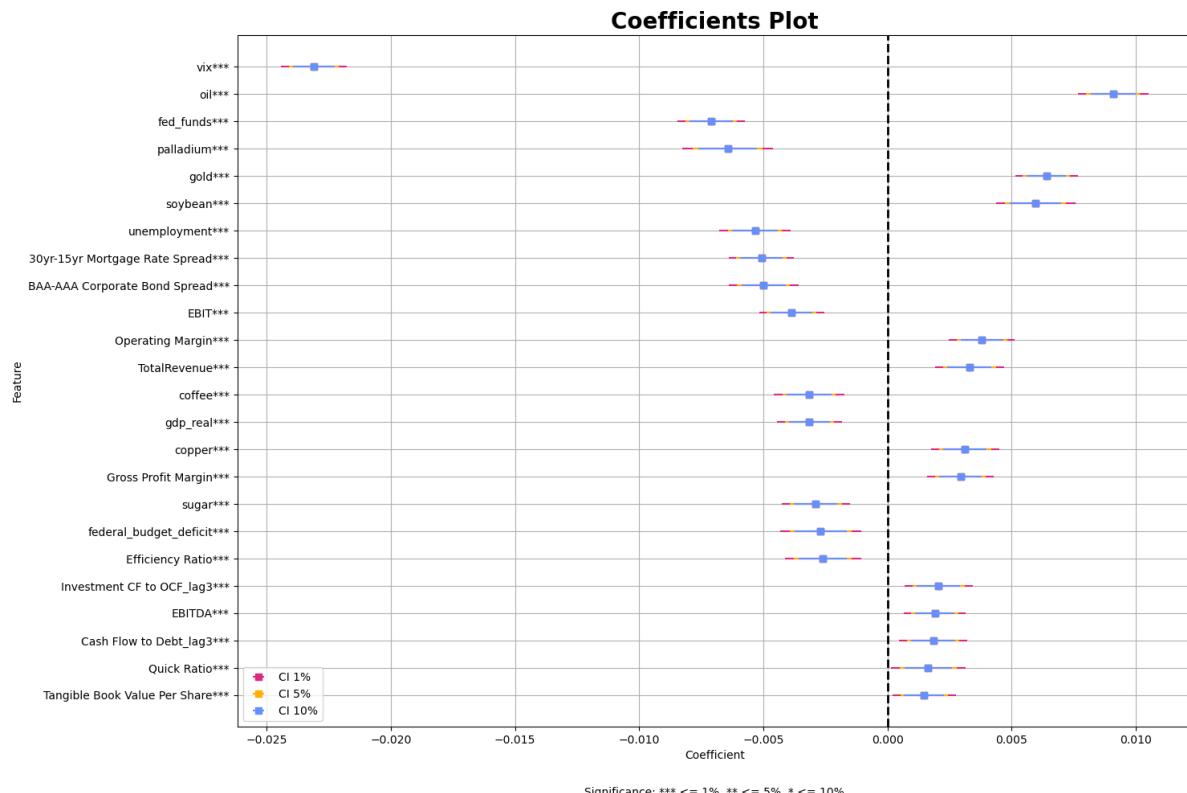


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure F2

Consumer Staples Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table F1 for coefficient statistics.

DECODING SECTOR VALUATION DYNAMICS

Table F1

Consumer Staples Sector: Linear Regression Coefficient Statistics (Median Model)

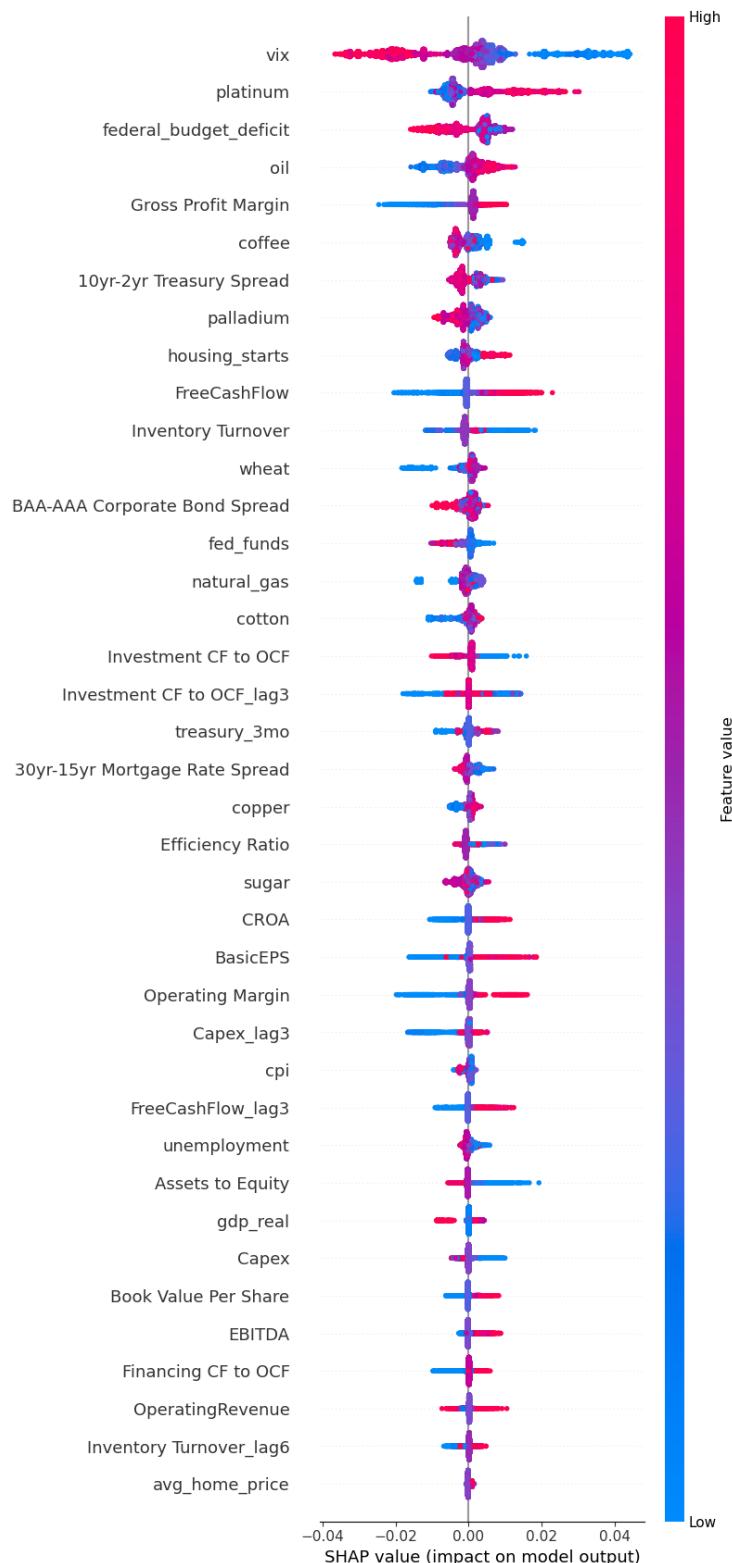
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|--------------------------------|-----------|----------|-----------|--------------|----------|----------|----------|----------|----------|----------|
| vix | -0.023115 | 0.000513 | 45.017084 | 0.000000e+00 | 1.645064 | 0.000845 | 1.960292 | 0.001007 | 2.576508 | 0.001323 |
| oil | 0.009093 | 0.000553 | 16.445982 | 0.000000e+00 | 1.645064 | 0.000910 | 1.960292 | 0.001084 | 2.576508 | 0.001425 |
| fed_funds | -0.007107 | 0.000526 | 13.514298 | 0.000000e+00 | 1.645064 | 0.000865 | 1.960292 | 0.001031 | 2.576508 | 0.001355 |
| palladium | -0.006433 | 0.000712 | 9.035043 | 0.000000e+00 | 1.645064 | 0.001171 | 1.960292 | 0.001396 | 2.576508 | 0.001834 |
| gold | 0.006400 | 0.000489 | 13.081798 | 0.000000e+00 | 1.645064 | 0.000805 | 1.960292 | 0.000959 | 2.576508 | 0.001261 |
| soybean | 0.005965 | 0.000623 | 9.578772 | 0.000000e+00 | 1.645064 | 0.001024 | 1.960292 | 0.001221 | 2.576508 | 0.001605 |
| unemployment | -0.005335 | 0.000558 | 9.557536 | 0.000000e+00 | 1.645064 | 0.000918 | 1.960292 | 0.001094 | 2.576508 | 0.001438 |
| 30yr-15yr Mortgage Rate Spread | -0.005077 | 0.000513 | 9.897096 | 0.000000e+00 | 1.645064 | 0.000844 | 1.960292 | 0.001006 | 2.576508 | 0.001322 |
| BAA-AAA Corporate Bond Spread | -0.004984 | 0.000545 | 9.150436 | 0.000000e+00 | 1.645064 | 0.000896 | 1.960292 | 0.001068 | 2.576508 | 0.001403 |
| EBIT | -0.003857 | 0.000512 | 7.539640 | 5.284662e-14 | 1.645064 | 0.000841 | 1.960292 | 0.001003 | 2.576508 | 0.001318 |
| Operating Margin | 0.003808 | 0.000514 | 7.409519 | 1.409983e-13 | 1.645064 | 0.000845 | 1.960292 | 0.001007 | 2.576508 | 0.001324 |
| TotalRevenue | 0.003308 | 0.000540 | 6.122992 | 9.663046e-10 | 1.645064 | 0.000889 | 1.960292 | 0.001059 | 2.576508 | 0.001392 |
| coffee | -0.003154 | 0.000550 | 5.733069 | 1.025948e-08 | 1.645064 | 0.000905 | 1.960292 | 0.001079 | 2.576508 | 0.001418 |
| gdp_real | -0.003142 | 0.000503 | 6.246555 | 4.433407e-10 | 1.645064 | 0.000827 | 1.960292 | 0.000986 | 2.576508 | 0.001296 |
| copper | 0.003124 | 0.000533 | 5.864485 | 4.703459e-09 | 1.645064 | 0.000876 | 1.960292 | 0.001044 | 2.576508 | 0.001373 |
| Gross Profit Margin | 0.002945 | 0.000518 | 5.689538 | 1.323531e-08 | 1.645064 | 0.000852 | 1.960292 | 0.001015 | 2.576508 | 0.001334 |
| sugar | -0.002887 | 0.000533 | 5.414068 | 6.358496e-08 | 1.645064 | 0.000877 | 1.960292 | 0.001045 | 2.576508 | 0.001374 |
| federal_budget_deficit | -0.002688 | 0.000631 | 4.260280 | 2.067562e-05 | 1.645064 | 0.001038 | 1.960292 | 0.001237 | 2.576508 | 0.001626 |
| Efficiency Ratio | -0.002601 | 0.000595 | 4.374488 | 1.234235e-05 | 1.645064 | 0.000978 | 1.960292 | 0.001166 | 2.576508 | 0.001532 |
| Investment CF to OCF_lag3 | 0.002058 | 0.000533 | 3.858674 | 1.149939e-04 | 1.645064 | 0.000877 | 1.960292 | 0.001046 | 2.576508 | 0.001374 |
| EBITDA | 0.001909 | 0.000485 | 3.935978 | 8.363445e-05 | 1.645064 | 0.000798 | 1.960292 | 0.000951 | 2.576508 | 0.001249 |
| Cash Flow to Debt_lag3 | 0.001844 | 0.000538 | 3.431040 | 6.046300e-04 | 1.645064 | 0.000884 | 1.960292 | 0.001054 | 2.576508 | 0.001385 |
| Quick Ratio | 0.001645 | 0.000586 | 2.806297 | 5.024824e-03 | 1.645064 | 0.000964 | 1.960292 | 0.001149 | 2.576508 | 0.001510 |
| Tangible Book Value Per Share | 0.001480 | 0.000491 | 3.012346 | 2.601329e-03 | 1.645064 | 0.000808 | 1.960292 | 0.000963 | 2.576508 | 0.001266 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure F3

Consumer Staples Sector: LightGBM SHAP Beeswarm Plot (Median Model)



