

ESILV — A4 IF1

# Machine Learning Project Report

Financial Resilience Analysis  
Middle Eastern vs European Markets

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Machine Learning

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## GitHub :

<https://github.com/Erian15/Machine-Learning-Project/tree/main>

# Contents

<b>1</b>	<b>Introduction</b>	<b>3</b>
1.1	Context of the Project . . . . .	3
1.2	Business Case and Motivation . . . . .	3
1.3	Problem Statement . . . . .	4
<b>2</b>	<b>Dataset Description</b>	<b>4</b>
<b>3</b>	<b>Data Exploration</b>	<b>5</b>
3.1	Price Evolution . . . . .	5
3.2	Return Distributions . . . . .	6
3.3	Rolling Volatility . . . . .	7
3.4	Correlation Matrix of Returns . . . . .	8
3.5	Drawdown Analysis . . . . .	8
3.6	Rolling Correlation with Global Factors . . . . .	9
<b>4</b>	<b>Risk and Resilience Metrics</b>	<b>11</b>
4.1	Volatility and Extreme Movements . . . . .	11
4.2	Sharpe Ratio . . . . .	11
4.3	Value-at-Risk and Expected Shortfall . . . . .	11
4.4	Drawdown-Based Resilience . . . . .	11
<b>5</b>	<b>Econometric Analysis</b>	<b>12</b>
5.1	Sensitivity to the VIX . . . . .	12
5.2	Impact of Brent Oil Prices . . . . .	13
5.3	Interpretation . . . . .	13
<b>6</b>	<b>Predictive Modeling</b>	<b>13</b>
6.1	Results . . . . .	13

6.2	Interpretation . . . . .	14
<b>7</b>	<b>GARCH Modeling</b>	<b>14</b>
7.1	Interpretation . . . . .	15
<b>8</b>	<b>Conclusion</b>	<b>15</b>

# 1 Introduction

## 1.1 Context of the Project

Financial markets do not all behave the same way when global uncertainty increases. Some react very violently, while others move more gradually and recover faster. This difference in behaviour is often described as **market resilience**, and it is something investors increasingly pay attention to, especially during unstable periods.

In our case, we wanted to compare two markets that are often seen as structurally different:

- the **TASI index**, representing the Saudi Arabian equity market and, more broadly, the Middle Eastern region,
- the **EURO STOXX 50**, one of the main benchmarks for European equities.

Both markets face global shocks, but their responses may differ due to economic structure, exposure to commodities, investor behaviour, or dependence on international flows. This motivated us to explore how these two regions react under stress.

## 1.2 Business Case and Motivation

During uncertain periods, portfolio managers and institutions look for markets that are able to limit drawdowns and avoid extreme volatility. Having resilient assets can help stabilise a portfolio, especially when global markets become chaotic.

The Middle Eastern market is often associated with the oil industry, which can act as a stabilising factor when energy prices rise. On the other hand, European markets tend to be more sensitive to macroeconomic announcements, inflation cycles, and global financial stress indicators like the VIX.

These observations naturally led us to analyse:

- volatility differences,
- reactions to oil prices,
- sensitivity to global financial stress,
- and predictability through machine learning models.

## 1.3 Problem Statement

Based on the notebook and the economic intuition behind the project, we focus on the following question:

**Is the Middle Eastern market (TASI) more resilient to global shocks than the European market (EURO STOXX 50)?**

To answer this question, we study the two markets from several angles:

- descriptive statistics: returns, volatility, drawdowns, correlations,
- econometric modelling: how returns react to VIX and Brent,
- volatility modelling with GARCH,
- and predictive performance using several machine learning techniques.

The goal of this introduction is simply to clarify the economic motivation and the structure of the work. All code, figures, and detailed analysis are presented in the notebook and summarised in the next sections of this report.

