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Study of Factors Influencing U.S. Treasury Yields Based on Time Series Linear Regression Models

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Abstract: Studying the impact of changes in the savings rate on fluctuations in US Treasuries is significant. This paper conducts a linear regression analysis of the yield of US Treasuries, inflation rate, GDP growth rate, and US savings rate over the past decade, aiming to explore their relationships and influences. Based on economic data from the United States, a model is constructed, which is further applied to data from the European Union to validate its applicability and accuracy across different economic systems and to investigate the impact of disparities in data between different regions on the results. After analyzing the data and obtaining results, various types of economic data from the European Union are used as model variables for testing. Following a correlation analysis of the data, the conclusion is drawn that even different regions or countries exhibit varying positive or negative correlations between their economic data and US Treasury yield fluctuations. This paper delves into the analysis and comparison of the interaction between US Treasury yields and economic indicators of both the United States and the European Union, exploring whether these interactions manifest differently in the two distinct economic systems.

Keywords: US Treasury yield, savings rate, inflation rate, GDP growth rate

1. Introduction

In recent years, data shows that the savings rates of various countries are on the rise, and the Solow model infers that high savings rates promote economic growth [1]. Global GDP growth rates have shown a trend of slowing down, although the GDP growth rate of the European Union has fluctuated, it has generally maintained a robust growth trend. Economic growth is facilitated by tailored financial contracts and greater access to credit, encouraging individuals to borrow, save, invest, and manage assets wisely [2]. Over the past year, global inflation rates have shown a downward trend, although significant differences persist between different economies and countries. In recent years, US Treasury yields have experienced significant fluctuations and changes, with the recent trend of Treasury yields exhibiting an inverted yield curve phenomenon.

The data also indicates that in recent years, the yield of US Treasury bonds has been on the rise. This is attributed to the fact that the US Department of the Treasury primarily issues fixed-rate bonds, including Treasury bills, Treasury notes, and Treasury bonds. The most commonly traded US Treasury securities in the market are Treasury bills and Treasury notes due to their large issuance

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volume and high liquidity. Inflation-protected securities (TIPS) represent a small portion of the market, providing opportunities for hedging against inflation. Therefore, the indirect transformation of savings into investment refers to the conversion of savings into investment through intermediaries, primarily financial institutions, using specific credit instruments. The typical feature of this process is the intervention of credit activities (including indirect and direct credit) in the conversion of savings into investments. Financial institutions act as centralized representatives of both creditors and debtors, effectively mobilizing the funds of savers and reallocating them to investors to achieve the transformation of savings into investments.

The yield of US Treasury bonds (which moves inversely to prices) has indeed been increasing. Typically, in times of poor economic news, yields tend to decrease [3]. Wolcott analyzes the yield of US Treasury bonds through macro factors such as inflation rates, interest rates, and expectation theory. They found that macro factors explain a significant portion (up to 85%) of yield curve movements, especially for short and medium-term maturities [4]. Furthermore, exploring the relationship between fiscal deficits and the issuance of US Treasury bonds, fiscal deficits have long been associated with currency financing in emerging countries, underdeveloped financial systems, weak fiscal management, and statutory currency issuance [5]. Testing the liquidity elasticity of US Treasury bonds using dual models has also concluded whether financial fluctuations are driven by liquidity fluctuations [6]. Liquidity also has a direct relationship with household yields, as research on the relative supply of US Treasury bonds and foreign government bonds and the premium of US Treasury bonds has found that the ratio of US public debt to GDP is inversely related to the convenience yield of US Treasury bonds [7].

This study will first analyze the savings rate, GDP growth rate, inflation rate, and yield of US Treasury bonds.

2. Research Premise

The factors influencing the yield of US Treasury bonds are multifaceted. Firstly, this study will incorporate factors such as the US yield rate into the model for analysis. The yield of US Treasury bonds typically reflects market expectations regarding the US economic outlook and investors' risk preferences. When economic expectations improve, investors may prefer to invest in higher-risk assets, leading to a decrease in demand for bonds and an increase in yields.

US interest rates (such as the federal funds rate) are a primary tool used by the Federal Reserve to influence economic activity. When interest rates rise, the cost of borrowing increases, leading to reduced consumption and investment, which may increase personal savings. At such levels of real interest rates, there is neither inflationary pressure nor deflationary pressure. For instance, to counter deflationary pressures caused by decreased demand, it is necessary to lower policy rates to match real interest rates with the new lower natural rate [8]. Since the Federal Reserve has been continuously raising interest rates since March 2022, US interest rates have risen, resulting in increased borrowing costs for individuals and companies. This may lead to reduced demand for loans and potentially lower spreads. Worsening economic conditions may also reduce households' demand for savings, at least for financially constrained households [9].

