DEFAULT RISK PREMIUM AND THE YIELD CURVE

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1 Introduction

In this paper, we examine the impact of various macroeconomic variables on the risk premium and term structure for Greece, using OLS regression model with monthly data from 2000 to 2020. According to the literature on the risk premium and term structure, we expected the variables we used to be statistically significant, as it has been noted that these two variables have a close relationship with the macroeconomic environment and help in interpreting the results. As a proxy for the term risk, we used the difference between the 10-year Greece bond yield and the 10-year German bond yield. For the term structure level proxy, we used the difference between the 10-year Greece bond yield and the 3-month Greece bond yield. Our findings regarding the risk premium show a negative impact from the S&P 500, indicating that an improvement in the overall economic conditions enhances Greece's economy and therefore reduces the likelihood of default. As a result, there is a lower additional yield required from an investor to hold a Greek bond. For the term structure, none of the variables were statistically significant based on the model analysis. One of the possible factors is that the long-term economic crisis experienced by Greece significantly altered the interactions between macroeconomic variables and the risk premium and term structure. Additionally, due to Greece's poor economic condition, the bond market did not contribute significantly to the country's economic growth, thereby influencing the interaction of the yield curve level with macroeconomic variables.

2 Literature Review

Starting with default risk, the study by Gharghori et al. (2009) showed, using a Fama-MacBeth regressions model, that default risk is negatively related to equity returns. Based on a sample of Australian companies from 1995 to 2003 and using default probability as a proxy for default risk. In 2007, one of the most severe financial crises began on a global scale. Related to this event is the research by Naifar (2011), which studies the effects of the subprime crisis on the default risk premium. According to this study, the default risk premium for Japanese market during the period from 2006 to 2009 can be explained by the condition and volatility of the stock market, which includes Japanese index returns, and macroeconomic variables, specifically the consumer price index(CPI) and changes in the industrial production index(IPI). A subsequent study was conducted by Mpapalika and Malikane (2019), in which they examined the factors determining the sovereign risk premium for African countries. According to their findings, factors such as debt/GDP, GDP growth, inflation rate, foreign exchange reserve, market sentiment, and commodity price have statistically significant effects on the sovereign risk premium. Based on the above, we can say that macroeconomic variables play an important role in determining the default risk premium. Finally, Deng (2024) studies how progressive taxation, which has been implemented by the state to reduce inequality, affects the Sovereign default risk using U.S state-level data. His findings indicate that quantitatively, income inequality explains on-fifth of the average U.S state government spread.

Continuing with the term structure of interest rates, Dewachter and Lyrio (2006) modeled the term structure of interest rates using an essentially affine model with macroeconomic variables and their long-run expectations, applying it to the U.S. economy. According to their study, they found that inflation expectations are important for modeling the term structure. Additionally, by using macroeconomic variables(inflation, real interest rate, long-run inflation expectation, and output gap), they modeled the term structure quite well. Next, a model incorporating macroeconomic variables along with latent factors was utilized by Lemke (2008) to capture the common variability between macroeconomic variables and the term structure of interest rates for the euro area. To estimate the parameters of the term structure, bond yield observations from 1998 to 2006 were utilized, while inflation, output growth, and the short-term interest rate used as macroeconomic variables. Within this analytical framework one of the main findings, was that shocks to macroeconomic variables influence the term structure. A similar combined model was employed by Tam and Yu (2008) to model the sovereign bond yield curves of the US, Japan, and Germany. It was found that there exists a dynamic bidirectional relationship between the latent factors of the yield curve and the macroeconomic variables(capacity utilization, policy rate, and inflation) for the bond markets of US and German. Additionally, it was found that there is a positive correlation in the yield curve of the three bond markets. Finally, Medeiros and Rodríguez (2011) used models with macroeconomic variables (manufacturing capacity utilization, the federal funds rate, and annual price inflation) and the Nelson-Siegel model to study changes in the term structure of interest rates for the United States during financial crisis of 2007-2010. Both models successfully capture the dynamics of the term structure for the U.S. Additionally, the latend factors exert a significant influence on the macroeconomic variables.