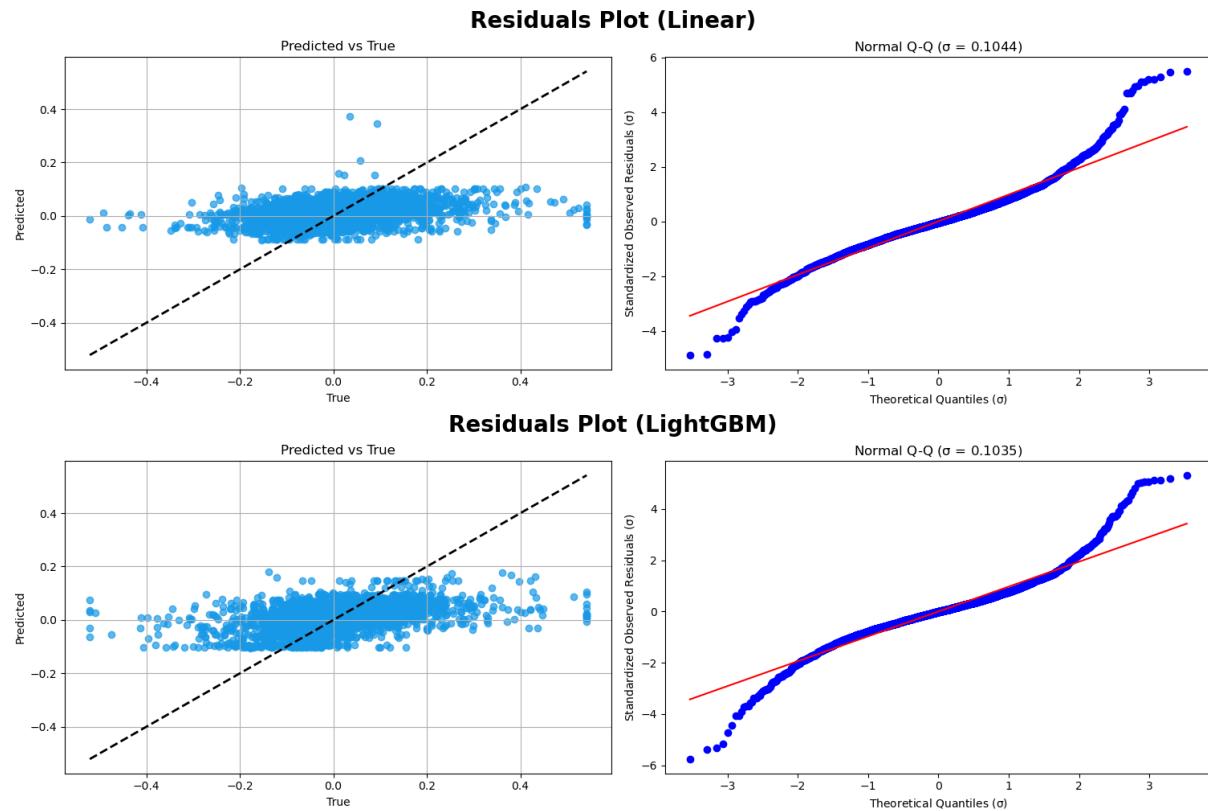
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix G

Health Care Sector

Figure G1

Health Care Sector: Residuals Plots (Median Model)

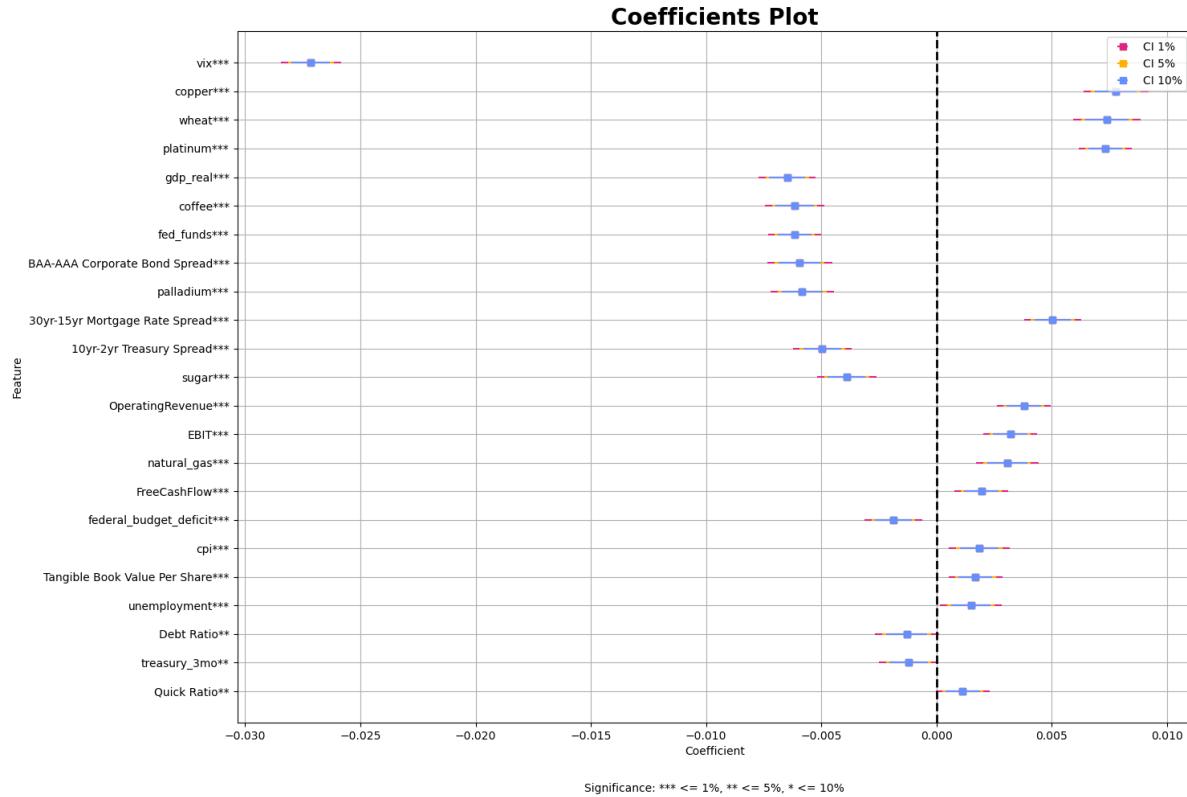


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure G2

Health Care Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table G1 for coefficient statistics.

Table G1

Health Care Sector: Linear Regression Coefficient Statistics (Median Model)

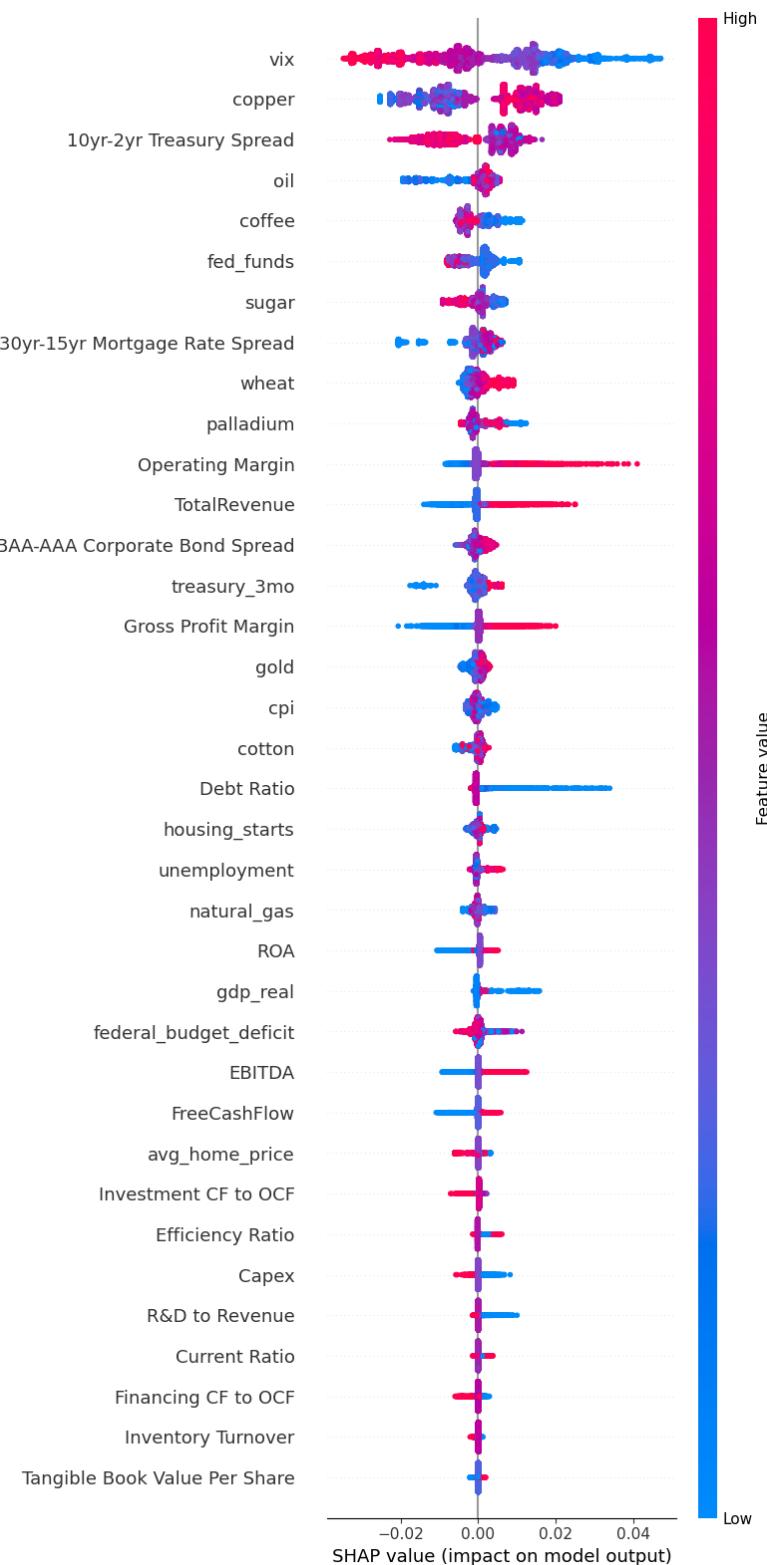
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|--------------------------------|-----------|----------|-----------|--------------|----------|----------|---------|----------|----------|----------|
| vix | -0.027151 | 0.000507 | 53.533995 | 0.000000e+00 | 1.644966 | 0.000834 | 1.96014 | 0.000994 | 2.576193 | 0.001307 |
| copper | 0.007791 | 0.000550 | 14.167818 | 0.000000e+00 | 1.644966 | 0.000905 | 1.96014 | 0.001078 | 2.576193 | 0.001417 |
| wheat | 0.007393 | 0.000571 | 12.945928 | 0.000000e+00 | 1.644966 | 0.000939 | 1.96014 | 0.001119 | 2.576193 | 0.001471 |
| platinum | 0.007327 | 0.000452 | 16.210130 | 0.000000e+00 | 1.644966 | 0.000744 | 1.96014 | 0.000886 | 2.576193 | 0.001164 |
| gdp_real | -0.006476 | 0.000482 | 13.432324 | 0.000000e+00 | 1.644966 | 0.000793 | 1.96014 | 0.000945 | 2.576193 | 0.001242 |
| coffee | -0.006157 | 0.000503 | 12.231627 | 0.000000e+00 | 1.644966 | 0.000828 | 1.96014 | 0.000987 | 2.576193 | 0.001297 |
| fed_funds | -0.006153 | 0.000450 | 13.665211 | 0.000000e+00 | 1.644966 | 0.000741 | 1.96014 | 0.000883 | 2.576193 | 0.001160 |
| BAA-AAA Corporate Bond Spread | -0.005935 | 0.000550 | 10.783855 | 0.000000e+00 | 1.644966 | 0.000905 | 1.96014 | 0.001079 | 2.576193 | 0.001418 |
| palladium | -0.005828 | 0.000537 | 10.858062 | 0.000000e+00 | 1.644966 | 0.000883 | 1.96014 | 0.001052 | 2.576193 | 0.001383 |
| 30yr-15yr Mortgage Rate Spread | 0.005047 | 0.000482 | 10.470082 | 0.000000e+00 | 1.644966 | 0.000793 | 1.96014 | 0.000945 | 2.576193 | 0.001242 |
| 10yr-2yr Treasury Spread | -0.004953 | 0.000499 | 9.920136 | 0.000000e+00 | 1.644966 | 0.000821 | 1.96014 | 0.000979 | 2.576193 | 0.001286 |
| sugar | -0.003892 | 0.000497 | 7.827187 | 5.329071e-15 | 1.644966 | 0.000818 | 1.96014 | 0.000975 | 2.576193 | 0.001281 |
| OperatingRevenue | 0.003801 | 0.000451 | 8.431924 | 0.000000e+00 | 1.644966 | 0.000741 | 1.96014 | 0.000884 | 2.576193 | 0.001161 |
| EBIT | 0.003210 | 0.000453 | 7.083093 | 1.479483e-12 | 1.644966 | 0.000745 | 1.96014 | 0.000888 | 2.576193 | 0.001167 |
| natural_gas | 0.003074 | 0.000526 | 5.847129 | 5.116860e-09 | 1.644966 | 0.000865 | 1.96014 | 0.001031 | 2.576193 | 0.001354 |
| FreeCashFlow | 0.001950 | 0.000449 | 4.341565 | 1.425015e-05 | 1.644966 | 0.000739 | 1.96014 | 0.000881 | 2.576193 | 0.001157 |
| federal_budget_deficit | -0.001868 | 0.000482 | 3.876103 | 1.066445e-04 | 1.644966 | 0.000793 | 1.96014 | 0.000945 | 2.576193 | 0.001242 |
| cpi | 0.001853 | 0.000513 | 3.612629 | 3.042077e-04 | 1.644966 | 0.000844 | 1.96014 | 0.001005 | 2.576193 | 0.001321 |
| Tangible Book Value Per Share | 0.001691 | 0.000452 | 3.740541 | 1.843841e-04 | 1.644966 | 0.000743 | 1.96014 | 0.000886 | 2.576193 | 0.001164 |
| unemployment | 0.001505 | 0.000521 | 2.885837 | 3.909928e-03 | 1.644966 | 0.000858 | 1.96014 | 0.001022 | 2.576193 | 0.001343 |
| Debt Ratio | -0.001284 | 0.000539 | 2.383092 | 1.718163e-02 | 1.644966 | 0.000887 | 1.96014 | 0.001057 | 2.576193 | 0.001389 |
| treasury_3mo | -0.001204 | 0.000503 | 2.393118 | 1.671942e-02 | 1.644966 | 0.000828 | 1.96014 | 0.000987 | 2.576193 | 0.001297 |
| Quick Ratio | 0.001144 | 0.000453 | 2.523703 | 1.162396e-02 | 1.644966 | 0.000746 | 1.96014 | 0.000889 | 2.576193 | 0.001168 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure G3