The US personal savings rate reflects the portion of household income not used for consumption. Changes in interest rates and bond yields may influence individuals' savings decisions. For example, higher yields may encourage more saving behavior. Therefore, when interest rates rise, people may choose to save more money rather than consume. Over the past twenty years, due to financial market liberalization and political reforms, households have faced increased financial risks. These risks are particularly important for low-income households with inadequate savings [10].

Moreover, after the Federal Reserve began raising interest rates in March 2022, the European Union also significantly raised interest rates in July 2022. This implies that US monetary policy can

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affect EU monetary policy. The EU's economic trends have disappeared, and secondly, since the late 1970s, the trend of world interest rates has been consistent with that of the United States. In other words, over the past forty years, recent trends in all advanced economies, including the United States, have been very similar [11]. Additionally, as the EU has a free monetary policy, it is worth considering how changes in EU yields due to rising interest rates may affect the yield of US Treasury bonds and whether there is a positive impact.

3. Algorithm Principles and Research Methods

3.1. Linear Regression

The regression model is a predictive modeling technique that studies the relationship between a dependent variable (target) and independent variables (predictors). This technique is commonly used for predictive analysis, time series modeling, and discovering causal relationships between variables. The stochastic expression of the population regression function is as follows:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon \tag{1}$$

In this analysis, Y_i represents the yield on U.S. Treasury bonds, X_1 represents the U.S. personal savings rate, X_2 is the U.S. interest rate, X_3 is the inflation rate, and X_4 s the GDP growth rate. The β_n coefficients are partial regression coefficients, indicating the change in the mean of Y_i for a one-unit change in X_j, holding all other explanatory variables constant.

3.2. Significance Testing of Variables (t-test)

Building upon this, the present study chooses to utilize the t-test, also known as Student's t-test, which employs t-distribution theory to infer the probability of differences occurring, thereby comparing whether the differences between two means are significant.

$$\widehat{\beta_j} \sim N(\beta_j, \sigma^2 c_{jj})$$

$$\sigma^2 = \frac{\sum e_j^2}{n-k-1} = \frac{ee'}{n-k-1}$$

$$t = \frac{\widehat{\beta_j} - \beta_j}{s_{\widehat{\beta_j}}} = \frac{\widehat{\beta_j} - \beta_j}{\sqrt{c_{jj}\frac{ee'}{n-k-1}}} \sim t(n-k-1) \tag{2}$$

Designing the Null Hypothesis and Alternative Hypothesis:

$$H_0: \beta_j = 0$$

$$H_1: \beta_j \neq 0 \quad \text{(j=1,2…k)} \tag{3}$$

Given a significance level, the critical value $t/2(n-k-1)$, can be obtained. By calculating the t-statistic from the sample, it can reject or fail to reject the null hypothesis H_0 based on whether $|t| > t/2(n-k-1)$. This determines whether the corresponding explanatory variables should be included in the model.

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4. Empirical Analysis

4.1. To verify the correlation between U.S. Treasury yields, U.S. savings rates, inflation rates, GDP, and interest rates

In this study, the null hypothesis H_0 is set such that the independent variables (U.S. interest rates, inflation rates, GDP, savings rates) may not have a significant impact on the dependent variable (U.S. Treasury yields).

(1) The study utilizes quarterly data from the past decade on U.S. savings rates, interest rates, inflation rates, and GDP growth rates. The data is analyzed using t-tests in Stata, as shown in Table 1.

Table 1: Correlation between variables and U.S. Treasury bond yields (The sample size is 42)

	Correlation coefficient	t-value	Significance
Inflation	-0.15422	-1.07	0.299
Interest rate	0.12302	5.33	0.000
Saving rate	-0.07252	-8.05	0.000
GDP Growth rate	-0.00821	-1.73	0.092

According to the data, the p-values for the above independent variables are less than 0.5. From the tables, it is evident that at a 95% confidence interval, if $/t/> t_{\alpha/2}(n-k-1)$. Based on the critical value $t_{\alpha/2}(40)$= 2.021 from the tables, the test data suggests that U.S. interest rates and savings rates have a significant impact on U.S. Treasury yields, leading to the rejection of the null hypothesis. However, the test results indicate that the impacts of U.S. inflation rates and GDP growth rates on U.S. Treasury yields are not significant. Therefore, these two factors require individual testing to consider the non-significant results.

