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Dynamic Interactions between Key Macroeconomic Indicators and Sectoral Stock Indices: Applying the Johansen Methodology to the US and Eurozone

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Abstract This thesis investigates the dynamic interactions between macroeconomic indicators and sectoral stock indices in the United States and the Eurozone using the Johansen methodology. Based on monthly data from 2002 to 2024, the analysis covers twelve equity indices alongside inflation, money supply, and interest rates for both regions. The Johansen cointegration test confirms persistent long-term relationships between equities and macroeconomic fundamentals, with US variable sets generally exhibiting two cointegrating vectors and Eurozone sets showing three. However, sector-specific and regional differences emerge, particularly in how inflation and long-term interest rates interact with equity prices in the long-term. Results indicate that most sector indices adjust significantly to deviations from equilibrium. Short-run dynamics reveal that inflation has a stronger positive impact on US equities than on those in the Eurozone, while long-term interest rates exert a negative effect in both regions. Short-term interest rates and money supply respond endogenously to stock market movements. Faster market adjustments in the US compared to the Eurozone is observed, where deviations from equilibrium persist longer. The findings challenge traditional asset pricing models by demonstrating that stock prices are systematically linked to macroeconomic variables over the long term, raising questions about market efficiency. These results underscore the evolving nature of dynamic macro-financial linkages, particularly in the post-2020 economic landscape.

Kurzfassung Diese Masterarbeit untersucht die dynamischen Wechselwirkungen zwischen makroökonomischen Indikatoren und sektoralen Aktienindizes in den USA und der Eurozone unter Verwendung der Johansen-Methodologie. Basierend auf monatlichen Daten von 2002 bis 2024 umfasst die Analyse zwölf Aktienindizes sowie Inflation, Geldmenge und Zinssätze für beide Regionen. Der Johansen-Kointegrationstest bestätigt persistente langfristige Beziehungen zwischen Aktienmärkten und makroökonomischen Fundamentaldaten, wobei die US-Variablensätze in der Regel zwei Kointegrationsvektoren und die Eurozonen-Sätze drei aufweisen. Jedoch treten sektor- und regionalspezifische Unterschiede auf, insbesondere in der Art und Weise, wie Inflation und langfristige Zinssätze Dauer mit Aktienpreisen interagieren. Die Ergebnisse zeigen, dass sich die meisten Sektorindizes signifikant an Abweichungen vom Gleichgewicht anpassen. So offenbart die kurzfristige Dynamik, dass Inflation einen stärkeren positiven Einfluss auf US-Aktien als auf jene in der Eurozone hat, während langfristige Zinssätze in beiden Regionen eine negative Wirkung entfalten. Darüberhinaus reagieren kurzfristige Zinssätze und Geldmenge endogen auf Bewegungen der Aktienmärkte. Auch werden in den USA schnellere Marktanpassungen im Vergleich zur Eurozone beobachtet, wobei Abweichungen vom Gleichgewicht in der Eurozone länger bestehen bleiben. Insgesamt stellen die Ergebnisse traditionelle Asset-Pricing-Modelle infrage, da sie zeigen, dass Aktienkurse langfristig systematisch mit makroökonomischen Variablen verknüpft sind, was Fragen zur Markteffizienz aufwirft. Diese Erkenntnisse unterstreichen die sich verändernde Dynamik von makroökonomischen Variablen und Aktienmärkten, insbesondere im Zeitraum nach 2020.

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1 Introduction

After the Great Depression, early work on the relationship between macroeconomic and financial variables attracted considerable attention. Fisher (1933) was among the first to explain how debt and deflation interact dynamically during economic downturns, forming a vicious circle. Later contributions diverged from Fisher's idea of dynamic macro-financial interactions. Morley (2016) and Claessens and Kose (2018) identify two categories of approaches: the first, without frictions, sees financial markets as passive reflections of the real economy, the second considers financial frictions and endogeneity. A notable example of the former is Modigliani and Miller (1958)'s irrelevance theorem which states that in a model without frictions, a firm's capital structure does not impact its market value, suggesting a separation between financial markets and macroeconomic factors.

However, in real-world markets, these conditions rarely hold. Fazzari et al. (1988) show that external finance premiums prevent firms from freely substituting between debt and equity, establishing that financial constraints are procyclical and affect firm behavior. This insight laid the foundation for the financial accelerator introduced by Bernanke and Gertler (1989) in which financial market frictions amplify economic fluctuations through a feedback mechanism, again connecting to Fisher's vicious circle. Therefore, it can be concluded that the macro-financial relationship under real-world frictions is endogenous.

Building on these theoretical foundations, empirical research has increasingly focused on the long-term equilibrium relationships between macroeconomic indicators and financial markets. Studies such as Kwon and Shin (1999) and Ratanapakorn and Sharma (2007) show that macroeconomic variables and equity market indices are cointegrated. However, the strength and nature of these long-run relationships vary across different economies and over time frames. More recent contributions, such as Bhuiyan and Chowdhury (2020) have expanded the scope to include sectoral indices, highlighting the heterogeneous effects of macroeconomic variables across different sectors.

While existing literature has significantly contributed to the understanding of macro-financial dynamics, several gaps remain. Notably, prior studies have predominantly focused on aggregate stock market indices, leaving sector-specific dynamics underexplored. Additionally, much of the research has centered on individual countries, without a comprehensive analysis that compares dynamics across different economies. Based on the idea of Bhuiyan and Chowdhury (2020), these gaps are addressed by investigating the dynamic interactions between key macroeconomic indicators and sectoral stock indices in both the United States and Europe.

The objective of this thesis is to examine the short- and long-term interactions between macroeconomic variables and sectoral stock indices, focusing on macro-financial linkages across sectors in the United States and the Eurozone. To achieve these objectives, the study employs the Johansen procedure to determine cointegrating vectors, followed by Vector Error Correction Models (VECM) to capture dynamic relationships. Impulse Response Functions (IRF) are utilized to visualize the insights derived from the VECM analysis.

This thesis contributes to the literature by offering a sector-specific perspective rather than focusing solely on aggregate indices, thereby highlighting the heterogeneous effects across economic sectors. Additionally, it provides a comparative analysis of regional differences in macro-financial linkages at the sectoral level between the US and the Eurozone. Finally, the use of the most recent data adds insights into the current state of macro-financial relationships.

The structure of this thesis is organized as follows: Section 2 reviews the related literature on macro-financial linkages, and establishes a foundation for the selection of macroeconomic variables in the empirical analysis. Section 3 introduces the methodology, covering the Johansen procedure. Section 4 introduces the data, including descriptive statistics. Section 5 presents the empirical findings. Finally, Section 6 concludes by discussing key insights.

2 Literature Review

2.1 Equity Markets and Macroeconomic Dynamics

Chen et al. (1986) show in a multivariate regression framework that economic state variables significantly explain expected stock returns in the US, which is based on the idea of the Arbitrage Pricing Theory by Ross (1976). Macroeconomic variables are found to be adequately priced. However, the approach does not incorporate dynamic interactions between stock prices and economic variables or lagged stock returns.

The presence of such feedback mechanisms or stock returns being explained by their past values raises questions about the validity of the Efficient Market Hypothesis (EMH) introduced by Fama (1970), which suggests that stock prices should reflect all available information. Pesaran and Timmermann (1995) explore this issue by demonstrating that stock returns can be predicted using lagged macroeconomic variables and stock-specific factors in a recursive modeling framework. Their findings provide some evidence challenging the EMH.

Innovations in the treatment of cointegration within Vector Autoregressive (VAR) models by Engle and Granger (1987) and Johansen (1991) significantly advanced the methodological toolkit. These developments addressed the need to account for both short-term dynamics and long-term equilibrium relationships, leading to the introduction of Vector Error Correction Models (VECMs). VECMs allow for the simultaneous modeling of multidirectional linkages between macroeconomic variables and stock market returns, thereby providing a more comprehensive framework for analyzing the interactions identified in previous studies.

Mukherjee and Naka (1995) apply the VECM approach to demonstrate that the Japanese stock market is cointegrated with key domestic macroeconomic variables. Positive relationships were found between the stock market index and the exchange rate, industrial production, and money supply, while inflation had a negative impact. The role of interest rates is more complex, as short-term interest rates exhibit a positive relationship with stock returns, whereas long-term interest rates show a negative one. Furthermore, their findings highlight stock returns as a significant factor within a dynamic system, influencing both subsequent stock returns and macroeconomic variables.

This contrasts with Chen et al. (1986), who observed that lagged stock returns did not significantly affect expected stock returns. Cheung and Ng (1998) also find a cointegrated relationship for five developed countries between national stock market indices and consumption, output, money supply, and the oil price in real terms. Their findings reveal that oil prices have a negative relationship with stock prices, whereas consumption is linked positively. However, the effects of output and money supply remain inconclusive. This study contributes into the heterogeneous effects across different countries, although it does not account for potential interactions between these national markets.

Maysami and Koh (2000) demonstrate that the Singapore stock market is cointegrated not only with domestic macroeconomic variables but also with the U.S. and Japanese stock markets, suggesting significant international linkages. Similarly, Nasseh and Strauss (2000) find that stock prices, along with short-term interest rates, and industrial production in Germany, share a long-run relationship with the stock prices of five other European economies. However, the strength and direction of these relationships vary across countries. Humpe and Macmillan (2009) identify two conflicting long-term equilibrium relationships within the Japanese market. One cointegrating vector indicates that stock prices are positively influenced by industrial production, while the other reveals that industrial production is negatively affected by both the consumer price index and long-term interest rates. For the US, a single cointegrating vector exists among these variables, suggesting a more straightforward relationship. This discrepancy, potentially influenced by the fallout from Japan's asset price bubble in the 1990s, underscores the importance of heterogeneity in long-run relationships across countries.

Lee and Brahmasrene (2018) examine the Korean market and find that exogenous shocks do not lead to structural breaks in the long-term interactions between endogenous variables. Fromentin (2022) comes to a different conclusion for the US using a time-varying Granger causality approach. Especially after the Covid crisis, the macro-financial relationship broke down except for unemployment and money supply. The contribution makes an important point to the dynamic nature of macro-financial linkages, illustrating that these relationships can change not only in strength but also in direction over time, connecting to the findings of Humpe and Macmillan (2009) for Japan.

Yunus (2023) employs recursive cointegration to capture time-varying interactions. It is shown that convergence across stock markets and other asset classes of the US, other major economies, and macroeconomic fundamentals increased following the global financial crisis. This does not necessarily contradict findings of Fromentin (2022), as the period analyzed ends in 2019:Q2, excluding the Covid period. Together, these studies suggest that financial integration and macroeconomic linkages have strengthened over time, though shocks may at least temporarily disrupt these connections.

While most studies rely on aggregate indices as proxies for stock markets, a gap remains in understanding the relationships between sector-specific indices and macroeconomic variables. Addressing this, Maysami et al. (2005) explore long-run equilibrium linkages in Singapore across three sector indices -property, finance, and hotel- and key macroeconomic variables including the consumer price index, industrial production, short-term and long-term interest rates, money supply, and the exchange rate. Except for the aggregate index, only the property index was cointegrated with the other variables. No link was detected between the finance index, industrial production, and money supply. For the hotel index, both money supply and interest rates were not relevant.