Health Care Sector: LightGBM SHAP Beeswarm Plot (Median Model)



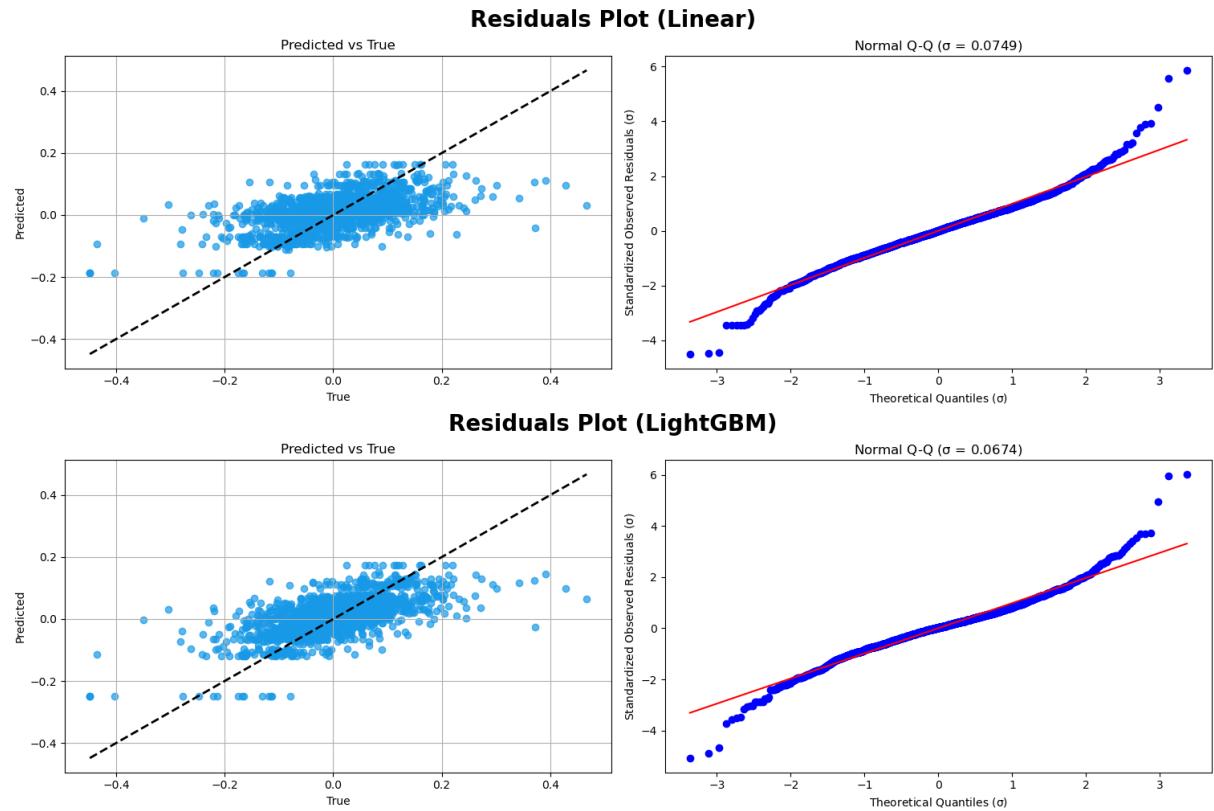
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix H

Financial Services Industry Group

Figure H1

Financial Services Industry Group: Residuals Plots (Median Model)

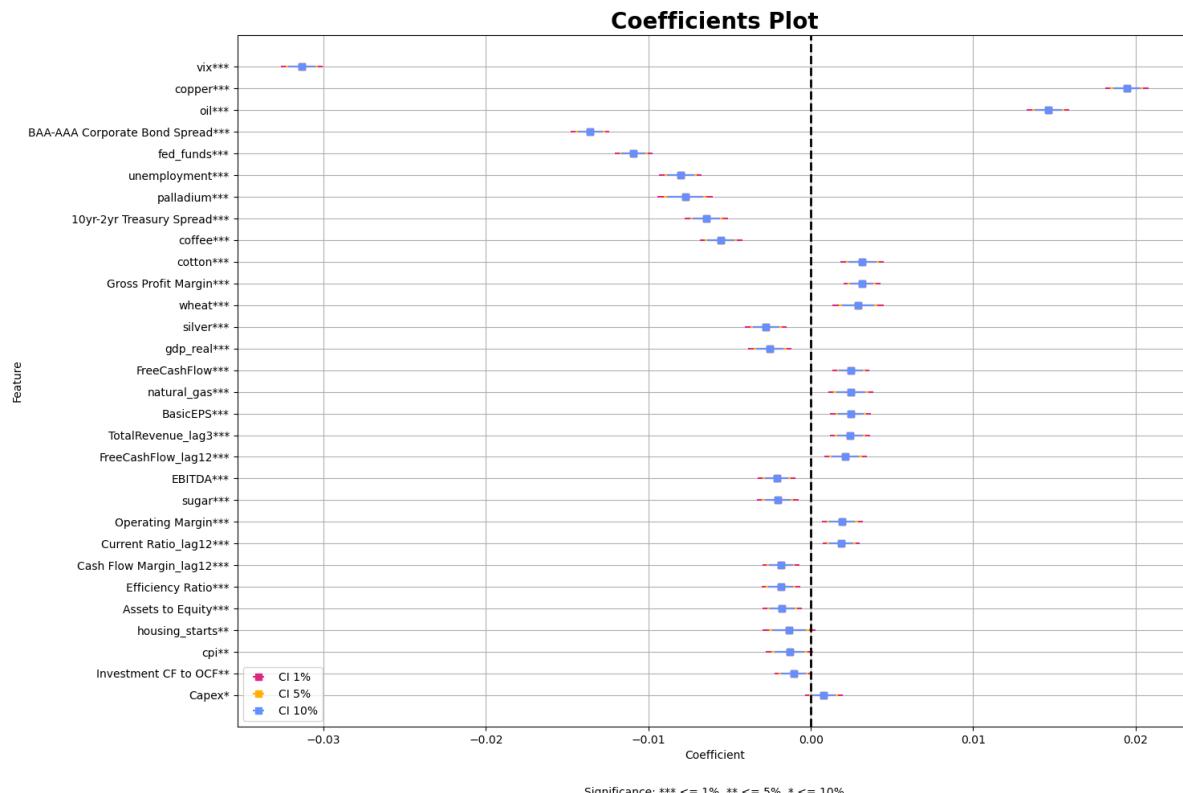


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure H2

Financial Services Industry Group: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table H1 for coefficient statistics.

DECODING SECTOR VALUATION DYNAMICS

Table H1

Financial Services Industry Group: Linear Regression Coefficient Statistics (Median Model)

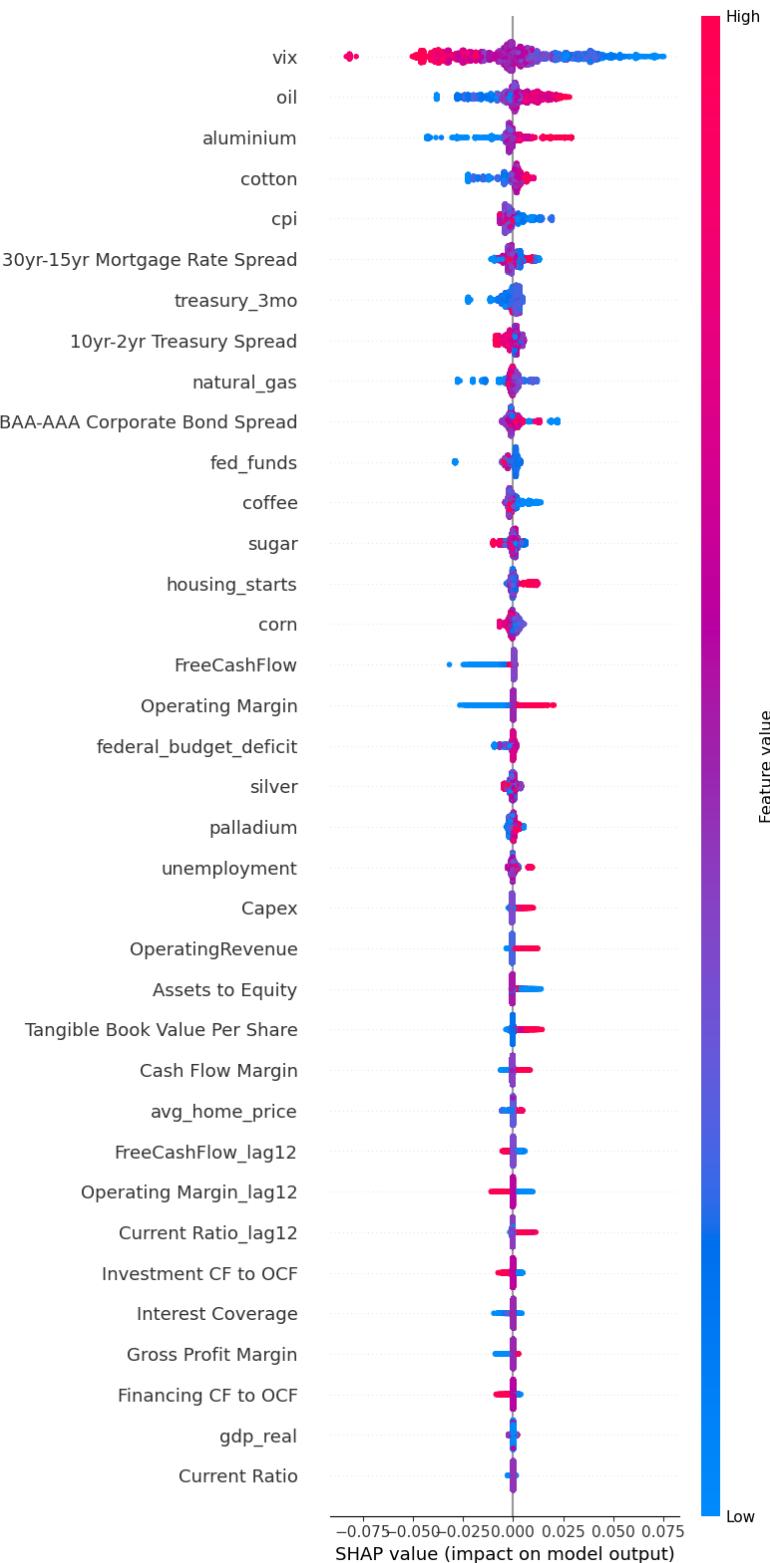
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|-------------------------------|-----------|----------|-----------|--------------|----------|----------|----------|----------|----------|----------|
| vix | -0.031343 | 0.000504 | 62.185638 | 0.000000e+00 | 1.645066 | 0.000829 | 1.960295 | 0.000988 | 2.576515 | 0.001299 |
| copper | 0.019458 | 0.000520 | 37.439433 | 0.000000e+00 | 1.645066 | 0.000855 | 1.960295 | 0.001019 | 2.576515 | 0.001339 |
| oil | 0.014617 | 0.000510 | 28.674433 | 0.000000e+00 | 1.645066 | 0.000839 | 1.960295 | 0.000999 | 2.576515 | 0.001313 |
| BAA-AAA Corporate Bond Spread | -0.013591 | 0.000464 | 29.304031 | 0.000000e+00 | 1.645066 | 0.000763 | 1.960295 | 0.000909 | 2.576515 | 0.001195 |
| fed_funds | -0.010910 | 0.000448 | 24.359437 | 0.000000e+00 | 1.645066 | 0.000737 | 1.960295 | 0.000878 | 2.576515 | 0.001154 |
| unemployment | -0.008026 | 0.000507 | 15.841387 | 0.000000e+00 | 1.645066 | 0.000834 | 1.960295 | 0.000993 | 2.576515 | 0.001305 |
| palladium | -0.007736 | 0.000666 | 11.610142 | 0.000000e+00 | 1.645066 | 0.001096 | 1.960295 | 0.001306 | 2.576515 | 0.001717 |
| 10yr-2yr Treasury Spread | -0.006435 | 0.000511 | 12.600030 | 0.000000e+00 | 1.645066 | 0.000840 | 1.960295 | 0.001001 | 2.576515 | 0.001316 |
| coffee | -0.005530 | 0.000510 | 10.842056 | 0.000000e+00 | 1.645066 | 0.000839 | 1.960295 | 0.001000 | 2.576515 | 0.001314 |
| cotton | 0.003173 | 0.000515 | 6.156642 | 7.830778e-10 | 1.645066 | 0.000848 | 1.960295 | 0.001010 | 2.576515 | 0.001328 |
| Gross Profit Margin | 0.003143 | 0.000443 | 7.094863 | 1.418643e-12 | 1.645066 | 0.000729 | 1.960295 | 0.000868 | 2.576515 | 0.001141 |
| wheat | 0.002904 | 0.000607 | 4.784202 | 1.750976e-06 | 1.645066 | 0.000999 | 1.960295 | 0.001190 | 2.576515 | 0.001564 |
| silver | -0.002758 | 0.000498 | 5.539282 | 3.144755e-08 | 1.645066 | 0.000819 | 1.960295 | 0.000976 | 2.576515 | 0.001283 |
| gdp_real | -0.002524 | 0.000519 | 4.866904 | 1.157808e-06 | 1.645066 | 0.000853 | 1.960295 | 0.001016 | 2.576515 | 0.001336 |
| FreeCashFlow | 0.002474 | 0.000444 | 5.567412 | 2.678954e-08 | 1.645066 | 0.000731 | 1.960295 | 0.000871 | 2.576515 | 0.001145 |
| natural_gas | 0.002465 | 0.000544 | 4.528330 | 6.041212e-06 | 1.645066 | 0.000895 | 1.960295 | 0.001067 | 2.576515 | 0.001402 |
| BasicEPS | 0.002451 | 0.000485 | 5.057535 | 4.352422e-07 | 1.645066 | 0.000797 | 1.960295 | 0.000950 | 2.576515 | 0.001249 |
| TotalRevenue_lag3 | 0.002408 | 0.000484 | 4.976034 | 6.641083e-07 | 1.645066 | 0.000796 | 1.960295 | 0.000949 | 2.576515 | 0.001247 |
| FreeCashFlow_lag12 | 0.002141 | 0.000510 | 4.200322 | 2.697623e-05 | 1.645066 | 0.000839 | 1.960295 | 0.000999 | 2.576515 | 0.001313 |
| EBITDA | -0.002106 | 0.000446 | 4.720292 | 2.399726e-06 | 1.645066 | 0.000734 | 1.960295 | 0.000875 | 2.576515 | 0.001150 |
| sugar | -0.002037 | 0.000491 | 4.146316 | 3.417593e-05 | 1.645066 | 0.000808 | 1.960295 | 0.000963 | 2.576515 | 0.001266 |
| Operating Margin | 0.001941 | 0.000482 | 4.025912 | 5.733945e-05 | 1.645066 | 0.000793 | 1.960295 | 0.000945 | 2.576515 | 0.001242 |
| Current Ratio_lag12 | 0.001881 | 0.000446 | 4.214626 | 2.532609e-05 | 1.645066 | 0.000734 | 1.960295 | 0.000875 | 2.576515 | 0.001150 |
| Cash Flow Margin_lag12 | -0.001847 | 0.000446 | 4.141938 | 3.483357e-05 | 1.645066 | 0.000734 | 1.960295 | 0.000874 | 2.576515 | 0.001149 |
| Efficiency Ratio | -0.001844 | 0.000467 | 3.951351 | 7.845646e-05 | 1.645066 | 0.000768 | 1.960295 | 0.000915 | 2.576515 | 0.001202 |
| Assets to Equity | -0.001771 | 0.000469 | 3.776696 | 1.602071e-04 | 1.645066 | 0.000771 | 1.960295 | 0.000919 | 2.576515 | 0.001208 |
| housing_starts | -0.001331 | 0.000631 | 2.109679 | 3.492054e-02 | 1.645066 | 0.001038 | 1.960295 | 0.001237 | 2.576515 | 0.001626 |
| cpi | -0.001316 | 0.000562 | 2.340544 | 1.928294e-02 | 1.645066 | 0.000925 | 1.960295 | 0.001103 | 2.576515 | 0.001449 |
| Investment CF to OCF | -0.001064 | 0.000458 | 2.325950 | 2.004893e-02 | 1.645066 | 0.000753 | 1.960295 | 0.000897 | 2.576515 | 0.001179 |
| Capex | 0.000794 | 0.000454 | 1.747355 | 8.061852e-02 | 1.645066 | 0.000747 | 1.960295 | 0.000890 | 2.576515 | 0.001170 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure H3