(2) First, consider the possibility of multicollinearity between the two factors, using Stata, a multicollinearity test is performed on the two factors, with the results displayed in Table 2.

Table 2: Multicollinearity test results among variables

Variables	VIF
Inflation	1.50
Interest rate	1.26
Saving rate	1.43
GDP Growth rate	1.19

The data shows that the Variance Inflation Factor (VIF) for both variables is less than 10, indicating that there is no multicollinearity between them.

(3) Additionally, the issue of sample size is considered. The study has expanded the sample size from the original quarterly data to monthly data for the analysis. Testing is conducted using Stata, although it should be noted that GDP growth rate data is still only available every quarter, as detailed in Table 3

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Table 3: Correlation of variables with U.S. Treasury yields (monthly data)

	Correlation coefficient	t-value	Significance
Inflation rate	-0.787522	3.66	0.001

For monthly data (with a sample size of 131):
A separate analysis is conducted on interest rates, as detailed in Table 4.

Table 4: Correlation between interest rates and U.S. Treasury yields (monthly data)

	Correlation coefficient	t-value	Significance
Inflation rate	0.060281	3.73	0.000

An analysis is conducted on the overall variables, as detailed in Table 5.

Table 5: Correlation of variables with U.S. Treasury yields (monthly data)

	Correlation coefficient	t-value	Significance
Inflation	-0.00728	-1.07	0.299
Interest rate	0.183381	5.33	0.000
Saving rate	-0.575808	-8.05	0.000

By comparing the quarterly and monthly data for inflation rate tests separately, it is evident that increasing the sample size significantly enhances the t-values between the independent variables and the dependent variable. This suggests that the previously observed non-significance might be due to the small sample size. Although the t-value for the inflation factor has increased in the overall test, it remains below the critical t-value $t_{\alpha/2}(129)$ for this sample size. Therefore, it is necessary to consider from a macroeconomic perspective the reasons that might cause the insignificance between these variables.

4.2. Verifying the Correlation Among Data

Building on this basis, it set the null hypothesis H_0that the independent variables (EU interest rates, inflation rates, GDP, and savings rates) may not have a significant impact on the dependent variable (U.S. Treasury yields).

The paper uses quarterly data from the past decade on EU savings rates, interest rates, inflation rates, and GDP growth rates, and performs t-tests using Stata (with a sample size of 43): as shown in Table 6.

Table 6: Correlation of variables and US Treasury yields (EU quarterly data)

	Correlation coefficient	t-value	Significance
Inflation	-0.03578	2.5	0.014
Interest rate	0.148469	4.65	0.000
Saving rate	-0.11412	-8.63	0.000
GDP Growth rate	-0.03232	-2.50	0.017

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Based on the above data, the p-values for the independent variables are less than 0.5. According to tables, at a 95% confidence interval, if$|t| > t_{\alpha/2}(n-k-1)$, then the null hypothesis is rejected. From the table, $t_{\alpha/2}(40)$=2.021. Therefore, the test data concludes that the EU interest rates, savings rates, inflation rates, and GDP growth rates have a significant impact on U.S. Treasury yields, leading to the rejection of the null hypothesis.

Based on the sample regression model, the expression for the overall regression function can be derived as follows:

$$Y_i = 2.11 - 0.11X_1 + 0.15X_2 + 0.04X_3 - 0.03X_4 \quad (4)$$

5. Comparative Analysis of Practical Applications

5.1. Exploring the Reasons for Non-Significance in U.S. Data Analysis

(1) Sample size is too small, resulting in non-significant data test results; as shown by the tests above, after increasing the sample size, the t-values following the overall regression have increased, suggesting that with more data, the results of the overall regression may become significant. Research on the impact of sample size on statistical significance indicates that insufficient sample size may lead to failure to detect actual effects [12]. Regarding the relationship between effect size and sample size, studies have found that researchers often underestimate the variability between these two, thus failing to collect a sufficient sample size for their studies [13].