Bhuiyan and Chowdhury (2020) extend the analysis to the US and Canadian markets, finding that most sector indices in the US are cointegrated with industrial production, money supply, and the long-term interest rate, but not in Canada. Interestingly, US macroeconomic variables affect Canadian stock market indices. Most sector indices had a positive relationship with money supply, a negative one for interest rates, though the effect of industrial production remains inconclusive. This ambiguity may stem from the US economy's shift toward a service-oriented structure, reducing the significance of industrial production as a key macroeconomic indicator (Bhuiyan and Chowdhury (2020)).

López et al. (2023) identify cointegration between US stock sector indices and various measures of uncertainty, such as volatility indices, 10-year treasury bond yields, crude oil prices, and the EUR/USD exchange rate. In the short-term, the findings reveal that sector returns are primarily driven by volatility shocks, with crude oil price shocks also playing a significant role, highlighting the critical impact of external shocks on sector performance.

2.2 Economic Intuition and Hypotheses

Kwon and Shin (1999) approach the selection of relevant macroeconomic variables as an empirical question, which may be due to the endogeneity inherent in these relationships. For instance, third-party macroeconomic variables can influence both stock prices and a given macroeconomic variable. Theoretically, most macroeconomic variables that affect stock prices are likely to interact with others, and economic intuition is often complex and counteracting in its effects. As a result, determining the relevant variables is frequently an empirical matter. Cheung and Ng (1998) argue that asset pricing theories lack a clear framework for explaining how macroeconomic factors influence stock prices, leading researchers to rely on existing literature.

Nonetheless, many studies base their empirical analyses on economic intuition. Chen et al. (1986) pioneered the approach of selecting relevant macroeconomic factors using "simple and intuitive financial theory," which is still widely adopted. This framework assumes that stock prices reflect the expected discounted dividends of firms, which are tied to expected cash flows. The discounted cash flow (DCF) model, shown below, encapsulates this idea:

$$DCF = \sum_{t=1}^{N} \frac{CF_t}{(1+r)^t} \tag{1}$$

where CF_t is the cashflow at time t and r is the discount rate. Thus, macroeconomic variables affecting future cash flows and the discount rate are deemed relevant. In the following, mechanisms and hypotheses are presented for a selective choice of macro variables emphasized in previous studies.

Chen et al. (1986) argue that inflation positively changes both nominal cash flows and the nominal risk-free rate. The primary effect operates through the nominal risk-free rate, as investors demand higher returns to offset inflation, driving up yields on risk-free assets. In response to rising inflation, central banks also tend to raise nominal interest rates, further elevating the risk-free rate. Mukherjee and Naka (1995), Maysami et al. (2005), and Humpe and Macmillan (2009) suggest that, although inflation may raise nominal cash flows, these increases are generally smaller than the rise in the nominal risk-free rate, resulting in a negative relationship between inflation and stock prices. This conclusion aligns with the findings of DeFina (1991).

The theoretical relationship between money supply and stock prices is ambiguous. Mukherjee and Naka (1995) and Maysami et al. (2005) identify two primary mechanisms: first, as money supply growth is often associated with rising inflation, it can increase the discount rate through the inflation channel previously described, leading to a negative relationship with stock prices. Second, money supply growth can stimulate economic activity, suggesting a positive relationship with stock prices. Ratanapakorn and Sharma (2007), Humpe and Macmillan (2009), and Bhuiyan and Chowdhury (2020) introduce a third mechanism based on portfolio theory, where increased liquidity encourages a shift from non-interest-bearing assets to financial assets, including equities. Because these theoretical mechanisms suggest both positive and negative effects, the overall relationship between money supply and equities remains an empirical question.

Interest rates, meanwhile, have a direct influence on the discount rate. Higher interest rates raise the discount rate, increasing the risk-free rate and reducing the present value of future cash flows, leading to a theoretical negative relationship with stock prices. Additional channels exist through changes in expected future cash flows due to the impact of interest rates on debt financing costs. Mukherjee and Naka (1995) further demonstrate that this relationship holds primarily for long-term interest rates in Japan, suggesting that long-term rates may serve as a better proxy for the discount rate than short-term rates.

3 Empirical Methodology

The empirical methodology follows established approaches in the literature (Mukherjee and Naka (1995), Cheung and Ng (1998), Kwon and Shin (1999), Nasseh and Strauss (2000), Lee and Brahmasrene (2018), Bhuiyan and Chowdhury (2020)). First, the stationarity of each time series is evaluated using unit root tests and determine the order of integration. Next, the appropriate lag lengths for the cointegration analysis are selected. Then, the Johansen cointegration test is applied to determine the number of cointegrated relationships and identify the cointegrating vectors. Following this, a Vector Error Correction Model (VECM) is estimated to account for both the cointegrating relationships and the short-term deviations from equilibrium. Finally, impulse response functions (IRFs) are computed to provide an additional perspective on the dynamics captured by the VECM.

3.1 Unit root tests

Unit root tests are a prerequisite to proceed with the multivariate Johansen cointegration test. Predominantly, time series with the same order of integration are tested in practice for cointegration, where the desired order of integration is $I(1)$. However, stationary variables can also be included in the process, which is further specified in section 3.3. A time series integrated of order zero ($I(0)$) is stationary in levels, whereas a time series integrated of order one ($I(1)$) is non-stationary in levels but becomes stationary after first differencing. To address this, stationarity is tested using the Augmented Dickey-Fuller (ADF) test for both levels and first differences. For robustness, the Phillips-Perron test serves as an alternative to the ADF test. The following equation represents the model used in the ADF test:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \sum_{i=1}^{p} \delta_i \Delta y_{t-i} + \varepsilon_t \tag{2}$$

Here, Δy_t represents the first difference of the variable y_t. The intercept is denoted by α, βt captures a deterministic time trend, and ε_t represents the error term. The coefficient γ is crucial for assessing stationarity, as it measures the influence of the lagged variable y_{t-1}. The term $\sum_{i=1}^{p} \delta_i \Delta y_{t-i}$ accounts for the lagged differences of y_t with p representing the lag length. The lag length p is determined prior to testing, using model selection criteria Akaike information criterion (AIC) and Bayesian information criterion (BIC). In the ADF test equationm an autoregressive model of order $p+1$ in levels corresponds to p lagged terms in first differences, as differencing reduces the number of included lags by one.

The null hypothesis of the ADF test, $H_0 : \gamma = 0$ indicates the presence of a unit root, implying non-stationarity. Conversely, the alternative hypothesis $H_1 : \gamma < 0$ indicates stationarity.

3.2 Johansen cointegration test

Cointegration occurs when a set of variables, integrated of the same order (e.g. $I(1)$) , forms a stationary linear combination ($I(0)$). This property indicates a long-run equilibrium relationship among the variables despite their individual non-stationarity. The inclusion of a stationary variable introduces an additional stationary relationship, thereby expanding the dimension of the cointegrating space. This extends the concept slightly, as stationary variables themselves can constitute cointegrating vectors. Hence, stationary variables can be included as well if considered economically meaningful (Johansen (1995)). The Johansen cointegration test is designed to detect the number of cointegrating relationships. To perform this test, it is necessary to reformulate the general form of the VAR(p) model in differences. Adopting the notation of Bhuiyan and Chowdhury (2020) based on Johansen (1995), the model is expressed as:

$$\Delta \mathbf{Y}_t = \nu + \Pi \mathbf{Y}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta \mathbf{Y}_{t-i} + \epsilon_t \tag{3}$$

Here, Y is the vector of variables of interest, ν is a vector of parameters, and ϵ is the vector of error terms. The matrix Π is decomposed as $\Pi = \alpha\beta'$, where α is the loading matrix containing the adjustment coefficients of the cointegrating relations, and β is the cointegration matrix containing the cointegrating vectors. The rank r of matrix Π indicates the cointegrating rank of the system (Kilian and Lütkepohl (2017)). Γ_i is a matrix of coefficients for the lagged differences of the variables of interest.

The specification of lag lengths is a critical step before conducting the Johansen cointegration test. A common challenge in the choice of lag lengths is the presence of autocorrelation in errors, which may invalidate model assumptions. To address this, diagnostic tests are applied to residuals so that errors can be considered white-noise. Specifically, the Lagrange Multiplier (LM) test is recommended for lower-order autocorrelation, while the portmanteau test is better suited for higher-order dependencies (Lütkepohl (2005)). In this analysis, the portmanteau type Ljung-Box Q test is implemented, checking up to 12 lags. Lag lengths are selected such that the corresponding p-values exceed 0.1.

The Johansen test uses two statistics to find the number of cointegrating relationships (r): the trace test and the maximum eigenvalue test. The trace test cumulatively tests for all cointegrating ranks greater than r. The null hypothesis $H_0 : \text{rank}(\Pi) = r$ is evaluated against the alternative hypothesis $H_1 : \text{rank}(\Pi) > r$. The maximum eigenvalue test sequentially tests for the next higher rank $r + 1$. The null hypothesis is $H_0 : \text{rank}(\Pi) = r$, and the alternative hypothesis $H_1 : \text{rank}(\Pi) = r + 1$.

3.3 Vector error correction model

When variables are non-stationary in levels but cointegrated, the unrestricted VAR model in levels is correctly specified and can be consistently estimated using OLS. However, it is often preferable to use a model that explicitly separates stable and unstable dynamics to avoid issues such as finite-sample biases. The Vector Error Correction Model (VECM) achieves this by reformulating the VAR in differences while incorporating an error correction mechanism that captures the cointegration relationships. This framework corrects short-term deviations from the long-term equilibrium. In this context, the VECM can be expressed as:

$$\begin{aligned} \Delta I_t = \nu + \sum_{i=1}^{p} \Gamma_{1i} \Delta I_{t-i} + \sum_{i=1}^{p} \Gamma_{2i} \Delta P_{t-i} + \sum_{i=1}^{p} \Gamma_{3i} \Delta MS_{t-i} \\ + \sum_{i=1}^{p} \Gamma_{4i} \Delta SIR_{t-i} + \sum_{i=1}^{p} \Gamma_{5i} \Delta LIR_{t-i} + \alpha\beta' Y_{t-1} + \varepsilon_t \end{aligned} \tag{4}$$

This setup builds on the general VECM representation from equation (3), here representing only the first equation of the full system. ΔI_t denotes the change in the respective index. Inflation is represented by P, money supply by MS, and the short-term and long-term interest rate by SIR and LIR. The intercept is denoted by ν and the error term by ε_t. The coefficient vector Γ captures the short-term dynamics of both the lagged dependent variable and the lagged explanatory variables.

The key addition in the VECM in comparison to a commmon VAR is the error correction term, denoted by $\beta' Y_{t-1}$, which captures the deviation from the cointegrating relationships in the previous period. The loading matrix α contains the adjustment coefficients, indicating the speed at which deviations from the cointegrating relationships are corrected. This is equivalent to the expression ΠY_{t-1} in equation (3), where $\Pi = \alpha\beta'$. As mentioned previously, the rank r of matrix Π determines the number of cointegrating relationships.

3.4 Impulse Response Functions

Impulse response functions (IRF) illustrate the impact of a unit shock to one of the model's variables on the entire system over time. While IRFs in this case do not add new information beyond what is already embedded in the VECM estimates, they provide a valuable graphical representation of the dynamic relationships between variables.