3 Analysis of Data and Justification of Research Method

To conduct the following study, monthly data were collected from 2000 to 2020. The data were sourced from the FRED and OECD databases. The data consist of 10-year goverment bonds for Greece, Germany and the United States, as well as 3-month goverment bonds for Greece. Additionally, there is a dummy variable that takes the value of 1 if month is January and 0 for all other months. The dataset also includes the values of the S&P 500 stock market index and the Federal Funds Effective Rate, which is the interbank lending rate. The Economic Policy Uncertainty Index for Europe, calculated based on the work of Baker, Bloom, and Davis (2012), reflects political uncertainty by measuring the frequency of articles containing related keywords from newspapers. Finally, the dataset includes Greece's inflation rate as the annual growth rate. Below, we will see the method of calculating the default risk premium, term structure, and inflation for Greece:

$$\textit{Default Risk Premium} \ = \ \textit{10-year Greece bond} \ - \ \textit{10-year German bond}$$

The Risk Premium is the additional interest(yield) an investor requires to hold a more risky bond(Greece) compared to a default-free bond that carries no risk of default(Germany).

$$\textit{Term Structure} \ = \ \textit{10-year Greece bond} \ - \ \textit{3-Month Greece bond}$$

Using this calculation as an approximation for the level of the yield curve, meaning the average interest rate across all maturities.

$$\textit{Inflation} \ = ln(CPI)_t - ln(CPI)_{t-12}$$

We calculate inflation of Greece by comparing the Consumer Price Index for month t with that of month $t-12$, using logarithms to obtain a percentage result.

Next, we examined all variables for missing values. Only the 10-year Greece bond had one missing value, which we replaced with the variable's mean. Furthermore, we took the natural logarithm of the S&P 500 and the Economic Policy Uncertainty Index for Europe to address extreme values and for interpretation purposes in subsequent analysis. Afterward, we examined for extreme values, considering a value extreme if it deviates more than $Q_1 - 3 \cdot IQ$ from Q_1 with $IQ = Q_3 - Q_1$, or if it deviates more than $Q_3 + 3 \cdot IQ$ from Q_3. According to the above definition, we did not have any extreme values. Below we will see the aforementioned, along with visual representation of the data and descriptive statistics.

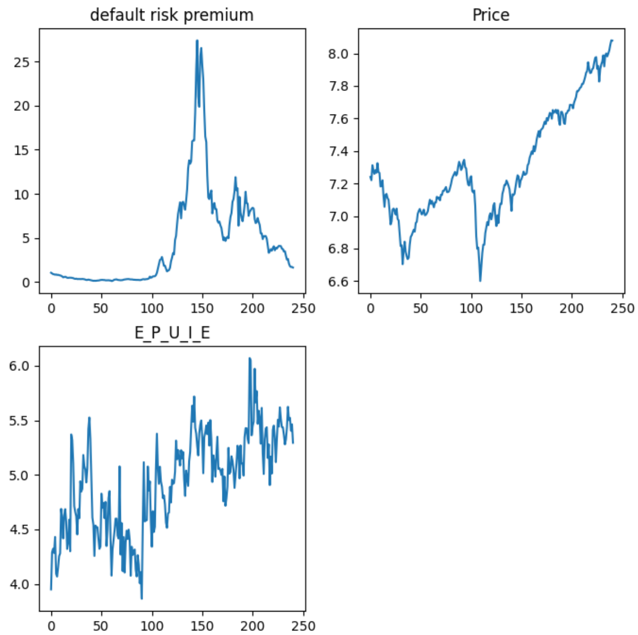

Figure 1: Time series of the variables to be used for the risk premium analysis.

