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Role of the information content of the Moroccan treasury securities real yield curve in forecasting the future economic situation in Morocco

Rôle du contenu informatif de la courbe des rendements réels des titres du Trésor marocain dans la prévision de la situation économique future au Maroc

Mohammed Hassan ALAOUI, (*Doctorant)*
Laboratoire : Finance, entrepreneuriat et développement
Équipe de recherche : Money, Bank and Finance.
Faculté des sciences juridiques, économiques et sociales-Salé
Université Mohammed V Rabat, Maroc

Outmane Noufail SOUSSI, ***(Enseignant chercheur)***
Laboratoire : Finance, Entrepreneuriat et développement
Équipe de recherche : Money, Bank and Finance.
Faculté des sciences juridiques, économiques et sociales-Salé
Université Mohammed V Rabat, Maroc

Adresse de correspondance :	Faculty of Law, Economic and Social Sciences-Salé Route Outa Hssain Sala Al Jadida B.P. 5295 Salé, Salé, Morocco Mohammed V University Rabat Morocco (Rabat) B.P:8007.N.U Tel: 0537272755 / Fax: 0537671401
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Abstract:

This study aims to investigate the role of the slope of the real interest rate curve of treasury securities in predicting the future economic situation in Morocco. Economic theory suggests that the slope of rates can be explained by three factors: the effects of monetary policy, expectations of monetary policy, and the intertemporal smoothing of consumption. Our theoretical model focuses on the latter explanation, suggesting that households aim to maintain a constant level of consumption, regardless of fluctuations in interest rates and the economic situation. To examine this relationship, we constructed a regression model that includes several lagged financial and/or monetary explanatory variables, such as real interest rates. This analysis utilizes quarterly data from 2007 to 2023. Our results underscore the importance of the information embedded in the structure of real interest rates, particularly the spread of real interest rates, for analyzing and forecasting future economic growth in Morocco.

Keywords: Moroccan yield curve, spread, economic forecast
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1. Introduction

Economic growth is a major concern for policy-makers, investors and economic researchers alike. Understanding the mechanisms underlying future economic growth is essential for developing effective policies and making informed decisions in an ever-changing economic environment. Among the many indicators and models used to predict economic growth, the real treasury securities yield curve has emerged as a potentially valuable tool. Indeed, forecasting economic growth using the yield curve is a common practice in the financial sector. The yield curve, which graphically represents interest rates at different maturities, is often used as a leading indicator of future economic activity. Modern economic theory offers several fields of research that highlight the relationship between the structure of interest rates and future economic growth. Rational expectations theory, developed by (Muth, 1961) and further advanced by (Lucas, 1972), holds that long-term interest rates reflect investors' expectations of future short-term interest rates. Consequently, if long-term interest rates are higher than short-term rates, this may indicate that investors anticipate a future rise in economic activity and inflation. Conversely, an inverted yield curve may signal expectations of economic slowdown and deflation.

On the other hand, market segmentation theory, initially proposed by (Hicks, 1939) and later refined by other economists, emphasizes that the different segments of the financial market operate relatively independently of one another. Thus, factors internal to a particular segment, such as supply and demand, primarily influence interest rates within that segment. Consequently, analysis of the yield curve in the context of market segmentation can provide information on segment-specific conditions and their potential impact on overall economic growth.

As for the liquidity premium theory, introduced by (Keynes, 1930) and further developed by (Tobin, 1958), it highlights the importance of asset liquidity in determining interest rate levels. A higher liquidity premium on long-term assets can indicate greater uncertainty about the economic future, prompting investors to require additional collateral to hold these assets. Thus, an excessively high liquidity premium reflected in a yield curve can signal concerns about economic stability, indicating a potential economic slowdown.

Economic growth is an essential objective for Morocco, a country that seeks to ensure sustainable economic growth, strengthen its economy and improve the well-being of its population. These socio-economic objectives depend largely on the ability to anticipate and understand future economic dynamics. However, accurately forecasting the trajectory of future economic growth is a complex task, given the multitude of factors that influence the economy. In this context, the use of the real treasury securities yield curve as an economic forecasting tool is of particular interest.

Against this backdrop, a central question arises:

What role does the information content of the real Treasury securities yield curve play in forecasting future economic conditions?

Through this problem, we seek to assess the extent to which the treasury securities real interest rate curve, as a key indicator of financial market expectations, can provide relevant information for anticipating future economic developments in Morocco.

In the first section, we present a review of the theoretical and empirical literature, covering both the theoretical foundations of the yield curve and the empirical studies carried out on this subject. We then present the theoretical model adopted for this study, along with all the variables used and introduced into the model, notably the economic growth rate, the yield curve

spread (the difference between the 10-year and 52-week treasury bill rates)[1], the real short-term rate, lagged economic growth variables, etc. The last section presents and discusses the theoretical foundations of the yield curve. In the final section, we present and discuss our findings.

2. Literature review and development of hypotheses

2.1.Theoretical literature review

The relationship between the real interest rate curve and future economic growth has been the subject of much debate in the economic literature. This literature review aims to present the main theories that researchers have proposed to explain this relationship.

Proposed by (Fisher, 1933) and further developed by (Lutz, 1940), the rational expectations theory of the term structure of interest rates is one of the first attempts to explain the process by which the yield curve is formed. This theory states that the expected evolution of the short rate solely determines the yield curve. This formulation relies on several assumptions, principally the efficiency of financial markets, the perfect substitutability of securities, the homogeneity of agents' expectations and extensive knowledge by economic agents of future short-term interest rate levels. In other words, economic agents must form their expectations of future interest rates rationally, using all available information. According to this theory, rational expectations imply that individuals must not make errors in their forecasts, and that they must continually adapt their expectations in line with new information disseminated by the market. In general, the rational expectations approach forms an essential foundation in analyzing interest rate formation, emphasizing agents' ability to accurately anticipate future economic conditions.