When implementing IRFs, a common challenge arises due to the correlation of shocks, which can make it difficult to isolate the individual effects of a particular shock. To address this, orthogonalization of shocks is applied to ensure that they become uncorrelated. A widely used method for orthogonalization is the Cholesky decomposition, which takes the form:

$$P^{-1}\Sigma P'^{-1} = I_m \quad \text{or} \quad \Sigma = PP' \tag{5}$$

Here, Σ is the covariance matrix of the residuals obtained from the VECM model, and P is a lower triangular matrix. The Cholesky decomposition (Lütkepohl (2005)) ensures that the off-diagonal elements in the resulting covariance matrix are zero, indicating that the shocks are orthogonal (uncorrelated). The resulting matrix is denoted by I_m, which is an identity matrix.

The recursive structure of the Cholesky decomposition requires an ordering of the variables, making the choice of ordering essential. Typically, the first variable in the ordering is treated as contemporaneously exogenous (Lee and Brahmasrene (2018)). Although economic reasoning can often guide the selection of an appropriate ordering, this can be challenging in practice. As an alternative, different combinations of orderings can be tested, with their results compared to assess robustness. Cheung and Ng (1998) provide evidence that similar outcomes can be obtained across different orderings.

4 Data

4.1 Variables and descriptive statistics

The dataset comprises monthly observations spanning the period from January 2002 to September 2024 with a total of 273 observations for both the United States (US) and the Eurozone (EZ). Equity data was sourced from Bloomberg, while macroeconomic data for the US was obtained from the Federal Reserve Economic Data (FRED) API. For the Eurozone, macroeconomic variables were retrieved from Eurostat database, with the exception of inflation and money supply data, which was obtained from the European Central Bank (ECB) Statistical Data Warehouse. Notably, all macroeconomic variables for the Eurozone exclusively refer to data from countries that were members of the Eurozone during the study period. The selection of time series was guided by the need to ensure comparability with prior studies and consistency between the two regions of interest.

An overview of all variables and their respective time series for both regions is provided in Table 1. For the United States (US), the S&P 500 is selected as the primary stock index. This index includes the 500 largest publicly traded US companies by market capitalization, representing a significant portion of the country's total market capitalization. For the Eurozone (EZ), the MSCI EMU[1] Index is used as the main index. According to MSCI Inc. (2024), this index captures approximately 85% of the total EMU market capitalization and includes 222 companies across 10 developed EMU markets, all of which are part of the Eurozone. While alternatives such as the EURO STOXX 50 or the STOXX Europe 600 were considered, they were deemed less suitable. The EURO STOXX 50 is limited to only 50 companies, whereas the STOXX Europe 600 includes non-Eurozone countries, such as the United Kingdom and Switzerland, making it incompatible with Eurozone macroeconomic variables.

[1] European Economic and Monetary Union

Sector indices are derived from the respective aggregate indices (AG) and are classified according to the Global Industry Classification Standard (GICS), which is widely adopted in the investment industry. Uncapped indices are employed, with classifications made at the sector level according to GICS Level 1. A total of 11 sectors are included: Energy (EN), Materials (MA), Industrials (ID), Consumer Discretionary (CD), Consumer Staples (CS), Health Care (HC), Financials (FN), Information Technology (IT), Communication Services (CM), Utilities (UT), and Real Estate (RE) (MSCI Inc. (2023)).

Table 1: Choice of equity and macroeconomic variables by region.

	US	**Eurozone**
Equity variables		
Aggregate Index	S&P 500 Index	MSCI EMU Index
Sector Indices	S&P 500 Sector Indices (GICS 1)	MSCI EMU Sector Indices (GICS 1)
Macroeconomic Variables		
Inflation	HICP index (all items)	HICP index (all items)
Money Supply	M2 Money Stock	M2 Money Stock
Short-Term Interest Rate	3-Month T-Bill Rate	3-Month EURIBOR
Long-Term Interest Rate	10-Year Government Bond Yield	10-Year Government Bond Yield

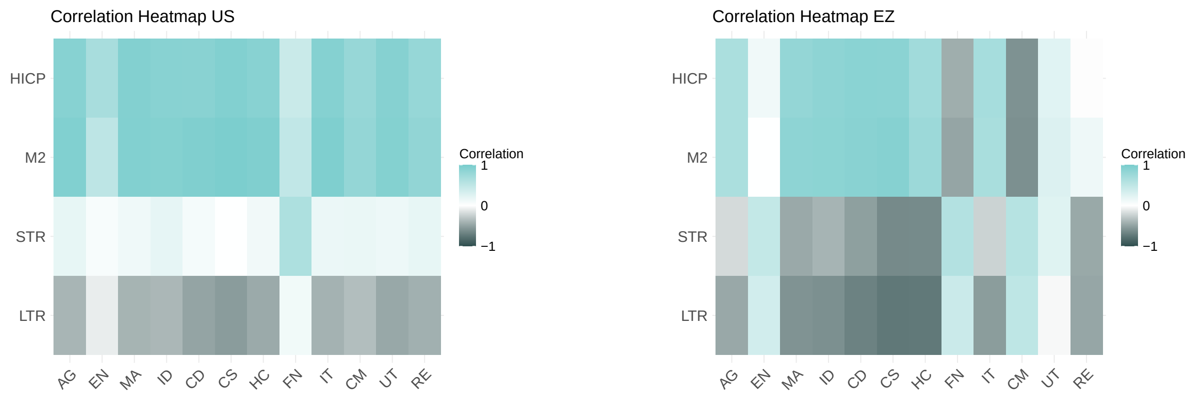
Inflation is measured using the Harmonized Index of Consumer Prices (HICP), which includes all items and serves as the standard inflation metric for the Eurozone (EZ). Although the Consumer Price Index (CPI) is the standard measure for the US, HICP is used here for consistency with the Eurozone. The M2 series is employed for both regions to represent money supply. While M1 might typically align with earlier studies, the US Federal Reserve's 2020 redefinition of M1 to include certain savings deposits previously classified under M2 necessitates the use of M2 to maintain comparability with the Eurozone. The short-term interest rate (STR) is represented by the 3-Month Treasury Bill Secondary Market Rate for the US and the 3-Month Euro Interbank Offered Rate (EURIBOR) for the Eurozone. Long-term interest rates (LTR) are represented by 10-year government bond yields for both regions. For the Eurozone, the measure used is the 10-year EMU convergence criterion bond yield, which averages the bond yields of member states. This proxy is necessary because the Eurozone does not issue bonds collectively.

Humpe and Macmillan (2009) and Bhuiyan and Chowdhury (2020) utilize seasonally adjusted data to address strong seasonality in their time series. In contrast, this study employs non-adjusted time series, incorporating seasonal dummies within the Johansen procedure to account for seasonality. While this approach may influence descriptive statistics in certain cases, it ensures that seasonal patterns are explicitly modeled.

A comparison of descriptive statistics for all variables between the US and the Eurozone is provided in Appendix A (Table A.1). All time series in levels are transformed into their natural logarithmic form. While most variables do not include values $\leqslant 0$, the short-term and long-term interest rates for the Eurozone were temporarily negative. Since the natural logarithm is undefined for values $\leqslant 0$, these time series were adjusted in levels by using $log(1 + r)$. This transformation is applied for both the US and the Eurozone for consistency.

Correlation heatmaps for the US and Eurozone (EZ), illustrating the relationships between equity variables and macroeconomic variables, are shown in Figure 1. US macroeconomic data is paired exclusively with US equity data, and the same applies to the Eurozone. When compared to the economic hypotheses outlined in subsection 2.2, the expected signs are largely confirmed, keeping in mind the preliminary nature of this descriptive analysis. However, it is important to note that the use of non-seasonally adjusted variables may influence some of these relationships.

Figure 1: Comparison of correlation heatmaps between US and EZ.



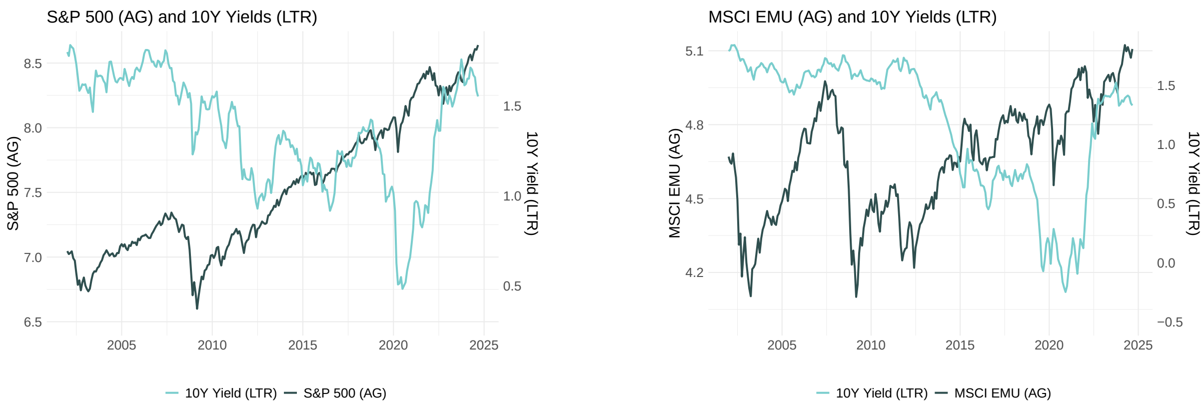
For the US, the relationships appear straightforward: inflation (HICP), and money supply (M2) exhibit strong positive correlations with equities, while the long-term interest rate (LTR) shows a strong negative correlation. The short-term interest rate has zero to slightly positive correlation with most sectors, whereas the Financials (FN) sector index is the only one to have a strong positive relationship.

In contrast, the relationships in the Eurozone are less clear. Most equity indices exhibit a strong negative correlation with STR, whereas STR is either weakly positively correlated or uncorrelated with equities in the US. Further divergences include instances where Eurozone indices display correlations with macroeconomic variables that have opposite signs compared to the US. This is particularly evident in the Financials (FN) and Communication Services (CM) sectors, which are negatively correlated with HICP and M2, but positively correlated with both STR and LTR. Additionally, Utilities (UT) are uncorrelated with the long-term interest rate (LTR) and Real Estate (RE) is uncorrelated with inflation (HICP).

While correlation between variables cannot capture the full picture, it can sometimes even be misleading. This is particularly evident when examining the relationship between the aggregate index (AG) and the 10-Year Government Bond Yield (LTR) in Figure 2 for both the US and the Eurozone. Over the full time frame, a strong negative relationship emerges, consistent with economic theory on the inverse relationship between equities and long-term interest rates.

However, this relationship turns positive after 2020, suggesting a shift in dynamics. Notably, the period from 2021 coincided with rising inflation, central bank tightening, and shifting market expectations regarding economic growth, all of which may have contributed to this changing dynamic. This shift will be examined in greater detail in subsection 5.2 and subsequent sections.

Figure 2: Aggregate Equity Index (AG) and 10Y Bond Yield (LTR) for the US and EZ.



4.2 Unit root tests

Unit root tests are applied to the variables in their natural logarithmic form, both in levels and first differences, to determine their order of integration. The Augmented Dickey-Fuller (ADF) serves as the primary method, with the Phillips-Perron (PP) test included for robustness. The tests are conducted under the null including a constant and a deterministic time trend, with the lag length selected using the Akaike Information Criterion (AIC) prior to testing. A variable is considered stationary if both tests reject the null hypothesis of a unit root at the 5% significance level.