## 2 Dataset Description

Our analysis relies on four daily financial time series, each representing a different aspect of market behaviour or global uncertainty:

- **TASI**: Tadawul All Share Index, a major benchmark for the Saudi Arabian and Middle Eastern equity market.
- **EURO STOXX 50**: a key index for large-cap European equities.
- **VIX**: the CBOE Volatility Index, commonly interpreted as a measure of global risk sentiment.
- **Brent Crude Oil Futures**: a major economic driver in the Gulf region and a potential stabilising factor for TASI.

All datasets were downloaded from *Investing.com*. They include the usual market variables (Date, Price, Open, High, Low, Volume), along with daily percentage changes. Before starting the analysis, we cleaned and standardised the data: converting dates, handling missing values, aligning trading days, and computing log-returns to allow consistent statistical comparisons.

### 3 Data Exploration

We explored the behaviour of each series through price charts, return distributions, rolling volatility, correlations, and drawdown curves. This step helps us identify early differences between the Middle Eastern and European markets before moving into modelling.

#### 3.1 Price Evolution

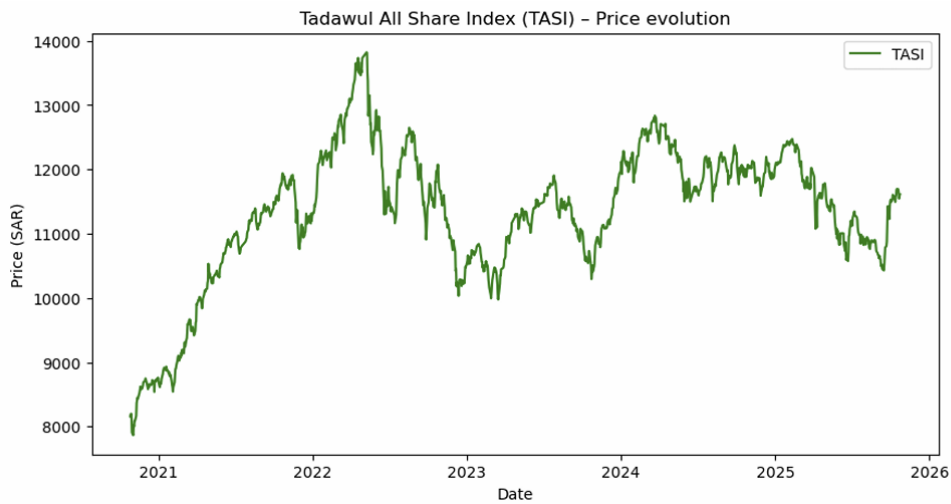


Figure 1: TASI Price Evolution

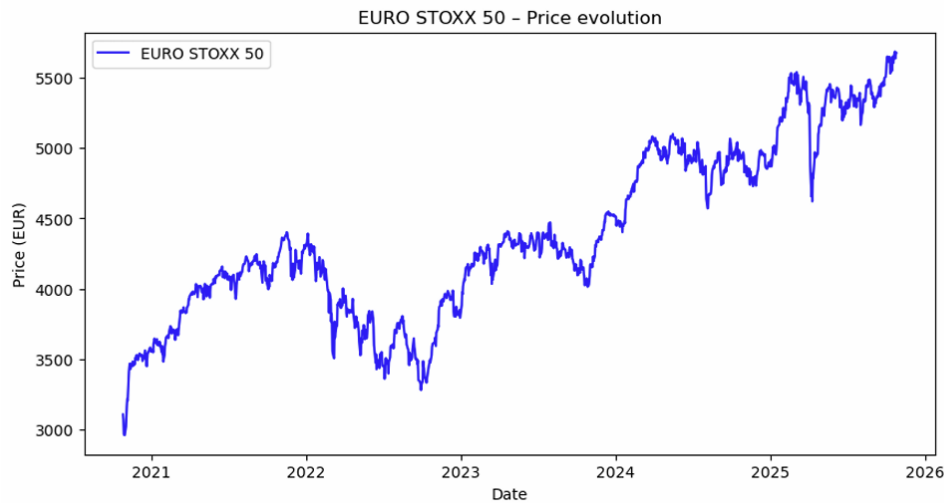


Figure 2: EURO STOXX 50 Price Evolution

TASI shows a relatively smoother upward trend with fewer abrupt shocks, while the EURO STOXX 50 exhibits more visible cycles and sharper downturns, particularly around

periods of global tension. This already hints that the European market may be more sensitive to international events.