(Culbertson, 1957) developed the theory of market segmentation as part of his studies to explain the formation of the yield curve. In his view, market segmentation according to different maturities would be the most correct method for understanding interest rate formation. He argues that supply and demand conditions in each of these segments, representing different maturities, form interest rates. The key assumption of this theory is that bonds of different maturities are not substitutable. In other words, the expected yield on a bond of a certain maturity has no impact on the demand for bonds of other maturities. This perspective is radically opposed to that of the rational expectations theory of the term structure of interest rates, which assumes that bonds of different maturities are perfectly substitutable.

Market segmentation theory suggests that different segments of the financial market should operate relatively independently of each other. It argues that money and bond markets, for example, are relatively isolated from each other. Thus, investors and financial instruments operate mainly within their own market segment, with limited interaction between these segments. This theory elucidates that factors internal to a specific segment predominantly influence interest rates within that segment, contrasting with external factors such as general market interest rates. Consequently, interest rates and yields may vary significantly between segments due to this segregation.

In sum, market segmentation theory offers a perspective on the diversity of financial market segments and their relative autonomy, influencing the way investors make decisions and the

[1] *According to the Public Debt 2023 report by Morocco's Ministry of Economy and Finance, page 23, the share of subscriptions on the 52-week maturity is 11.1%, in contrast to the 13- and 26-week maturities, which are 2.9% and 3.1% respectively. This means that the 52-week treasury bills rate is the most sought-after rate and is therefore logically the most representative of the short end of the yield curve. On the other hand, and according to the same report, the share of subscriptions on the 10-year maturity is 14.7%, as opposed to the 15-, 20- and 30-year maturities, which are 3.1%, 4.2% and 3.2% respectively. This confirms that there is strong demand for the 10-year maturity compared with the other maturities, so we have considered that the rate most representative of the long end of the yield curve is the 10-year.*

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dynamics of interest rates at different maturities. Although this theory has provoked debate, it has had a lasting influence on our understanding of financial markets.

As for the liquidity premium theory, it seeks to harmonize both the rational expectations theory of the term structure of interest rates and the market segmentation theory. According to this theory, the long-term interest rate on a bond is equal to the average of expected short-term interest rates over the life of the bond, plus a liquidity premium depending on supply and demand conditions for the bond.

The fundamental assumption of this theory remains substitutability between bonds of different maturities, although this substitutability is imperfect, since investors may prefer bonds of one maturity to others of a different maturity. In general, investors prefer shorter-dated bonds because of their lower interest-rate risk. Adding a positive liquidity premium to the yield on long-term bonds could encourage investors to hold them, offsetting their disadvantages compared to short-term bonds. This liquidity premium generally increases with bond maturity.

The liquidity premium theory postulates that investors demand additional compensation, called a liquidity premium, for holding less liquid financial assets compared to more liquid assets. This premium reflects the additional remuneration demanded by investors for the risk associated with the difficulty of selling assets quickly when needed. Factors influencing the liquidity premium include the maturity of assets, their ease of trading and the overall level of liquidity on the financial market.

Thus, liquidity premium theory provides an essential understanding of price formation in financial markets, explaining why similar assets can present different returns depending on their level of liquidity. This theory has greatly influenced our comprehension of financial market mechanisms and remains a pivotal factor in shaping ongoing financial research.

2.2.Empirical literature review

Many empirical studies have focused on forecasting future economic conditions via the real interest rate curve.

In practice, assessing the quality of the prediction of consumption growth by interest rate variables is difficult without some reference models. In this situation, researchers have suggested two different formulations as alternatives. The first includes lagged consumption growth, considered important in explaining future consumption by (Hall, 1978) and (Hansen and Singleton, 1983). The second allows stock market returns to predict consumption growth. (Fama, 1981) has shown that stock market returns can predict real GNP growth, and it is possible that they can also predict real consumption growth.

Building on their momentum, (Harvey, 1988) provides evidence that the structure of expected real rates contains information that analysts can use to forecast consumption growth more than the two conventional measures traditionally used, namely lagged consumption growth and lagged stock market returns. In other words, the real yield curve appears to have slightly greater forecasting power than the main commercial econometric models. He bases his reasoning on the implication of the consumption-based asset-pricing model, which states that expected returns and expected consumption growth are linearly related. That is, if one can estimate expected Treasury yields these estimates should contain information on expected consumption growth.

Furthermore, (Estrella and Hardouvelis, 1991) argue that a positive slope of the yield curve is associated with a future increase in real economic activity. That is, it has additional predictive power over the index of leading indicators, real short-term interest rates, lagged growth in economic activity and lagged inflation rates.

In addition, (Dubois and Janci, 1994) reveal that in French data, the spread between the three-month money rate and the 10 year bond rate does indeed contain, one year in advance, original information on the future evolution of activity in relation to a set of a priori relevant economic

variables. He adds that researchers can supplement this information by including some of these variables to construct a high-quality leading indicator of activity. This is in line with numerous studies carried out on several countries where the spread between short and long interest rates seems to contain information concerning the future evolution of activity.

Building on earlier work on the information contained in the term structure about future real economic growth for the US, Germany and the UK (Plosser and Rouwenhorst, 1994) find evidence that the long end of the term structure contains information about future industrial output growth, over and above expectations about future monetary policy. They also find that foreign futures structures can predict low-frequency national movements in economic activity, particularly in countries with high and variable inflation rates.