The test statistics and corresponding significance levels of the ADF test are presented in Table 2 for both the US and the Eurozone (EZ). The PP test statistics are provided in Appendix A (Table A.2). Based on these results, the tests reject the presence of a unit root in levels only for the following variables: the Materials (MA) sector index for the US, and the Consumer Discretionary (CD) sector index for the Eurozone. Therefore, there is evidence for these variables being stationary in levels and the order of integration is $I(0)$.

For all remaining variables across both regions, the tests reject the null hypothesis of a unit root at the 1% significance level only in differences. Thus, the order of integration for these variables is $I(1)$. While Bhuiyan and Chowdhury (2020) exclude $I(0)$ variables in levels from further analysis, they can still be incorporated into the Johansen procedure. Consequently, only two variable sets contain both $I(0)$ and $I(1)$ variables: the set containing the US Materials sector index (MA) and the set containing the Eurozone Consumer Discretionary sector index (CD). As already discussed in Section 3.3, including stationary variables in the system increases the dimension of the cointegrating space.

Table 2: Comparison of ADF test statistics between US and EZ.

(a) Test statistics for the US.

	Level	**Diff.**
Index		
AG	-2.273	-12.410***
EN	-2.228	-12.365***
MA	-3.495**	-11.851***
ID	-2.763	-12.491***
CD	-2.538	-12.480***
CS	-3.369*	-13.650***
HC	-2.672	-12.942***
FN	-1.541	-11.942***
IT	-2.443	-12.042***
CM	-3.089	-11.769***
UT	-3.127	-13.263***
RE	-2.785	-13.533***
Macroeconomic variables		
HICP	-2.168	-10.213***
M2	-1.913	-10.386***
STR	-1.187	-8.350***
LTR	-2.215	-10.685***

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

(b) Test statistics for the EZ.

	Level	**Diff.**
Index		
AG	-2.749	-11.689***
EN	-2.833	-12.467***
MA	-3.309*	-11.514***
ID	-2.901	-12.054***
CD	-3.514**	-11.494***
CS	-2.939	-11.731***
HC	-2.460	-11.024***
FN	-2.225	-12.023***
IT	-2.851	-12.332***
CM	-2.624	-12.992***
UT	-1.597	-12.784***
RE	-1.764	-11.197***
Macroeconomic variables		
HICP	-0.889	-12.194***
M2	-1.362	-12.367***
STR	-1.360	-5.488***
LTR	-1.410	-11.099***

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

5 Results

5.1 Johansen cointegration test

Each dataset used in the Johansen procedure initially comprises 12 variable sets for both the US and the Eurozone (EZ), with each set consisting of five variables. Specifically, these are five-dimensional models that include four macroeconomic variables alongside one sector-specific equity index. Before conducting the cointegration test, optimal lag lengths were determined. If residual autocorrelation was detected, lag lengths were iteratively increased until no significant autocorrelation was observed at the 10% significance level.

Testing up to 12 lags, the final maximum lag length for the US variable sets was determined to be 8. For the Eurozone, higher lag lengths were required, with 7 out of 12 variable sets requiring 9 lags. This is still reasonable given the sample size and data frequency. However, residual autocorrelation could not be eliminated for the variable set containing the Healthcare sector index (HC) in the Eurozone, leading to its exclusion from further analysis. To maintain a parsimonious representation, all Eurozone variable sets requiring more than 9 lags were also excluded. These included the Consumer Staples (CS), Information Technology (IT), Communication Services (CM), and Utilities (UT) variable sets. A similar decision was made for the US Energy (EN) variable set, which was also excluded. Further details on the lag lengths used in the Johansen procedure and the p-values from the Ljung-Box Q test are provided in Appendix B, in Table B.1 and Table B.2 for the US and Eurozone datasets.

Following the framework described in section 3.2, the Johansen cointegration test is applied to each model to determine the number of cointegrating vectors. The setup includes a constant but no linear trend in cointegration. Seasonal dummies are incorporated to address seasonality in the data, and an additional dummy variable for 2020 is introduced to account for the Covid-19 outlier, which significantly impacted equities and macroeconomic variables.

The test results are presented in Table 3 for the US and Table 4 for the Eurozone. Both the trace and maximum eigenvalue test statistics are reported for each variable set. It is common in practice for these tests to suggest differing numbers of cointegrating relationships. Lütkepohl et al. (2001) argue that while such differences may arise in small samples, the statistical power of both tests is comparable, rendering the choice somewhat arbitrary. Following Ratanapakorn and Sharma (2007), who regard the trace statistic as more robust in certain settings, this study also relies on the trace test statistic. Accordingly, the number of cointegrating relationships is determined at the 5% significance level.

The test results indicate the presence of two cointegrating vectors in all US variable sets, except for the set containing the Communication Services (CM) sector, which shows evidence of only one cointegrating vector. This conclusion is based on the rejection of the null hypothesis of $r \leqslant 0$ for CM and $r \leqslant 1$ for the remaining US variable sets at the 5% significance level. In contrast, the Eurozone variable sets generally exhibit three cointegrating vectors, with the null hypothesis of $r \leqslant 2$ being rejected. An exception is the Materials (MA) variable set, where only two cointegrating vectors are identified. These findings provide strong evidence of one to three long-term equilibrium relationships between sectoral equity indices and macroeconomic variables in all variable sets.

Table 3: Cointegration test statistics for US variable sets.

	test	$r = 0$	$r \leqslant 1$	$r \leqslant 2$	$r \leqslant 3$	$r \leqslant 4$
AG	trace	132.63***	54.76**	28.71	13.10	4.57
	max	77.87***	26.05*	15.60	8.54	4.57
MA	trace	122.83***	62.60***	31.09	15.79	5.54
	max	60.23***	31.51**	15.30	10.25	5.54
ID	trace	118.50***	60.29***	28.34	12.43	4.51
	max	58.20***	31.96**	15.91	7.92	4.51
CD	trace	132.41***	55.29**	27.91	12.86	4.66
	max	77.11***	27.38*	15.05	8.20	4.66
CS	trace	133.23***	59.55**	29.69	13.49	4.77
	max	73.68***	29.86**	16.20	8.72	4.77
HC	trace	128.94***	56.88**	31.85	15.50	5.44
	max	72.07***	25.02	16.35	10.06	5.44
FN	trace	127.6***	63.29***	32.22*	17.43	4.70
	max	64.31***	31.07**	14.79	12.73	4.70
IT	trace	138.45***	60.22***	33.19*	16.62	4.55
	max	78.24***	27.03*	16.57	12.07	4.55
CM	trace	110.23***	50.73*	31.06	17.63	5.49
	max	59.5***	19.67	13.43	12.14	5.49
UT	trace	125.12***	53.90**	26.50	10.70	4.31
	max	71.21***	27.40*	15.81	6.39	4.31
RE	trace	132.20***	56.61**	27.21	12.25	4.56
	max	75.60***	29.40**	14.95	7.69	4.56

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 4: Cointegration test statistics for EZ variable sets.

	test	$r = 0$	$r \leqslant 1$	$r \leqslant 2$	$r \leqslant 3$	$r \leqslant 4$
AG	trace	147.70***	86.14***	41.68***	17.56	4.22
	max	61.56***	44.45***	24.12**	13.34	4.22
EN	trace	138.36***	77.37***	37.66**	13.27	5.07
	max	60.99***	39.71***	24.39**	8.20	5.07
MA	trace	148.12***	74.95***	33.43*	13.47	4.27
	max	73.17***	41.52***	19.96*	9.20	4.27
ID	trace	143.93***	83.45***	39.88**	16.93	4.05
	max	60.48***	43.57***	22.95**	12.88	4.05
CD	trace	146.20***	81.96***	40.62**	16.96	4.59
	max	64.24***	41.34***	23.66**	12.37	4.59
FN	trace	140.91***	86.49***	43.59***	18.11*	3.56
	max	54.41***	42.90***	25.48**	14.55*	3.56
RE	trace	144.56***	76.26***	36.78**	14	3.11
	max	68.31***	39.47***	22.79**	10.89	3.11

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5.2 Cointegrating vectors

Cointegrating vectors are ordered by the magnitude of their associated eigenvalues for representation purposes. For the United States, the vectors are presented in Table 5 through Table 6, and for the Eurozone in Table 7 through Table 9. The cointegrating vectors were normalized relative to the equity indices, assigning a unit coefficient to these indices, which is therefore omitted from the tables. To interpret macroeconomic variables relative to equity indices, the signs of normalized coefficients in the cointegrating vectors must be reversed, as recommended by various studies including Mukherjee and Naka (1995), Nasseh and Strauss (2000), Maysami et al. (2005), Ratanapakorn and Sharma (2007), Humpe and Macmillan (2009), and Bhuiyan and Chowdhury (2020). Since the time series are expressed in natural logarithms, these coefficients represent long-run elasticities. The sign reversal is simply a rearrangement and does not alter the underlying long-run dynamics.

Interpreting multiple cointegrating vectors can be challenging. Consequently, some practitioners adopt the approach of focusing on the vectors associated with the largest eigenvalues (Mukherjee and Naka, 1995), particularly when the remaining vectors exhibit similar patterns. In this analysis, however, relying solely on the vector with the highest eigenvalue would be inappropriate, as vectors capture distinct long-run relationships. The full relationship is correctly specified only when all relevant long-run relationships are included.

Examining the first US cointegrating vectors in Table 5 reveals that the implied long-run relationships relative to most equity indices are positive across all macroeconomic variables, including inflation (HICP), money supply (M2), short-term interest rates (STR), and long-term interest rates (LTR). However, there are exceptions, such as negative relationships between HICP and LTR with the Consumer Staples (CS) and Healthcare (HC) sectors. The pattern shifts in the second cointegrating vector, shown in Table 6, particularly for HICP and LTR, where relationships with equity indices become predominantly negative. In contrast, the signs for money supply (M2) and the short-term interest rate (STR) remain largely unchanged.

The overall pattern for the Eurozone cointegrating vectors is clearer than that of the US. This observation has to be treated with caution since only seven variable sets compared to eleven for the US are involved. The results indicate mostly negative relationships with equity indices for inflation (HICP), positive relationships for money supply (M2) and the short-term interest rate (STR), and negative relationships for the long-term interest rate (LTR). However, there are deviations, including positive relationships for HICP and positive ones for LTR, similar to the observations in the first US cointegrating vector. This is particularly evident for Industrials (ID) in Table 7 and Financials (FN) in Table 8.

Comparing the results with the economic hypotheses based on the Discounted Cash Flow (DCF) model outlined in section subsection 2.2 proves challenging. The findings for some variables are contradictory, suggesting that multiple mechanisms may be at play. In the US, both positive and negative relationships with inflation are observed, which is also evident in the Eurozone, even though to a lesser degree. A positive relationship may suggest that the increase in nominal cash flows driven by inflation exceeds the impact of a higher nominal risk-free rate, while a negative relationship implies the reverse.

The relationship of equity indices with money supply is generally positive across most variable sets in both regions. It can be inferred that the effect of increased money supply stimulating economic activity and liquidity, which encourages a shift toward equities, outweighs the opposing effect, where higher money supply leads to inflation and reduces the present value of cash flows through an increase in the nominal risk-free rate.

The relationship with short-term interest rates is predominantly positive across most variable sets in both the US and Eurozone. Assuming that the short-term interest rate serves as a proxy for the nominal risk-free rate, this finding appears contradictory. Mukherjee and Naka (1995) also report a positive relationship for Japanese data and suggest that the short-term interest rate may not be a reliable proxy, as this role is fulfilled by the long-term interest rate. This explanation could also apply here, making the relationship with short-term interest rates an empirical question.