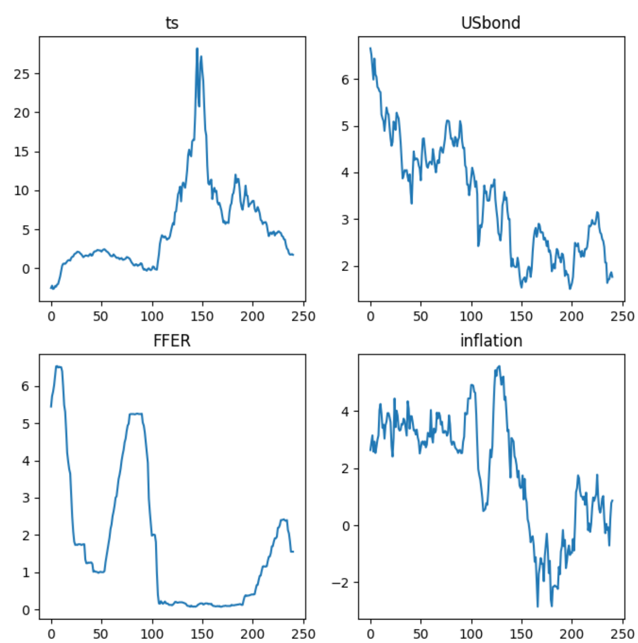

Figure 2: Time series of the variables to be used for the term structure analysis.

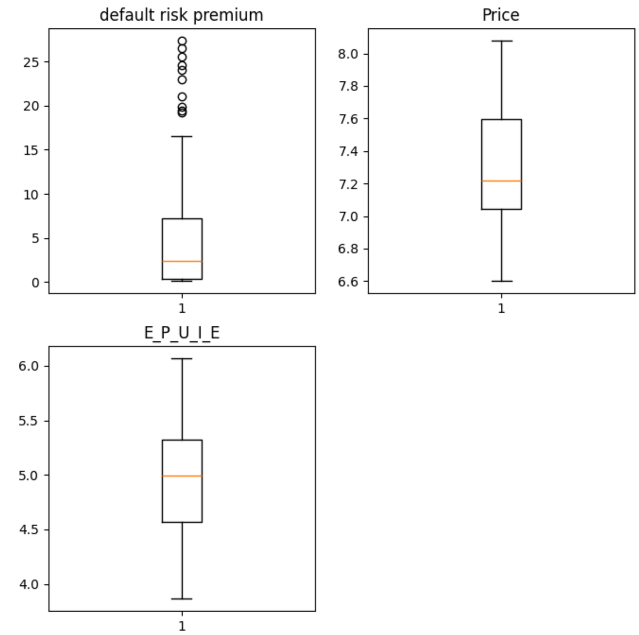

Figure 3: Boxplot of the variables to be used for the risk premium analysis.

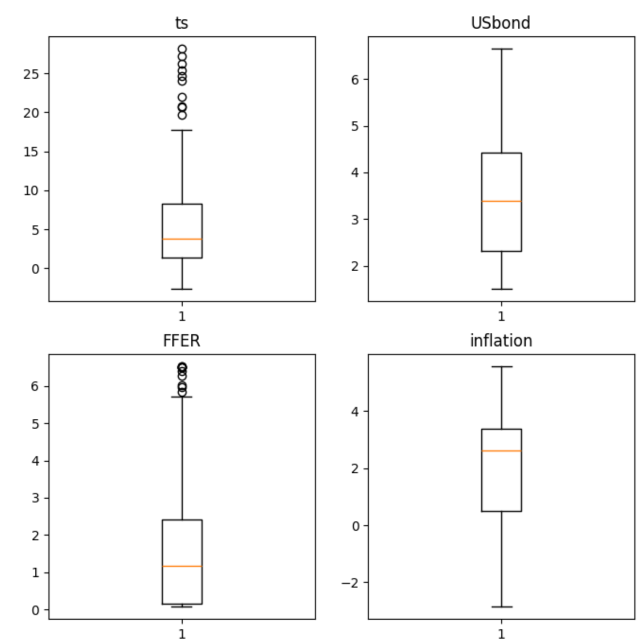

Figure 4: Boxplot of the variables to be used for the term structure analysis.