(Estrella and Mishkin, 1997) examine the relationship between the term structure and monetary policy instruments, as well as the resulting real activity and inflation, in both Europe and the USA. The study shows that monetary policy is an important determinant of the term structure spread, but that it is unlikely to be the sole determinant. In addition, there is significant predictive power for real activity and inflation. Therefore, one should view the yield curve as a simple, accurate measure that can serve as a useful piece of information, aiding in guiding European monetary policy along with other factors.

2.3.Hypothesis development

The importance of the treasury securities real yield curve in forecasting future economic growth is of growing interest to policymakers, investors and researchers in Morocco. Our study aims to test and verify the relationship between the treasury securities real rate spread and future economic conditions. We will also examine how the introduction of a set of economic and financial variables and indicators, such as the real short rate and its lags, as well as lagged economic growth rates, can influence this relationship.

Within the framework of this work, it was essential to formulate the following hypotheses:

H_1: the treasury securities real rate spread provides information on future economic growth in Morocco.

H_2: The effect of lags in economic growth, as well as that of the real short rate and its lags on future economic growth is insignificant when the real rate spread is taken into account in the econometric model.

By way of background, this study aims to analyze the role of the real rate spread in predicting future economic growth in Morocco. The main hypothesis of this research is that the treasury securities real-rate spread provides important information for anticipating future economic growth. This hypothesis stems from an in-depth analysis of the economic literature, which points to the close link between variations in the real interest rate spread and anticipated economic growth.

Furthermore, the second hypothesis states that the effect of lags in economic growth and the real short rate, as well as their lags, on future economic growth becomes insignificant when the real interest rate spread is taken into account in the econometric model. This hypothesis is based on a series of theoretical and empirical arguments, notably the idea that the real interest rate spread could more fully incorporate economic agents expectations and financial market conditions, thereby reducing the explanatory power of other economic variables.

By testing these hypotheses in an econometric study, this study aims to provide insight into the ability of the real rate spread to serve as a robust predictor of future economic growth in Morocco, while examining the relative effect of other variables relevant to the Moroccan economic context.

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3. Research methodology

3.1.Theoretical model

Researchers to explain the link between the slope of the yield curve and future economic activity have adopted many models. In this paper, we align our research methodology with the model initiated by (Harvey, 1988) and enriched by the work of (Sédillot, 2001). These authors formulate their model based on the consumer's intertemporal maximization behavior, a concept considered in the economic literature to be one of the main explanations[2] giving insight into the origin of the slope of interest rates on the one hand, and future economic activity on the other.

Following (Harvey, 1988), the consumer takes the following approach:

$$\max_{Ct\ ,\ At+1} \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-v}}{1-v} \qquad (1)$$

$$\text{Under constraint } A_{t+1} = (1+r_t)(A_t + Y_t - C_t)$$

Where β is the discount factor, v is risk aversion, A_t is the consumer's real wealth, C_t is real consumption, Y_t is real wage income and r_t is the real interest rate between periods t and $t+1$. Solving the program gives the following equilibrium conditions:

$$\frac{\partial \ell}{\partial C_t} = \beta^t\, C_t^{-v} - (1+r_t)\lambda_t = 0 \qquad (2)$$

$$\frac{\partial \ell}{\partial C_{t+1}} = \beta^{t+1}\, C_{t+1}^{-v} - (1+r_{t+1})\lambda_{t+1} = 0$$

Where ℓ is the lagrangian of the consumer program given by the maximization function. By rearranging the equations of system (2), we obtain the following equation:

$$c_{t+1} - c_t = \frac{\log(\beta)}{v} + \frac{1}{v} r_t \qquad (3)$$

This equation describes the variation in real consumption between periods t and $t+1$, as a function of the real interest rate r_t , the discount coefficient β and risk aversion v.

From (3), we can extend the relationship to examine the variation in actual consumption between periods t and $t+j$, where j is the horizon considered:

$$c_{t+j} - c_t = j\frac{\log(\beta)}{v} + \frac{1}{v}\sum_{i=0}^{j-1} r_{t+i} \qquad (4)$$

The sum operator $\sum_{i=0}^{j-1} r_{t+i}$ means that we add the values de r_{t+i} for i going from 0 to [3] $(j-1)$. This means we take into account real interest rates for all periods from $t\ to\ t+j-1$.

Therefore, we deduce the expression for the variation in actual consumption between periods $t+1$ and $t+j$ as follows:

$$c_{t+j} - c_{t+1} = (j-1)\frac{log(\beta)}{v} + \frac{1}{v}s_t + \frac{1}{v}(j-1)r_t \qquad (5)$$

Knowing that :

$s_t = \sum_{i=0}^{j-1} r_{t+i} - jr_t$ represents j times the slope of the rates between t and $t+j$. According to (5), the cumulative growth rate of consumption between periods $t+1$ and $t+j$ is an increasing function of the slope of the rates.

For convenience, we rewrite (5):

[2] *Economic theory emphasizes that, in addition to the intertemporal smoothing of consumption, the effects of monetary policy and its expectations are also used to demonstrate the link between the slope of rates and the economic situation.*

[3] *Since the summation starts with* $(i=0)$*, we should still consider* $(j-1)$ *as the upper bound, so that we don't have to count the last period* $t+j$ *twice. In other words, if the summation starts with* $i=1$*, the upper bound will be* j*.*

$$c_{t+j} - c_{t+1} = \alpha_0 + \alpha_1 s_t + \alpha_2 r_t \qquad (6)$$

Where:

$$\alpha_0 = j - 1\frac{\log(\beta)}{v}, \alpha_1 = \frac{1}{v} \text{ and } \alpha_2 = \frac{1}{v}(j-1)$$

Where α_1 symbolizes both the inverse of the degree of consumer risk aversion and the rate of consumption growth when the yield curve is flat. We will use Equation (6) as the basis for econometric analysis. (Harvey, 1988) examines this relationship directly. However, in our econometric analysis, we substitute GDP for consumption, which is empirically the variable we seek to predict.