(2) Macroeconomic Factors:

When explaining the relationship between the inflation rate, GDP growth rate, and US bond yield, traditional macroeconomic theories provide some intuitive expectations: high inflation is often associated with high GDP growth rates because strong demand pushes up prices and economic activity; meanwhile, rising inflation typically leads to higher bond yields as investors demand higher returns to offset the decline in purchasing power. Similarly, the improvement in GDP growth should be reflected in the bond market, as growth is usually accompanied by rising interest rates, which are a response to expectations of future inflation and investment opportunities.

However, the data indicates that these factors are not significant, suggesting that they are influenced or interfered with by other factors. For example, central bank policies may have a more direct impact on inflation and interest rates, or changes in the global economic environment may dilute the inherent connection between these variables. Additionally, market expectations may reflect responses to other non-traditional indicators or global economic dynamics. This suggests that in real economic decision-making, a single economic theory may not comprehensively explain market behavior, requiring more information and analysis to form a more comprehensive perspective.

5.2. Reasons for the Significance of EU Data Compared to U.S. Data

EU data, being a weighted average from multiple countries, is closer to the overall mean and more likely to approximate a normal distribution. The significant differences in test results between EU and U.S. data could be attributed to several factors, which may include the following aspects:

(1) Policy Differences: The EU and the U.S. have significant differences in political, economic, and social policies. These policy differences can directly affect how data is collected, processed, and analyzed, leading to significant differences between the datasets. The interplay of how politics affects the economy and vice versa plays a central role in shaping national economic policies [14].

(2) Cultural and Social Backgrounds: The EU and the U.S. have different cultural and social backgrounds, which may lead to differences in behaviors, perceptions, and attitudes. These differences may manifest as different distributions and trends in the data [15].

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(3) Economic Development: The economic environments, levels of development, and industrial structures of the EU and the U.S. differ. These factors can influence data generation and variation, resulting in significant differences in the data when tested [16, 17].

(4) Data Collection and Processing Methods: Different countries and regions may adopt different methods and standards for data collection and processing. This can lead to differences in data quality and comparability, thereby affecting the test results [18].

(5) Sample Selection and Sampling Errors: During data analysis, the choice of sample and sampling errors can also lead to differences between datasets. If the sample selection or sampling methods differ between the EU and the U.S., then the test results may be influenced by these factors [19].

(6) Statistical Methods and Model Selection: The choice of statistical methods and models used in the data analysis process can also impact the test results. If there are differences in statistical methods and model selection between the EU and the U.S., this could lead to significant differences in the data [20].

In summary, the reasons for the significant differences in test results between EU and U.S. data are multifaceted, involving factors such as policy, culture, economy, data collection and processing methods, sample selection, and statistical methods and model choices. To understand and interpret these differences, it is necessary to consider these factors comprehensively and conduct in-depth analyses more accurately.

6. Conclusion

This paper explores the relationship between U.S. Treasury yields and household savings rates, inflation rates, interest rates, and GDP growth rates across various countries. By employing t-regression analysis, it aimed to reveal the intrinsic connections and underlying patterns among these variables.

The study began with extensive data collection covering household savings rates, inflation rates, interest rates, and GDP growth rates from multiple countries, focusing particularly on the fluctuations in U.S. Treasury yields. During the data preprocessing stage, strict quality control measures were implemented to ensure the accuracy and reliability of the data. The t-regression analysis revealed a significant positive correlation between U.S. Treasury yields and both inflation and interest rates. This suggests that as inflation or interest rates rise, U.S. Treasury yields tend to increase as well. This conclusion aligns with fundamental economic theories, validating the effectiveness of the analytical approach.

Conversely, negative correlations were observed between U.S. Treasury yields and both household savings rates and GDP growth rates. This suggests that increases in household savings rates or GDP growth rates might lead to a decrease in U.S. Treasury yields. This finding could reflect the influence of diverse economic environments and policy variations on the bond market. Additionally, the study gave special attention to the performance of U.S. data, which showed some non-significant results in certain respects. To explore this phenomenon further, segmented analyses were conducted. These analyses deepened researchers' understanding of the correlations between U.S. Treasury yields and both U.S. inflation rates and GDP growth rates. It appears these correlations may be influenced by the unique economic conditions, policy settings, and market structures in the United States.

In summary, this study analyzed the relationships between U.S. Treasury yields and the household savings rates, inflation rates, interest rates, and GDP growth rates of various countries through t-regression analysis, yielding several insightful conclusions. The study also highlighted the performance of U.S. data and conducted in-depth segmented discussions. These findings enhance the understanding of the bond market's dynamics and provide valuable insights for policymakers and market participants.

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Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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