Table 1: Descriptive statistics

	N	mean	sd	min	max
default risk premium	241	4.50	5.57	0.13	27.39
Price	241	7.30	0.35	6.60	8.08
E_P_U_I_E	241	4.93	0.45	3.86	6.07
January Dummy	241	0.09	0.28	0	1
ts	241	5.26	5.78	-2.66	28.19
USbond	241	3.42	1.24	1.50	6.66
FFER	241	1.78	1.91	0.07	6.54
inflation	241	1.91	2.03	-2.85	5.57

Descriptive statistics of the variables to be used for the analysis.

In addition to the charts, we have Table 1, which contains the descriptive statistics for the default risk premium, Price(S&P 500), E_P_U_I_E, January Dummy, (Economic Policy Uncertainty Index for Europe), ts (term structure), USbond (10-year bond of the United States), FFER (Federal Funds Effective Rate), and inflation. Observing the table, we see that there is a very high standard deviation for the default risk premium and term structure, indicating that certain events caused high uncertainty in future returns, which is reflected in the 10-year Greece bond and the level of the yield curve for Greece. We will use two OLS models to analyze the factors that affect the risk premium and the term structure for Greece. Below are the two models:

$$\textit{default risk premium}_t = \alpha + \sum_{i=1}^{n} \beta_i \cdot x_{it} + e_t$$

$$ts_t = \alpha + \sum_{i=1}^{n} \beta_i \cdot x_{it} + e_t$$

In the first model, the dependent variable is the default risk premium, and the independent variables are the January Dummy, $Price$, and $E\_P\_U\_I\_E$. In the second model, the dependent variable is ts, and the independent variables are Usbond, FFER, and inflation. The variable α represents the constant, and e_t represents the residuals.

4 Empirical Findings and their Interpretations

Before presenting the quantitative results of our analysis for the risk premium and the term structure, we conducted additional statistical test and adjustments to our models to achieve unbiased estimators. To begin with, we examined whether our time series are stationary using the Augmented Dickey Fuller (ADF) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. This is because we do not want the properties of the time series to be related to time, as this can cause spurious correlations and unreliable statistics, both in the subsequent model evaluation and in the estimation of parameters. None of the time series were statistically significant for both tests at the 1% significance level with an order of integration $I(0)$. The order of integration refers to the minimum number of differentiations required to make a time series stationary. Finally, by differentiating all variables once ($I(1)$), we achieved statistical significance at the 1% level for all the variables in both statistical tests, as shown below in both the tests and the graphical representation of the variables.

Table 2: ADF,KPSS tests for unit root

	ADF-I(0)	KPSS-I(0)	ADF-I(1)	KPSS-I(1)
default_risk_premium	-1.49	0.85***	-13.40***	0.15
Price	0.38	1.67***	-14.30***	0.34
E_P_U_I_E	-3.50***	1.73***	-12.64***	0.12
ts	-1.88	0.85***	-7.72***	0.21
USbond	-2.33	1.95***	-12.74***	0.09
FFER	-2.55	0.86***	-6.53***	0.16
inflation	-1.76	1.37***	-15.39***	0.05

*** p<0.01, ** p<0.05, * p<0.1, (ADF)h_0: The series has a unit root, (KPSS)h_0: The process is trend stationary.

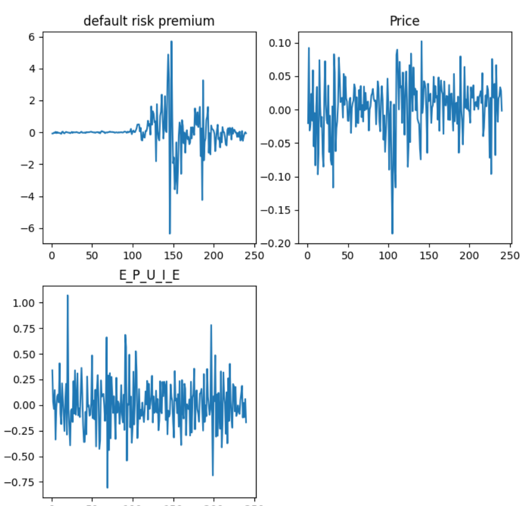

Figure 5: stationary time series for risk premium analysis.

