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Macroeconomic Determinants of Sovereign Credit Risk

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Abstract

This report analyzes the macroeconomic determinants of sovereign bond yields in three different economies: the US, a large open economy and a benchmark in the financial markets, Sweden, a small open economy that has successfully dealt with financial crisis, and Italy, a large open economy with a history of financial distress. Cointegration techniques of the VECM and the ARDL model were used to derive the short-run and the long-run determinants of sovereign bond yields. The results show that for the US, Sweden, and Italy the macroeconomic fundamentals explain in aggregate 3.9%, 38.2%, and 66.1% respectively of the variation in yields. With inflation as the leading variable for Sweden and debt to GDP for Italy. Two important conclusions are deduced from this data: firstly, macroeconomic fundamentals in countries with higher perceived riskiness have more influence on investment decisions in the financial markets and secondly, investors pay attention to different macroeconomic variables depending on the country. The results also explain how the US have benefitted from "safe haven" flows, as the fundamentals show relationships with yields that are contradictory to economic theory.

Keywords: Macroeconomic Determinants, Credit Risk, Government Bond Yields, Cointegration, Long-run and Short-run Determinants, VECM, ARDL, FEVD.

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1. Introduction

Throughout history, sovereign countries have defaulted on their debt and economic commitments. Although sovereign default is typically rare, a sovereign debt crisis has occurred multiple times, and is often induced by poor economic fundamentals and succeeded by economic deterioration, political turmoil, and uncontrolled government spending. During the covid crisis many countries revealed signs of economic deterioration, unemployment rate rose to record levels and GDP growth precipitously declined into negative rates. Many central banks quickly counteracted this "flash recession" with extremely generous quantitative easing programs. This was immensely effective for some countries, leading to positive growth in GDP and a decline in unemployment rate. However, as time proceeded some economies started to show signs of stagflationary winds and increase in debt levels. Some economists argue that the economy is in a worse shape post-covid than it was pre-covid. The inflationary pressure from the quantitative easing programs were only exacerbated by the Russian occupation of Ukraine, which caused bottlenecks in the supply chains. In an era of rising debt levels, stagflationary winds, and full-scale war, the risk of financial distress is surely on the rise.

A sovereign debt crisis increases the probability of a country to dishonor its commitments, causing lenders to demand higher interest rates as the possibility of default increases. This is in line with the efficient market hypothesis, which states that all public information of an asset should be reflected in the price, markets only react to new and unexpected information.

Government spending that exceeds its tax base requires financing through issuing bonds in the open market, making governments vulnerable to increases in borrowing costs. This can lead to damaging effects on the economy with reduction in investments and increase in unemployment rate that can possibly cause a recession.

In this report we further analyze and model the macroeconomic variables that can induce investors to require higher risk premium on a sovereign bond. Suffice to say, we want to determine which economic variables have the most significant effect on the risk of the sovereign bond. We use the sovereign 10-year bond yields as a proxy for the country's riskiness. Risk in this context is fully dependent on the country's ability to honor its debt and pay its coupons and principal at maturity, thus, to get a more accurate and fair representation of perceived risk we not only include risk of default we also add the risk of restructuring of debt, risk of a debt restructuring plan or risk of required assistance plan from the IMF or any other international source.

Investors always seek to maintain an acceptable risk-return profile on their portfolios, thus they will always try to minimize risk whenever possible by either diversifying their portfolio or investing in assets whose risk profile could temporarily be exaggerated by the market sentiment. In our model we explore the latter, i.e. if our models have high explanatory values and low variance it could provide investors with an insight on which macroeconomic variables most significantly affect the risk-profile of a sovereign bond. Thus, it can be used by investors to act as a red flag and warn against upcoming crises. Since a country's ability to honor its debt in the long-term is directly correlated with its underlying macroeconomic fundamentals. And thus in practice, allow investors to use our model ex-ante to further explore a country's riskiness. We have also taken into consideration to use our model as a tool to exploit arbitrage opportunities in the financial bond markets. For instance if our model predicts that a country with a certain level of macroeconomic variables should yield a certain risk premium on their sovereign bond we can compare that rate to the current market risk premium, if there is a significant deviation, one could explore the possibility to exploit such opportunity and trade long/short accordingly. The model could also be used by policy makers to monitor the overall health of the economy and thus mitigate political upheaval and instability.

1.1 Limitations

This report consists of a number of limitations due to the timeframe and the availability of data. The chosen countries were limited to three different types of economies, however, a similar study could be made with more countries. This approach will assist us to thoroughly analyze if there exist any discprenensies between these three economies as well as answering our research question. The number of macroeconomics variables studied are also limited due to the bias-variance trade of. Increasing the number of variables will increase the variance, and decreasing the number of variables will increase the bias. Although we omitted variables that correlate with the dependent variable such as educational levels, political stability and market sentiments toward the countries. We conclude that the variables analyzed explain the overall health of an economy. The thesis is limited to examine the reported variables and not the variance of the variables. All variables are in annual form since some variables are only reported once a year. This significantly reduces the number of observations. Given the scarcity of the available data we were induced to only study developed economies. To fully answer the research question many models could be employed, in this report we only used two models: the Vector Error Correction Model (VECM) and the Autoregressive Distributed Lag Model (ARDL) to differentiate between the long-run and short-run dynamic effects.

1.2 Structure

The report is structured as follows: Chapter 2 covers earlier studies regarding the research question. Chapter 3 describes the data and the methodology, which explain the models, assumptions, and the empirical techniques. Chapter 4 goes through the results, where the focus is on the significant values. Chapter 5 analyzes the results, discusses the implications of the results, and concludes the main ideas. Chapter 6 displays the references which are arranged in alphabetical order.

2. Literature Review

Empirical studies on this topic can be divided into two parts: empirical research that analyzes single countries and panel data that examines multiple countries. Most single-country studies have mainly focused on the United States, since it's the largest global economy. The panel data studies that have examined macroeconomic determinants of the long-term government bond yield have mainly focused on the long-run relationships between government bond yield and its determinants. And thus did not consider the short-run dynamic effects in their analysis.

Most of the single country studies show that current fiscal values have significant effects on the long-term government bond yield. Although all current fiscal variables explain the riskiness of a sovereign bond, Laubach (2009) brings forth evidence that the long-term government bond yield is mainly determined by the projected future government deficit and debt to GDP ratio. A 1 % increase in the projected debt to GDP ratio leads to an increase by 3-4 basis points in yields. This is in line with other single-country studies from the United States, such as Engen and Hubbard (2004).

Despite the fact that the majority of the single country studies focus on the dependencies between the fiscal variables and the long-term government bond yields for the United States, some studies analyze other countries. Chinn and Frankel (2005) have examined the five largest economies in Europe: Germany, the United Kingdom, France, Italy, and Spain. The statistical methods that they applied in their report were the use of single regression for each of the observed countries; they concluded that most of the variation in the long term government bond yields for the five countries is explained by debt to GDP, the ceteris paribus effects of a 1 % increase in debt to GDP have a positive effects on the government bond yields. The impact on the yields is between 5 to 16 basis points for the five observed countries. Although the change of a 1 % increase in debt to GDP ratio on government bond yields varies between the five countries, the results are statistically significant.

Studies that used cross-section panel data for their analysis of the long-run relationships between fiscal variables and the long-term government bond yield are in line with earlier studies, which shows that most of the variation in the long-term government bond yields is explained by debt to GDP. In a research paper consisting of 10 euro countries, Faini (2006) finds that a 1 % increase in debt to GDP will in the long run be followed by an increase of 3 basis points in yields. This too is in line with earlier studies. The report also finds that the impact of the debt to GDP ratio on yields differs between the countries and highlights that countries with a higher debt to GDP ratio are more vulnerable to increasing budget deficits when it comes to borrowing costs relative to countries with lower levels.

Kumar and Baldacci (2010) conducted a panel data study of 31 both advanced and emerging economies, and found that the macroeconomic fundamentals of the countries are essential when analyzing the fiscal effects on the long term government bond yield. Borrowing cost for countries with weaker economic fundamentals tends to be more sensitive to changes in the fiscal variables.

The majority of literature focuses their analysis on government debt as the main determinant of long-term government bond yield. We expand this initial thought and study other fundamentals such as unemployment rate and current account balance that have strong relationships with public debt. While most litteratures either use a panel data approach to examine multiple countries or a single country report that mainly focuses on the US. This report aims to investigate the determinants of the long-term government bond yield by examining three different economies using a single country study approach. As well as examining both the short and long-run macroeconomic effects on the long-term government bond yield. This approach gives us the advantage of focusing on three different types of economies, while also evaluating the short and long run relationships as well as assisting us with forecasting which would not be possible using a panel data approach .We also examined if investors put different emphasis on fiscal variables among countries, depending on market sentiment, in order to determine which macroeconomic variables explains the riskiness of a sovereign bond.