For the long-term interest rate, both positive and negative relationships are observed across US variable sets, which is also evident to a lesser degree in the Eurozone. According to theory, a negative relationship is expected, given the inverse relationship between the present value of cash flows and the risk-free interest rate. Therefore, the result in the first U.S. cointegrating vector contradicts this theoretical hypothesis.

However, the shift in the first US cointegrating vector may align with more recent developments, particularly after 2020, driven by rising inflation and the subsequent monetary tightening by central banks. One possible explanation for the positive relationship is that markets anticipate a decline in inflation and expect interest rate cuts. While such expectations typically reduce bond yields, strong economic growth prospects may counteract this effect by increasing demand for risk assets. If investors foresee economic expansion, they may shift capital from bonds to equities, reducing bond demand, exerting upward pressure on yields, and reinforcing this dynamic.

The results from related literature are predominantly based on aggregate equity indices rather than sector indices. Given that most sectors exhibit similar long-run relationships in this analysis, such comparisons appear reasonable. Mukherjee and Naka (1995), in their study of Japanese equities, find a negative relationship with inflation, a positive one with money supply and short-term interest rates, and a negative one with long-term interest rates. These findings align with the second U.S. cointegrating vector and most Eurozone cointegrating vectors.

Table 5: Cointegrating vectors for US variable sets (highest eigenvalue).

	HICP	M2	STR	LTR	constant
AG	-2.12	-0.66	-0.18	-0.64	10.04
MA	-3.07	-0.09	-0.10	-0.31	10.32
ID	-1.71	-0.72	-0.21	-0.46	9.91
CD	-2.74	-0.80	-0.26	-0.62	16.00
CS	6.87	-2.93	-0.12	1.39	-13.33
HC	17.45	-6.50	-0.24	2.45	-31.95
FN	1.67	-1.25	-0.40	-0.73	-0.06
IT	-1.37	-1.73	-0.15	-1.00	18.14
CM	-2.62	0.11	-0.07	-0.46	7.19
UT	-7.12	1.46	-0.20	-0.34	15.42
RE	-6.65	1.50	-0.37	0.11	12.61

Table 6: Cointegrating vectors for US variable sets (second highest eigenvalue).

	HICP	M2	STR	LTR	constant
AG	1.94	-1.70	-0.35	0.69	-1.36
MA	-1.07	-0.22	-0.32	1.15	-0.09
ID	0.83	-0.95	-0.47	1.34	-2.58
CD	2.85	-2.08	-0.49	1.38	-1.48
CS	0.44	-1.04	-0.20	0.65	0.91
HC	3.57	-2.47	-0.29	0.54	-0.36
FN	4.61	-1.41	-0.78	1.69	-15.74
IT	3.44	-3.23	-0.21	-0.08	8.00
CM	-	-	-	-	-
UT	-1.10	-0.07	-0.39	1.28	-1.09
RE	-0.73	0.22	-0.66	2.22	-6.36

Table 7: Cointegrating vectors for EZ variable sets (highest eigenvalue).

	HICP	M2	STR	LTR	constant
AG	-0.30	-0.67	-0.11	0.05	7.62
EN	0.98	-1.11	0.09	-0.59	9.14
MA	1.45	-2.06	0.23	-0.64	22.10
ID	-1.11	-1.02	-0.00	-0.09	16.51
CD	-5.29	0.64	0.08	0.21	9.18
FN	2.81	-1.20	-0.36	0.04	2.38
RE	5.02	-2.96	0.58	-1.15	21.06

Table 8: Cointegrating vectors for EZ variable sets (second highest eigenvalue).

	HICP	M2	STR	LTR	constant
AG	0.81	-0.11	-0.92	1.34	-8.90
EN	4.28	-1.93	-0.41	-0.03	5.91
MA	3.49	-2.45	-0.22	-0.19	17.83
ID	-0.82	-0.54	-0.53	0.70	5.70
CD	-3.08	0.28	-0.36	0.71	3.34
FN	-1.84	-2.54	2.16	-4.15	52.39
RE	5.15	-2.05	0.13	-0.46	3.85

Table 9: Cointegrating vectors for EZ variable sets (third highest eigenvalue).

	HICP	M2	STR	LTR	constant
AG	7.37	-2.16	-1.20	2.09	-5.80
EN	11.82	-3.68	-1.18	1.75	-1.83
MA	-	-	-	-	-
ID	7.34	-2.62	-1.32	2.29	0.82
CD	-0.73	0.15	-0.81	1.90	-5.80
FN	21.51	-6.19	-2.08	3.05	-5.93
RE	32.22	-11.75	-1.73	1.98	33.73

Similarly, Nasseh and Strauss (2000) report a positive relationship between European equities and both inflation and short-term interest rates, while finding a negative relationship with long-term interest rates. This aligns with most Eurozone cointegrating vectors for interest rates but deviates in the case of inflation. Ratanapakorn and Sharma (2007) identify a positive relationship between US equities and both inflation and money supply, consistent with the first US cointegrating vector and certain variable sets in the first and second Eurozone cointegrating vectors. Additionally, they report a positive relationship with short-term interest rates and a negative one with long-term interest rates.

Bhuiyan and Chowdhury (2020) examine long-run relationships between nine U.S. sector indices and macroeconomic variables, including money supply and long-term interest rates. They find that the relationship between money supply and equity indices is predominantly positive, with exceptions for the Energy (EN) and Financials (FN) sectors. For long-term interest rates, the relationship is largely negative, except for the Energy (EN) and Materials (MA) sectors. Similar patterns are observed for EN and MA across all Eurozone cointegrating vectors.

Overall, the findings in long-run relationships align broadly with both theory and related literature. However, the results for inflation and long-term interest rates in the first US cointegrating vector, as well as certain Eurozone vectors, exhibit contradictions. This discrepancy may stem from structural shifts following 2020, initially driven by rising inflation and quantitative tightening, followed by market expectations of interest rate cuts and economic expansion. The two distinct long-term equilibria observed for inflation and long-term interest rates appear to correspond to pre-2020 and post-2020 periods, with this divergence being more pronounced in the US than in the Eurozone.

5.3 Vector error correction model

VECM estimates for all equity indices are represented from Table 10 to Table 11 for the US and in Table 12 for the Eurozone. US models were split in two tables, with Table 10 reaching from the S&P500 (AG) index to the Healthcare (HC) index, and Table 10 from Financials (FN) to Real Estate (RE) index. Due to the dimension of the models, the full VECMs including equations for the macroeconomic variables are not shown in detail here. However, these models were analyzed and feedback effects from equity indices to macroeconomic variables were looked into. A year dummy for 2020 and seasonal dummies were included in the estimation, but are not displayed in the tables.

Looking at US error correction terms, it can be observed that they are significant at least at the 5% significance level for almost all indices, which aligns well with the cointegrating rank found in subsection 5.1. The second error correction term is insignificant for Industrials (ID), Utilities (UT) and Real Estate (RE). The only US sector with both error correction terms being insignificant is Communications (CM), which indicates it does not respond at all to disequilibria from the the long-term equilibrium. Also the second error correction term is positive and significant for Materials (MA), indicating a movement in the same direction as the short-term disequilibrium which could potentially result from MA being I(0).

In terms of the magnitude, it can be observed that deviations from the first long-term equilibrium for the S&P500 (AG) index are corrected by 6.9%, and for the second long-term equilibrium by 13.8% per month on average. The impact is strongest for Financials (FN), and Information technology (IT), where the correction is even 32.1% and 33.7% on a monthly basis respectively.

Eurozone error correction terms for the first cointegrating relationship are all negative and significant, except for Real Estate (RE). Magnitudes are relatively strong, for instance with a correction to the long-term equilibrium of 13.7% for the MSCI EMU (AG) index. However, second and third error correction terms are less meaningful, because they are either insignificant or significant and positive. While this could be potentially explained again with mixing I(0) and I(1) variables in the Consumer Discretionary (CD) variable set, this does not hold for others. Real Estate (RE) has no significant error correction term, i.e. not responding at all relative to the long-term equilibrium.

The presence of insignificant error-correction terms does not fully align with the cointegrating rank indicated in subsection 5.1 for some Eurozone (EZ) variable sets. From a practical standpoint, however, this discrepancy is less problematic because the cointegrating vectors for the Eurozone are similar in their underlying economic relationships.

An interesting aspect is also the long-run interaction, which is observed in the significance of the error correction terms of the macroeconomic variable equations from the VECM. Inflation adjusts not at all to the long-run equilibrium, as error correction terms are insignificant in most variable sets. It can be inferred that inflation is weakly exogenous in the Johansen sense regarding cointegrating relationships. In turn, money supply is adjusting to the equilibrium in most variable sets, even though with very low magnitude. The error correction terms for the short-term interest rate equation are significant for the Eurozone, but not for the US. However, it moves in the same direction as the disequilibrium in the Eurozone. The long-term interest rate is strongly adjusting to the long-term equilibrium in the US. This also holds for the Eurozone, but not for all cointegrating relationships.

While US short-term estimates for lags of inflation are positive and significant for some equity indices, this is mostly not the case for the Eurozone. There is also no significant feedback from equities to inflation for most sectors. In the US, short-run lagged differences of inflation have a significant predictive impact on current changes in most equities, at the first lag. Exceptions are Consumer Discretionary (CD), Communications (CM), and Utilities (UT). The short-term impact of lagged differences in money supply is insignificant for the US, but significant and positive for Eurozone equities at the seventh lag. However, there is negative feedback in the money supply equation from equities at the same lag.

The short term relationship for the short-term interest rate is endogenous for almost all variable sets across both regions. Some lags of the long-term interest rate have a significant negative predictive impact on Consumer Staples (CS), Healthcare (HC), and Utilities (UT) in the US, and in the Eurozone for the MSCI EMU (AG), Industrials (ID), Consumer Discretionary (CD), and Real Estate (RE). There is no short-term feedback in the long-term interest rate equation except for RE in the US.

Overall, the VECM results indicate that most equity indices exhibit significant long-run equilibrium relationships, with broadly similar error correction dynamics in the US and Eurozone (EZ), though sector-specific deviations persist. Notably, US Real Estate (RE) and Eurozone Communications (CM) show no significant adjustment to disequilibria. Inflation appears weakly exogenous in both regions, showing no meaningful long-term adjustment, while money supply reverts to equilibrium only gradually. The short-term interest rate's long-term behavior remains inconclusive, whereas the long-term interest rate strongly adjusts in both regions, although to a lesser extent in the Eurozone.

In the short run, inflation significantly impacts US equities but plays a more muted role in the Eurozone, with no feedback from equities to inflation. Money supply and the short-term interest rate exhibit endogeneity in short-run dynamics, while long-term interest rates negatively influence some sectors in both regions. These findings highlight the dynamic interaction between equities and macroeconomic variables, with distinct patterns emerging across sectors and regions in both the short- and long-run.