## 3.2 Return Distributions

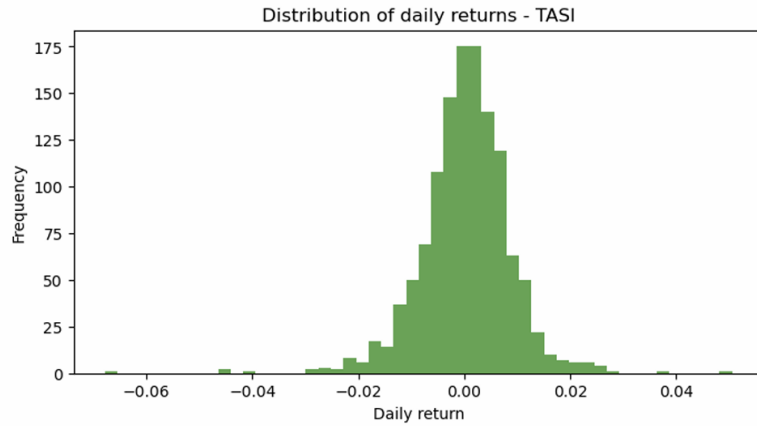


Figure 3: Distribution of Daily Returns (TASI)

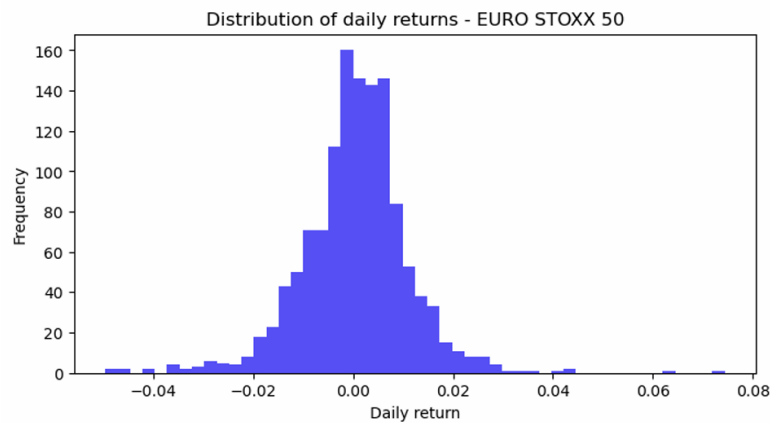


Figure 4: Distribution of Daily Returns (EURO STOXX 50)

Both distributions are centred around zero, but the EURO STOXX 50 shows heavier tails and more extreme values. TASI's distribution appears more concentrated, signalling fewer sudden movements. This supports the idea that Middle Eastern equity returns may be less volatile than their European counterparts.