3. Methodology

3.1 Data

The data analyzed in this report is in annual form and obtained from the International Monetary Fund (IMF) and the Federal Reserve Economic Data (FRED). The countries analyzed are the United States, the largest economy in the world, Sweden which is a small open economy, and Italy which is the third largest economy in the European Union but has experienced financial stress due to the great recession and the European debt crisis. The number of observations varies between the countries, for the United States the number of observations are 42, ranging from 1980 - 2021. While for Sweden the number of observations are 28, ranging from 1993-2020 and for Italy the observations are 29, ranging from 1992-2020. The dependent variable is the 10 year long-term government bond yield for the individual countries and the independent macroeconomic variables that are examined are:

Table 1 - Independent variables[1]

Independent variables	
Nominal GDP	Y = C+I+G+NX → total goods and services produced by a country in a year
Unemployment rate	Number of unemployed people divided by the labor force
Debt to GDP	General government gross debt divided by GDP
Current account to GDP	(Netexport + Net Income from abroad + Net current transfers) divided by GDP
CPI	(Value of market basket in year t divided by the value of market basket in base year) multiplied by 100
Total investments to GDP (Instrumental variable)	The sum of private and public investments divided by GDP

[1] Total Investments to GDP was used as an instrumental variable for unemployment rate regarding Italy due to the variable not fulfilling critical assumptions.

3.2 Descriptive Statistics

A descriptive statistics Table was constructed to get an overview of the chosen macroeconomic variables, it includes: mean, median, maximum - and minimum value, standard deviation, skewness, kurtosis, and Jarque-Bera tests. Skewness is a measure of symmetry of the distribution of the variable. It measures how much the distribution is skewed to either tail, if the value is zero then the distribution is perfectly symmetrical, if it is positive, the distribution is skewed to the right, and it is skewed to the left if it is negative. The absolute value indicates the magnitude of the skewness. Kurtosis is a measure of the amplitude of the distribution, i.e. degree of peakedness (Lee, 2009). A high value of kurtosis indicates a sharp peak around the mean, while a low kurtosis indicates a flatter distribution with a low range within a standard deviation, i.e. the difference between maximum and minimum value tends to be lower. Jarque-bera statistics is a goodness of fit test that incorporates the skewness and kurtosis to analyze if the data is normally distributed . The null hypothesis is a joint hypothesis of the skewness being zero and excess kurtosis (which is equal to kurtosis of 3) being zero (Jarque and Bera, 1981). Thus, if the null hypothesis is rejected, the model is not normally distributed (Gujarati and Porter, 2009).

The general Jarque-Bera statistics is as follows

$$JB = \frac{n}{6}\left(S^2 + \frac{1}{4}(K - 3)^2\right) \tag{1}$$

where *n* is the number of observations, the *skewness* is defined as:

$$S = \frac{\mu_3}{\sigma^3} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^3}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2\right)^{3/2}} \tag{2}$$

and the *kurtosis* is defined as:

$$K = \frac{\mu_4}{\sigma^4} = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^4}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2\right)^{2}} \tag{3}$$

3.2 Stationarity Test

One critical assumption in time series modeling is the assumption of stationarity, meaning that the data is normally distributed with a constant mean and variance, and with no trend over time (Enders, 2004). If the series is not stationary the results will not be interpreted correctly. In the case when the series is not stationary it can be transformed into a stationary variable by differencing over time (Kmenta, 2015). If the variable is still not stationary at first difference I(1) it can cause some issues with the model, since most models can not interpret data that is integrated of order two, I(2). To test for the stationarity of the time series model, the unit root test was conducted through the Augmented Dickey Fuller test (ADF) and the Philip Perron test (PP), and were applied at constant and trend only.

The Augmented Dickey-fuller test is specified as

$$\Delta Y = \alpha + \beta t + \delta Y_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta Y_{t-1} + \varepsilon_t \qquad (4)$$

The null hypothesis states that the variable is nonstationary, thus, by rejecting the null hypothesis we assume the alternative hypothesis: the variable is stationary (Dickey and Fuller, 1979).

The Phillip and Perron test (1988) is specified as

$$\Delta Y = \beta_0 X_t + \alpha Y_{t-1} + U_t \qquad (5)$$

Similar to the Augmented Dickey-fuller test, the null hypothesis states that the variable is nonstationary. Although these two tests are similar, the PP-test ignores autocorrelation whereas the ADF implements a parametric regression to estimate the residuals. However, the PP-test does not require homoscedastic residuals (Dritsaki, 2013). Thus it is common that the PP-test rejects the null hypothesis more often than the ADF-test does (Leybourne and Newbold, 1999). To get a more accurate understanding of the nature of the data, both tests were implemented.

3.4 Determination of Optimal Lag-Length

Since the variables that are analyzed in this report are inherently serially correlated, for instance, yields 2020 will inevitably affect yields 2021; and since the VECM analyzes the lagged version of the variables, it is of paramount importance to choose the correct lag-length. Too many lags will overfit the model and too few lags will cause the power of the test to suffer (Gordon, 1995). There are different information criterias that determine the optimal amounts of lags to select. The three main ones employed in this report are: Akaike information criterion (AIC), Bayesian information criterion (BIC), and Hannan-Quinn information criterion (HQ). These information criterions differ slightly in how they choose the optimal lag length and penalize in different ways.

3.4.1 Akaike Information Criterion (AIC)

The Akaike criterion is a lag length order selection where the first term (2k) increases as the number of parameters increases, this penalizes models that are complicated by increasing the AIC score. The second term (2ln(L) decreases as the model gets better at explaining the data, this rewards models that fit the data well as the AIC score decreases. Thus, the information criteria rewards goodness of fit and penalizes overfitting (Stock and Watson, 2020). The optimal lag length is selected when the AIC score has the minimum value.

$$AIC = 2k - 2ln(\widehat{L}) \qquad (6)$$

Where k is the number of parameters and $\widehat{L}$ is measure of goodness of fit

3.4.2 Bayesian Information Criterion (BIC)

This criteria is closely related to the Akaike criteria, it increases when the parameter of the model increases and when the number of observations in the data increases. The information criteria penalizes models that are complicated. The ln(n) term is more sensitive than the k term and thus the BIC penalizes the increase of observations more than it penalizes the increase in parameters. As the Akaike criteria does, the BIC also decreases when the data fit the model well (Schwarz, 1978). The optimal lag length is selected when the BIC score has the minimum value.

$$BIC = kln(n) - 2\ln(\widehat{L}) \qquad (7)$$

Where n is the number of observations

3.4.3 Hannan–Quinn information Criterion (HQC)

An alternative criterion to the Akaike (AIC) and Beyesian (BIC) is the Hannan-Quinn (HQC) information criteria. The criteria is placed somewhere between the AIC and BIC. It increases when both the parameter and the number of observations of the model increase and decreases when the model fits the data well (Hannan and Quinn, 1979). The model is more efficient to use when the number of observations are high. The optimal lag length is selected when the HQC score has the minimum value.

$$HQC = \; - 2L_{max} + 2k\, ln(ln(n)) \qquad (8)$$

When the observations are less than 60 and the three criterias don't show unanimous results, the AIC criteria is selected due to its superior accuracy compared to the SCIC and the HQIC (Liew, 2004).

3.5 Tests for Cointegration

A time series is said to be cointegrated if the individual variables are non-stationary at level, however, at least one linear combination of the variables is stationary (Engle and Granger, 1987). This implies that the variables show some form of underlying long-run relationship. Given that the variables are stationary of the same order of integration, a long-run relationship can be observed through testing for cointegration.

3.5.1 Johansens Test for Cointegration

When the variables are integrated of order one, i.e. after the first difference, the Johansens test can be applied to the test for cointegration (Johansen, 1988). The Johansens test tests for multiple cointegration relationships, unlike the Engle-Granger test, which tests for only one relationship and is, therefore, more applicable in this report when analyzing multiple variables and estimating the number of relationships that exist.

The test is based on estimating the following model

$$\Delta Y_t = \mu + \prod Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-1} + \varepsilon_t \tag{9}$$

The Johansens test consists of the Max-Eigenvalue and the Trace statistics. The null hypothesis states that there is no cointegration at a given number of hypothesized numbers of cointegration equations. If the Max-Eigenvalue and the Trace statistics exceed their respective 5 % critical value, then the null hypothesis is rejected and the specific number of cointegration equations exist.

The formula for computing the Max-Eigenvalue and the Trace statistics is as follows

$$J_{max} = \ - T \sum_{i=r+1}^{n} ln(1 - \overline{\lambda}_i) \tag{10}$$

$$J_{tace} = \ - T ln(1 - \overline{\lambda_{r+1}}) \tag{11}$$

According to (Lütkepohl et al., 2001) the Max-Eigenvalue is superior to the Trace statistics and should be employed when choosing the number of cointegration relationships.

3.5.2 Autoregressive Distributed Lag (ARDL) Bound Test for Cointegration

Contrary to the Johansens test for cointegration, the ARDL bound test for cointegration can be applied when variables are integrated at different orders, i.e. when some of the variables are stationary at level I(0) and other variables at first difference I(1). The null hypothesis states that there is no cointegration and is rejected when the F-statistics exceeds the lower (I0) and upper bound (I1) of each significance level. Another advantage includes the possibility of deriving an ECM from the results. The drawback of this model is that it does not specify how many cointegration equations there are, it only specifies if there is at least one cointegration equation (Pesaran, 2015). Hence, to get the most reliable results, both the Johansens test for cointegration and the ARDL bound test for cointegration have been implemented.