Table 10: VECM estimates for US indices and macro variables (A)

	AG	MA	ID	CD	CS	HC
ect1	-0.069*** (0.019)	-0.101*** (0.024)	-0.067*** (0.019)	-0.052*** (0.016)	-0.052*** (0.018)	-0.046*** (0.015)
ect2	-0.138*** (0.037)	0.178*** (0.047)	-0.023 (0.022)	-0.149*** (0.046)	-0.051** (0.021)	-0.185*** (0.059)
I.dl1	-0.07 (0.066)	-0.075 (0.068)	-0.049 (0.067)	-0.045 (0.065)	-0.1 (0.065)	-0.068 (0.065)
I.dl2	-0.076 (0.065)	-0.072 (0.068)	-0.112* (0.066)	-0.045 (0.065)	-0.13** (0.064)	-0.06 (0.064)
I.dl3		0.06 (0.068)	0.031 (0.066)			
I.dl4						
HICP.dl1	2.012** (0.802)	2.977*** (1.067)	1.863* (0.986)	0.851 (0.986)	1.292** (0.612)	1.998*** (0.721)
HICP.dl2	-0.806 (0.797)	-1.918* (1.143)	-2.011* (1.081)	-0.825 (0.973)	-0.178 (0.602)	-0.831 (0.708)
HICP.dl3		1.753* (1.056)	1.43 (0.973)			
HICP.dl4						
M2.dl1	0.655 (0.706)	1.759* (0.902)	0.039 (0.867)	1.104 (0.874)	-0.039 (0.536)	0.774 (0.619)
M2.dl2	-0.495 (0.637)	-0.909 (0.988)	0.378 (0.939)	-0.636 (0.792)	-0.355 (0.486)	-0.7 (0.566)
M2.dl3		1.367 (0.831)	0.768 (0.791)			
M2.dl4						
STR.dl1	0.194*** (0.048)	0.297*** (0.061)	0.236*** (0.059)	0.259*** (0.06)	0.095** (0.037)	0.14*** (0.043)
STR.dl2	-0.131** (0.051)	-0.195*** (0.068)	-0.194*** (0.065)	-0.126* (0.064)	-0.071* (0.039)	-0.12*** (0.046)
STR.dl3		0.115* (0.065)	0.153** (0.063)			
STR.dl4						
LTR.dl1	-0.08 (0.058)	-0.053 (0.074)	-0.057 (0.072)	-0.127* (0.073)	-0.132*** (0.044)	-0.139*** (0.051)
LTR.dl2	0.002 (0.057)	0 (0.076)	0.046 (0.072)	-0.016 (0.072)	0.009 (0.044)	0.009 (0.052)
LTR.dl3		-0.106 (0.075)	-0.053 (0.072)			
LTR.dl4						

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. A year dummy for 2020 and seasonal dummies were included when estimating the model, but are not displayed here.

Table 11: VECM estimates for US indices and macro variables (B)

	FN	IT	CM	UT	RE
ect1	-0.093*** (0.018)	-0.102*** (0.023)	-0.016 (0.014)	-0.042** (0.018)	-0.048*** (0.017)
ect2	-0.321*** (0.066)	-0.337*** (0.077)		0.044 (0.035)	0.043 (0.046)
I.dl1	-0.036 (0.065)	-0.079 (0.065)	-0.031 (0.065)	-0.123* (0.066)	-0.05 (0.064)
I.dl2	-0.137** (0.064)	-0.06 (0.065)	0.038 (0.064)	-0.095 (0.066)	-0.147** (0.062)
I.dl3	0.099 (0.065)		0.074 (0.065)		
I.dl4			-0.058 (0.064)		
HICP.dl1	3.532*** (1.163)	2.442** (1.066)	1.417 (1.043)	1.264 (0.789)	4.197*** (1.22)
HICP.dl2	-4.083*** (1.276)	-0.216 (1.058)	-1.104 (1.142)	-0.721 (0.777)	-1.669 (1.211)
HICP.dl3	3.396*** (1.16)		1.936* (1.152)		
HICP.dl4			-2.216** (1.034)		
M2.dl1	1.761* (1.035)	0.962 (0.935)	0.203 (0.913)	-0.627 (0.684)	1.165 (1.056)
M2.dl2	-0.794 (1.121)	-0.055 (0.841)	0.986 (0.996)	0.785 (0.625)	-1.711* (0.962)
M2.dl3	1.596* (0.946)		0.569 (0.985)		
M2.dl4			0.093 (0.822)		
STR.dl1	0.284*** (0.07)	0.166*** (0.064)	0.166*** (0.062)	0.229*** (0.047)	0.381*** (0.074)
STR.dl2	-0.152* (0.077)	-0.139** (0.067)	-0.178*** (0.069)	-0.073 (0.051)	-0.172** (0.079)
STR.dl3	0.224*** (0.074)		0.064 (0.068)		
STR.dl4			0.106 (0.065)		
LTR.dl1	-0.016 (0.085)	-0.033 (0.075)	-0.152** (0.072)	-0.252*** (0.057)	-0.422*** (0.089)
LTR.dl2	0.077 (0.086)	-0.062 (0.075)	-0.013 (0.075)	0.066 (0.059)	0.079 (0.091)
LTR.dl3	-0.058 (0.086)		-0.004 (0.075)		
LTR.dl4			-0.045 (0.073)		

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. A year dummy for 2020 and seasonal dummies were included when estimating the model, but are not displayed here.

Table 12: VECM estimates for EZ indices and macro variables

	AG	EN	MA	ID	CD	FN	RE
ect1	-0.137*** (0.034)	-0.1*** (0.038)	-0.131*** (0.032)	-0.131*** (0.034)	-0.202*** (0.038)	-0.098*** (0.031)	-0.032 (0.02)
ect2	0.025 (0.064)	-0.158 (0.119)	-0.247*** (0.058)	0.128* (0.076)	0.939*** (0.181)	-0.205 (0.175)	-0.069 (0.197)
ect3	0.084*** (0.028)	0.126** (0.055)		0.121*** (0.04)	-0.111*** (0.022)	0.098* (0.058)	0.045 (0.082)
I.dl1	-0.003 (0.069)	-0.154** (0.07)	0.042 (0.068)	0.009 (0.069)	-0.135* (0.069)	-0.004 (0.069)	0.141** (0.069)
I.dl2	-0.098 (0.067)	-0.088 (0.071)	-0.083 (0.067)	-0.124* (0.068)	-0.111 (0.068)	-0.11 (0.067)	-0.071 (0.071)
I.dl3	0.003 (0.067)	0 (0.07)	0.021 (0.068)	0.045 (0.069)	-0.079 (0.068)	0.078 (0.068)	0.085 (0.071)
I.dl4	-0.017 (0.068)	-0.054 (0.07)	0.019 (0.068)	0.037 (0.07)	-0.195*** (0.068)	0.01 (0.069)	-0.054 (0.071)
I.dl5	-0.033 (0.067)	-0.152** (0.069)	-0.082 (0.067)	-0.043 (0.068)	-0.084 (0.069)	-0.032 (0.068)	-0.032 (0.07)
I.dl6	-0.145** (0.067)	-0.066 (0.069)	-0.157** (0.067)	-0.132* (0.068)	-0.166** (0.068)	-0.09 (0.069)	-0.008 (0.071)
I.dl7	-0.044 (0.067)	-0.01 (0.071)	-0.1 (0.068)	-0.073 (0.069)	-0.105 (0.068)	-0.059 (0.069)	0.01 (0.069)
I.dl8	0.018 (0.067)	-0.031 (0.072)	0.042 (0.068)	0.016 (0.068)	-0.041 (0.067)	0.03 (0.069)	0.031 (0.068)
HICP.dl1	1.494 (1.383)	2.74* (1.64)	1.548 (1.669)	2.242 (1.618)	1.623 (1.595)	2.124 (2.158)	0.885 (1.698)
HICP.dl2	-1.683 (1.448)	-0.166 (1.689)	-2.11 (1.747)	-1.853 (1.696)	-2.074 (1.672)	-3.837* (2.239)	-3.251* (1.754)
HICP.dl3	-1.584 (1.433)	-0.328 (1.647)	-1.763 (1.73)	-2.064 (1.678)	-1.583 (1.663)	-0.049 (2.242)	-0.433 (1.763)
HICP.dl4	-1.153 (1.505)	-3.149* (1.715)	-1.748 (1.825)	-1.384 (1.763)	-0.795 (1.743)	-2.956 (2.345)	-0.529 (1.846)
HICP.dl5	-0.949 (1.512)	0.74 (1.72)	-1.536 (1.833)	-1.741 (1.772)	-0.422 (1.749)	0.416 (2.357)	-0.953 (1.851)
HICP.dl6	-1.573 (1.499)	-1.489 (1.719)	-2.639 (1.833)	-0.93 (1.759)	-0.961 (1.739)	-3.306 (2.332)	-2.583 (1.846)
HICP.dl7	-2.87* (1.461)	-3.332** (1.685)	-1.891 (1.77)	-2.529 (1.704)	-3.188* (1.704)	-4.289* (2.271)	-2.664 (1.774)
HICP.dl8	-1.248 (1.422)	0.435 (1.645)	-2.65 (1.735)	-1.298 (1.666)	-1.04 (1.673)	-2.471 (2.192)	-0.785 (1.731)
M2.dl1	-1.018 (0.871)	-0.156 (0.997)	-0.623 (1.086)	-1.46 (1.039)	-0.543 (1.004)	-2.907** (1.329)	-1.222 (1.065)
M2.dl2	0.05 (0.876)	0.504 (1.007)	0.885 (1.101)	0.472 (1.048)	-0.821 (1)	0.088 (1.349)	-0.28 (1.096)
M2.dl3	1.347 (0.854)	0.276 (0.991)	2.389** (1.073)	1.993* (1.011)	1.137 (0.982)	1.442 (1.32)	1.759 (1.091)
M2.dl4	1.478* (0.855)	1.512 (0.987)	2.369** (1.06)	2.133** (1.01)	1.827* (0.985)	2.458* (1.325)	2.106* (1.071)