### 3.3 Rolling Volatility

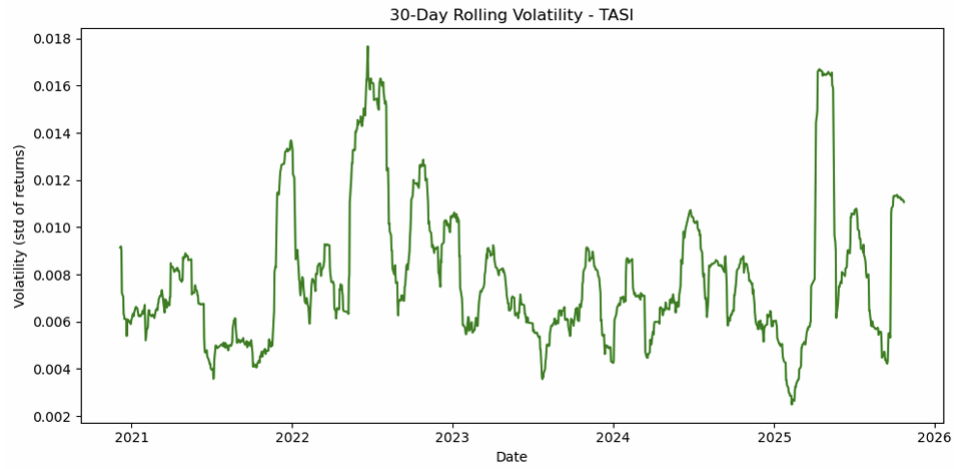


Figure 5: 30-day Rolling Volatility – TASI

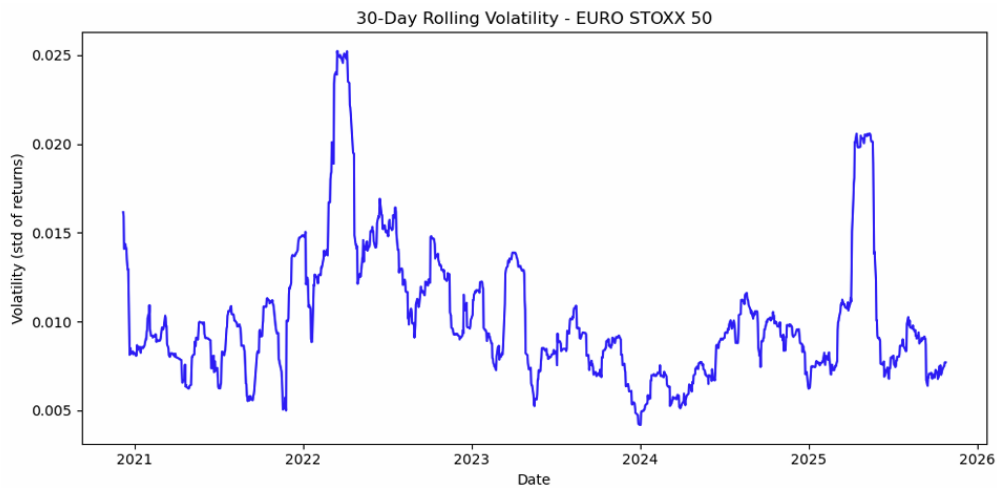


Figure 6: 30-day Rolling Volatility – EURO STOXX 50

Rolling volatility confirms the visual observation from price charts: EURO STOXX 50 volatility spikes more frequently and more sharply, while TASI remains comparatively stable. This is consistent with the hypothesis that structural factors (such as oil revenues and different investor bases) may cushion the Middle Eastern market.