3.6 Vector Error Correction Model (VECM)

The vector error correction model (VECM) estimates the long and short run relationships in integrated multivariate time series. One important assumption for the use of the model is the existence of cointegration. When there exists cointegration between variables, they are nonstationary individually, but stationary when they are combined into a linear combination (Engle and Granger, 1987). Hence, by virtue of being cointegrated the variables intrinsically adjust to the long run equilibrium if there is a short term deviation, and the VECM specifies how fast this correction adjusts to the equilibrium by estimating an error correction term(ECT). The VECM takes into account the lagged version of the variables but subtracts one lag, then it estimates the model in first difference form and adds an ECT as an explanatory variable (Meniago et al., 2013).

$$\Delta y_t = \beta_{11}\Delta y_{t-1} + \beta_{12}\Delta x_{t-1} + v_t^{\Delta y} \tag{12}$$

$$\Delta x_t = \beta_{21}\Delta y_{t-1} + \beta_{22}\Delta x_{t-1} + v_t^{\Delta x} \tag{13}$$

The VECM is widely used to interpret economic data and has had a greater impact on economics than other models, such as the ARDL. This is because the VECM does not require that the explanatory variables are weakly exogenous, as the ARDL model does. The variance decomposition, which shows how much variation in the macroeconomic indicators explains the variation in yields, is more suitable for VECM and VAR than it is for other models. The VECM can also be used for forecasting, which is appropriate in this report. Lastly, the VECM simply and effectively displays the long-run model, the short-run model, and the error correction term. All these results have significant economic interpretations.

3.7 Autoregressive Distributed Lag Model (ARDL)

The ARDL model is used when variables exhibit different order of integration, i.e. when some variables are stationary at level I(0) and other at first difference I(1) (Peseran and Shin, 1999). As opposed to the VECM, the ARDL model assigns different numbers of lags to each of the variables, while the VECM assigns the same number of lags for all variables. If the ARDL bound test shows cointegrations between variables, the ARDL model estimates the long run relationships among these variables and the short run error correction. As the variables exhibit long run relationships, the error correction term explains the speed of adjustment to equilibrium in the current period due to a shock in the previous one (Nkoro and Uko, 2016).

The formula for deriving the long run model is as follows:

$$Y_t = \delta_0 + \sum_{i=1}^{k} \alpha_1 X_{1t} + \sum_{i=1}^{k} \alpha_2 X_{2t} +\ldots \sum_{i=1}^{k} \alpha_n X_{nt} + \varepsilon_{1t} \tag{14}$$

where X is the explanatory variable and k is the optimal lag length.

And, the formula for the error correction term is given as:

$$ECT = \varepsilon_t = y_t - \sum_{i=1}^{k} \theta_i x_{it} - \Psi w_t \tag{15}$$

where x_t and w_t is the first difference plus the lagged version of the variables.

3.8 Forecast Error Variance Decomposition (FEVD)

The Forecasted error variance decomposition displays which independent variables have the most significant effect on the dependent variable. More specifically, the FEVD describes how much of the forecasted error variance of each variable is explained as a consequence of exogenous imbalance in the other variables (Lütkepohl, 2007). In this report yields will be the response variable i.e. the variable we want to study as a result of shocks in the independent variables, the impulses. And the impulses are yields (to analyze how shocks in yields affect itself) current account to GDP, debt to GDP, unemployment rate (or total investments as IV for unemployment rate for Italy), logCPI and logGDP. Per definition, all the percentages for each period in the FEVD have to add up to 100%. Another benefit of the FEVD is that it shows how those percentages change over time, for instance one variable could have a minor effect in the short term, but significant effect in the long run.

The general formula for the forecasted error variance decomposition is as follows:

$$w_{jl,h} = \frac{\sum_{i=0}^{h-1} (e_j' \Theta_i e_l)^2}{MSE\left[y_{j,t}(h)\right]} \quad , \tag{16}$$

where MSE is defined as:

$$MSE[y_{j,t}(h)]\,) \; = \; \sum_{i=0}^{h-1} \sum_{l=1}^{k} (e_j' \Theta_i e_l)^2 \; = \; (\sum_{i=0}^{h-1} \Theta_i \Theta_i')_{jj} = \; (\sum_{i=0}^{h-1} \Phi_i \Sigma_u \Phi_i')_{jj} \tag{17}$$

3.9 Diagnostic Tests

3.9.1 Test for Normal Distribution of the Residuals - Jarque-Bera Test

Normal distribution of the residuals is a common assumption in many statistical models. To test for this, one can conduct the Jarque-Bera test, which is a goodness-of-fit test that takes into account both Kurtosis and Skewness. The Jarque-Bera statistics is nonnegative and a lower absolute value indicates a more normally distributed data.

The general Jarque-Bera statistics in regression is defined as:

$$JB \; = \frac{n-k}{6} (S^2 + \frac{1}{4}(K \; - \; 3)^2) \tag{17}$$

where n is the number of observations and k the number of regressors[2]

3.9.2 Test for Serial Correlation - Lagrange Multiplier Test

Serial correlation or autocorrelation refers to the correlation between a variable and the lagged version of that same variable. Forecasting with the VECM requires no autocorrelation at the selected lag-length, since that would not give an accurate representation of the results. To test for autocorrelation at the given lag-length, the Lagrange Multiplier test was employed. The null hypothesis states that there is no autocorrelation of any order at that given lag length.

[2] The formula for Skewness and Kurtosis can be seen in the descriptive statistics section of the methodology

3.9.3 Test for Stability - AR Root Test

Another diagnostic test is the stability test, which tests for how stable the model is. The model is considered to be stable if the unit root of the model is smaller than one and is inside the unit root circle (Usman et al., 2017). The stability test evaluates if the number of cointegration relationships is correctly identified.

According to (Lutkepohl, 2005) the formula for deriving the stability model is defined as:

$$y_t = c + \emptyset_1 y_{t-1} + \ldots \emptyset_p y_{t-p} + \varepsilon_t \tag{18}$$

4. Results

4.1 Descriptive Statistics Results

As seen in Table 2, there is not a significant difference between the mean and the median. The average deviation of the mean from the median for the US, Sweden, and Italy is 6.8%, 2.5%, and -5.36% respectively, this indicates that our data is somewhat symmetrical. The skewness test shows that there is relatively low skewness in our variables, most variables fall around the -0.5 to 0.5 intervall, indicating an approximately symmetrical distribution. However we do have some outliers, this is due to the nature of the data, some variables can change considerably during a relatively quick period due to unanticipated events and thus lead to skewness in the data. This can be observed by the quite high standard deviation scaled by the mean for a few variables. However in aggregate the data is relatively normally distributed as can be seen by the Jarque-Berra test, which is a goodness-of-fit test and takes into account both the skewness and kurtosis. The null hypothesis states that the residuals of the variables are normally distributed. As seen in Table 2, the residuals of all the variables for all countries can not be rejected at 5% significance level, with the exception of Yields for Italy.

Table 2 - Descriptive statistics

US	YIELD	LGDP	LCPI	UNEMPLOYEMNT RATE	CURRENT ACOOUNT TO GDP	DEBT TO GDP
MEAN	5,799206	9,156285	4,255374	6,307246	-2,536452	69,35751
MEDIAN	5,140833	9,251014	4,29963	5,84962	-2,32	61,27358
MAXIMUM	13,91083	10,04308	4,739046	9,860857	0,16	137,2
MINIMUM	0,8941667	7,957635	3,548725	3,718367	-5,76	31,01925
STD, DEV,	3,392751	0,6013883	0,3315931	1,693112	1,48131	26,59174
SKEWNESS	0,6920987	-0,3526958	-0,4114094	0,5904236	-0,2786102	0,7974246
KURTOSIS	2,655824	1,950618	2,041815	2,458599	2,735643	2,899574
JARQUE-BERA	3,56	2,798	2,792	2,953	0,6657	4,469
PROBABILITY	0,1686	0,2469	0,2476	0,2284	0,7169	0,1071
OBSERVATIONS	42	42	42	42	42	42
Sweden	**YIELD**	**LGDP**	**LCPI**	**UNEMPLOYEMNT RATE**	**CURRENT ACOOUNT TO GDP**	**DEBT TO GDP**
MEAN	3,914524	5,967729	4,490768	7,873607	4,503536	48,50921
MEDIAN	3,795833	6,063229	4,4895	7,596	4,4825	44,3055
MAXIMUM	10,24417	6,374755	4,67869	11,15	8,076	68,679
MINIMUM	-0,0383333	5,361072	4,269502	5,825	-1,249	34,873
STD, DEV,	0,3450837	0,3450837	0,12416	1,617907	2,045809	11,43061
SKEWNESS	-0,3401432	-0,3401432	-0,1483093	1,617907	-0,5291313	0,7227425
KURTOSIS	1,505784	1,505784	1,734495	2,58592	3,822204	2,06573
JARQUE-BERA	1,593	3,145	1,971	3,303	2,095	3,456
PROBABILITY	0,4509	0,2076	0,3732	0,1918	0,3508	0,1776
OBSERVATIONS	28	28	28	28	28	28
Italy	**YIELD**	**LGDP**	**LCPI**	**INVESTMENTStoGDP**	**CURRENT ACOOUNT TO GDP**	**DEBT TO GDP**
MEAN	5,229061	28,13766	4,422033	19,69486	0,4134828	120,2076
MEDIAN	4,487259	28,25027	4,449685	19,735	0,801	119,109
MAXIMUM	13,2663	28,50601	4,636426	22,246	3,547	155,812
MINIMUM	1,168292	27,69396	4,050341	16,892	-3,295	103,889
STD, DEV,	3,180002	0,2684994	0,1797555	1,652697	2,011242	13,00268
SKEWNESS	1,157745	-0,3338814	-0,4728762	-0,208596	-0,2457957	0,6854517
KURTOSIS	3,551833	1,494176	2,031795	1,814248	1,91527	2,930199
JARQUE-BERA	6,846	3,279	2,214	1,909	1,714	2,277
PROBABILITY	0,0326	0,1941	0,3306	0,385	0,4245	0,3203
OBSERVATIONS	29	29	29	29	29	29

4.2 Unit Root Results

Results for the stationary tests presented in Table 3 show that most of the variables are stationary at first difference I(1), with minor exceptions. In the case of the **United States**, logCPI and logGDP are stationary at level I(0). In the case of **Sweden**, the variable current account to GDP is stationary at level I(0). And the results for **Italy** indicate that the variables logCPI and Unemployment rate deviate from the rest of the variables; while the former is stationary at level I(0), the latter is stationary at the second difference I(2). Thus, the null hypothesis of no unit root at first difference could not be rejected. Time series models that have some variables stationary at level I(0) and others at first difference I(1) can still be analyzed if it is a multivariate model; in that case, testing the ARDL model for cointegration is appropriate (Pesaran and Shin, 1999).