Financial Services Industry Group: LightGBM SHAP Beeswarm Plot (Median Model)



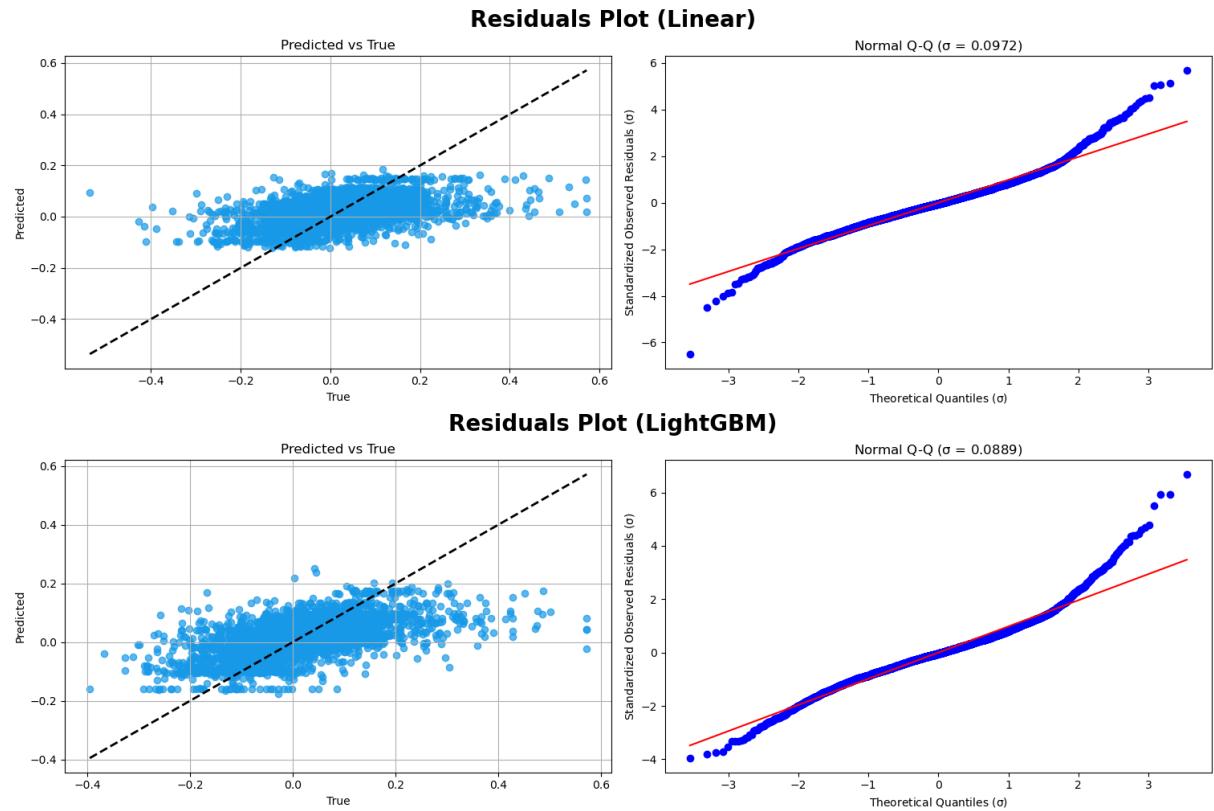
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix I

Information Technology Sector

Figure I1

Information Technology Sector: Residuals Plots (Median Model)

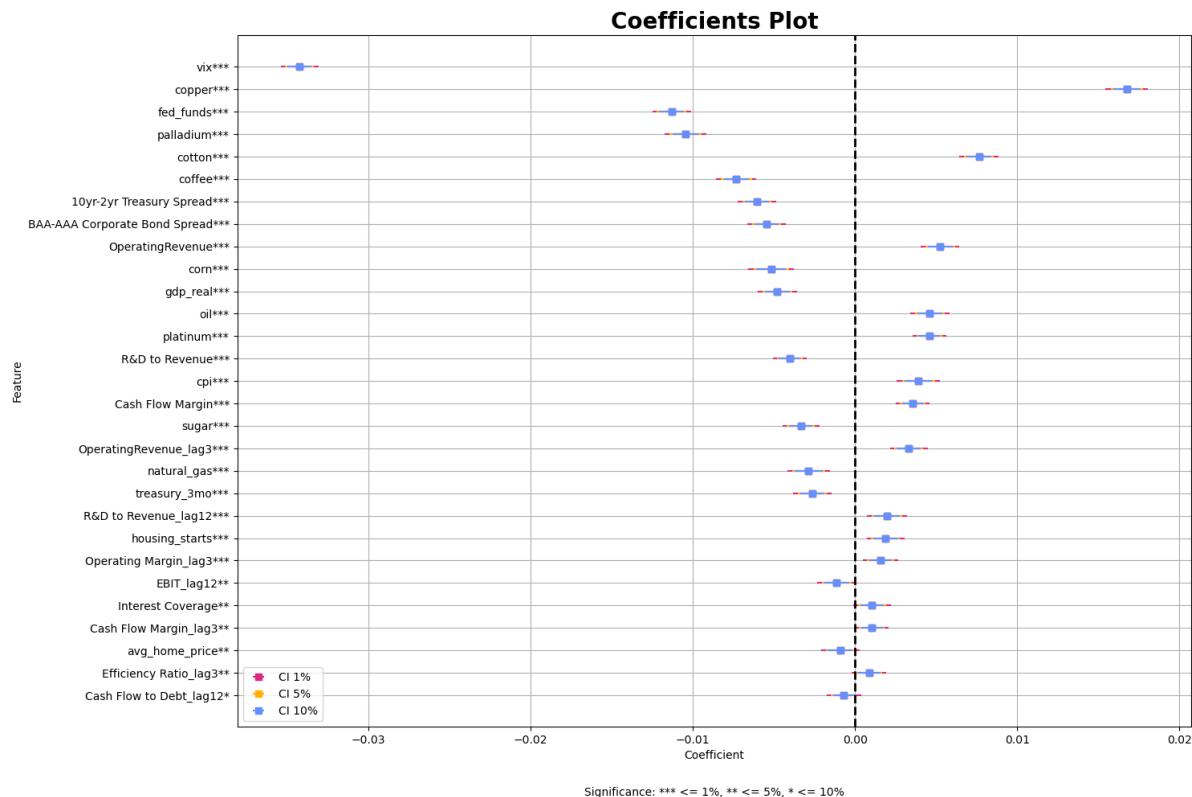


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure I2

Information Technology Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table I1 for coefficient statistics.

DECODING SECTOR VALUATION DYNAMICS

Table I1

Information Technology Sector: Linear Regression Coefficient Statistics (Median Model)