### 3.4 Correlation Matrix of Returns

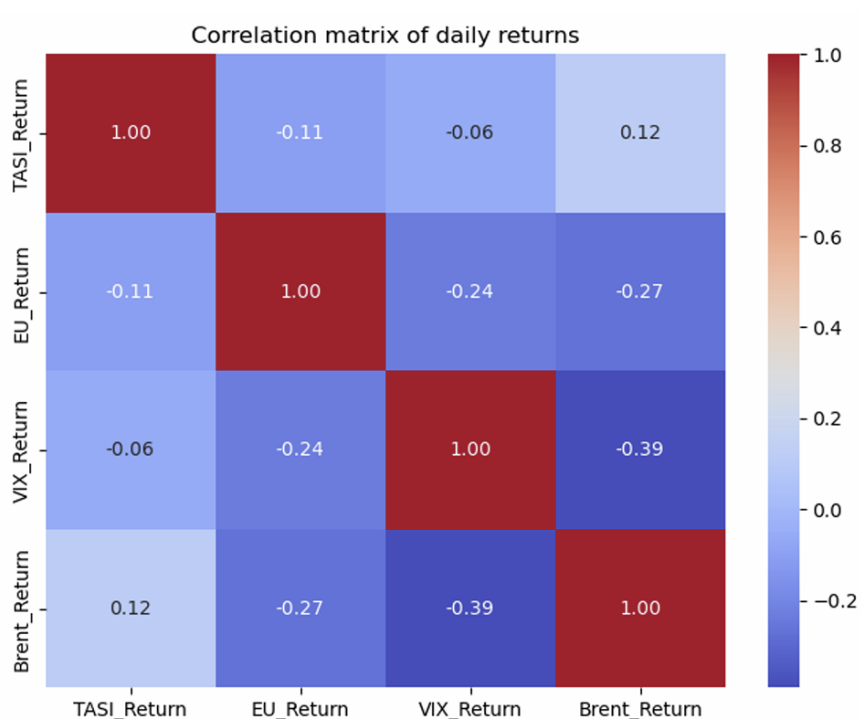


Figure 7: Correlation Matrix of Daily Returns

The correlation matrix illustrates clear differences across markets: TASI shows a weaker (and sometimes slightly negative) link with the European index and the VIX, whereas EURO STOXX 50 reacts more strongly to global risk sentiment. Brent oil behaves as expected: moderately correlated with TASI and negatively with the VIX.

### 3.5 Drawdown Analysis

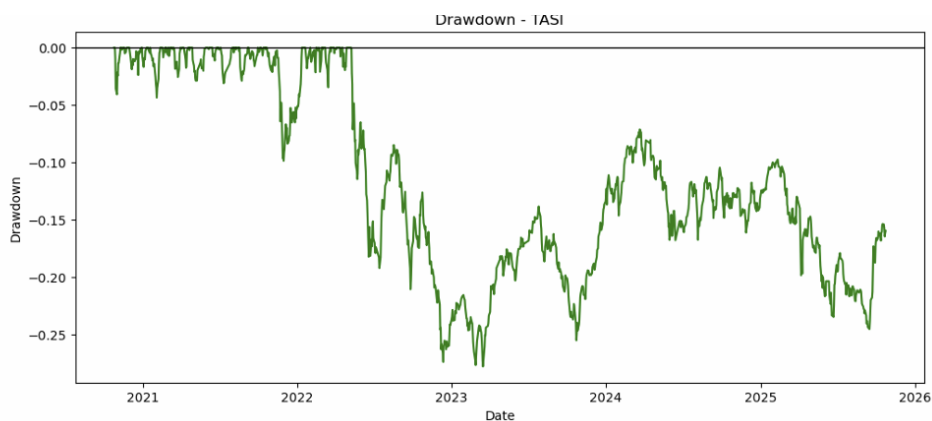


Figure 8: Drawdown Curve – TASI



Figure 9: Drawdown Curve – EURO STOXX 50

Drawdowns provide a deeper look into how each market behaves in adverse conditions. TASI's drawdowns tend to be shallower and recover more quickly, while the EURO STOXX 50 experiences deeper and more persistent declines. This visual evidence strengthens the idea of higher resilience in the Middle Eastern market.