	AG	EN	MA	ID	CD	FN	RE
M2.dl5	0.028 (0.863)	0.128 (0.989)	0.462 (1.073)	0.362 (1.022)	0.314 (0.992)	-0.642 (1.339)	-1.022 (1.08)
M2.dl6	1.368 (0.855)	0.827 (0.975)	2.01* (1.059)	1.437 (1.01)	1.668* (0.991)	1.873 (1.321)	0.648 (1.066)
M2.dl7	2.277*** (0.853)	1.946** (0.975)	3.254*** (1.041)	2.19** (1.007)	2.191** (0.999)	3.39** (1.327)	1.065 (1.053)
M2.dl8	-0.084 (0.848)	1.093 (0.96)	0.186 (1.024)	-0.355 (0.997)	-0.043 (0.992)	0.891 (1.32)	0.18 (1.042)
STR.dl1	0.213* (0.108)	0.022 (0.122)	0.114 (0.129)	0.166 (0.127)	0.267** (0.124)	0.308* (0.169)	0.136 (0.129)
STR.dl2	-0.044 (0.128)	0.116 (0.143)	-0.025 (0.152)	0.039 (0.149)	0.082 (0.151)	-0.135 (0.197)	-0.051 (0.152)
STR.dl3	0.183 (0.127)	0.111 (0.143)	0.187 (0.153)	0.103 (0.149)	0.044 (0.151)	0.323 (0.197)	0.042 (0.153)
STR.dl4	0.047 (0.126)	0.046 (0.139)	0.028 (0.15)	0.071 (0.147)	-0.061 (0.149)	0.104 (0.194)	-0.068 (0.15)
STR.dl5	0.086 (0.125)	0.054 (0.138)	-0.008 (0.149)	0.044 (0.146)	0.267* (0.148)	-0.03 (0.192)	0.085 (0.149)
STR.dl6	-0.242* (0.126)	-0.267* (0.138)	-0.248* (0.149)	-0.228 (0.146)	-0.254* (0.149)	-0.313 (0.193)	-0.062 (0.148)
STR.dl7	0.009 (0.124)	-0.183 (0.135)	-0.033 (0.146)	0.031 (0.144)	-0.019 (0.146)	-0.077 (0.188)	-0.208 (0.146)
STR.dl8	0.244** (0.098)	0.364*** (0.107)	0.278** (0.116)	0.236** (0.115)	0.269** (0.115)	0.4*** (0.149)	0.18 (0.117)
LTR.dl1	-0.143** (0.063)	0.092 (0.072)	-0.055 (0.076)	-0.17** (0.074)	-0.149** (0.075)	-0.055 (0.098)	-0.238*** (0.076)
LTR.dl2	0.132* (0.069)	-0.019 (0.077)	0.12 (0.083)	0.176** (0.081)	0.077 (0.081)	0.081 (0.106)	0.213** (0.084)
LTR.dl3	-0.078 (0.076)	0.029 (0.085)	-0.077 (0.092)	-0.121 (0.089)	-0.143 (0.089)	0.034 (0.117)	-0.071 (0.092)
LTR.dl4	0.072 (0.077)	-0.021 (0.085)	0.109 (0.093)	0.132 (0.09)	0.104 (0.09)	-0.001 (0.117)	0.135 (0.093)
LTR.dl5	-0.134* (0.076)	-0.063 (0.085)	-0.046 (0.091)	-0.177** (0.089)	-0.221** (0.089)	-0.072 (0.116)	-0.119 (0.092)
LTR.dl6	0.065 (0.075)	-0.005 (0.082)	0.078 (0.089)	0.106 (0.088)	0.017 (0.089)	0.008 (0.115)	0.03 (0.09)
LTR.dl7	-0.002 (0.075)	0.042 (0.083)	0.08 (0.088)	-0.032 (0.088)	0.04 (0.089)	0.038 (0.114)	0.014 (0.089)
LTR.dl8	-0.053 (0.068)	0.013 (0.076)	-0.082 (0.081)	-0.021 (0.08)	-0.107 (0.08)	-0.016 (0.104)	0.061 (0.082)

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. A year dummy for 2020 and seasonal dummies were included when estimating the model, but are not displayed here.

5.4 Impulse Response Functions

Impulse response functions (IRFs) in the context of vector error correction models (VECMs) serve primarily as a means of illustrating the dynamic interactions already embedded in the model, rather than generating new insights about the underlying relationships. They depict the system's response to a unit shock in a specific variable, representing a short-term deviation from equilibrium. Over time, if the system exhibits a significant error correction mechanism, the deviations should gradually diminish as the system converges back to its long-run equilibrium.

The analysis focuses on unit shocks to two specific variables: inflation (HICP) and equities (I). In the context of macroeconomic dynamics, variables such as money supply (M2), short-term interest rates (STR), and long-term interest rates (LTR) typically respond to inflation rather than driving initial movements, which justifies the consideration of an inflation shock. This is also evident from the VECM results, where there is evidence for inflation to be weakly exogenous within this system. The objective of this exercise is to illustrate the dynamic nature of these relationships — specifically, how equities respond to shocks in macroeconomic variables and, conversely, how macroeconomic variables react to shocks in equities.

The implementation of the impulse response functions (IRFs) relies on the Cholesky decomposition for the orthogonalization of shocks, as outlined in subsection 3.4. This method requires a specific ordering of variables, which is determined based on economic reasoning here. For an inflation shock, the variable ordering is HICP $\rightarrow$ STR $\rightarrow$ M2 $\rightarrow$ LTR $\rightarrow$ I, while for an equity shock, the ordering is I $\rightarrow$ HICP $\rightarrow$ STR $\rightarrow$ M2 $\rightarrow$ LTR. Alternative orderings were tested but did not affect the results.

The equity index used for both regions is the aggregate index S&P 500 for the US and MSCI EMU for the Eurozone — since the results were consistent for most equity indices. The only notable exception was that certain sectoral indices did not converge to the long-term equilibrium, which was already identified in the VECM analysis. The impulse response horizon spans five years (60 monthly data points), which is a reasonable choice given the focus on long-term equilibrium dynamics.

Impulse response functions (IRFs) for an inflation (HICP) shock are presented in Figure 3 for the US and Figure 4 for the Eurozone. The impact of the shock is considerably stronger in the Eurozone compared to the US. Both short-term (STR) and long-term interest rates (LTR) initially increase, likely reflecting a monetary tightening response. However, money supply (M2) remains largely unaffected in both regions, a pattern already evident from the VECM results which indicate a significant but slow response.

In the US, variables revert more quickly to their long-term equilibrium, whereas in the Eurozone, even after five years, STR and LTR have not fully returned to equilibrium. This persistence is particularly pronounced for STR, LTR, and I. The response of equities is relatively weak across both regions but differs in direction: in the Eurozone, equities respond negatively to inflation shocks, whereas in the US, the response is positive. This aligns with theoretical expectations and findings in related literature only for the Eurozone.

Furthermore, while two conflicting cointegrating vectors were identified in Section subsection 5.2, it appears that in the case of an inflation shock, the dominant cointegrating relationship is the one implying a positive long-term association between equities and long-term interest rates. This is consistent with the previously discussed dynamic in the first US cointegrating vector, which may reflect more recent macroeconomic developments, particularly after 2020, when rising inflation and monetary tightening influenced market expectations and asset allocation dynamics.

Impulse response functions (IRFs) for an equity shock are presented in Figure 5 for the US and Figure 6 for the Eurozone. Similar to the IRFs for an inflation shock, the magnitude of the response is significantly lower in the US compared to the Eurozone. Inflation (HICP) and money supply (M2) remain largely unchanged in both regions. In the Eurozone, short-term (STR) and long-term interest rates (LTR) exhibit a persistent increase, deviating further from equilibrium rather than reverting. In contrast, in the US, STR and LTR move in the same direction as the equity index, suggesting a more synchronized response. However, the shock's effect on LTR in the US remains persistent, as it does not fully revert to its initial level even after five years, staying below its pre-shock value.

Overall, the impulse response analysis highlights notable regional differences in how macroeconomic variables and equities interact in response to shocks. While the US exhibits a faster reversion to long-term equilibrium, the Eurozone shows more persistent deviations, particularly in interest rates. The weak response of money supply (M2) in both regions underscores its limited role in the short-term transmission of shocks within this system. Additionally, the diverging equity market reactions suggest structural differences in how inflation expectations and monetary policy are priced in across the two economies.

Specifically, the positive long-term relationship between inflation, long-term interest rates, and equities is dominant in the US but not in the Eurozone, where the relationship is negative. These findings reinforce the broader conclusions from subsection 5.2 and subsection 5.3, highlighting the importance of accounting for region-specific dynamics when assessing macro-financial linkages. Furthermore, the results once again demonstrate the bidirectional nature of these relationships — equities are not only influenced by macroeconomic variables but also exert an impact on them.

Figure 3: Impulse Responses to a Shock in Inflation for the US.

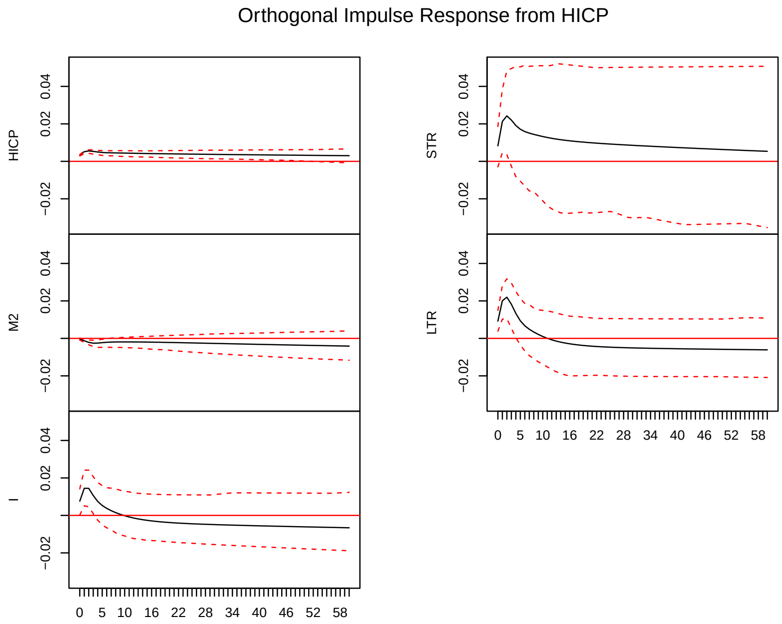


Figure 4: Impulse Responses to a Shock in Inflation for the EZ.

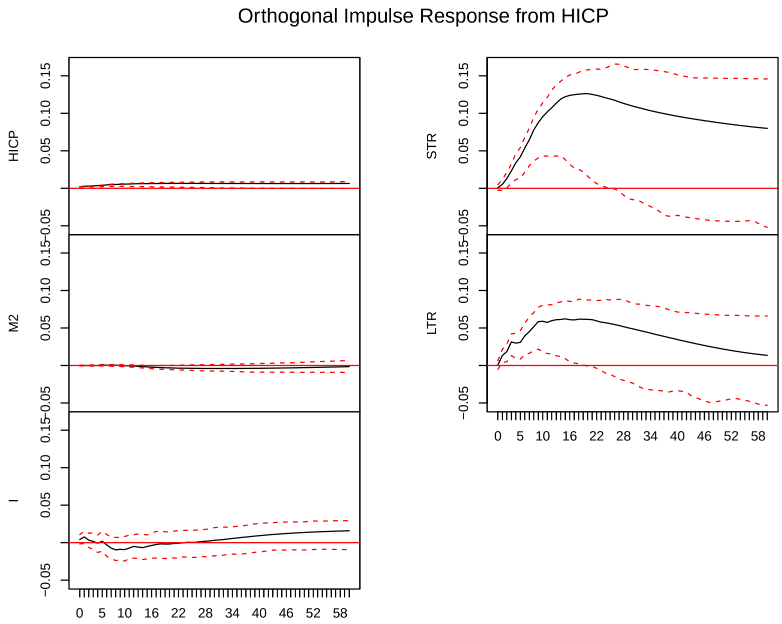


Figure 5: Impulse Responses to a Shock in Equities for the US.