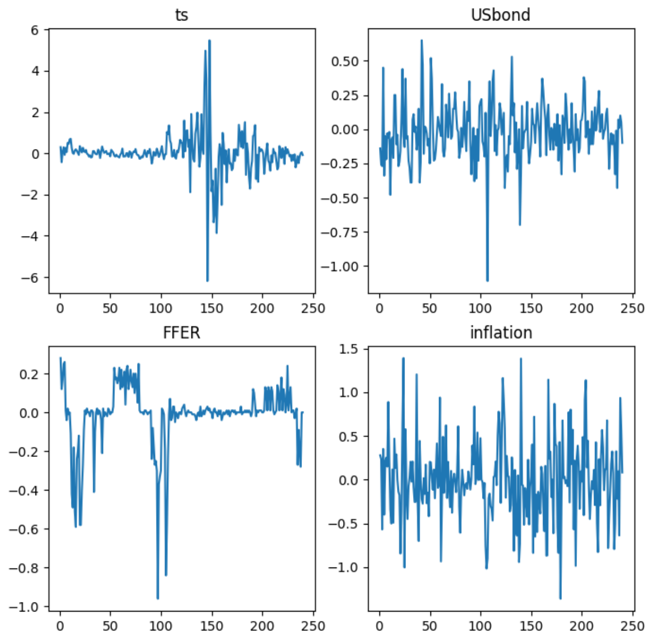

Figure 6: stationary time series for term structure analysis.

Next, we examined both models for multicollinearity using the Variance Inflation Factor (VIF). Multicollinearity occurs when two or more independent variables in a regression model are highly correlated, making it difficult to distinguish their individual effects on the dependent variable. Below are the results of VIF:

Table 3: VIF measurement

Variables	VIF
Price	1.07
E_P_U_I_E	1.06
January_Dummy	1.00
USbond	1.02
FFER	1.01
inflation	1.02

$VIF = 1$ means no collinearity.

When the $VIF = 1$, it indicates no collinearity between the independent variables. A VIF greater than 5 suggests high multicollinearity. In our case, we have a value very close to 1 and less than 1.5, which means that for both multiple regression models, there is no correlation between the independent variables. Finally, we conducted a Durbin-Watson test to examine the autocorrelation of the residuals in both models. Residuals are autocorrelated when e_{t+1} is related to e_t. After performing the test for both models, we found that for risk premium model, $d = 1.728$, and for the term structure model, $d = 1.505$. These values are not less than 1 and are close to 2, indicating that there is no autocorrelation in either model.

Table 4: OLS Regression model

Dependent variable: default_risk_premium	
Price	-3.950**
	(1.667)
E_P_U_I_E	-0.134
	(0.294)
January_Dummy	0.190
	(0.246)
constant	0.001**
	(0.071)
Observations	240
R-squared	0.026