Table 3 - Unit root test[3]

US	**ADF TEST**			**PP TEST**			
Variables	T - Values (lags)	5 % Critical value	P-value	T- Values (Bandwidth)	5 % Critical value	P-value	**Order of Intergation**
YIELD	-1,231	-2,955	0,6600	-1,116	-2,955	0,7087	**I(1)**
LGDP	-4,237	-2,955	0,0006	-5,259	-2,955	0,0000	**I(0)**
LCPI	-5,233	-2,955	0,0000	-4,853	-2,955	0,0000	**I(0)**
UNEMPLOYMENT RATE	-2,465	-2,955	0,1243	-2,594	-2,955	0,0943	**I(1)**
CURRENT ACCOUNT TO GDP	-1,957	-2,955	0,3056	-2,178	-2,955	0,2143	**I(1)**
DEBT TO GDP	1,428	-2,955	0,9972	1,168	-2,955	0,9958	**I(1)**
Sweden	**ADF TEST**			**PP TEST**			
Variables	T - Values (lags)	5 % Critical value	P-value	T- Values (Bandwidth)	5 % Critical value	P-value	**Order of Intergation**
YIELD	-0,962	-2,994	0,7667	-1,337	-2,994	0,768	**I(1)**
LGDP	-1,554	-2,994	0,1065	-1,556	-2,994	0,5058	**I(1)**
LCPI	-1,703	-2,994	0,4295	-1,441	-2,994	0,5624	**I(1)**
UNEMPLOYMENT RATE	-2,235	-2,994	0,1938	-2,628	-2,994	0,1758	**I(1)**
CURRENT ACCOUNT TO GDP	-3,232	-2,994	0,0182	-3,115	-2,994	0,0255	**I(0)**
DEBT TO GDP	-2,994	-2,994	0,6782,	-1,209	-2,994	0,6697	**I(1)**
Italy	**ADF TEST**			**PP TEST**			
Variables	T - Values (lags)	5 % Critical value	P-value	T- Values (Bandwidth)	5 % Critical value	P-value	**Order of Intergation**
YIELD	-2,524	-2,992	0,1096	-2,634	-2,992	0,0862	**I(1)**
LGDP	-1,025	-2,992	0,7442	-1,086	-2,992	0,7208	**I(1)**
LCPI	-6,084	-2,992	0,0000	-5,33	-2,992	0,0000	**I(0)**
UNEMPLOYMENT RATE	-1,209	-2,992	0,6698	-1,758	-2,992	0,4015	**I(2)**
CURRENT ACCOUNT TO GDP	-1,513	-2,992	0,5272	-1,932	-2,992	0,3171	**I(1)**
DEBT TO GDP	0,456	-2,992	0,9835	0,341	-2,992	0,9791	**I(1)**
INVESTMENTStoGDP	-1,629	-2,992	0,4679	-1,759	-2,992	0,4009	**I(1)**

4.3 Lag-length Selection Results

Selection of the optimal lag length was determined by using the three most common information criteria. The Akaike (AIC), Hannan-Quinn (HQC) and Schwarz-Bayesian (SBIC) information criteria. Table 4 shows that 2 lags is the optimal choice of lag length for all three countries and will be used when conducting the remaining tests. Given that the three information criteria's selection of lag length can differ at some points, the Akaike criteria was applied due to its accuracy when observations are few (Khim and Liew, 2004).

[3] ADF = Augmented Dickey Fuller, PP = Philips Perron

Table 4 - Lag length selection

lags **US**	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-237,567				0,007837	12,1783	12,2699	12,4317
1	73,8764	622,89	36	0	8,40E-09	-1,59382	-0,952644	**0,179501***
2	137,034	**126,32***	36	0	**2,4e-09***	**-2,95171***	**-1,76095***	0,341606
lags **Sweden**	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-133,023				0,001777	10,6941	10,7777	10,9844
1	17,8245	301,7	36	0	2,80E-07	1,85965	2,44488	**3,89196***
2	66,9421	**98,235***	36	0	**1,7e-07***	**0,850607***	**1,93747***	4,6249
lags **Italy**	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-181,782				0,044278	13,9098	13,9954	14,1978
1	23,7836	411,13	36	0	1,70E-07	1,34936	1,94875	**3,36511***
2	74,344	**101,12***	36	0	**8,9e-08***	**0,270817***	**1,38396***	4,01435

4.4 Cointegration Results

Johansens test for cointegration was conducted to see if the variables are cointegrated, when the trace statistics exceeds the 5% critical value, the null hypothesis of no cointegration relationships is rejected. Thus the results in Table 5 show that: for the **United States** there are at least two cointegration equations, for **Sweden** there are at least three cointegration equations and for **Italy** there are at least four cointegration equations. However according to (Lütkepohl et al., 2001) the Max-Eigenvalue Statistics is preferred over the trace statistics, this implies that Sweden has at least two rather than three cointegration equations. Employing the Max-Eigenvalue Statistics one can observe that the value for the **United States** is larger than the 5% critical value for zero and one cointegration equations. Thus the **United States** has at least two long run relationships between yields and the independent variables, since 21.7855 is less than 27.07. For **Sweden** one can observe that the Max-Eigenvalue Statistics is less than the 5% critical value on two cointegration equations, since 20.5012 is less than 27.07. For **Italy** the Max-Eigenvalue Statistics is less than the 5% critical value at four cointegration equations, since 9.6584 is less than 14.07.

Due to the different levels of integration, the Autoregressive Distributed lag model was also applied to test for cointegration between the variables. The null hypothesis states that there is no cointegration and is rejected when the F-statistics exceeds the lower (I0) and upper bound (I1) of each significance level. For the US, Sweden, and Italy the F-statistics are 7.09, 14.253, and 21.913 respectively. These values all exceed the upper bound of the critical value at 1% significance level. Thus the two tests are consistent, and show that there is cointegration between the variables.

Table 5 - Johansens test for cointegration

Hypothesized No. Of CE(S) US	Parms	LL	EigenValue	Trace Statistic	5% critical value	Max-Eigen Statistics	5% critical value
0	42	59,663865	NA	154,7406	94,15	70,6681	39,37
1	53	94,997912	0,8291	84,0725	68,52	44,5845	33,46
2	62	117,29015	0,67196	**39,4881***	47,21	**21,7855**	27,07
3	69	128,18289	0,41995	17,7026	29,68	8,7788	20,97
4	74	132,57228	0,19706	8,9238	15,41	8,318	14,07
5	77	136,73129	0,18775	0,6058	3,76	0,6058	3,76
6	78	137,03418	0,01503	NA	NA	NA	NA
Hypothesized No. Of CE(S) Sweden	Parms	LL	EigenValue	Trace Statistic	5% critical value	Max-Eigen Statistics	5% critical value
0	42	-8,2381542	NA	150,3605	94,15	64,4519	39,37
1	53	23,987779	0,91617	85,9087	68,52	36,094	33,46
2	62	42,03479	0,75048	49,8147	47,21	**20,5012**	27,07
3	69	52,285382	0,54548	**29,3135***	29,68	17,3531	20,97
4	74	60,961948	0,48697	11,9603	15,41	8,0751	14,07
5	77	64,999504	0,26698	3,8852	3,76	3,8852	3,76
6	78	66,942115	0,1388	NA	NA	NA	NA
Hypothesized No. Of CE(S) Italy	Parms	LL	EigenValue	Trace Statistic	5% critical value	Max-Eigen Statistics	5% critical value
0	42	-7,9925741	NA	164,6731	94,15	56,0243	39,37
1	53	20,019574	0,87444	108,6488	68,52	42,25	33,46
2	62	41,144578	0,79087	66,3988	47,21	26,9598	27,07
3	69	54,624477	0,63157	39,439	29,68	25,5005	20,97
4	74	67,374743	0,61111	**13,9384***	15,41	**9,6584**	14,07
5	77	72,20395	0,30073	4,28	3,76	4,28	3,76
6	78	74,343966	0,14659	NA	NA	NA	NA

Table 6 - ARDL bound test for cointegration

ARDL bound test			Significance	I0 bound	I1 bound
US	F-statistics	**7,09**	10,0%	2,26	3,35
Sweden	F-statistics	**14,253**	5,0%	2,62	3,79
Italy	F-statistics	**21,913**	2,5%	2,96	4,18
			1,0%	3,41	4,68

4.5 Vector Error Correction Model (VECM) Results

4.5.1 VECM Long Run Estimates Results for the US

Since all the variables are either in percentage -or natural logarithmic form, the coefficient should be interpreted as long run elasticities. All coefficients will be interpreted as a Ceteris paribus effect, meaning that a change in one variable should be interpreted as keeping everything else constant.

$$YIELD =- 89.86 + 3.11CAtoGDP - 0.62DEBTtoGDP - 3.12Urate - 111.92logCPI + 68.76logGDP \quad (19)$$

The results from the VECM show a positive and significant long run relationship between current account to GDP and yields. When the current account to GDP increases by 1% the yields tend to increase by 3.11%. At first glance the magnitude seems to be relatively high, however by examining the descriptive statistics one can observe that the maximum and minimum values for the yields has a longer range than the ones for current account to GDP, thus a 1% increase in current account to GDP is a significant amount considering that the historical values oscillates between -5% and 0%. However, the negative relationship is not in line with general economic theory. Debt to GDP and yields show a significant negative relationship. When debt to GDP increases by 1% the yields tend to decrease by 62 basis points, this is also contrary to economic theory. There is a significant negative relationship between unemployment rate and yields. When the unemployment rate increases by 1% the yields tend to decrease by 3.12%. By examining the VECM estimates for the United States one can also see that there is a significant negative relationship between logCPI and yields, as well as a significant positive relationship between logGDP and yields. When CPI increases by 1% yields tend to decrease by 1.12% and when GDP increases by 1% yields tend to increase by 69 basis points.