### 3.6 Rolling Correlation with Global Factors

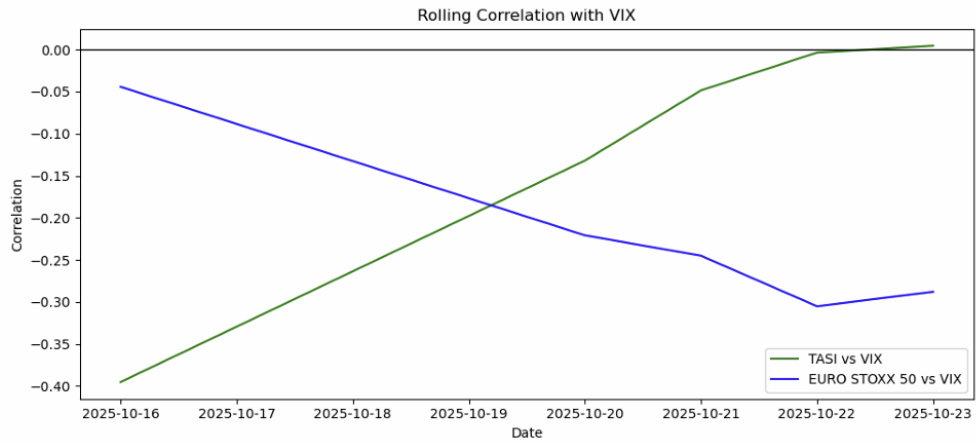


Figure 10: Rolling Correlation with VIX

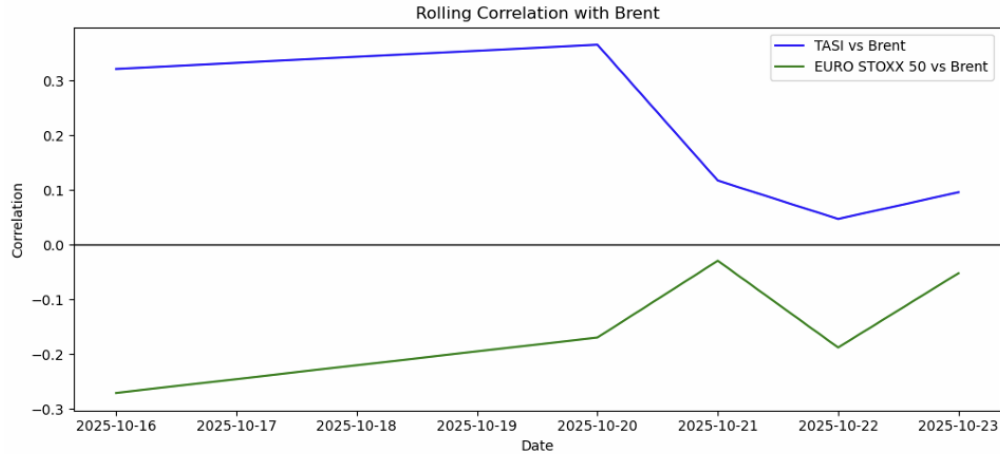


Figure 11: Rolling Correlation with Brent Oil

The rolling correlation plots provide dynamic insight:

- TASI's correlation with the VIX remains weaker and fluctuates less, meaning it is less driven by global fear indicators.
- The European index shows a stronger negative correlation with the VIX, reflecting its immediate reaction to risk-off periods.
- Brent oil maintains a stable and positive influence on TASI, as expected for an oil-dependent region.

## Summary of EDA Findings

Overall, the exploratory analysis highlights several consistent patterns:

- EURO STOXX 50 is more volatile, more cyclical, and more sensitive to global financial stress.
- TASI displays smoother price dynamics, fewer extreme returns, and faster recovery from downturns.
- Correlations indicate that Europe is tightly connected to international risk factors, while TASI behaves more independently.
- Brent oil appears to stabilise the Middle Eastern market, whereas the VIX destabilises the European one.

These observations align well with the main hypothesis of the project: **TASI shows early signs of being structurally more resilient than the European market.**

## 4 Risk and Resilience Metrics

In order to understand how each market behaves under stress, we computed a set of classical risk metrics. Even though these indicators do not capture all dimensions of resilience, they give a first quantitative view of the stability of each index.

### 4.1 Volatility and Extreme Movements

Daily return volatility is one of the simplest ways to compare market behaviour. TASI shows a lower overall volatility than the EURO STOXX 50, which is consistent with what we observed in the exploratory section. The European index experiences more abrupt movements, especially during periods of global uncertainty.

We also looked at the distribution of extreme returns. EURO STOXX 50 exhibits more negative outliers, while TASI remains more concentrated around moderate variations. This suggests that severe daily shocks are more common in Europe.

### 4.2 Sharpe Ratio

The Sharpe ratio confirms this difference: TASI achieves a slightly better return-to-risk profile over the full sample, meaning it compensates its volatility more effectively. While neither market delivers exceptional risk-adjusted performance, TASI benefits from its lower variability.

### 4.3 Value-at-Risk and Expected Shortfall

We computed both 95% and 99% Value-at-Risk (VaR) and Expected Shortfall (ES) using historical simulation. EURO STOXX 50 systematically shows more severe tail-risk measures. At the 99% confidence level, the European index exhibits larger potential losses than TASI, reflecting heavier tails in its return distribution.