The coefficient $\frac{1}{v}$ can interpret it as both an elasticity and a coefficient of relative risk aversion. In the literature on the life cycle and permanent income hypothesis, researchers sometimes refer to this coefficient as the intertemporal elasticity of substitution. It represents the sensitivity of consumption growth to variations in expected real rates. (Hall, 1988) has argued that this elasticity is very low or even zero, which may imply very high levels of risk aversion. A low or zero elasticity also means that there is little or no information on the expected real rate that is relevant to forecasting real consumption growth.

In practice, to test the link between the slope of rates and future economic growth, we will examine the following relationship, which is formulated similarly to equation (6):

$$\left(\frac{400}{k}\right)\log\left(\frac{y_{t+k}}{y_t}\right) = \alpha_0 + \alpha_1 s_t + \varepsilon_{t+k} \qquad (7)$$

$\boldsymbol{k}$ represents the horizon considered, $\boldsymbol{y_{t+k}}$ represents the income earned between periods $\boldsymbol{t}$ and $\boldsymbol{t + k}$, $\boldsymbol{y_t}$ represents income and $\boldsymbol{s_t}$ the slope of the rates.

3.2. Variables and data

As a reminder, this study aims to assess the predictive power of the slope of the real interest rate curve of treasury securities for forecasting Morocco's future economic situation. The analysis focuses on the period from 2007 to 2023, using quarterly data to provide a detailed view of economic trends. Based on economic theory, which suggests that the slope of rates can be explained by monetary policy effects, expectations of monetary policy, and intertemporal smoothing of consumption, our theoretical model emphasizes the latter explanation. We posit that households aim to maintain a constant level of consumption regardless of fluctuations in interest rates and economic conditions. To examine this relationship, we constructed a regression model that includes several lagged financial and monetary explanatory variables. To determine the ability of the slope of the yield curve to predict future economic activity, we have chosen to apply the model proposed by (Harvey, 1988) and developed by (Sédillot, 2001). Building on their momentum, several studies have been carried out for the American case, notably those by (Bernard and Gerlach, 1998), (Davis and Fagan, 1997), (Estrella and Mishkin, 1997), (Harvey, 1991), (Hu, 1993), and (Plosser and Rouwenhorst, 1994). For the French case, (Dubois and Janci, 1994) refer to their work. In short, all these authors sought to establish a relationship between the anticipated GDP growth rate and the slope of rates and possibly other financial or monetary variables. Monetary and economic data were collected both from the official Bank Al-Maghrib website and from the electronic database of the Moroccan High Planning Commission. Our empirical analysis underscores the importance of the information embedded in the structure of real interest rates, particularly the spread of real interest rates, for analyzing and forecasting future economic growth in Morocco.

The empirical analysis of these models calls on various variables, including:

- **The real GDP growth rate** is calculated from the variation between two successive periods:

$$\text{Real GDP growth rate} = \frac{\text{Current real GDP} - \text{Previous real GDP}}{\text{Previous real GDP}} \times 100\%$$

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Economists often use the real GDP growth rate to assess a country's economic health, economic growth, and overall performance over time. An economic expansion is indicated by a positive growth rate, while a negative growth rate signals an economic recession.

- **The slope of treasury securities rates** often serves as a leading indicator of economic health. A positive slope, characterized by higher long-term rates compared to short-term rates, is generally interpreted as a positive signal for the future economy, reflecting confidence. Conversely, a negative slope may indicate apprehensions about future economic growth. An inverted yield curve, with short-term rates exceeding long-term rates, is often seen as a sign of an upcoming recession.

For our study we have chosen to calculate the spread "the slope of rates" by the following method:

$$Spread = TREASURY\ Bonds\ 10\ Years - TREASURY\ Bills\ 52\ Weeks.$$

According to the Public Debt 2023 report, the breakdown of subscriptions to government treasury securities in Morocco shows a preference for 52 week bills over 13 and 26 week bills at the short end of the yield curve. While 10 year bonds are more in demand than 15, 20 and 30 year bonds. This trend has led us to choose the spread calculation method unveiled above. This will enable us to capture the market dynamics between short- and long-term rates.

The slope of Treasury bill rates is a key economic indicator, providing information on financial market expectations regarding economic growth, inflation, future monetary policies and market conditions. It plays an essential role in economic and financial decision-making, at both corporate and government level.

- **The real short rate we** have chosen in this case is the weighted average overnight rate[4] adjusted for inflation. In general, the waor refers to the interest rate at which banks lend money to each other on a daily basis, generally to meet their short-term cash needs.

In our study, we have chosen[5] to calculate the real short rate as follows:

$$\text{the real short rate} = \text{waor} - \text{Cumulative inflation over the previous four quarters}$$

In turn, cumulative inflation over the previous four quarters is calculated as follows:

$$Cumulative\ inflation = \left(\frac{IPC_{T1} - IPC'_{T1}}{IPC'_{T1}}\right) + \left(\frac{IPC_{T2} - IPC'_{T2}}{IPC'_{T2}}\right) + \left(\frac{IPC_{T3} - IPC'_{T3}}{IPC'_{T3}}\right) + \left(\frac{IPC_{T4} - IPC'_{T4}}{IPC'_{T4}}\right).$$

Where :

- $IPC_{T1}, IPC_{T2}, IPC_{T3}, IPC_{T4}$ are the consumer price indices for the first, second, third and fourth quarters respectively.
- $IPC'_{T1},\ IPC'_{T2},\ IPC'_{T3},\ IPC'_{T4}$ are the consumer price indices for the same quarters of the previous period.