Table 7 - Long run VECM results and error correction terms for the US

Variables	Coef.	Std. ERR	z	P>|z|	[95% confidence interval]	
_ce1	-0,0175	0,0262	-0,67	0,504	-0,0688	0,0338
YIELD	1					
CAtoGDP	-3,1134	1,2191	-2,55	0,011	-5,5028	-0,7240
DEBTtoGDP	0,6165	0,1485	4,15	0,000	0,3254	0,9076
Urate	3,1185	0,4140	7,53	0,000	2,3071	3,9300
logCPI	111,9242	48,2006	2,32	0,020	17,4528	206,3956
logGDP	-68,7577	30,0427	-2,29	0,022	-127,6403	-9,8750
Constant	89,86356					
Variables	**D(YIELD)**	**D(CAtoGDP)**	**D(DEBTtoGDP)**	**D(Urate)**	**D(logCPI)**	**D(logGDP)**
Error correction term	-0,017504	-0,035919	0,048900	-0,049279	-0,000378	-0,000065
P>|z|	0,504	0,022	0,759	0,128	0,146	0,92

The Table also shows that the error correction term is insignificant for all variables except for current account to GDP. However the ECT for our dependent variable is negative, this is theoretically correct since we expect yields to move towards equilibrium. The adjustment speed of previous year's shocks is 1.75%, however it is statistically insignificant and can not be interpreted.

4.5.2 VECM Long Run Estimates Results for Sweden

The VECM results show a negative and significant long run relationship between Current account to GDP and yields. When Current account to GDP increases by 1% the yields tend to decrease by 22 basis points. Debt to GDP and yields show a significant negative relationship. When Debt to GDP increases by 1% yields tend to decrease by 12 basis points. There is also a significant positive relationship between unemployment rate and yields. When the unemployment rate increases by 1% the yields tend to increase by 50 basis points. By examining the VECM estimates for Sweden one can also see that there is a significant negative relationship between logCPI and yields, as well as a significant positive relationship between logGDP and yields. When CPI increases by 1% yields tend to decrease by 31 basis points and when GDP increases by 1% yields tend to increase by 1.5 basis points.

$$YIELD = 138.41 - 0.22CAtoGDP - 0.12DEBTtoGDP + 0.50Urate - 31.24logCPI + 1.47logGDP \quad (20)$$

Table 8 - Long run VECM results and error correction terms for Sweden

Variables	Coef.	Std. ERR	z	P>|z|	[95% confidence interval]	
_ce1	-1,0012	0,2302	-4,35	0,000	-1,4524	-0,5500
YIELD	1					
CAtoGDP	0,2160	0,0513	4,21	0,000	0,1154	0,3166
DEBTtoGDP	0,1228	0,0177	6,95	0,000	0,0881	0,1574
Urate	-0,5048	0,0528	-9,56	0,000	-0,6082	-0,4013
logCPI	31,2381	2,3867	13,09	0,000	26,5601	35,9160
logGDP	-1,4725	0,6315	-2,33	0,000	-2,7101	-0,2348
Constant	-138,4066					
Variables	**D(YIELD)**	**D(CAtoGDP)**	**D(DEBTtoGDP)**	**D(Urate)**	**D(logCPI)**	**D(logGDP)**
Error correction term	-1,0012	-0,2910	0,7270	0,6340	0,0005	0,0507
P>|z|	0,000	0,567	0,605	0,043	0,846	0,221

The Table also shows that the error correction term is insignificant for all variables except for yields and unemployment rate. The ECT for our dependent variable is negative, this is theoretically correct since we expect yields to move towards equilibrium, the adjustment speed of previous year's shocks is approximately 100%, unemployment rate also has significant ECT, which is 63.4%, however its positive, meaning that the process will not converge in the long run.

4.5.3 VECM Long Run Estimates Results for Italy

The long run VECM results for Italy show a significant negative relationship between Current account to GDP and yields. As current account to GDP increases by 1% the yields tend to decrease by 27 basis points. Debt to GDP and yields show a significant positive relationship. When debt to GDP increases by 1% the yields tend to increase by 9 basis points.

By examining the VECM estimates for Italy one can also see that there is a significant negative relationship between CPI and yields. When CPI increases by 1% yields tend to decrease by 4.5 basis points. There is also an insignificant negative relationship between Total investments to GDP and a positive insignificant relationship between yields and logGDP and yields. These two results will not be analyzed.

$$YIELD =- 5.29 - 0.27CAtoGDP + 0.09DEBTtoGDP - 0.16InvestmenttoGDP - 4.5logCPI + 0.75lognGDP \quad (21)$$

Table 9 - Long run VECM results and error correction terms for Italy

Variables	Coef.	Std. ERR	z	P>|z|	[95% confidence interval]	
_ce1	-0,1173	0,1689	-0,69	0,487	-0,4484	0,2137
YIELD	1					
CAtoGDP	0,2681	0,1186	2,26	0,024	0,0356	0,5005
DEBTtoGDP	-0,0867	0,0360	-2,41	0,016	-0,1574	-0,0161
INVESTMENTStoGDP	0,1603	0,2275	0,7	0,481	-0,2856	0,6062
logCPI	4,5024	2,0267	2,22	0,026	0,5302	8,4747
logGDP	-0,7534	0,9581	-0,79	0,432	-2,6313	1,1245
Constant	5,2887					
Variables	**D(YIELD)**	**D(CAtoGDP)**	**D(DEBTtoGDP)**	**D(INVESTMENTStoGDP)**	**D(logCPI)**	**D(logGDP)**
Error correction term	-0,117333	-0,6016205	-1,911829	0,3252644	0,0052271	0,0062516
P>|z|	0,487	0,000	0,089	0,047	0,002	0,747

Table 9 also shows that the error correction term is insignificant for all variables except for current account to GDP, Total investments to GDP and CPI at the 5 % critical value. The ECT for our dependent variable is negative, this is theoretically correct since we expect yields to move towards equilibrium, the adjustment speed of previous year's shock is approximately 11%, however this result is statistically insignificant. Current account to GDP, Total investments to GDP and logCPI have significant ECT's, negative 60 % and positive 33 % and positive 0.2 % respectively. Since total investment to GDP was used as an instrument for unemployment rate, we would expect similar results for unemployment rate. However, due to a negative 0.81 correlation between unemployment rate and total investments to GDP the sign of total investment to GDP should be switched to interpret the effect of unemployment rate.

4.5.4 VECM Short Run Estimates Results for the US

The short-run error correction results for the **United States** show that none of the coefficients are significant. The adjustment coefficient of – 0.0175 for yields explains that the previous period's deviation from the long-run equilibrium is corrected in the current period at an adjustment speed of 1.75 %. In the short run, current account and debt to GDP positively affect yields, while the Unemployment rate, CPI, and GDP have a negative effect on yields. This is contrary to economic theory, but since all variables are insignificant at a 5% level, we infer that the coefficients of the variables are inconclusive in the short run. The R squared value indicates that the independent variables explain only 25 percent of our model and the model is statistically insignificant.

Table 10 - Short run VECM results for US

Variables	Coefficient	P>|z|
_ce1	-0,0175036	0,504
D(YIELD)(-1))	-0,0204804	0,906
D(CAtoGDP(-1))	0,000711	0,998
D(DEBTtoGDP(-1))	0,0685663	0,317
D(Urate(-1))	-0,2288508	0,445
D(logCPI(-1))	-14,48775	0,358
D(logGDP(-1))	-3,084108	0,851
R-squared	**0,2464**	**0,2339**

4.5.5 VECM Short run Estimates Results for Sweden

The results for **Sweden** in Table 11 show that the adjustment coefficient of -1.001 for yields explains the previous year's deviation from the long run equilibrium is corrected at an adjustment rate of 100 % within this year; this value is significant at the 5 % level. All variables except logGDP positively affect yields in the short run, while only logCPI and yields are significant at the 5 % level. An increase of 1 % in CPI in the previous year will increase yields this year by approximately 39 basis points. While a 1 % increase in yields last year will increase yields this year by 49 basis points. The model is significant and the R-squared value implies that the observed variables explain about 68 % of the model.