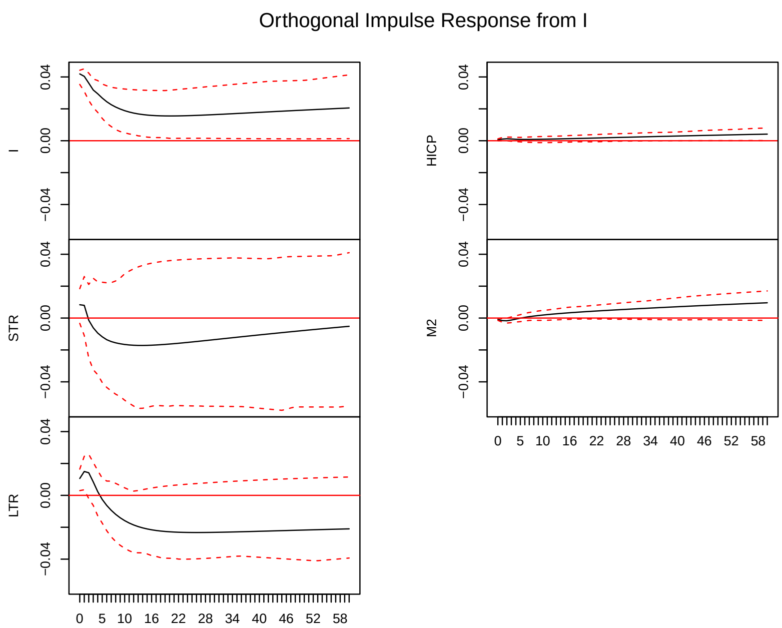
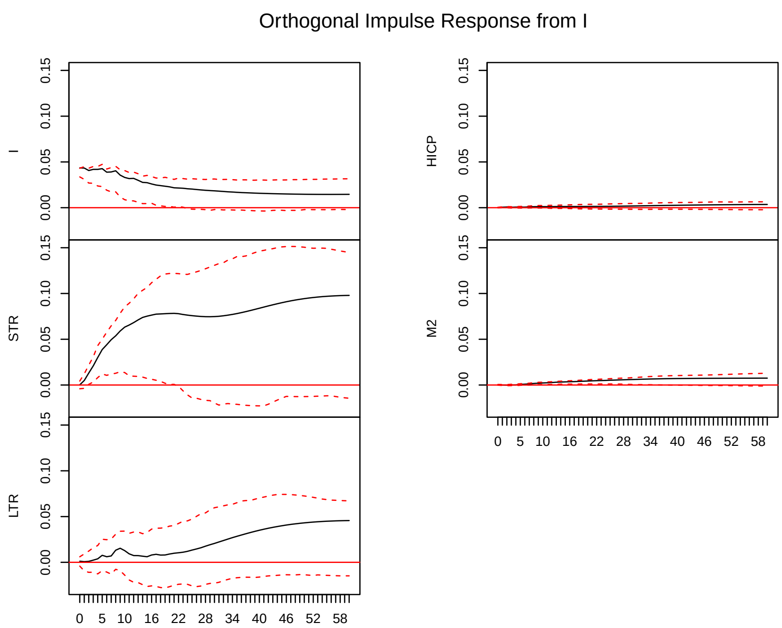


Figure 6: Impulse Responses to a Shock in Equities for the EZ.



6 Conclusion

This thesis investigates the dynamic interactions between key macroeconomic indicators and sectoral stock indices in the United States and the Eurozone, employing the Johansen methodology. Using monthly data spanning from January 2002 to September 2024, the analysis covers 11 sector indices and an aggregate stock market index (S&P 500 for the US and MSCI EMU for the Eurozone), along with four key macroeconomic variables: inflation, money supply, short-term interest rates, and long-term interest rates.

The Johansen cointegration test results indicate the presence of two cointegrating vectors in all US variable sets, except for the one including the Communication Services (CM) sector index, which exhibits only one. In contrast, Eurozone (EZ) variable sets generally show three cointegrating vectors, except for the one including the Materials (MA) sector index, which has two. These findings confirm the existence of persistent long-term relationships between stock indices and macroeconomic fundamentals.

The Johansen cointegration test confirms the presence of stable long-term relationships, with US variable sets generally containing two cointegrating vectors, whereas Eurozone (EZ) sets show three, with some sector-specific exceptions. This reinforces the idea that equity markets are not purely driven by short-term fluctuations but maintain persistent links to macroeconomic conditions. However, the nature of these relationships differs: in the US, inflation and long-term interest rates show two conflicting cointegrating vectors—one supporting a positive long-run association and another suggesting a negative relationship. The first contradicts classical economic theory based on the Discounted Cash Flow (DCF) model and diverges from pre-2020 literature, suggesting potential shifts in dynamics post-2020 .

The VECM analysis highlights that most sectoral indices adjust significantly to deviations from long-term equilibrium, implying that stock prices react to macroeconomic forces over time. Notably, Real Estate (RE) in the US and Communication Services (CM) in the Eurozone exhibit no significant long-run adjustment, suggesting these sectors do not conform to the broader equilibrium dynamics. Inflation is found to be weakly exogenous, meaning it does not adjust to deviations from equilibrium, whereas money supply shows a significant but slow reversion. Long-term interest rates, particularly in the US, strongly adjust to the long-run equilibrium after short-term deviations, while short-term interest rates display less conclusive patterns.

Short-run dynamics further reveal regional distinctions. Inflation significantly impacts US equities in the short term, whereas its effect is weaker in the Eurozone. Importantly, there is no feedback effect from equities to inflation, reinforcing the idea that inflation is largely exogenous in this system. Money supply and short-term interest rates are endogenous, responding to movements in equity markets, while long-term interest rates exhibit sector-dependent negative and one-directional effects on equities.

The impulse response analysis demonstrates that the US market adjusts more swiftly to shocks than the Eurozone, where deviations from equilibrium persist for longer periods, particularly in interest rates. The weak response of money supply (M2) in both regions suggests its limited role in short-term macro-financial transmission. A crucial distinction arises in the interaction between equities and inflation: in the US, equities exhibit a positive long-term relationship with both inflation and long-term interest rates, whereas in the Eurozone, the relationship is mostly negative.

From a theoretical standpoint, these findings present challenges to traditional asset pricing models and raise questions about market efficiency. The presence of cointegrating relationships suggests that macroeconomic fundamentals play a systematic role in shaping equity prices over the long term, which partially contradicts the Efficient Market Hypothesis (EMH). If stock prices fully reflected all available information, one would not expect persistent long-run relationships with macroeconomic variables. However, the presence of short-term deviations and the observed adjustment mechanisms imply that markets gradually incorporate new information, rather than doing so instantaneously.

It remains an open question whether the newly found long-term relationships, particularly the positive link between inflation, long-term interest rates, and equities in the US as well as some sector indices in the Eurozone, will persist in the future. The post-2020 shifts, influenced by inflationary pressures, central bank tightening, and evolving market expectations, may represent a transitory phase rather than a permanent transformation.

In summary, this thesis contributes to the literature by providing a sector-level perspective on macro-financial linkages and emphasizing regional distinctions. The findings underscore the need for a nuanced understanding of the dynamic relationship between equities and macroeconomic variables, particularly in light of potential shifts in economic conditions.

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A Appendix

Table A.1: Comparison of descriptive statistics between US and EZ.

(a) Descriptive statistics for the US.

	Mean	**SD**	**Min**	**Max**
Index				
AG	7.52	0.52	6.60	8.64
EN	6.08	0.36	5.17	6.59
MA	5.58	0.43	4.73	6.39
ID	6.02	0.48	5.00	7.01
CD	6.16	0.68	4.93	7.38
CS	5.99	0.45	5.25	6.78
HC	6.43	0.58	5.58	7.51
FN	5.87	0.39	4.62	6.63
IT	6.51	0.83	5.25	8.39
CM	5.02	0.27	4.42	5.74
UT	5.33	0.36	4.49	5.95
RE	5.05	0.38	3.88	5.78
Macroeconomic Variables				
HICP	4.58	0.14	4.31	4.86
M2	9.29	0.43	8.60	9.99
STR	0.71	0.64	0.01	1.85
LTR	1.36	0.31	0.48	1.84

(b) Descriptive statistics for the EZ.

	Mean	**SD**	**Min**	**Max**
Index				
AG	4.66	0.24	4.10	5.12
EN	5.01	0.16	4.46	5.38
MA	5.18	0.33	4.27	5.69
ID	5.35	0.40	4.44	6.16
CD	4.70	0.46	3.75	5.53
CS	4.91	0.40	4.16	5.47
HC	5.05	0.32	4.34	5.54
FN	4.08	0.32	3.38	4.88
IT	4.54	0.47	3.64	5.65
CM	4.10	0.19	3.68	4.60
UT	4.60	0.26	4.05	5.24
RE	5.07	0.33	4.38	5.74
Macroeconomic Variables				
HICP	4.58	0.12	4.36	4.84
M2	16.02	0.35	15.35	16.55
STR	0.55	0.82	-0.87	1.81
LTR	1.19	0.55	-0.25	1.84

Table A.2: Comparison of PP test statistics between US and EZ.

(a) Test statistics for the US.

	Level	**Diff.**
Index		
AG	-2.378	-16.253***
EN	-2.217	-17.021***
MA	-3.731**	-16.208***
ID	-2.980	-16.264***
CD	-2.599	-16.644***
CS	-3.291*	-17.130***
HC	-2.629	-17.188***
FN	-1.661	-15.809***
IT	-2.442	-16.472***
CM	-3.560**	-16.883***
UT	-3.376*	-16.900***
RE	-3.004	-16.873***
Macroeconomic Variables		
HICP	-1.608	-9.013***
M2	-1.829	-10.960***
STR	-1.021	-10.168***
LTR	-1.913	-11.911***

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

(b) Test statistics for the EZ.

	Level	**Diff.**
Index		
AG	-2.892	-15.569***
EN	-2.873	-17.009***
MA	-3.362*	-14.740***
ID	-3.035	-15.435***
CD	-3.754**	-16.628***
CS	-3.024	-16.006***
HC	-2.683	-15.612***
FN	-2.351	-15.590***
IT	-2.829	-16.743***
CM	-2.883	-16.983***
UT	-1.686	-17.187***
RE	-1.722	-14.176***
Macroeconomic Variables		
HICP	-0.464	-14.002***
M2	-1.253	-15.958***
STR	-0.173	-5.695***
LTR	-1.154	-11.257***

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

B Appendix

Table B.1: Lag lengths and Ljung-Box p-values of equation residuals for the US.

	Lags	r_I	r_HICP	r_M2	r_STR	r_LTR
AG	3	0.37	0.15	0.45	0.11	0.97
EN	8	0.15	0.41	0.78	0.82	1.00
MA	4	0.59	0.50	0.31	0.41	1.00
ID	4	0.32	0.41	0.25	0.37	1.00
CD	3	0.44	0.13	0.48	0.13	0.93
CS	3	0.58	0.14	0.49	0.19	0.96
HC	3	0.40	0.15	0.52	0.10	0.99
FN	4	0.36	0.44	0.18	0.44	1.00
IT	3	0.65	0.22	0.50	0.12	0.98
CM	5	0.11	0.67	0.29	0.72	0.99
UT	3	0.35	0.14	0.53	0.10	0.97
RE	3	0.41	0.14	0.44	0.12	0.94

r_I is the residual, where the equity index is the dependent variable. Residual autocorrelation was tested up to lag 12.

Table B.2: Lag lengths and Ljung-Box p-values of equation residuals for the EZ.

	Lags	r_I	r_HICP	r_M2	r_STR	r_LTR
AG	9	0.68	0.74	0.17	0.98	0.30
EN	9	0.17	0.82	0.12	1.00	0.62
MA	9	0.52	0.79	0.17	0.97	0.75
ID	9	0.55	0.70	0.22	0.98	0.26
CD	9	0.92	0.51	0.10	0.99	0.42
CS	11	0.23	0.83	0.16	1.00	0.84
HC	12	0.06	0.94	0.67	1.00	0.65
FN	9	0.97	0.87	0.11	0.96	0.32
IT	11	0.83	0.91	0.19	0.99	0.62
CM	11	0.96	0.90	0.24	1.00	0.95
UT	11	0.25	0.89	0.22	0.99	0.97
RE	9	0.55	0.78	0.11	0.98	0.43

r_I is the residual, where the equity index is the dependent variable. Residual autocorrelation was tested up to lag 12.