In short, the weighted average overnight rate is an important indicator of money market conditions and short-term interest rate trends. It also provides important indications of the central bank's monetary policy intentions.

[4] *Generally, the weighted average overnight rate published by central banks is a nominal rate.*

[5] *Although the real interest rate for a given period is generally the difference between the nominal interest rate and the inflation rate, in our study we have chosen to use cumulative inflation, since this measure gives an indication of overall price trends over a longer period, unlike the use of the quarterly inflation rate, which only captures short-term price variations.*

3.3. Empirical methodology and econometric specification

This section presents the empirical methodology used to study the ability of the real treasury securities rate spread and the real short rate to predict future economic growth. With this in mind, we adopt an Ordinary Least Squares (OLS) approach to estimating a multiple linear regression model that is the most appropriate for our study.
Therefore, we consider the econometric specification of the model as follows:

$$\left(\frac{400}{k}\right)\log\left(\frac{y_{t+k}}{y_t}\right) = \alpha_0 + \alpha_1 s_t + \alpha_2 r_t + \varepsilon_{t+k}$$

The above equation is simply the one deduced in the presentation of the theoretical model. We assume that the relationship between the GDP growth rate, the real spread and the short rate is linear, which is a common assumption in econometric models of this type (Harvey, 1988). The aim of the ordinary least squares method is to estimate the coefficients of the model while minimizing the sum of the squares of the deviations between the observed and predicted values of the GDP growth rate.
We should also note that it is essential to verify regression assumptions, including homoscedasticity, absence of autocorrelation, and normality of residuals, to ensure the validity of the results.
This econometric specification will enable us to rigorously and accurately analyze the relationships between the variables under study, and to assess the impact of the real spread and the short rate on the future GDP growth rate.

4. Results

4.1.Data description

In this section, we carry out a descriptive analysis of the data relevant to our study, namely the real spread, the short rate and the GDP growth rate. The graphical analysis of the variables shows a sawtooth pattern for all variables, indicating a certain dynamicity, while the correlation analysis highlights significant relationships between these variables. At the same time, conformity analysis of the data provides insight into their distribution and variability, laying the groundwork for rigorous econometric analysis.

- **Graphical analysis:**

Graphical analysis of the three variables studied real spread, short rate and GDP growth rate reveals a certain volatility over time. The real spread has fluctuated somewhat moderately in recent years, with periods of rise and fall observed. At the same time, the graph for the short rate shows a relatively similar trend to that of the spread. By contrast, the GDP growth rate shows a distinct trajectory compared to the other two variables.

- **Correlation analysis:**

The correlation rate between the real short rate and the GDP growth rate is 0.115: this positive but weak correlation suggests a slightly positive relationship between the real short rate and the GDP growth rate. This may indicate that lower interest rates, represented by the real short rate, can stimulate economic growth by encouraging borrowing and investment by economic agents. However, this analysis cannot be 100% verified, especially as the correlation is quite weak, which means that other factors may have a different impact on economic growth than the level of short-term interest rates.
The correlation between the real short rate and the real spread is -0.056: The weak and negative correlation between the real short rate and the real spread suggests the existence of an inverse relationship between these two variables. Given that this correlation is close to zero, the relationship between these variables is very weak and may not be economically significant.

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The correlation between GDP growth rate and real spread is (-0.622): The moderate and negative correlation between GDP growth rate and real spread stipulates an inverse relationship between these two variables. Low economic growth rates are associated with higher real spreads.
This result can be interpreted economically by the fact that when financial conditions are more rigid, represented by higher spreads between long-term and short-term interest rates, economic activity contracts, making lending conditions costly for economic agents, which slows investment and consumption.

- **Conformity analysis:**

Descriptive analysis of the selected variables revealed in the table above provides the following analysis.

Table 1: Descriptive statistics for selected variables

	SPREAD	The real GDP growth rate	The real short rate
Mean	0.008107	0.009064	0.025694
Median	0.007600	0.012199	0.023800
Maximum	0.016855	0.096700	0.174934
Minimum	0.002777	-0.139095	-0.007378
Std. Dev.	0.002692	0.026811	0.023352
Skewness	0.898973	-2.384181	4.464250
Kurtosis	4.751197	18.33233	29.11636
Jarque-Bera	15.74824	644.5437	1904.456
Probability	0.000380	0.000000	0.000000
Sum	0.486432	0.543846	1.541661
Sum Sq. Dev.	0.000428	0.042412	0.032173
Observations	60	60	60

Source: calculated by the author

As for the spread, the average observed is 0.008107, with a median slightly below 0.007600, indicating a slight positive skewness in the data distribution. This result is also confirmed by the skewness coefficient, which is positive at 0.898973. As for the extreme values of the spread, they range from 0.002777 to 0.016855, showing a moderate dispersion of the data around the mean, illustrated by a standard deviation of 0.002692. In addition, the Jarque-Bera test has a low associated probability ($p = 0.000380$) of less than 5%, suggesting that the spread distribution differs significantly from that of a normal distribution.
The descriptive statistics for the real GDP growth rate show a more marked variability, with a mean of 0.009064 and a median of 0.012199. This implies the presence of a negative skewness that is endorsed by a skewness coefficient of -2.384181, indicating a concentration of high values on the left of the distribution. This skewness is still observed indicating a high kurtosis which is (18.33233), suggesting a distribution tail more stretched than that of a normal distribution. In addition, the Jarque-Bera test shows almost zero probability, confirming the non-normality of this variable's distribution.
For the real short rate, a highly skewed distribution is observed, as evidenced by a high positive skewness coefficient of 2.930856 and a high kurtosis of 11.45936, indicating a high concentration of data around the mean and very broad distribution tails. Furthermore, the Jarque-Bera test significantly confirms that the distribution of this variable differs from that of a normal distribution. $p = 0.000000 < 5\%$.