Table 11 - Short run VECM results for Sweden

Variables	Coefficient	P>|z|
_ce1	-1,001235	0,000
D(YIELD)(-1))	0,4432185	0,009
D(CAtoGDP(-1))	0,1889097	0,098
D(DEBTtoGDP(-1))	0,0382863	0,373
D(Urate(-1))	0,0341259	0,833
D(logCPI(-1))	38,6128	0,046
D(logGDP(-1))	-0,547983	0,672
R-squared	**0,6794**	**0,0000**

4.5.6 VECM Short Run Estimates Results for Italy

The short-run error results for **Italy** can be observed in Table 12. The results show that all variables affect yields positively with the exception of Current account to GDP and logGDP which have negative effects on yields. The variables that are significant are Debt to GDP and Total Investments to GDP, and implies that a 1 % increase in Debt to GDP in previous year will negatively affect the yield this year by 23 basis points. While an increase in Total investments to GDP by 1 % the previous year will positively affect yields the current year by 76 basis points. The deviation from the previous period long run equilibrium is adjusted at a rate of 11.7 % this period, this value is insignificant at 5 % level. The model is significant and has an R-squared of 0.66 , i.e approximately 66 % of the variation in yields are explained by the observed variables. Since total investment to GDP was used as an instrument for unemployment rate, we would expect similar results for unemployment rate. However, due to a negative 0.81 correlation between unemployment rate and total investments to GDP the sign of total investment to GDP should be switched to interpret the effect of unemployment rate.

Table 12 - Short run VECM results for Italy

Variables	Coefficient	P>|z|
_ce1	-0,117333	0,487
D(YIELD)(-1))	0,2226403	0,194
D(CAtoGDP(-1))	-0,257107	0,205
D(DEBTtoGDP(-1))	0,2256322	0,000
D(INVESTMENTStoGDP(-1))	0,7613867	0,022
D(logCPI(-1))	20,81496	0,542
D(logGDP(-1))	-0,642508	0,741
R-squared	**0,6565**	**0,0000**

4.6 Diagnostic Tests Results

Three diagnostic tests were conducted to test for stability, autocorrelation, and normal distribution of residuals of the model. The stability of the model was conducted through an AR test, the result shows that the VECM for all three countries is stable. To test for autocorrelation, a Lagrange-multiplier test was conducted, at a 5% critical P-value and at 2 lags no autocorrelation was found in the models for all three countries. To test if the residuals are normally distributed, a Jarque-Bera test was applied. The result states that the model is not normally distributed, however, by analyzing the detailed results, one can observe that it is only one variable that is not normally distributed. But since it has an unusually high Chi-squared value it skews the average Chi-squared value of the entire model, nonetheless the majority of the variables are normally distributed.

The model is stable, shows no autocorrelation, and has a good fit, implying that correct causal relationship analysis could be made and that the model is consequential in explaining the determinant of yields.

Table 13 - Diagnostic results

Country		US		Sweden		Italy		All
Test	**Null Hypothesis**	**Test statistics**	**P-value**	**Test statistics**	**P-value**	**Test statistics**	**P-value**	**Conclusion**
AR root graph	Stable model	$\sum_{i=1}^{n} a_i < 1$	NA	$\sum_{i=1}^{n} a_i < 1$	NA	$\sum_{i=1}^{n} a_i < 1$	NA	The model is stable
Autocorrelation LM test	No autocorrelation	At lag 2, LM stat = 35,9289	0,47198	At lag 2, LM stat = 27,5877	0,84157	At lag 2, LM stat = 39,7714	0,30578	No serial correlation at 2 lags
Jarque Bera	Residuals are normally distributed	JB=612,213 due to DEBTtoGDP	0,0000	JB= 33,276 due to Yields	0,00088	JB=54,521 due to DEBTtoGDP	0,00000	Majority of the variables are normally distributed

4.7 Forecast Error Variance Decomposition (FEVD) Results

The variance decomposition describes how much variation in each variable is explained by the variations in the dependent variable.

4.7.1 United States

For the United States we observe that in the second year, shocks in yields account for most of the variation of itself. This trend continues throughout the 8 year time period. This is contrary to economic theory and will be further discussed in the analysis section. Below, one can observe that the variables of Sweden and Italy have higher explanatory strength compared to the US, this will also be discussed in detail.

Table 14 - Forecast error variance decomposition for the US

Period	YIELD	LogGDP	logCPI	CAtoGDP	DEBTtoGDP	Urate
0	0	0	0	0	0	0
1	100,0%	0,0%	0,0%	0,0%	0,0%	0,0%
2	98,5%	0,0%	0,8%	0,1%	0,4%	0,1%
3	98,0%	0,1%	1,4%	0,1%	0,3%	0,1%
4	97,7%	0,1%	1,7%	0,1%	0,3%	0,1%
5	97,4%	0,2%	1,8%	0,1%	0,2%	0,3%
6	97,0%	0,3%	1,8%	0,1%	0,3%	0,4%
7	96,6%	0,3%	1,8%	0,2%	0,4%	0,6%
8	96,1%	0,4%	1,7%	0,2%	0,7%	0,8%

4.7.2 Sweden

For Sweden we observe that in the second year, the variable unemployment rate explains most of the variation in yields. While in the third and fourth year it is Debt to GDP that accounts for most of the variation in yields. From the fifth year through the eighth year CPI explains most of the variation in the yields and accounts for almost 16 %.

Table 15 - Forecast error variance decomposition for Sweden

Period	YIELD	LogGDP	logCPI	CAtoGDP	DEBTtoGDP	Urate
0	0	0	0	0	0	0
1	100,0%	0	0	0	0	0
2	92,6%	0,3%	0,8%	1,0%	1,6%	3,7%
3	74,5%	0,3%	6,8%	1,4%	9,8%	7,3%
4	64,4%	0,2%	11,9%	2,6%	13,1%	7,8%
5	62,6%	0,2%	14,1%	2,6%	12,8%	7,7%
6	63,1%	0,2%	14,7%	2,3%	12,0%	7,7%
7	62,8%	0,2%	15,3%	2,0%	11,7%	8,0%
8	61,8%	0,2%	16,0%	1,9%	11,8%	8,2%

4.7.3 Italy

From the second year through the eighth year the variable Debt to GDP accounts for most of the variation in yields. Although debt to GDP has the most significant effect on the variation of yields, Current account to GDP and Investments to GDP also have minor affect in the variation of yields. Since total investment to GDP was used as an instrument for unemployment rate, we would expect similar results for unemployment rate.

Table 16 - Forecast error variance decomposition for Italy

Period	YIELD	LogGDP	logCPI	CAtoGDP	DEBTtoGDP	INVESTMENTStoGDP
0	0	0	0	0	0	0
1	100%	0	0	0	0	0
2	61,5%	0,1%	0,1%	4,8%	29,9%	3,6%
3	49,2%	0,3%	0,5%	4,4%	43,1%	2,4%
4	43,6%	0,3%	0,4%	4,3%	48,1%	3,3%
5	40,8%	0,3%	0,4%	4,4%	50,6%	3,4%
6	38,0%	0,4%	0,4%	4,6%	53,0%	3,6%
7	35,7%	0,5%	0,4%	4,7%	54,6%	4,1%
8	33,9%	0,6%	0,4%	4,8%	55,5%	4,7%

4.8 Autoregressive Distributed Lag Model (ARDL) Results

Some of the macroeconomic variables are inherently stationary at level, perhaps due to government policies to keep some variables stable at a given level. Hence, this report will also include the ARDL estimates which takes into account the different orders of integration. The coefficients should be interpreted as ceteris paribus effects and the signs should not be reversed as in the long-run VECM.

4.8.1 ARDL Long Run Estimates Results and Adjustment Coefficient for the US

The adjustment coefficient for yield is -0.847 and it is significant at a 5% critical level. The negative sign is correctly stated as one would expect the yields to adjust to equilibrium and not make the model explosive, and thus shocks in the previous period will be adjusted within the current period at a speed of 84.73%. The significant long run estimates are: CAtoGDP, DEBTtoGDP, and logCPI. Thus, 1% increase in current account to GDP will increase yields by 67 basis points and 1% increase in debt to GDP will decrease yields by 6.6 basis points. Lastly, 1% increase in CPI will decrease yields by 21 basis points.

Table 17 - Long run ARDL results and adjustment term for the US

Variables	Coef.	Std. ERR	z	P>|z|	[95% confidence interval]	
YIELD ADJ.	-0,847315	0,143879	-5,89	0,000	-1,14158	-0,553049
CAtoGDP	0,6724065	0,1913014	3,51	0,001	0,2811512	1,063662
DEBTtoGDP	-0,066365	0,0196645	-3,37	0,002	-0,106583	-0,0261461
Urate	0,2066648	0,1072018	1,93	0,064	-0,012588	0,4259172
logCPI	-21,41155	10,31453	-2,08	0,047	-42,50714	-0,3159635
logGDP	11,18122	5,957367	1,88	0,071	-1,002959	23,36541

4.8.2 ARDL Long Run Estimates Results and Adjustment Coefficient for Sweden

The long run estimates for Sweden show that all variables have a significant effect on yields except of current account to GDP and logGDP. The adjustment coefficient of yields will overshoot the current period by adjusting at a rate of 118 % due to the shock from the previous period. In the long run, 1 % increase in Debt to GDP tends to decrease yields by 14 basis points. An increase in unemployment rate by 1 % will increase yields by 44 basis points and an increase in CPI by 1 % will decrease yields by 35 basis points.