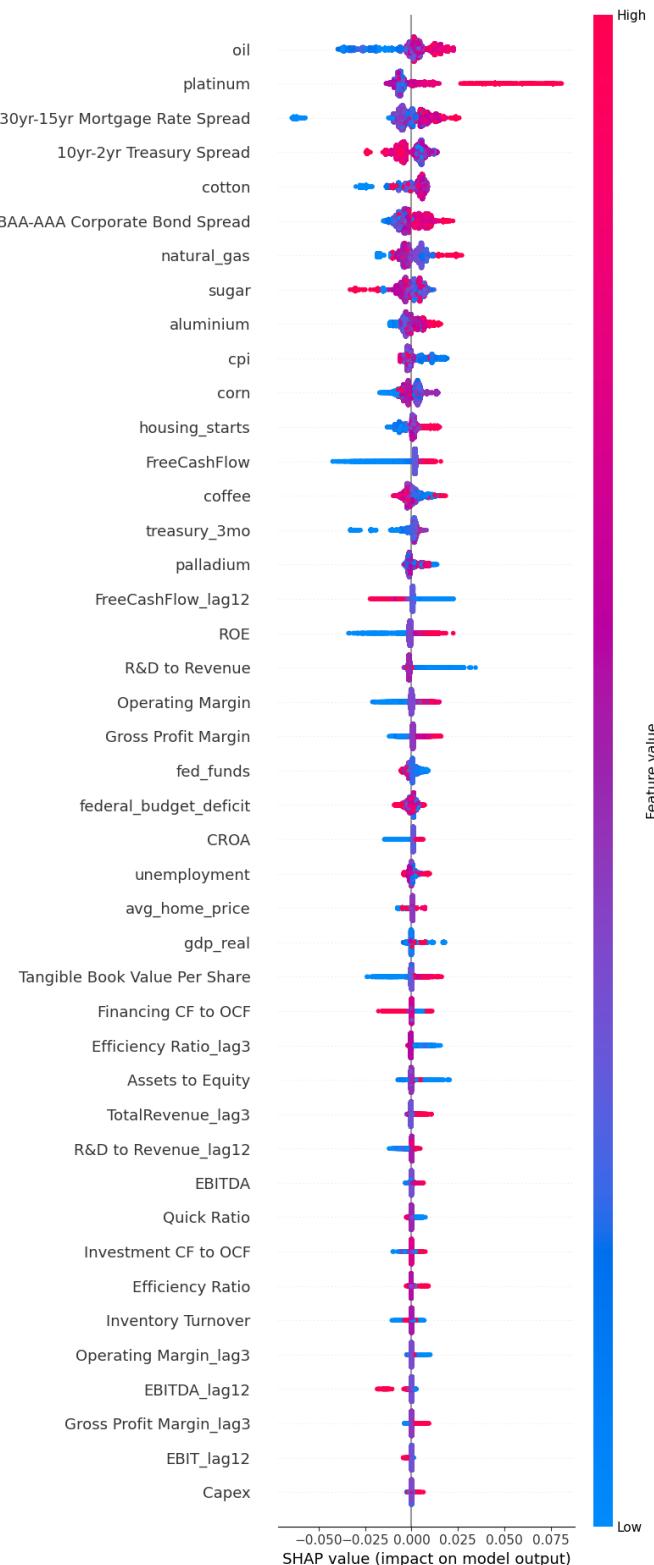
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|-------------------------------|-----------|----------|-----------|--------------|----------|----------|----------|----------|----------|----------|
| vix | -0.034253 | 0.000452 | 75.717710 | 0.000000e+00 | 1.64496 | 0.000744 | 1.960129 | 0.000887 | 2.576171 | 0.001165 |
| copper | 0.016759 | 0.000509 | 32.907494 | 0.000000e+00 | 1.64496 | 0.000838 | 1.960129 | 0.000998 | 2.576171 | 0.001312 |
| fed_funds | -0.011316 | 0.000462 | 24.475140 | 0.000000e+00 | 1.64496 | 0.000761 | 1.960129 | 0.000906 | 2.576171 | 0.001191 |
| palladium | -0.010444 | 0.000500 | 20.890312 | 0.000000e+00 | 1.64496 | 0.000822 | 1.960129 | 0.000980 | 2.576171 | 0.001288 |
| cotton | 0.007659 | 0.000469 | 16.336329 | 0.000000e+00 | 1.64496 | 0.000771 | 1.960129 | 0.000919 | 2.576171 | 0.001208 |
| coffee | -0.007310 | 0.000481 | 15.207499 | 0.000000e+00 | 1.64496 | 0.000791 | 1.960129 | 0.000942 | 2.576171 | 0.001238 |
| 10yr-2yr Treasury Spread | -0.006047 | 0.000457 | 13.234850 | 0.000000e+00 | 1.64496 | 0.000752 | 1.960129 | 0.000896 | 2.576171 | 0.001177 |
| BAA-AAA Corporate Bond Spread | -0.005453 | 0.000458 | 11.895580 | 0.000000e+00 | 1.64496 | 0.000754 | 1.960129 | 0.000898 | 2.576171 | 0.001181 |
| OperatingRevenue | 0.005248 | 0.000465 | 11.281356 | 0.000000e+00 | 1.64496 | 0.000765 | 1.960129 | 0.000912 | 2.576171 | 0.001198 |
| corn | -0.005168 | 0.000550 | 9.388277 | 0.000000e+00 | 1.64496 | 0.000905 | 1.960129 | 0.001079 | 2.576171 | 0.001418 |
| gdp_real | -0.004798 | 0.000472 | 10.161374 | 0.000000e+00 | 1.64496 | 0.000777 | 1.960129 | 0.000926 | 2.576171 | 0.001216 |
| oil | 0.004621 | 0.000474 | 9.756957 | 0.000000e+00 | 1.64496 | 0.000779 | 1.960129 | 0.000928 | 2.576171 | 0.001220 |
| platinum | 0.004591 | 0.000406 | 11.298270 | 0.000000e+00 | 1.64496 | 0.000668 | 1.960129 | 0.000796 | 2.576171 | 0.001047 |
| R&D to Revenue | -0.004023 | 0.000405 | 9.931424 | 0.000000e+00 | 1.64496 | 0.000666 | 1.960129 | 0.000794 | 2.576171 | 0.001044 |
| cpi | 0.003911 | 0.000518 | 7.543852 | 4.840572e-14 | 1.64496 | 0.000853 | 1.960129 | 0.001016 | 2.576171 | 0.001336 |
| Cash Flow Margin | 0.003564 | 0.000406 | 8.770319 | 0.000000e+00 | 1.64496 | 0.000669 | 1.960129 | 0.000797 | 2.576171 | 0.001047 |
| sugar | -0.003340 | 0.000441 | 7.580465 | 3.641532e-14 | 1.64496 | 0.000725 | 1.960129 | 0.000864 | 2.576171 | 0.001135 |
| OperatingRevenue_lag3 | 0.003311 | 0.000452 | 7.321115 | 2.589040e-13 | 1.64496 | 0.000744 | 1.960129 | 0.000886 | 2.576171 | 0.001165 |
| natural_gas | -0.002859 | 0.000516 | 5.539188 | 3.092084e-08 | 1.64496 | 0.000849 | 1.960129 | 0.001012 | 2.576171 | 0.001330 |
| treasury_3mo | -0.002622 | 0.000460 | 5.700590 | 1.217374e-08 | 1.64496 | 0.000757 | 1.960129 | 0.000902 | 2.576171 | 0.001185 |
| R&D to Revenue_lag12 | 0.001983 | 0.000482 | 4.112559 | 3.934718e-05 | 1.64496 | 0.000793 | 1.960129 | 0.000945 | 2.576171 | 0.001242 |
| housing_starts | 0.001896 | 0.000454 | 4.177916 | 2.959294e-05 | 1.64496 | 0.000747 | 1.960129 | 0.000890 | 2.576171 | 0.001169 |
| Operating Margin_lag3 | 0.001587 | 0.000427 | 3.712937 | 2.056412e-04 | 1.64496 | 0.000703 | 1.960129 | 0.000838 | 2.576171 | 0.001101 |
| EBIT_lag12 | -0.001144 | 0.000467 | 2.446628 | 1.443184e-02 | 1.64496 | 0.000769 | 1.960129 | 0.000916 | 2.576171 | 0.001204 |
| Interest Coverage | 0.001053 | 0.000448 | 2.346870 | 1.894532e-02 | 1.64496 | 0.000738 | 1.960129 | 0.000879 | 2.576171 | 0.001155 |
| Cash Flow Margin_lag3 | 0.001040 | 0.000409 | 2.544642 | 1.094935e-02 | 1.64496 | 0.000672 | 1.960129 | 0.000801 | 2.576171 | 0.001053 |
| avg_home_price | -0.000910 | 0.000461 | 1.972152 | 4.861136e-02 | 1.64496 | 0.000759 | 1.960129 | 0.000904 | 2.576171 | 0.001189 |
| Efficiency Ratio_lag3 | 0.000877 | 0.000414 | 2.115560 | 3.439936e-02 | 1.64496 | 0.000682 | 1.960129 | 0.000812 | 2.576171 | 0.001068 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure I3

Information Technology Sector: LightGBM SHAP Beeswarm Plot (Median Model)



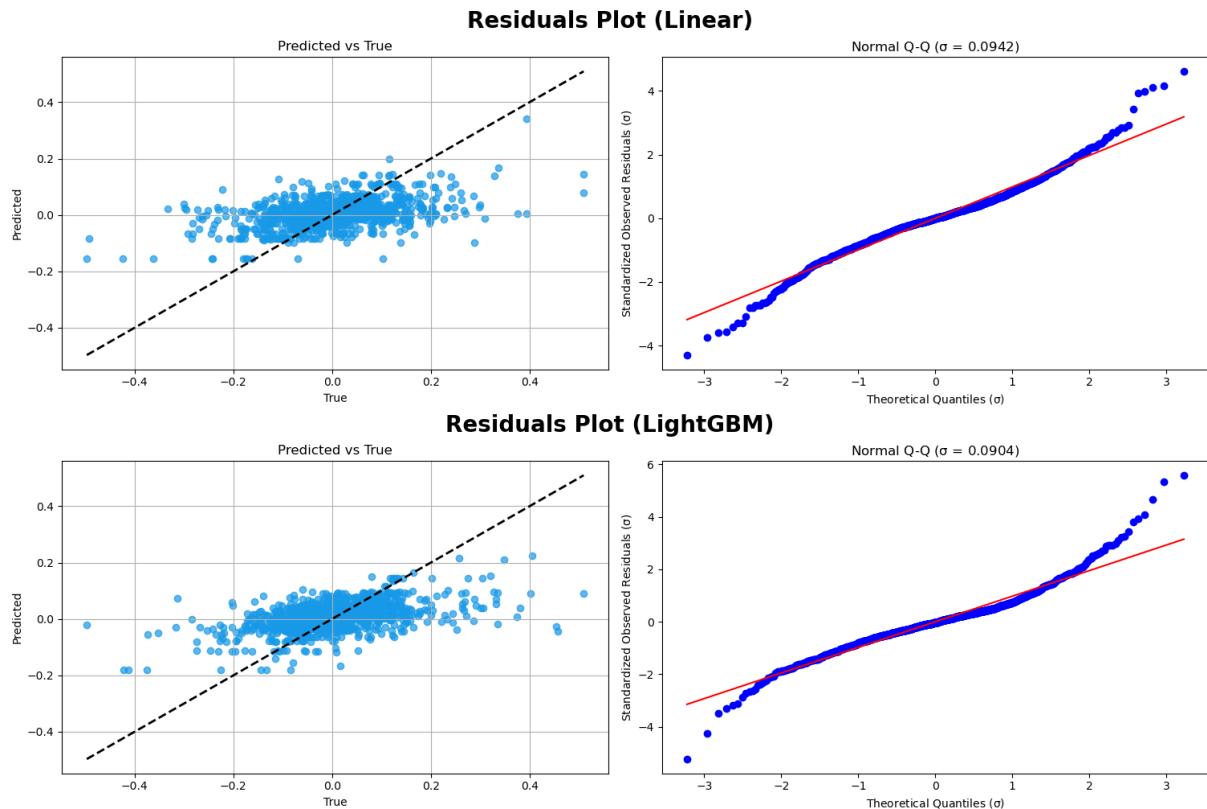
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix J

Communication Services Sector

Figure J1

Communication Services Sector: Residuals Plots (Median Model)

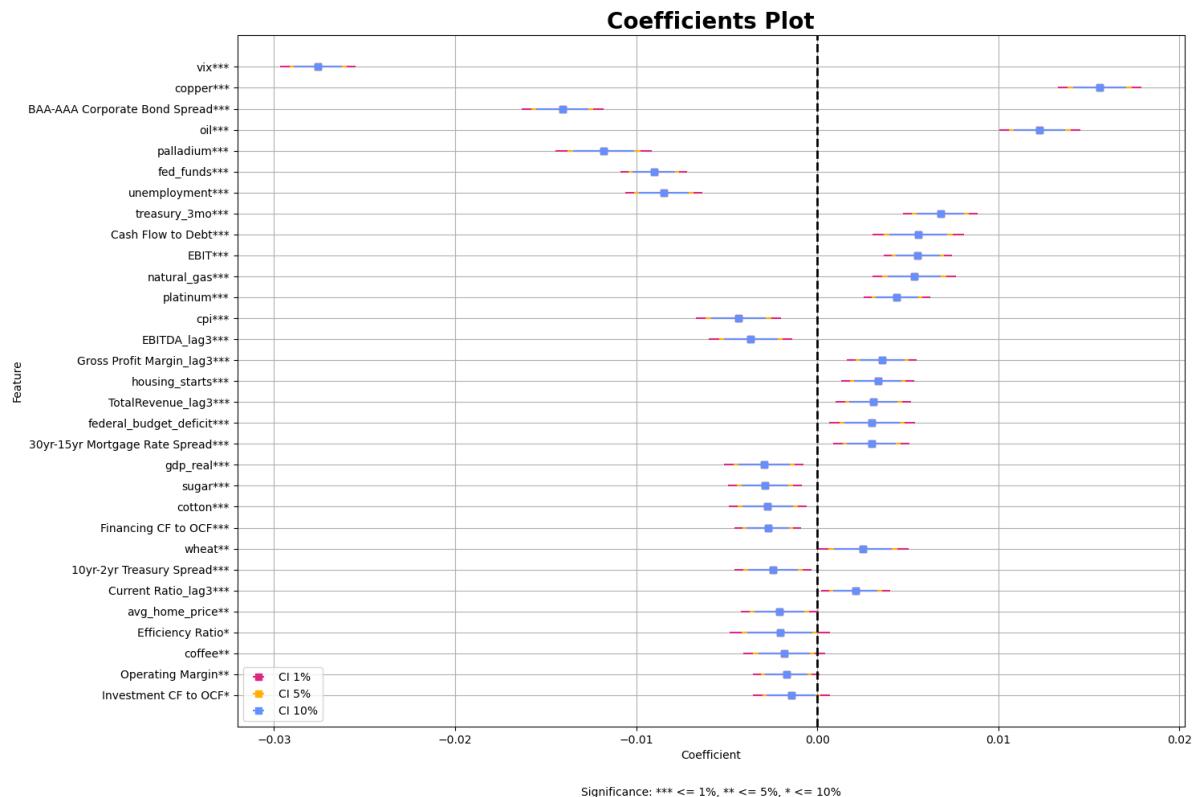


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure J2

Communication Services Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table J1 for coefficient statistics.