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Next, we will interpret the results of the regression models and see how they compare to the literature, starting with the term structure. Of the above variables, only the constant and price(S&P 500) were statistically significant at the 5% significant level. For the price variable, a 1% increase in price causes, on average a 3.95% decrease in the default risk premium per month all other variables constant. This means that as the S&P 500 rises, the additional return required by an investor to hold a 10-year Greece bond decreases, making it a less certain investment compared to a default-free bond(10-year German bond). COLLIN-DUFRESNE et al. (2001), using data from dealers' quotes and transactions prices on straight industrial bonds, studied the determinants of credit spread. They found that the returns of the S&P 500 have a statistically and economically significant negative relationship with the credit spread. Similar findings to ours, which explain that when the overall economic conditions are favorable (S&P 500), investment uncertainty in the bond market decreases. Regarding the (E_P_U_I_E) index (Economic Policy Uncertainty Index for Europe), Manzo (2013) decomposed sovereign credit spreads into default risk and risk premium for 19 European countries, including Greece, and studied the effect of political uncertainty. His findings show a statistically significant positive monthly relationship in both components, with Greece being an extreme case due to the highest variance in CDS spreads. Greece is also the first country in Europe to declare bankruptcy since the creation of the European Union. Clinebell et al. (1996) examined the properties of the historical default risk premium times series. They found that the *January_Dummy* variable, which takes the value of 1 if the month is January, has a statistically significant positive relationship with the default risk premium, indicating a higher risk premium for January months. The widely differing results from the literature could be attributed to Greece's long-term crisis, resulting in a change in the relationship of the risk premium with its macroeconomic enviroment. Below we will see Table 5, which contains the corresponding analysis for the term structure.

Table 5: OLS Regression model

Dependent variable: ts	
USbond	-0.491
	(0.309)
FFER	-0.225
	(0.390)
inflation	0.087
	(0.139)
constant	0.005
	(0.065)
Observations	240
R-squared	0.013

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

According to the results of the above analysis, none of the variables are statistically significant at the 10%, 5%, or 1% level. This means that no independent variable has a statistically significant impact on the term structure (ts). In other words, none of them affect the level of the yield curve for Greece. This observation is also reflected in the very low adjusted $R - squared$ of 1.3%, indicating that only 1.3% of the variability in the dependent variable is explained by the regression. Regarding the literature and its relation to our findings, Prasanna and Sowmya (2017) examined the dynamics of the yield curve for an emerging economy like India. They found that US long-term interest rate bonds had a negative impact on the Indian long-term interest rate bonds. Interestingly, pre-crisis, this relationship was positive and statistically significant. Afterwards, Paccagnini (2016) studied the relationship between macroeconomic variables and the term structure of interest rates during Great Moderation period, specifically between 1984 and 2007, using monthly US bonds to construct the term structure. They found that the yield curve is related to inflation and the Federal Funds rate. According to Sihombing et al. (2014), the bond market is a significant source of income for the government, aiding economic growth. Regarding the Indonesian government, funding through domestic bonds continues to increase. Based on their findings, they examined the factors influencing the yield curve of Indonesian government bonds. They found that it is influenced by various macroeconomic fundamentals such as inflation. According to the above findings, our results for Greece do not align with the literature. This discrepancy could be attributed to the long-term crisis experienced by Greece, analyzing its relationship with the macroeconomic enviroment and the yield curve. Additionally, the market uncertainty in Greece may prevent it from deriving significant income from the bond market for its development, which could explain the lack of impact from the macroeconomic enviroment.

5 Discussion of the results and concluding remarks

Using two OLS models, we examined the macroeconomic factors that affect the risk premium and the term structure using monthly data from 2000 to 2020. Our findings do not significantly align with the existing literature for either the risk premium or the term structure. From the two models, only one variable was found to be statistically significant in the risk premium model. The *price* (S&P 500) had a negative impact on the term risk, indicating that if the overall economic condition improves, Greece's economy also improves, resulting in a lower risk of default. Therefore, the additional return required by an investor to hold a 10-year Greek bond, compared to a bond with no default risk like a 10-year German bond, decreases. According to both the literature and our findings for Greece, the overall economic conditions might influence the interaction of macroeconomic variables with the risk premium and the term structure. Additionally, due to Greece's poor economic condition and high risk of default, the bond market was not a significant factor in the country's economic development regarding the term structure. This could explain the lack of a relationship between the yield curve and the macroeconomic environment. For future research, we suggest quantitatively studying the extent to which the crisis and the significance of government bonds in a country's development affect the relationship between macroeconomic variables, the risk premium, and the term structure.

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