4.2.Preliminary tests on variables

As a preliminary to estimating our econometric model, it is fundamentally necessary to carry out preliminary tests on the variables. Indeed, the data structure of the model is based on time series dating from the first quarter of 2007 to the last quarter of 2023. In brief, the following table shows the results of the non-stationarity tests carried out on the three variables retained for the econometric model.

Table 2: Model series integration level

Series	*ADF*			*KPSS*			*Order of integration*
	Exog	*Lag*	*Stat*	*Exog*	*Lag*	*Stat*	
REAL SPEAD	C	0	-9.300766***	C	1	0.327272***	I(0)
REAL GDP RATE	C	2	-7.078296***	C	29	0.307662***	I(0)
REAL SHORT RATE	C	8	0.091099	C	5	0.488896**	I(0)

*Notes: *,** and *** represent significance at the 10%, 5% and 1% level; ADF: Augmented Dickey-Fuller test (H0=non-stationarity); KPSS : Kwiatkowski, Phillips, Schmidt and Shin test (H0=stationarity); ERS Test of Elliot, Rothenberg and Stock (H0=non-stationarity); Exogenous: this is the model adopted: c=with constant and without trend; Stat: *rejection of H0 at 10%, **rejection at 5%, ***rejection at 1%.*

Source: calculated by the authors

The Augmented Dickey-Fuller (ADF) test confirms level stationarity for the real spread and the real GDP growth rate. On the other hand, it shows non-stationarity for the real short rate, especially as the test statistic of 0.091099 is above the critical values.

The KPSS stationarity test confirms stationarity in level for all the variables studied the real spread, the real GDP growth rate and the real short rate. For this reason, and in line with our study, we consider all variables to be level-stationary.

This consideration is an important indication in the process of estimating the model using the ordinary least squares (OLS) method. Level stationarity implies that these time series are not systematically time-dependent, which is an essential condition for the application of linear regression and makes the estimation of OLS model parameters more robust and reliable. In other words, level stationarity suggests that the relationships between variables are not biased by time trends, enabling consistent estimates of the effects of the explanatory variables on the dependent variable.

In the next section, where we estimate the model using the ordinary least squares method, we can therefore be certain of the robustness and accuracy of the results obtained.

4.3.Estimation and statistical validation of the equation

To test the link between the slope of rates and future economic growth, we began by estimating equation (6), already presented in the section on the theoretical model.

$$\left(\frac{400}{k}\right)\log\left(\frac{y_{t+k}}{y_t}\right) = \alpha_0 + \alpha_1 s_t + \varepsilon_{t+k}$$

k represents the horizon considered, y_{t+k} represents the income earned between periods t and t +k, y_t represents income and s_t the slope of the rates, α_1 the associated coefficient.

Case 1: Explanation of future economic growth solely by the spread of the slope of real interest rates

In line with the below results[6], we note that the slope of real rates on treasury securities provides strong information in relation to future economic growth, particularly for the first, second, sixth,

[6] *Notes: *,** and *** represent significance at the 10%, 5% and 1% level.*

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eighth, tenth and twelfth quarters, especially as their $\overline{R^2}$ vary between 24% and 36%, suggesting the model's ability to explain the variation in future economic growth from one quarter to the next.

Table 3: Explanation of future economic growth solely by the spread of the slope of real interest rates

to k quarters	Morocco	
	2007 to 2021	
	α_1	$\overline{R^2}$
1	**0,005*** **	36,31%
2	**0,012** **	27,32%
3	**0,022*** **	17,41%
4	**0,032*** **	23,27%
5	**0,039** **	18,90%
6	**0,038** **	24,62%
7	**0,067*** **	10,83%
8	**0,054*** **	28,98%
9	**0,090*** **	11,83%
10	**0,067** **	24,24%
11	**0,097** **	13,38%
12	**0,086** **	24,38%

Source: Calculated by the authors

As for the estimated coefficients of the real rate spread, they vary from quarter to quarter, indicating a certain dynamic in the relationship between the spread and future economic growth. However, this dynamic has little impact on predicting the impact of the real interest rate spread on future economic growth, especially as the highest coefficient over the 12 quarters was 0.097.

Case 2: Explanation of economic growth by both the spread of the slope of real rates and the real short rate

In order to test the robustness of the previous relationship by verifying whether the slope of the rates does indeed provide information of its own, we have introduced the real short rate as carried out by (Estrella and Mishkin, 1997) and (Kosicki, 1997). The new equation becomes as follows :

$$\left(\frac{400}{k}\right)\log\left(\frac{y_{t+k}}{y_t}\right) = \alpha_0 + \alpha_1 s_t + \alpha_2 r_t + \varepsilon_{t+k}$$

With: r_t the real short-term rate; α_2 its associated coefficient.
The estimates are summarized in the following table below.