DECODING SECTOR VALUATION DYNAMICS

Table J1

Communication Services Sector: Linear Regression Coefficient Statistics (Median Model)

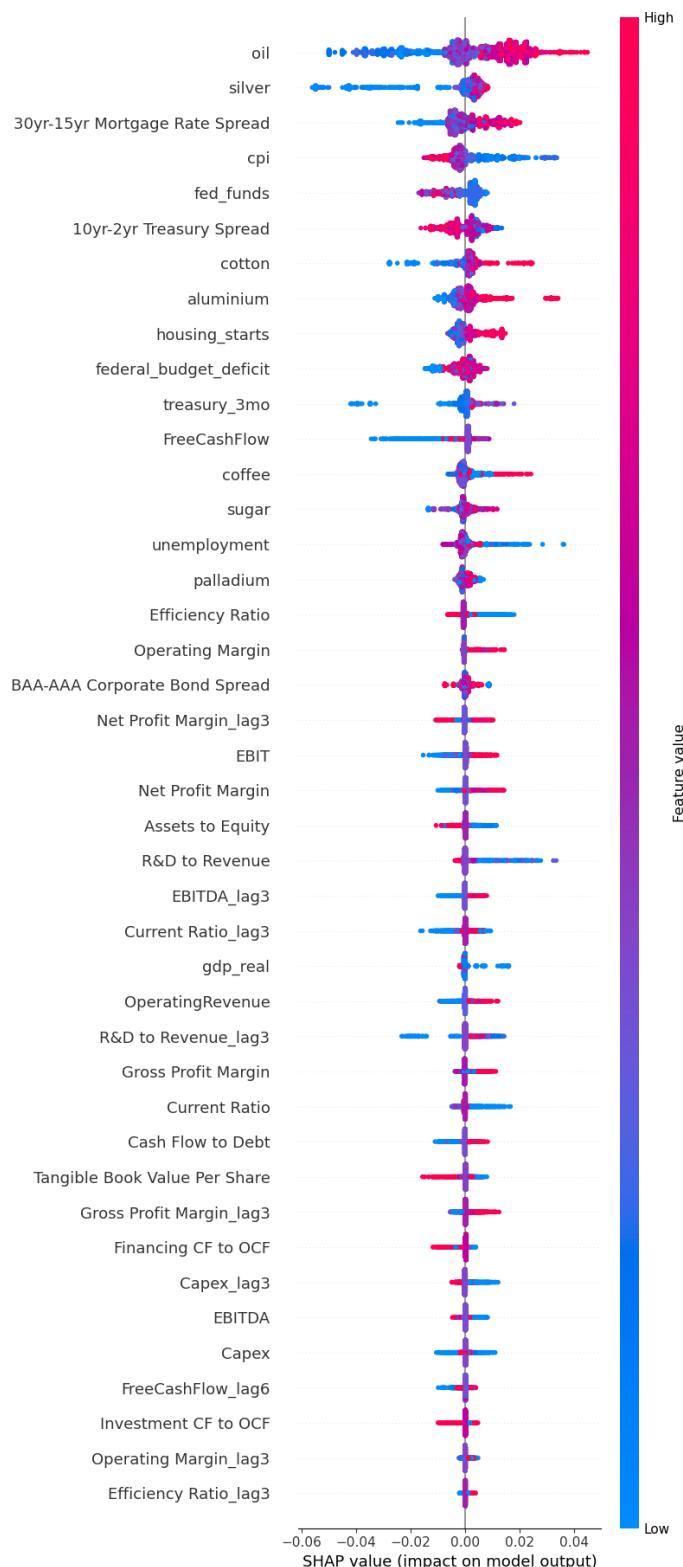
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|--------------------------------|-----------|----------|-----------|--------------|----------|----------|----------|----------|----------|----------|
| vix | -0.027567 | 0.000810 | 34.052027 | 0.000000e+00 | 1.645202 | 0.001332 | 1.960507 | 0.001587 | 2.576955 | 0.002086 |
| copper | 0.015589 | 0.000899 | 17.342420 | 0.000000e+00 | 1.645202 | 0.001479 | 1.960507 | 0.001762 | 2.576955 | 0.002316 |
| BAA-AAA Corporate Bond Spread | -0.014071 | 0.000874 | 16.094728 | 0.000000e+00 | 1.645202 | 0.001438 | 1.960507 | 0.001714 | 2.576955 | 0.002253 |
| oil | 0.012286 | 0.000863 | 14.241930 | 0.000000e+00 | 1.645202 | 0.001419 | 1.960507 | 0.001691 | 2.576955 | 0.002223 |
| palladium | -0.011791 | 0.001029 | 11.461653 | 0.000000e+00 | 1.645202 | 0.001692 | 1.960507 | 0.002017 | 2.576955 | 0.002651 |
| fed_funds | -0.009022 | 0.000714 | 12.634803 | 0.000000e+00 | 1.645202 | 0.001175 | 1.960507 | 0.001400 | 2.576955 | 0.001840 |
| unemployment | -0.008481 | 0.000831 | 10.207494 | 0.000000e+00 | 1.645202 | 0.001367 | 1.960507 | 0.001629 | 2.576955 | 0.002141 |
| treasury_3mo | 0.006799 | 0.000804 | 8.458643 | 0.000000e+00 | 1.645202 | 0.001322 | 1.960507 | 0.001576 | 2.576955 | 0.002071 |
| Cash Flow to Debt | 0.005575 | 0.000978 | 5.701626 | 1.264887e-08 | 1.645202 | 0.001609 | 1.960507 | 0.001917 | 2.576955 | 0.002520 |
| EBIT | 0.005551 | 0.000733 | 7.573000 | 4.418688e-14 | 1.645202 | 0.001206 | 1.960507 | 0.001437 | 2.576955 | 0.001889 |
| natural_gas | 0.005355 | 0.000897 | 5.968919 | 2.577463e-09 | 1.645202 | 0.001476 | 1.960507 | 0.001759 | 2.576955 | 0.002312 |
| platinum | 0.004390 | 0.000715 | 6.141115 | 8.922569e-10 | 1.645202 | 0.001176 | 1.960507 | 0.001402 | 2.576955 | 0.001842 |
| cpi | -0.004355 | 0.000919 | 4.738794 | 2.218219e-06 | 1.645202 | 0.001512 | 1.960507 | 0.001802 | 2.576955 | 0.002368 |
| EBITDA_lag3 | -0.003678 | 0.000898 | 4.095690 | 4.285285e-05 | 1.645202 | 0.001477 | 1.960507 | 0.001760 | 2.576955 | 0.002314 |
| Gross Profit Margin_lag3 | 0.003574 | 0.000751 | 4.760714 | 1.991472e-06 | 1.645202 | 0.001235 | 1.960507 | 0.001472 | 2.576955 | 0.001935 |
| housing_starts | 0.003337 | 0.000783 | 4.263052 | 2.059073e-05 | 1.645202 | 0.001288 | 1.960507 | 0.001535 | 2.576955 | 0.002017 |
| TotalRevenue_lag3 | 0.003098 | 0.000803 | 3.855605 | 1.171031e-04 | 1.645202 | 0.001322 | 1.960507 | 0.001575 | 2.576955 | 0.002070 |
| federal_budget_deficit | 0.003022 | 0.000923 | 3.274215 | 1.067810e-03 | 1.645202 | 0.001519 | 1.960507 | 0.001810 | 2.576955 | 0.002379 |
| 30yr-15yr Mortgage Rate Spread | 0.002983 | 0.000814 | 3.662821 | 2.524067e-04 | 1.645202 | 0.001340 | 1.960507 | 0.001597 | 2.576955 | 0.002099 |
| gdp_real | -0.002941 | 0.000853 | 3.447024 | 5.721427e-04 | 1.645202 | 0.001404 | 1.960507 | 0.001673 | 2.576955 | 0.002198 |
| sugar | -0.002896 | 0.000788 | 3.673396 | 2.422134e-04 | 1.645202 | 0.001297 | 1.960507 | 0.001545 | 2.576955 | 0.002031 |
| cotton | -0.002739 | 0.000839 | 3.262575 | 1.112532e-03 | 1.645202 | 0.001381 | 1.960507 | 0.001646 | 2.576955 | 0.002163 |
| Financing CF to OCF | -0.002725 | 0.000714 | 3.818428 | 1.361656e-04 | 1.645202 | 0.001174 | 1.960507 | 0.001399 | 2.576955 | 0.001839 |
| wheat | 0.002517 | 0.000979 | 2.570571 | 1.018592e-02 | 1.645202 | 0.001611 | 1.960507 | 0.001920 | 2.576955 | 0.002523 |
| 10yr-2yr Treasury Spread | -0.002444 | 0.000833 | 2.936001 | 3.342068e-03 | 1.645202 | 0.001370 | 1.960507 | 0.001632 | 2.576955 | 0.002145 |
| Current Ratio_lag3 | 0.002112 | 0.000740 | 2.855928 | 4.311367e-03 | 1.645202 | 0.001217 | 1.960507 | 0.001450 | 2.576955 | 0.001906 |
| avg_home_price | -0.002075 | 0.000836 | 2.483545 | 1.304540e-02 | 1.645202 | 0.001375 | 1.960507 | 0.001638 | 2.576955 | 0.002153 |
| Efficiency Ratio* | -0.002070 | 0.001081 | 1.914998 | 5.555795e-02 | 1.645202 | 0.001778 | 1.960507 | 0.002119 | 2.576955 | 0.002785 |
| coffee | -0.001832 | 0.000872 | 2.100911 | 3.570595e-02 | 1.645202 | 0.001435 | 1.960507 | 0.001710 | 2.576955 | 0.002247 |
| Operating Margin | -0.001707 | 0.000712 | 2.397284 | 1.655883e-02 | 1.645202 | 0.001172 | 1.960507 | 0.001396 | 2.576955 | 0.001835 |
| Investment CF to OCF | -0.001435 | 0.000820 | 1.750650 | 8.007640e-02 | 1.645202 | 0.001348 | 1.960507 | 0.001607 | 2.576955 | 0.002112 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure J3

Communication Services Sector: LightGBM SHAP Beeswarm Plot (Median Model)



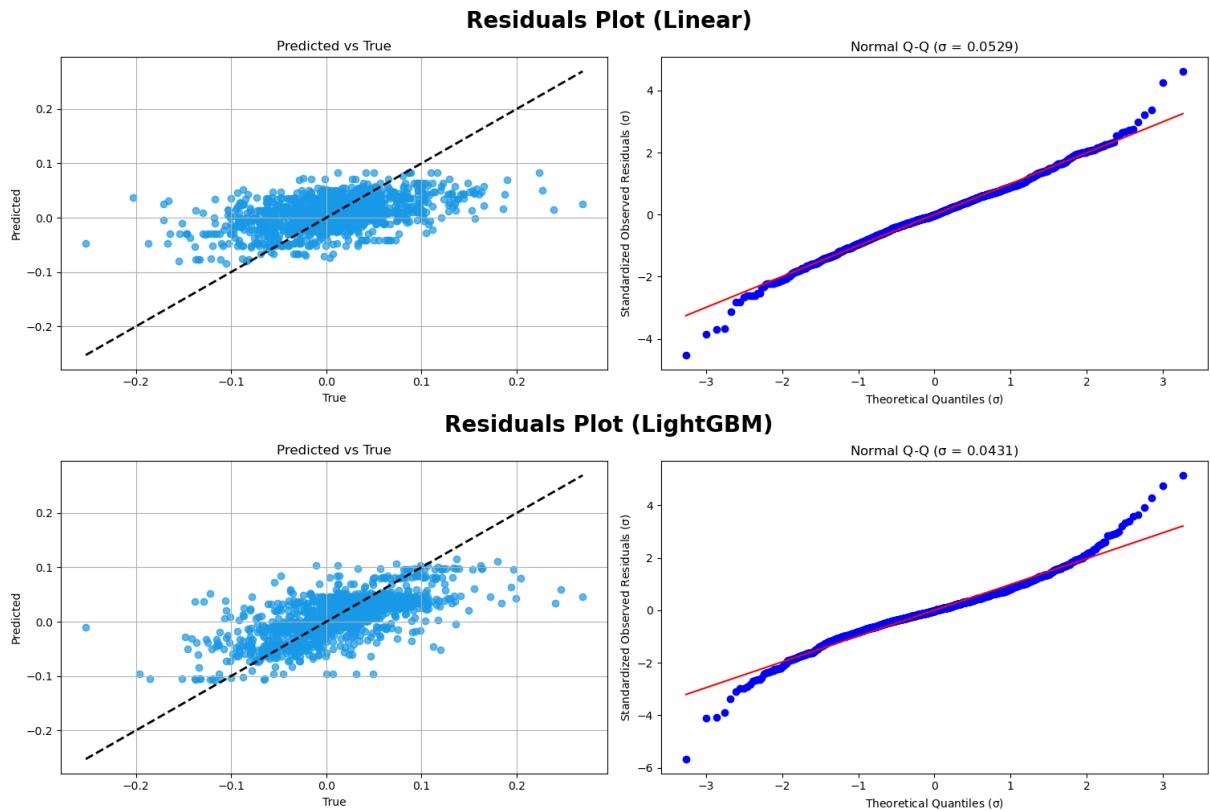
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix K

Utilities Sector

Figure K1

Utilities Sector: Residuals Plots (Median Model)