Table 18 - Long run ARDL results and adjustment term for Sweden

Variables	Coef.	Std. ERR	z	P>|z|	[95% confidence interval]	
YIELD ADJ.	-1,17894	0,2260809	-5,21	0,001	-1,69037	-0,6675092
CAtoGDP	-0,29591	0,1532408	-1,93	0,086	-,6425648	0,0507446
DEBTtoGDP	-0,144877	0,0475553	-3,05	0,014	-0,252454	-0,0372991
Urate	0,4414192	0,1230092	3,59	0,006	0,163153	0,7196853
logCPI	-35,25493	7,115392	-4,95	0,001	-51,35107	-19,1588
logGDP	2,357084	1,714233	1,38	0,202	-1,52078	6,234947

4.8.3 ARDL Long Run Estimates and Adjustment Coefficient Results for Italy

The adjustment coefficient for yields is -0.88 and it is significant at a 5% critical level. The negative sign is correctly stated as one would expect the yields to adjust to equilibrium and not make the model blow up, and thus shocks in the previous period will be adjusted within the current period at a speed of 88%. The significant long run estimates are: CAtoGDP, DEBTtoGDP, and CPI. Thus, 1% increase in current account to GDP will decrease yields by 48 basis points and 1% increase in debt to GDP will increase yields by 17 basis points. Lastly, 1% increase in CPI will decrease yields by 11 basis points.

Table 19 - Long run ARDL results and adjustment term for Italy

Variables	Coef.	Std. ERR	z	P>|z|	[95% confidence interval]	
YIELD ADJ.	-0,8808363	0,110598	-7,96	0,000	-1,11657	-0,6451023
CAtoGDP	-0,4754932	0,0984035	-4,83	0,000	-0,685235	-0,2657512
DEBTtoGDP	0,1663971	0,0244075	6,82	0,000	0,1143738	0,2184204
INVESTMENTStoGDP	0,3748878	0,1791302	2,09	0,054	-0,006919	0,7566948
logCPI	-10,8154	2,213613	-4,89	0,000	-15,5336	-6,097195
logGDP	1,200611	0,9653814	1,24	0,233	-0,857051	3,258273

4.8.4 ARDL Short Run Estimates[4]

Only the variables with one lag or more will be displayed in the short run model, since variables with zero lags can by definition not be interpreted in the short run due to them not responding to a shock that will trigger a deviation from the long run equilibrium.

[4] D1 stands for first difference while LD stands for lagged difference.

4.8.5 ARDL Short Run Estimates Results and Significance of the Model for the US

The short run Autoregressive distributed lag estimates for the **US** shows that there is a positive relationship between all the variables and yield. The variables that display significant relationships are: logCPI and logGDP. An increase in CPI by 1 % tends to increase yields by approximately 25 basis points. While an increase in GDP by 1 % will increase yields by 27 basis points. The model is significant and the adjusted R-squared is approximately 0.57, implying that 57% of the variation in the model is explained by the independent variables.

Table 20 - Significant short run ARDL results for the US

Variables	Coefficient	P>|z|
DEBTtoGDP(D1.)	0,0814911	0,089
logCPI(D1.)	25,44366	0,022
logGDP(D1.)	26,80762	0,011
logGDP(LD.)	12,62232	0,065
Adj. R-squared	**0,5731**	**0,0000**

4.8.6 ARDL Short Run Estimates Results and Significance of the Model for Sweden

The results for **Sweden** shows that there is a positive relationship between all variables and yields in the short run, with the exception of lagged difference of unemployment rate and the lagged difference of logGDP. However, the variables that are statistically significant at the 5 % critical value are: the lagged difference of current account to GDP, the first difference of debt to GDP, the lagged difference of debt to GDP, and the first difference of logCPI.

The effect that the significant variables have on yields in the short run are: a 1 % increase in the lagged version of the current account to GDP will increase yields in the current period by 39 basis points. While a 1 % increase in debt to GDP tends to increase yields by 10 basis points. A 1 % increase in the lagged version of debt to GDP will lead to an increase in yields by 11 basis points and a 1 % increase in CPI will increase yields by 76 basis points. The model is significant and the adjusted R-squared is approximately 0.82, implying that 82% of the variation in the model is explained by the independent variables.

Table 21 - Significant short run ARDL results for Sweden

Variables	Coefficient	P>|z|
Yields(LD.)	0,2289785	0,253
CAtoGDP(D1.)	0,2412766	0,108
CAtoGDP(LD.)	0,3869875	0,004
DEBTtoGDP(D1.)	0,1000202	0,022
DEBTtoGDP(LD.)	0,1106859	0,011
Urate(D1.)	0,0930783	0,580
Urate(LD.)	-0,2097886	0,170
logCPI(D1.)	76,06526	0,001
logGDP(D1.)	0,2078505	0,880
logGDP(LD.)	-1,478363	0,266
Adj. R-squared	**0,8154**	**0,0000**

4.8.7 ARDL Short Run Estimates Results and Significance of the Model for Italy

The short run estimates for **Italy** with the ARDL approach show that most of the variables have a positive relationship with yields with the exception of Debt to GDP and logGDP and all variables are statistically significant besides logGDP.

The effect that the significant variables have on yields in the short run are: A 1 % increase in Current account to GDP tends to increase yields by 34 basis points. While a 1 % increase in Debt to GDP will decrease yields by 15 basis points. LogCPI and the lagged version of logCPI are also statistically significant and indicate that a 1 % increase in CPI will decrease yields by 58 basis points and a 1 % increase in the lagged version of CPI will increase yields in the current period by 65 basis points. The adjusted R-squared is 0.90, that is 90 % of the model is explained by the observed variables.

Table 22 - Significant short run ARDL results for Italy

Variables	Coefficient	P>|z|
CAtoGDP(D1.)	0,3381113	0,017
DEBTtoGDP(D1.)	-0,1470473	0,000
logCPI(D1.)	57,74409	0,000
logCPI(LD.)	65,14312	0,003
logGDP(D1.)	-2,210999	0,061
Adj. R-squared	**0,9072**	**0,0000**

5. Analysis and Conclusion

One interesting conclusion from this report is that the macroeconomic variables that have the most effect on yields vary depending on the country in question. For instance, according to the variance decomposition, after 8 years the macroeconomic variables in the US explain in aggregate only 3.9% of the variation in yields, for Sweden the variables explain 38.2%, and for Italy they explain 66.1% of the variation. Hence it seems like the financial institutions in the financial markets that make up the majority of the trading volume, put varying emphasis on the macroeconomic variables depending on the perceived riskiness of the country. The US government bonds are considered to be risk-free and thus during both expansionary -and contractionary economic cycles, capital still flows to the US, regardless of the development of the macroeconomic variables. This can be attributed to the powerful position of the US, since the US debt is denominated in US dollars, the same currency as the global reserve currency. Suffice it to say, investors don't have a choice except to invest in the US, whether the macroeconomic variables are showing a positive or negative trend. One clear example is the fact that China owns approximately 20% of the total value of Treasury bills, notes, and bonds held by foreign countries or about 3.5% of the US national debt (United States Department of Treasury, 2021). China does not only own US bonds exclusively for the returns they offer, it simply does not have any other alternative to invest their funds. China also wants to artificially keep the RMB low compared to the US dollar to keep Chinese exports competitive, and it can use the US dollar's reserves as a financial weapon to increase US interest rates by selling a huge amount of bonds in the market, causing a precipitous hike in the US interest rates. The data suggests that the US is a special case of a country that has benefitted from the "flight to safety" and the "safe haven" flows phenomenon. Hence the fact that macroeconomic variables explain only a miniscule amount of the variation in yields and the fact that some variables can show causal effects that are counterintuitive to economic theory can be attributed to the explanation above.

These phenomena are illustrated in Table 23. The Table shows the long run relationships between the observed variables and yields from the VECM and ARDL model, with one minor adjustment for Italy. Unemployment rate and investment to GDP have strong negative correlation of -0.81, hence the sign of the IV variable has to be reversed to get the relationship of unemployment rate. The results show that the variables for the US have an inverse relationship to the variables for Sweden and Italy in the majority of cases, this is mainly due to the phenomena discussed previously.

Table 23 - Long run relationship between macroeconomic variable and yields

Relationship between variable and Yields

VECM long run	US	Sweden	Italy	ARDL long run	US	Sweden	Italy
Current account to GDP	positive**	negative***	negative**	Current account to GDP	positive***	negative*	negative***
Debt to GDP	negative***	negative***	positive**	Debt to GDP	negative***	negative**	positive***
Investments to GDP	NA	NA	negative	Investments to GDP	NA	NA	positive*
Unemployment	negative***	positive***	positive	Unemployment	positive*	positive***	negative
logCPI	negative**	negative***	negative**	logCPI	negative**	negative***	negative***
logGDP	positive**	positive***	positive	logGDP	positive*	positive	positive

*Significant at 10%,5%, 1% = *,**,*** Grey color indicate dispreptency between the two models and Orange color indicate contradiction to economic theory*

Some variables show relationships with yields that are in line with economic theory, for instance current account to GDP has a significant negative relationship and unemployment show a significant positive relationship with yields. For exporting countries such as Sweden and Italy an increase in current account indicates a strong economy and thus the bonds are perceived less risky. Higher unemployment rate indicates a deteriorating economy and thus the bonds become riskier, leading to a selloff and thus increase in yields.