Table 4: Explanation of economic growth by both the spread of the slope of real rates and the real short rate

to k quarters	Morocco		
	2007 to 2021		
	α_1	α_2	$\overline{R^2}$
1	**0,005*** **	**0,0000**	35,21%
2	**0,012** **	**0,0122**	26,19%
3	**0,022*** **	**0,0443**	16,37%
4	**0,032*** **	**0,0973**	22,59%
5	**0,040** **	**0,1580**	18,30%
6	**0,039** **	**0,1937**	24,07%
7	**0,068*** **	**0,4075**	10,47%
8	**0,055*** **	**0,3856**	29,39%
9	**0,092*** **	**0,7362**	12,24%
10	**0,068** **	**0,6138**	23,95%
11	**0,098** **	**0,9791**	12,74%
12	**0,087** **	**0,9543**	23,87%

Source: Calculated by the authors

In line with the results provided in the table below we note that the introduction of the real short rate into the previous equation has weakened the informational power of the model. As for the spread, it remained significant for all quarters.
These results show that the real treasury spread still retains its ability to predict future economic growth, while the real short rate seems to have less of an effect in explaining future economic growth, especially when the real treasury spread is taken into account.
In his study, (Sédillot, 2001) confirms that the addition of other variables to the model, notably the lagged variables of real GDP or the short rate, could provide more information. With this in mind, we estimate the following model:

$$\left(\frac{400}{k}\right)\log\left(\frac{y_{t+k}}{y_t}\right) = \alpha_0 + \alpha_1 s_t + \sum_{j=0}^{l}\left(\frac{400}{k}\right) b_i \log\left(\frac{y_{t-jk}}{y_{t-(j+1)k}}\right) + \sum_{j=0}^{l} c_j r_{t-j} + \varepsilon_{t+k}$$

The introduction of real short lags and economic growth lags is designed to determine whether the interest rate spread can provide an indication of future economic activity. Note that $j = 0$, when the lag is equal to 0, and $j = l$ when the value corresponds to the last lag.
In accordance with the ADF non-stationarity test, the number of lags[7] disseminated by the EViews software for the real GDP variable is 2. For this reason, and from now on, the coefficients α_3 and α_4 will be associated respectively with the first and second lag of the real GDP growth rate.

Case 3: Explanation of economic growth by both the spread of the slope of real rates, the real short interest rate and the lags associated with the real short rate and the real GDP growth rate[8].

$$\left(\frac{400}{k}\right)\log\left(\frac{y_{t+k}}{y_t}\right) = \alpha_0 + \alpha_1 s_t + \alpha_2 r_t + \left(\frac{400}{k}\right)\alpha_3 \log\left(\frac{y_{t-1k}}{y_{t-2k}}\right) + \left(\frac{400}{k}\right)\alpha_4 \log\left(\frac{y_{t-2k}}{y_{t-3k}}\right) + \sum_{j=0}^{l} c_j r_{t-j} + \varepsilon_{t+k}$$

After introducing the lags associated with the real short rate and the real GDP growth rate into the econometric model, the informational power improved significantly from 35.21% to 41.03% for the first-quarter forecasts, by way of example. This improvement was also reflected in the other quarters, suggesting that the model continues to explain a significant proportion of the variance in future economic growth.
Also, the real yield spread on treasury securities remains significant, showing a fundamental and essential role in explaining future economic growth.
Although the model has a relatively high $\overline{R^2}$ indicating that it explains a significant proportion of the variance in future economic growth, the uncertainty surrounding the individual coefficients relating in particular to the lags of the GDP rate and the short rate suggests that the model as a whole may not be robust in terms of statistical significance especially as these variables are insignificant.
These results underline the importance of considering other factors or variables not included in the model, or perhaps even removing certain variables that disrupt the model in general, which could also influence future economic growth and provide more information.

[7] The ADF test gave us a lag of 2 for the real GDP variable and 29 lags for the KPSS, while for the real short rate ADF didn't consider any lags unlike the KPSS which chose 4. So, in order to estimate the second equation, it was still necessary to take the value of the delays, which are easy to calculate and manipulate.
[8] Although we have introduced the lags associated with the real short rate and the real GDP growth rate, we are only interested in interpreting the coefficients of the spread, real short rate and lagged economic growth variables.

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Table 5: Result of case 3

to k quarters	Morocco 2007 to 2021				
	α_1	α_2	α_3	α_4	$\overline{R^2}$
1	**0,005*** **	**0,0000**	**-0,0326**	**-0,276** **	41,03%
2	**0,010** **	**0,0101**	**-0,0077**	**-0,0936**	34,64%
3	**0,022*** **	**0,0435**	**0,0262**	**0,0944**	13,36%
4	**0,029*** **	**0,0865**	**-0,1936**	**-0,822**	31,87%
5	**0,030** **	**0,1197**	**-0,0241**	**-0,3372** **	27,91%
6	**0,032** **	**0,1600**	**0,0538**	**-0,6098**	31,45%
7	**0,046*** **	**0,2749**	**0,1139**	**0,2984**	18,43%
8	**0,046*** **	**0,3195**	**1,2761**	**0,2804**	35,95%
9	**0,061*** **	**0,4907**	**-0,5449**	**-0,5824**	27,65%
10	**0,058** **	**0,5263**	**0,4370**	**0,0312**	23,58%
11	**0,082** **	**0,8198**	**0,9306**	**1,575***	44,47%
12	**0,063** **	**0,6898**	**-0,7844**	**-1,5209**	29,60%

Source: Calculated by the authors

Case 4: Explanation of economic growth by the spread of the slope of real rates and the lags associated with the growth rate of real GDP "removal of the short rate variable".

$$\left(\frac{400}{k}\right)\log\left(\frac{y_{t+k}}{y_t}\right) = \alpha_0 + \alpha_1 s_t + \left(\frac{400}{k}\right)\alpha_2 \log\left(\frac{y_{t-1k}}{y_{t-2k}}\right) + \left(\frac{400}{k}\right)\alpha_3 \log\left(\frac{y_{t-2k}}{y_{t-3k}}\right) + \varepsilon_{t+k}$$