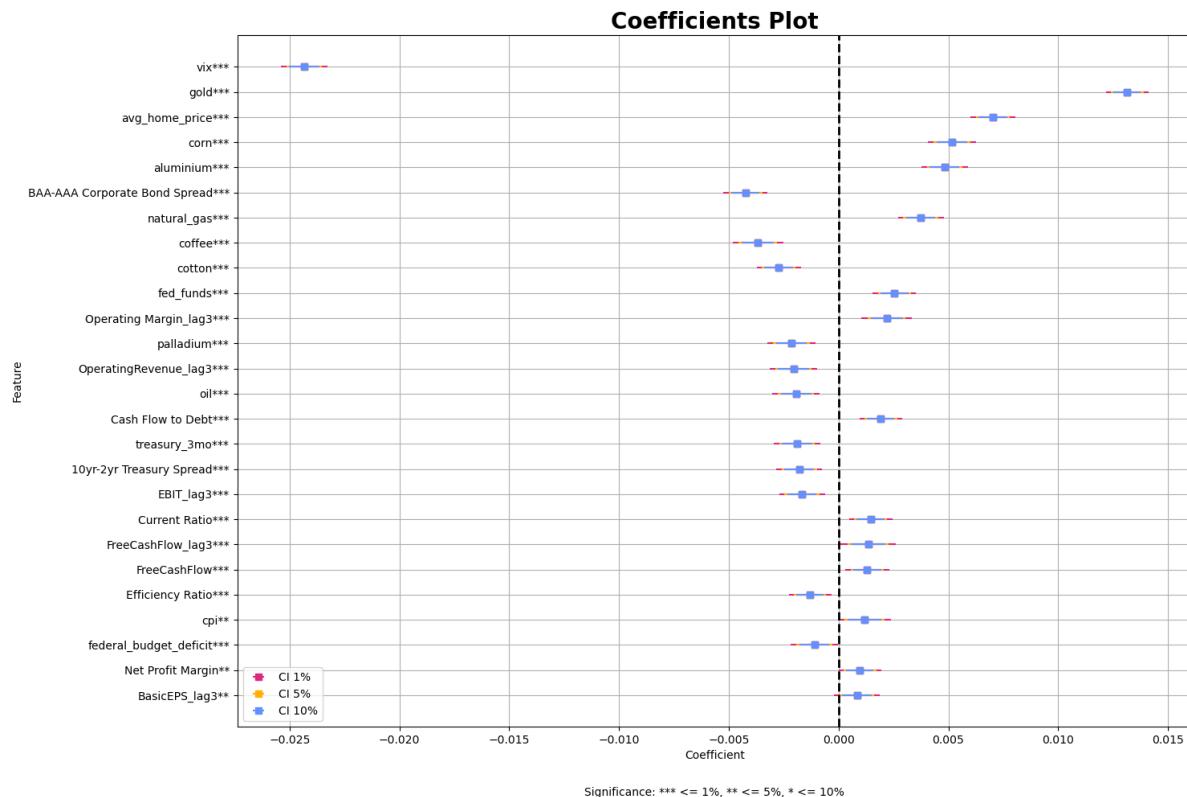


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure K2

Utilities Sector: Linear Regression Coefficient Plot (Median Model)



Significance: *** <= 1%, ** <= 5%, * <= 10%

Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table K1 for coefficient statistics.

DECODING SECTOR VALUATION DYNAMICS

Table K1

Utilities Sector: Linear Regression Coefficient Statistics (Median Model)

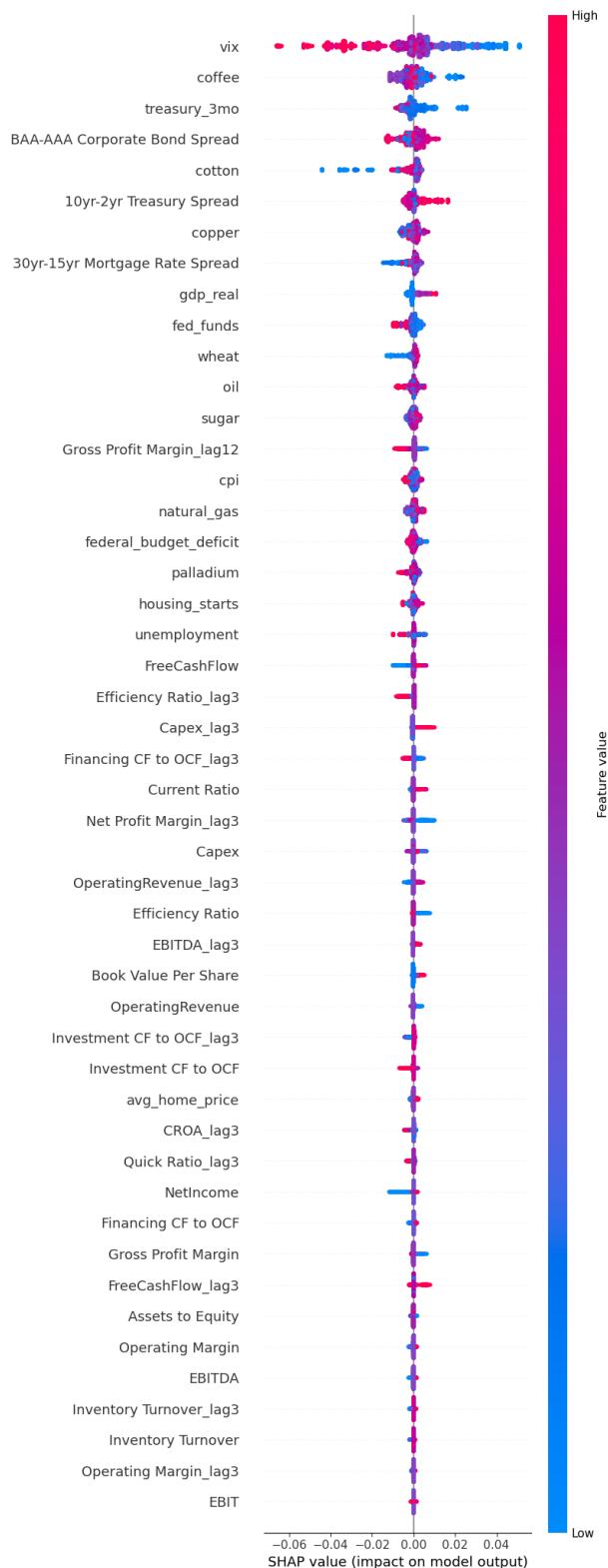
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|-------------------------------|-----------|----------|-----------|--------------|----------|----------|----------|----------|----------|----------|
| vix | -0.024343 | 0.000414 | 58.769465 | 0.000000e+00 | 1.645158 | 0.000681 | 1.960437 | 0.000812 | 2.576811 | 0.001067 |
| gold | 0.013144 | 0.000377 | 34.830485 | 0.000000e+00 | 1.645158 | 0.000621 | 1.960437 | 0.000740 | 2.576811 | 0.000972 |
| avg.home_price | 0.007028 | 0.000398 | 17.659898 | 0.000000e+00 | 1.645158 | 0.000655 | 1.960437 | 0.000780 | 2.576811 | 0.001026 |
| corn | 0.005156 | 0.000426 | 12.104872 | 0.000000e+00 | 1.645158 | 0.000701 | 1.960437 | 0.000835 | 2.576811 | 0.001098 |
| aluminium | 0.004828 | 0.000413 | 11.697316 | 0.000000e+00 | 1.645158 | 0.000679 | 1.960437 | 0.000809 | 2.576811 | 0.001064 |
| BAA-AAA Corporate Bond Spread | -0.004243 | 0.000392 | 10.815376 | 0.000000e+00 | 1.645158 | 0.000645 | 1.960437 | 0.000769 | 2.576811 | 0.001011 |
| natural_gas | 0.003740 | 0.000404 | 9.249836 | 0.000000e+00 | 1.645158 | 0.000665 | 1.960437 | 0.000793 | 2.576811 | 0.001042 |
| coffee | -0.003674 | 0.000447 | 8.227388 | 2.220446e-16 | 1.645158 | 0.000735 | 1.960437 | 0.000875 | 2.576811 | 0.001151 |
| cotton | -0.002731 | 0.000391 | 6.988364 | 3.145040e-12 | 1.645158 | 0.000643 | 1.960437 | 0.000766 | 2.576811 | 0.001007 |
| fed_funds | 0.002547 | 0.000383 | 6.644220 | 3.372191e-11 | 1.645158 | 0.000631 | 1.960437 | 0.000751 | 2.576811 | 0.000988 |
| Operating Margin_lag3 | 0.002187 | 0.000443 | 4.935853 | 8.238772e-07 | 1.645158 | 0.000729 | 1.960437 | 0.000869 | 2.576811 | 0.001142 |
| palladium | -0.002150 | 0.000428 | 5.023974 | 5.237102e-07 | 1.645158 | 0.000704 | 1.960437 | 0.000839 | 2.576811 | 0.001103 |
| OperatingRevenue_lag3 | -0.002057 | 0.000424 | 4.852759 | 1.254486e-06 | 1.645158 | 0.000697 | 1.960437 | 0.000831 | 2.576811 | 0.001092 |
| oil | -0.001942 | 0.000419 | 4.630235 | 3.744816e-06 | 1.645158 | 0.000690 | 1.960437 | 0.000822 | 2.576811 | 0.001081 |
| Cash Flow to Debt | 0.001919 | 0.000378 | 5.072649 | 4.064674e-07 | 1.645158 | 0.000622 | 1.960437 | 0.000742 | 2.576811 | 0.000975 |
| treasury_3mo | -0.001898 | 0.000415 | 4.574431 | 4.890306e-06 | 1.645158 | 0.000683 | 1.960437 | 0.000813 | 2.576811 | 0.001069 |
| 10yr-2yr Treasury Spread | -0.001797 | 0.000408 | 4.404003 | 1.084844e-05 | 1.645158 | 0.000671 | 1.960437 | 0.000800 | 2.576811 | 0.001052 |
| EBIT_lag3 | -0.001668 | 0.000405 | 4.113097 | 3.966407e-05 | 1.645158 | 0.000667 | 1.960437 | 0.000795 | 2.576811 | 0.001045 |
| Current Ratio | 0.001459 | 0.000385 | 3.793755 | 1.501349e-04 | 1.645158 | 0.000633 | 1.960437 | 0.000754 | 2.576811 | 0.000991 |
| FreeCashFlow_lag3 | 0.001342 | 0.000484 | 2.775828 | 5.526564e-03 | 1.645158 | 0.000795 | 1.960437 | 0.000948 | 2.576811 | 0.001246 |
| FreeCashFlow | 0.001303 | 0.000387 | 3.369357 | 7.591269e-04 | 1.645158 | 0.000636 | 1.960437 | 0.000758 | 2.576811 | 0.000997 |
| Efficiency Ratio | -0.001300 | 0.000374 | 3.480253 | 5.052090e-04 | 1.645158 | 0.000614 | 1.960437 | 0.000732 | 2.576811 | 0.000962 |
| cpi | 0.001187 | 0.000463 | 2.563738 | 1.038407e-02 | 1.645158 | 0.000762 | 1.960437 | 0.000908 | 2.576811 | 0.001194 |
| federal_budget_deficit | -0.001106 | 0.000417 | 2.654978 | 7.956448e-03 | 1.645158 | 0.000686 | 1.960437 | 0.000817 | 2.576811 | 0.001074 |
| Net Profit Margin | 0.000972 | 0.000378 | 2.572334 | 1.013007e-02 | 1.645158 | 0.000621 | 1.960437 | 0.000740 | 2.576811 | 0.000973 |
| BasicEPS_lag3 | 0.000832 | 0.000406 | 2.048424 | 4.057042e-02 | 1.645158 | 0.000668 | 1.960437 | 0.000796 | 2.576811 | 0.001047 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure K3

Utilities Sector: LightGBM SHAP Beeswarm Plot (Median Model)



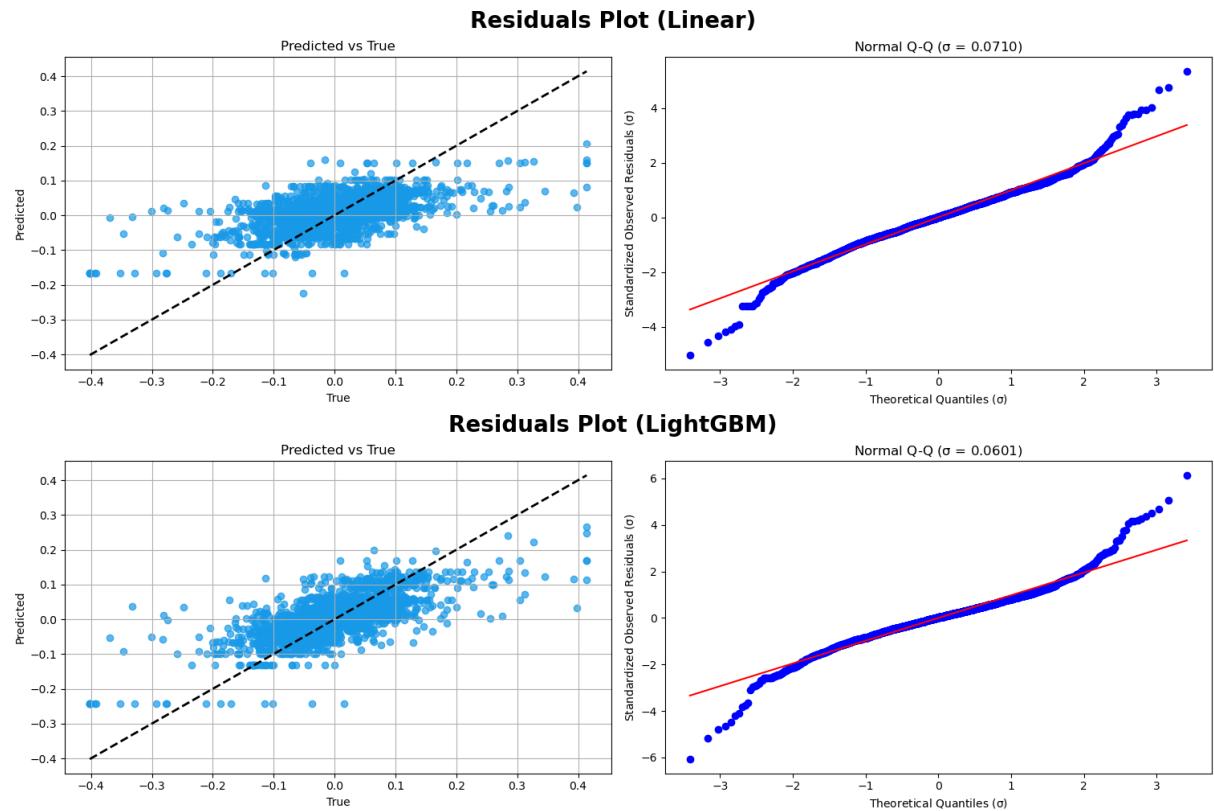
Median Model: Model with the median R^2 across 5-fold cross-validation.