LogGDP shows a positive relationship with yields, this result is ambiguous. Since higher GDP growth could be interpreted in two ways: firstly, higher growth leads to higher money demand and interest rates have to rise to compensate borrowers and it could also be an indicator that the economy is overheating and thus market participants expect inflation to rise and consequently bid up the yields in the market. Secondly, higher growth could also indicate a strong economy with an expected decrease in the debt to GDP ratio and thus lower the perceived riskiness, leading to decrease in yields.

However some variables show relationships that are not in line with economic theory. For instance, debt to GDP for Sweden shows a significant negative relationship with yields. This is contrary to economic theory, since higher debt levels should increase the riskiness of the bonds. Possible explanations could be that we have omitted important control variables or that the amount of observations for Sweden are not sufficient. Another possible explanation could be that Sweden has a rather low debt to GDP ratio that has steadily declined for the last 25 years and is well below the European average. Thus an increase in Sweden's debt to GDP could be interpreted as regression towards normality, indicating a strengthening economy if the return on investments exceeds the cost of debt.

LogCPI shows a significant negative relationship with yields for all countries in both models, this is also contrary to economic theory. According to the Fisher-effect, given a level of real interest rates, an increase in inflation should lead to the same increase in nominal interest rates (yields). This is intuitive, since investors require higher yields as inflation rises. Possible explanations for this could be that observations are too small or some important control variable is omitted. Another explanation for Sweden could be that there is an overshooting effect in the short-run and thus a negative adjustment in the long-run. This explanation can be reinforced by the data in Table 24; Sweden correctly shows a significant positive relationship between logCPI and yields as well as an adjustment speed that exceeds 100%, indicating overshooting in the short-run. Italy also shows a negative relationship between logCPI and yields, which is incorrect. Another possible explanation for this could be that Italy has been a huge beneficiary of the EMU system and has been able to secure cheap credit. Without the EMU Italy would probably not be able to borrow at these low rates, this is in line with the data since debt to GDP has been increasing for the last 30 year while yields have been decreasing. The EU zone may consider these cheap loans to Italy as a benefit for the whole union. Alternatively, the EU provides these cheap loans to Italy since it does not want Italy to secure credit from its adversaries, such as China or Russia. Lastly, we could have a case in which the massive quantitative easing (QE) programs have counteracted the market forces and made market participants follow the direction of the central banks and thus conduct trades that are not in line with economic theory. For instance if the unemployment rate increases and market participants expect the central bank to employ huge QE programs, they will not sell the bonds since they expect the price to go up despite the increasing unemployment rate.

Table 24 - Short run relationship between macroeconomic variable and yields

Relationship between variable and Yields

VECM short run	US	Sweden***	Italy	ARDL short run	US*	Sweden	Italy**
Adjustment speed	1,75%	100,12%	11,73%	Adjustment speed	84,7%	117,9%	88,1%
Current account to GDP	positive	positive*	negative	Current account to GDP			positive**
Debt to GDP	positive	positive	positive***	Current account to GDP(-1)		positive***	
Investments to GDP	NA	NA	positive**	Debt to GDP	positive*	positive**	negative***
Unemployment	negative	positive	negative	Debt to GDP(-1)		positive**	
logCPI	negative	positive**	positive	logCPI	positive**	positive***	positive***
logGDP	negative	negative	negative	logCPI(-1)			positive***
				logGDP	positive**		negative**
				logGDP(-1)	positive**		
R-squared	**0,2464**	**0,6794*** **	**0,6565*** **	**R-squared**	**0,5731*** **	**0,8154*** **	**0,9072*** **

*Significant at 10%,5%, 1% = *,**,*** [Country* indicate significance of ECT/ADJ term and R-squared* indicate significance of model] Grey color indicate dispreptency between the two models*

Regarding Sweden the results of the FEVD show that the macroeconomic variables explain 38.2% of the variance in yields, with logCPI (16%) , debt to GDP (11.8%), and unemployment rate (8.2%) as the main indicators. While the results for Italy show that the variables explain 66,1% of the variance in yields, with debt to GDP (55.5%), current account to GDP (4.8%), and total investments to GDP (4.7%, the instrumental variable for unemployment rate) as the main indicators. Two important conclusions can be drawn from this data: firstly, macroeconomic fundamentals in countries with higher perceived riskiness have more influence on investment decisions in the financial markets and secondly, investors pay attention to different macroeconomic variables depending on the country. First point, when investors decide to purchase sovereign bonds in a country that has a negative sentiment attached to it, they tend to base their thought process in line with the development of the underlying macroeconomic variables, i.e. buy the bonds when the variables show a positive change and sell the bonds when they show a negative change. For a country with low perceived risk, the market participants tend to put more emphasis on future expected outlook rather than macroeconomic variables, as seen in the US.

Second point, the data suggests that market participants put different weights on the macroeconomic variables depending on the country in question. For instance, in Sweden inflation is the main variable of interest, while in Italy, debt to GDP is the main indicator. One possible explanation for this is that investors are backward looking and thus put more emphasis on the variables that the country has faced difficulties with historically. Sweden had an inflation rate almost double that of the average EU zone in the late 1980s and early 1990s. While Italy is notorious for having a rather high debt to GDP ratio, in fact, it has been approximately 40 percentage points higher than that of the EU zone (Federal Reserve Economic Data, 2022). Thus, market participants put more emphasis on the macroeconomic variables that show signs of deterioration instead of using a standardized approach when determining the riskiness of a sovereign bond.

In an era of rising debt levels, stagflationary winds, and full-scale war, it is of paramount importance to further study the macroeconomic determinants of sovereign credit risk. We suggest improvements in further research by: Adding more countries, to get a more holistic view of how the interpretation of the macroeconomic variables changes. For instance one could add developing countries or choose countries with more available observations to analyze if there is a discrepancy. We believe that an interesting future research would build on our thought process and make adjustments to the independent variables. Possible improvements could be to use the variance of the variables instead of the reported values to differentiate between countries that have volatile economies that depend on commodity prices or are politically unstable. We would also suggest using other statistical models such as panel data models that can better analyze several countries. As well as employing creative ways to measure credit risk, for instance by using risk premia or credit ratings. Another crucial improvement is to control for variables that measure market psychology and the sentiment towards a country, since the perceived riskiness of a sovereign bond is greatly affected by market sentiment towards the specific country.

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Appendix[5]

```
// Adam & Rashid

//Choose Urate for the US and Sweden, and INVESTMENTStoGDP for Italy

// set yearly time series and generate log(variable)
tsset Year
gen logCPI = log(CPI)
gen logGDP = log(nGDP)

//descriptive statistics
sum Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP Urate logCPI logGDP, detail

//stationarity test
dfuller Yields
dfuller d.Yields
dfuller CAtoGDP
dfuller d.CAtoGDP
dfuller DEBTtoGDP
dfuller d.DEBTtoGDP
dfuller Urate
dfuller d.Urate
dfuller d2.Urate
dfuller logCPI
dfuller d.logCPI
dfuller logGDP
dfuller d.logGDP
corr INVESTMENTStoGDP Urate
dfuller INVESTMENTStoGDP
dfuller d.INVESTMENTStoGDP

pperron Yields
pperron d.Yields
pperron CAtoGDP
pperron d.CAtoGDP
pperron DEBTtoGDP
pperron d.DEBTtoGDP
pperron Urate
pperron d.Urate
pperron d2.Urate
pperron logCPI
pperron d.logCPI
pperron logGDP
pperron d.logGDP
pperron INVESTMENTStoGDP
pperron d.INVESTMENTStoGDP

// test for cointegration: Johansens and ARDL bound test

vecrank Yields CAtoGDP DEBTtoGDP Urate logCPI logGDP, max
vecrank Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP logCPI logGDP, max

ardl Yields CAtoGDP DEBTtoGDP Urate logCPI logGDP, maxlags(2) aic
ardl Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP logCPI logGDP, maxlags(2) aic
matrix list e(lags)
ardl Yields CAtoGDP DEBTtoGDP Urate logCPI logGDP, lags(1 1 1 0 2 1) ec btest
ardl Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP logCPI logGDP, lags(1 1 1 0 2 1) ec btest

//Choice of optimal lag-length
varsoc Yields CAtoGDP DEBTtoGDP Urate logCPI logGDP, maxlag(2)
varsoc Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP logCPI logGDP, maxlag(2)
```

[5] For complete appendix please email: gusalebad@student.gu.se

```

// Vector error correction model
vec Yields CAtoGDP DEBTtoGDP Urate logCPI logGDP, trend(constant) lags(2)
vec Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP logCPI logGDP, trend(constant) lags(2)

//diagnostic tests: autocorrelation, stability, and normal distribution

veclmar
vecstable
vecnorm

// Forcast error variance decomposition
irf set irf
irf create IRF, step(8)
irf table fevd, irf(IRF) impulse(Yields CAtoGDP DEBTtoGDP Urate logCPI logGDP) response(Yields) noci
irf table fevd, irf(IRF) impulse(Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP logCPI logGDP) response(Yields) noci

// Autoregressive distributed lag model
ardl Yields CAtoGDP DEBTtoGDP Urate logCPI logGDP, maxlags(2) aic
ardl Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP logCPI logGDP, maxlags(2) aic
matrix list e(lags)
ardl Yields CAtoGDP DEBTtoGDP Urate logCPI logGDP, lags(1 1 1 0 2 1) ec btest
ardl Yields CAtoGDP DEBTtoGDP INVESTMENTStoGDP logCPI logGDP, lags(1 1 1 0 2 1) ec btest

```