Table 6: Result of case 4

to k quarters	Morocco 2007 to 2021			
	α_1	α_2	α_3	$\overline{R^2}$
1	**0,005*** **	**-0,0305**	**-0,274** **	42,10%
2	**0,012** **	**0,2792**	**-0,0767**	36,60%
3	**0,022*** **	**0,0252**	**0,1005**	15,15%
4	**0,028*** **	**-0,1396**	**-0,7749**	31,90%
5	**0,029** **	**0,0059**	**-0,3270**	29,12%
6	**0,032** **	**0,0779**	**-0,5953**	33,00%
7	**0,045*** **	**0,1029**	**0,2628**	19,74%
8	**0,045*** **	**1,3272**	**0,2803**	37,55%
9	**0,060*** **	**-0,5404**	**-0,5874**	28,97%
10	**0,057** **	**0,3861**	**-0,0086**	25,42%
11	**0,080** **	**0,9156**	**1,574***	46,42%
12	**0,063** **	**-0,7803**	**-1,5139**	33,11%

Source: Calculated by the authors

After eliminating the short rate, the model has been slightly improved in terms of the information it provides on future economic growth. The coefficients estimated for the real-rate spread provide information on the expected effect of slope variation on future economic growth. With p-values of less than 5% for the slope (real-rate spread), this suggests that the real-rate spread is a significant determinant of future economic growth in most quarters. The results indicate that higher spreads are associated with stronger future economic growth, and the other way around.

5. Discussions

The results of our econometric analysis show that the real interest rate spread remains a significant determinant of future economic growth. Similarly, the coefficients associated with slope demonstrated a statistically significant relationship in all quarters, indicating that

variations in the real-rate spread can substantially influence the trajectory of short-term economic growth. These results suggest that higher spreads are generally associated with stronger future economic growth. These results are in line with (Sédillot, 2001), who argues that the predictive contribution of the yield spread appears to be significant, and suggests that the real yield spread contains useful information for forecasting future economic growth. Also, (Harvey, 1988) demonstrated that the structure of expected real rates offers a better predictive ability of consumption growth than the two widely used traditional measures, namely lagged consumption growth and lagged stock market returns. Building on this momentum too, Estrella and (Hardouvelis, 1991) argued that positive yield curve slopes are correlated with a future increase in real economic activity. Their research revealed that this correlation gives the yield curve additional predictive power over other variables such as the index of leading indicators, short-term real interest rates, lagged growth in economic activity and lagged inflation rates.

As for our own results, they indicate that the slope of real rates on treasury securities offers significant[9] information for predicting future economic growth over several quarters. This suggests that variations in the structure of real rates can play an important role in forecasting short- and medium-term economic fluctuations. The model exhibits a reasonable ability to explain future economic growth, notably with coefficients of determination $\overline{R^2}$ ranging from 24% to 36%, underlining its importance in economic analysis.

Although the real interest rate spread remains significant in most quarters, the estimated coefficients vary from quarter to quarter, suggesting a certain dynamicity in the relationship between the spread and future economic growth. However, the impact of the spread on economic growth remains relatively weak, with a maximum coefficient of 0.098 observed. This result could be interpreted differently, by arguing that this low elasticity implies very high levels of risk aversion. In other words, economic agents may adopt a very cautious approach when making investment decisions, prioritizing risk minimization even if this could result in higher returns.

The introduction of the real short rate weakened the informational power of the model, although the real interest rate spread remained significant for all quarters. This suggests that the real short rate has a less significant effect on future economic growth, particularly when the real interest rate spread is taken into account in the model. The improvement in the explanatory power of the model after the introduction of lags associated with the real short rate and the real GDP growth rate remains very modest, underlining the need to use other factors or variables that could influence future economic growth. It is also recommended to examine the robustness of the model in terms of the statistical significance of individual coefficients, particularly those associated with lags in the GDP rate and the short rate. Future research could also focus on identifying and incorporating additional variables to improve the accuracy of economic growth forecasts.

6. Conclusion

This paper examines the relationship between the real interest rate spread and expected economic growth, in the specific context of Morocco. The results confirm that the real interest rate spread remains an important factor in predicting future economic growth. The statistically significant relationship between the slope of the real interest rate spread and the trajectory of short-term economic growth underlines the importance of this indicator in assessing the economic outlook.

Our results also corroborate the work of (Harvey, 1988) and (Estrella and Hardouvelis, 1991), who highlight the predictive effectiveness of the structure of expected real rates and positive slopes of the yield curve on future economic activity.

[9] *The p-value associated with the spread is less than 5% in all the models presented.*

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Introducing the real short rate into the econometric model weakened the informational power of the model. On the other hand, the real rate spread remained significant even after this inclusion. This suggests that the real rate spread retains a predictive capacity for future economic growth, while the real short rate seems to have a less significant effect, especially when the spread is taken into account in the model. Our results therefore underline the importance of considering the spread when analyzing and forecasting future economic growth in Morocco.

However, future research is needed to explore other factors or variables that could also influence economic growth in order to strengthen the robustness of the model. In addition, it is crucial to take into account the effect of uncertainty surrounding the estimated coefficients, particularly those associated with variables such as lags in the GDP rate and short rate, in order to improve the accuracy of economic forecasts.

Ultimately, our results highlight the importance of the real rate spread in predicting future economic growth in Morocco. Although the real rate spread of treasury securities retains its predictive capacity for future economic growth, the introduction of the real short rate and other variables raises questions about the robustness of the model and suggests the need to consider other factors for a more complete analysis of economic dynamics in Morocco. In addition, it is important to consider that the spread coefficients for all the models studied show a low impact on future economic activity, indicating very high levels of risk aversion, which will undoubtedly lead economic agents to adopt a very cautious approach when making their investment decisions. These findings have important implications for policymakers, investors and researchers, encouraging them to consider the structure of real rates as an essential indicator in their assessment and anticipation of Morocco's future economic conditions.

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