Appendix L

Real Estate Sector

Figure L1

Real Estate Sector: Residuals Plots (Median Model)

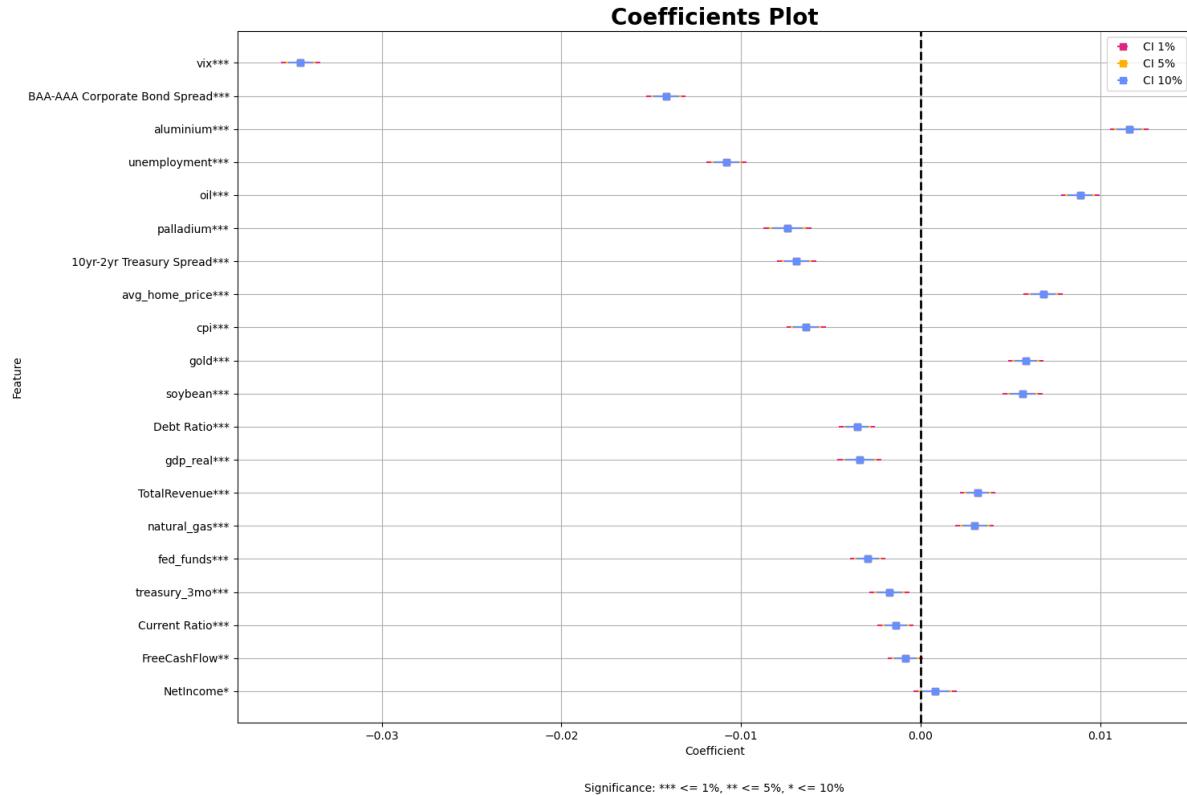


Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure L2

Real Estate Sector: Linear Regression Coefficient Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.

See Table L1 for coefficient statistics.

Table L1

Real Estate Sector: Linear Regression Coefficient Statistics (Median Model)

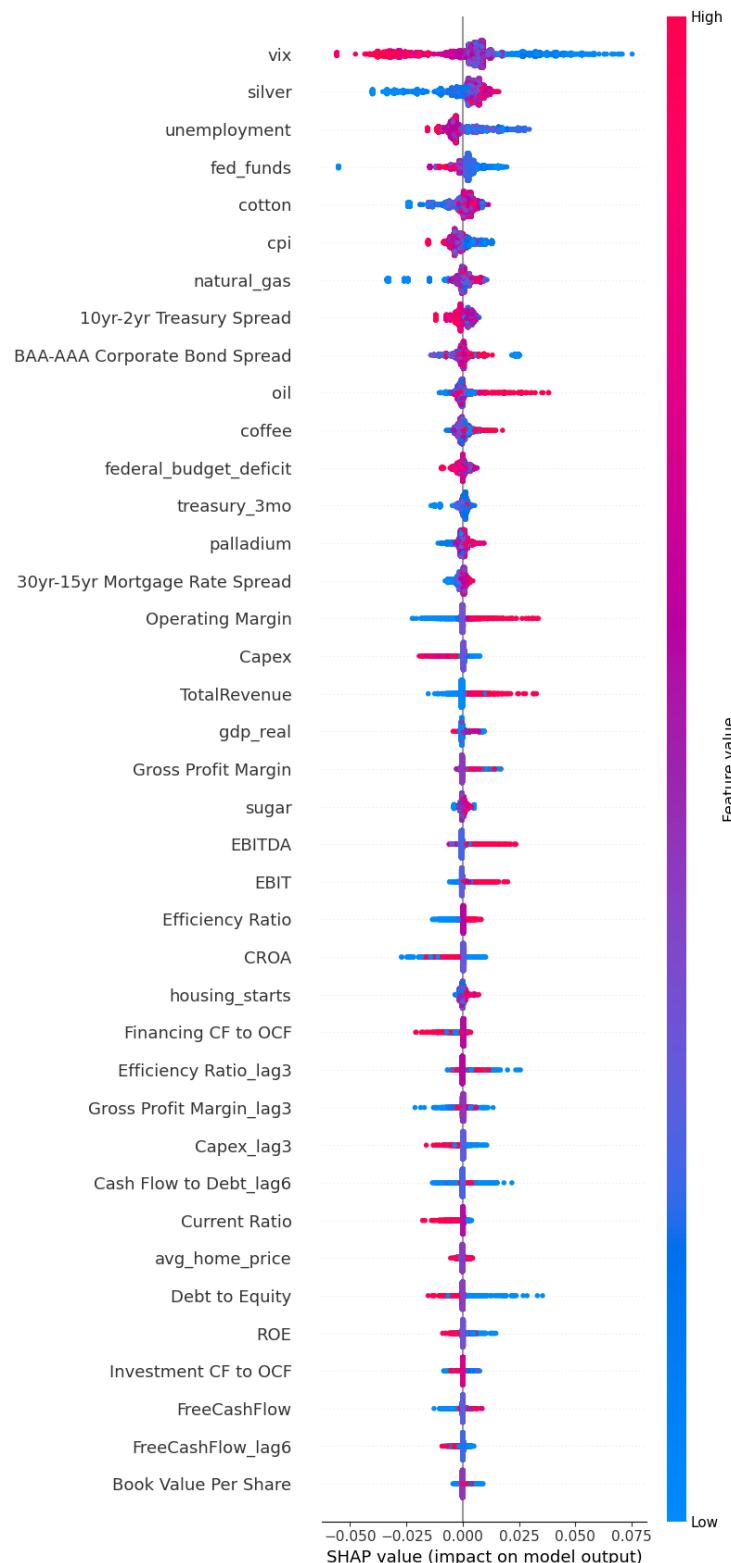
| | Coef | Std Err | -t- | P>-t- | t* (10%) | CI (10%) | t* (5%) | CI (5%) | t* (1%) | CI (1%) |
|-------------------------------|-----------|----------|-----------|--------------|----------|----------|---------|----------|----------|----------|
| vix | -0.034532 | 0.000427 | 80.928407 | 0.000000e+00 | 1.645031 | 0.000702 | 1.96024 | 0.000836 | 2.576401 | 0.001099 |
| BAA-AAA Corporate Bond Spread | -0.014171 | 0.000426 | 33.283127 | 0.000000e+00 | 1.645031 | 0.000700 | 1.96024 | 0.000835 | 2.576401 | 0.001097 |
| aluminium | 0.011610 | 0.000420 | 27.659970 | 0.000000e+00 | 1.645031 | 0.000691 | 1.96024 | 0.000823 | 2.576401 | 0.001081 |
| unemployment | -0.010829 | 0.000432 | 25.091283 | 0.000000e+00 | 1.645031 | 0.000710 | 1.96024 | 0.000846 | 2.576401 | 0.001112 |
| oil | 0.008890 | 0.000421 | 21.102733 | 0.000000e+00 | 1.645031 | 0.000693 | 1.96024 | 0.000826 | 2.576401 | 0.001085 |
| palladium | -0.007423 | 0.000522 | 14.219400 | 0.000000e+00 | 1.645031 | 0.000859 | 1.96024 | 0.001023 | 2.576401 | 0.001345 |
| 10yr-2yr Treasury Spread | -0.006910 | 0.000429 | 16.108630 | 0.000000e+00 | 1.645031 | 0.000706 | 1.96024 | 0.000841 | 2.576401 | 0.001105 |
| avg.home.price | 0.006825 | 0.000422 | 16.190385 | 0.000000e+00 | 1.645031 | 0.000693 | 1.96024 | 0.000826 | 2.576401 | 0.001086 |
| cpi | -0.006385 | 0.000425 | 15.031439 | 0.000000e+00 | 1.645031 | 0.000699 | 1.96024 | 0.000833 | 2.576401 | 0.001094 |
| gold | 0.005864 | 0.000386 | 15.210977 | 0.000000e+00 | 1.645031 | 0.000634 | 1.96024 | 0.000756 | 2.576401 | 0.000993 |
| soybean | 0.005672 | 0.000430 | 13.178291 | 0.000000e+00 | 1.645031 | 0.000708 | 1.96024 | 0.000844 | 2.576401 | 0.001109 |
| Debt Ratio | -0.003546 | 0.000386 | 9.191051 | 0.000000e+00 | 1.645031 | 0.000635 | 1.96024 | 0.000756 | 2.576401 | 0.000994 |
| gdp_real | -0.003396 | 0.000477 | 7.118287 | 1.180611e-12 | 1.645031 | 0.000785 | 1.96024 | 0.000935 | 2.576401 | 0.001229 |
| TotalRevenue | 0.003179 | 0.000388 | 8.203830 | 2.220446e-16 | 1.645031 | 0.000638 | 1.96024 | 0.000760 | 2.576401 | 0.000998 |
| natural_gas | 0.002998 | 0.000421 | 7.116107 | 1.199263e-12 | 1.645031 | 0.000693 | 1.96024 | 0.000826 | 2.576401 | 0.001085 |
| fed_funds | -0.002948 | 0.000385 | 7.654381 | 2.153833e-14 | 1.645031 | 0.000634 | 1.96024 | 0.000755 | 2.576401 | 0.000992 |
| treasury_3mo | -0.001752 | 0.000430 | 4.076393 | 4.615135e-05 | 1.645031 | 0.000707 | 1.96024 | 0.000842 | 2.576401 | 0.001107 |
| Current Ratio | -0.001388 | 0.000389 | 3.571926 | 3.563021e-04 | 1.645031 | 0.000639 | 1.96024 | 0.000762 | 2.576401 | 0.001001 |
| FreeCashFlow | -0.000849 | 0.000384 | 2.213978 | 2.685640e-02 | 1.645031 | 0.000631 | 1.96024 | 0.000752 | 2.576401 | 0.000988 |
| NetIncome | 0.000813 | 0.000473 | 1.718837 | 8.567995e-02 | 1.645031 | 0.000778 | 1.96024 | 0.000927 | 2.576401 | 0.001218 |

Median Model: Model with the median R^2 across 5-fold cross-validation.

DECODING SECTOR VALUATION DYNAMICS

Figure L3

Real Estate Sector: LightGBM SHAP Beeswarm Plot (Median Model)



Median Model: Model with the median R^2 across 5-fold cross-validation.