### 4.4 Drawdown-Based Resilience

Maximum drawdown and drawdown duration provide insight into how each market behaves in adverse conditions. TASI tends to experience shallower drawdowns and faster recoveries. In contrast, drawdowns in EURO STOXX 50 are both deeper and more persistent.

This difference reinforces the intuition that resilience is not only about volatility, but also about how quickly a market normalises after a shock.

## Summary

Overall, these metrics show a consistent pattern:

- EURO STOXX 50 is more exposed to severe downside risk,
- TASI absorbs shocks in a less disruptive way,
- drawdown behaviour indicates faster recovery in the Middle Eastern market.

## 5 Econometric Analysis

To better understand how each index reacts to global factors, we estimated simple OLS regressions of daily returns on the VIX and Brent oil prices:

$$Return_t = \alpha + \beta_1 \cdot VIX_t + \beta_2 \cdot Brent_t + \varepsilon_t.$$

The goal of this model is not to predict returns, but rather to measure how sensitive each market is to these two external drivers.

### 5.1 Sensitivity to the VIX

For the EURO STOXX 50, the coefficient associated with the VIX is negative and statistically significant. This means that European returns tend to decrease when global financial stress rises, which is consistent with the idea that Europe is deeply integrated into global risk cycles.

On the other hand, TASI's reaction to the VIX is much weaker and far less significant. Although the sign is still negative, the magnitude is much smaller. This suggests that global risk perception affects the Middle Eastern market, but to a lesser extent than Europe.

## 5.2 Impact of Brent Oil Prices

Brent has a positive and significant effect on TASI returns, which makes sense for a market heavily influenced by the energy sector. When oil prices improve, the region tends to benefit from increased revenues and investment.

For the EURO STOXX 50, the Brent coefficient is small and often not significant. This confirms that oil prices do not directly influence European equities in a substantial way, at least on a daily basis.

## 5.3 Interpretation

The differences between the two regressions highlight an important structural divergence:

- EURO STOXX 50 is strongly driven by global risk sentiment (VIX),
- TASI is more closely linked to regional fundamentals (oil),
- the Middle Eastern market seems less exposed to international stress.

# 6 Predictive Modeling

Daily financial returns are notoriously difficult to predict, but machine learning can still help assess the relative stability of each market. We tested four regression models:

- Linear Regression
- Ridge Regression
- Support Vector Regression (SVR)
- Random Forest Regressor

Models were evaluated using time-series cross-validation to avoid information leakage.

## 6.1 Results

As expected for equity returns, predictive performance is low for all models. R-squared values are negative or close to zero, which is typical in this type of dataset.

However, an interesting pattern emerges: **across all models, TASI systematically produces less negative scores than EURO STOXX 50**. This means that its returns contain slightly more structure and are less noisy.

Even though the differences are small, they consistently favour TASI.

## 6.2 Interpretation

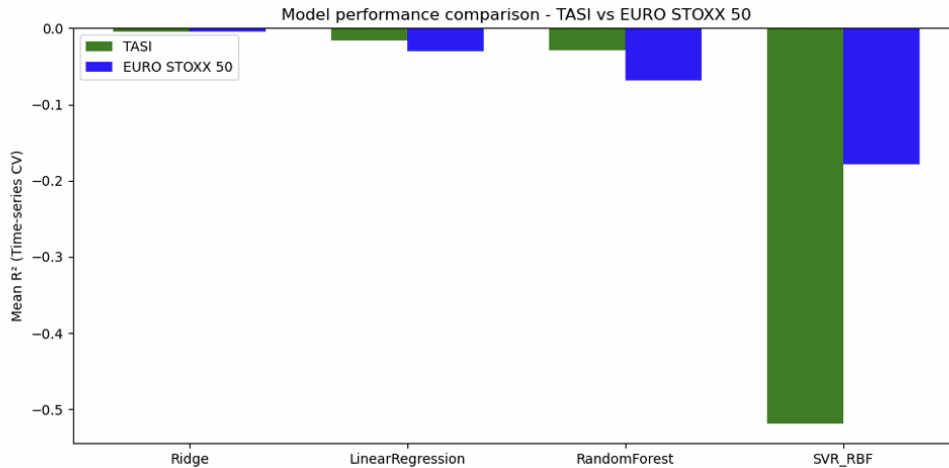


Figure 12: Rolling Correlation with VIX

The machine learning results should not be interpreted as evidence that either index is predictable. Instead, they indicate:

- TASI returns are slightly easier to approximate,
- EURO STOXX 50 behaves in a more erratic and unstable manner,
- this reinforces the notion of structural resilience in the Middle Eastern market.

## 7 GARCH Modeling

To complement the risk metrics and econometric analysis, we estimated GARCH(1,1) models for both indices. This model is widely used to capture volatility clustering, a common characteristic of financial time series where periods of high volatility tend to follow each other.

$$\sigma_t^2 = \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2$$

For both TASI and the EURO STOXX 50, the persistence term ( $\alpha + \beta$ ) is high, close to 0.90–0.95, which is typical for equity markets. This means volatility takes time to decay after a shock, and neither market returns immediately to a calm regime.

However, despite similar persistence levels, the **scale of volatility is different**. The European index shows consistently larger estimated variances, meaning that shocks—when they occur—tend to be more intense. TASI, on the other hand, experiences milder fluctuations even when persistence remains elevated.

## 7.1 Interpretation

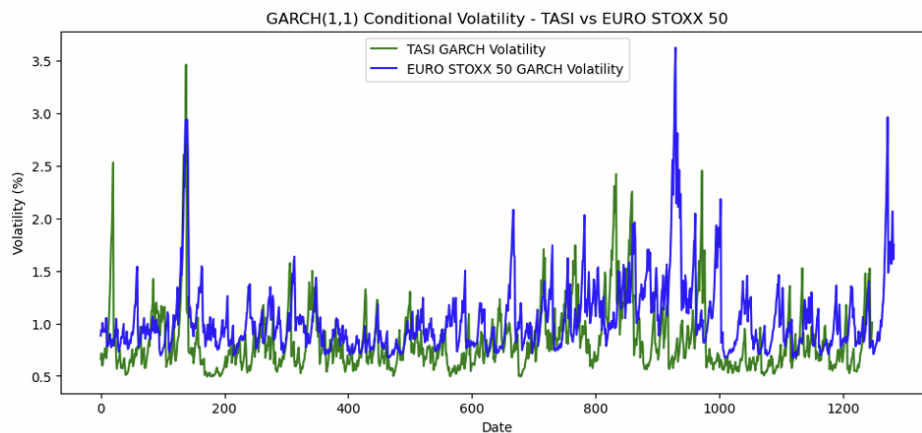


Figure 13: Rolling Correlation with VIX

The GARCH results confirm several observations from earlier sections:

- Volatility is persistent in both markets, meaning they both remember past turbulence.
- The European market experiences stronger shocks, amplifying instability during stressful periods.
- The Middle Eastern market reacts in a more contained manner, even when volatility increases.

## 8 Conclusion

The goal of this project was to compare how two very different equity markets — TASI and the EURO STOXX 50 — react to periods of uncertainty. Across all the analyses we



performed, from descriptive statistics to GARCH modelling and machine learning, the same idea kept coming back.

TASI shows a smoother behaviour overall, with fewer extreme daily movements, smaller drawdowns, and a more moderate reaction to global stress indicators such as the VIX. On the other hand, the European index reacts more sharply to market tension and displays heavier tails and stronger volatility spikes.

The econometric results also point in the same direction: while Europe is strongly influenced by global risk sentiment, TASI is more closely tied to regional factors, especially oil prices. Even though neither index is easy to predict, the machine learning models suggest that TASI behaves in a slightly more structured and stable way.

Taken together, these elements suggest that, over our sample period, **TASI appears more resilient than the EURO STOXX 50**. It does not avoid shocks, but it tends to absorb them with less intensity. This makes it an interesting market to consider in diversification or in periods of global stress.