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Yield curve dynamics and the performance of Iberian economies

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Abstract

The aim of this paper is to analyze the bidirectional relation between the term structure of interest rates components and macroeconomic factors. Using a factor augmented vector autoregressive model, impulse response functions and forecasting error variance decompositions we find evidence of a bidirectional relation between yield curve factors and the macroeconomic factors, with increased relevance of yield factors over it with increased forecasting horizons. The study was conducted for two Iberian countries using information of public debt interest rates of Spain and Portugal and macroeconomic factors extracted from a set of macroeconomic variables, including indicators of activity, prices and confidence. Results show that the inclusion of confidence and macroeconomic factors in the analysis of the relationship between macroeconomics and interest rate structure is extremely relevant. The results obtained allow us to conclude that there is a strong impact of changes in macroeconomic factors on the term structure of interest rates, as well as a significant impact factor of the term structure, in the future evolution of macroeconomic factors.

Keywords: confidence; factor models; macroeconomic factors; term structure of interest rates

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1. Introduction

The modelling of the term structure of interest rates has been one of the most relevant aspects in the economic and financial literature given the information that it incorporates in relation to the evolution of economic activity. Since the initial work of Litterman and Scheinkman (1991) in which the authors identify three latent factors governing the dynamics of the yield curve, corresponding to level, slope and curvature, several studies have emerged not only to confirm its existence and the explanatory capacity of the term structure but also to analyze it's relation with the macroeconomic dynamics.

In fact, the analysis of the relationship between the yield curve and macroeconomic variables has been the subject of numerous studies over the last decades. Tavares (2019) study the effect of several macroeconomic variables on the yield curve using a vector autoregressive (VAR) model. They show that most of the variation in the term structure of interest rates is driven by macroeconomic shocks and that, in particular, monetary policy has a significant effect on the slope of the yield curve and that a change in families' preferences for consumption has an important impact on the curve level (Campina, 2018; Korneeva, 2020).

Tavares's (2019) study confirm earlier findings such as the ones of Patel et al. (2018) and Vavrová et al. (2018) who also find favorable evidence that the slope factor is related to shocks in monetary policy. Studies by Boukhatem & Sekouhi (2017), Balcilar et al. (2016), Jain, (2018), and Barigozzi & Hallin (2017) conclude that monetary policy shocks affect the slope of the yield curve and that it is highly correlated with real activity. These results are present today in numerous articles, essentially varying the type of model used and the period of the sample.

Several recent studies try to evaluate this impact of changes in macroeconomic variables in the components of the term structure of the interest rate, but most of them focus in the study of the slope factor(Burgin, 2018; Michalkova & Frajtova Michalikova, 2017; Ciburiene et al. 2019) . However, there is some consensus that in addition to the slope of the yield curve, the two components, level and curvature, play an important role in the analysis of the macroeconomic dynamics (Kucuktamer & Uzunboylu, 2015). Borağan Aruoba (2020) use two latent factors (level and slope) of the yield curve and three observable macroeconomic variables (inflation, real activity and a monetary policy instrument), finding strong evidence of the effect of shocks on the yield curve factors on the macroeconomic variables, with the inverse effect being weaker. Lange (2017), in a study for Canada, uses the same variables and a dynamic model of latent factors stating that causality is bidirectional and much stronger than that found for the USA.

Hüseyin (2017) analyzes from an economic point of view the information contained in the three components of the yield curve determined by Nelson and Siegel's (1987) dynamic model: level, slope and curvature. It studies the evolution of the main macroeconomic variables in order to detect the impact of changes of the three components, concluding that unexpected shocks in the curvature factor incorporate more information on the future evolution of the yield curve and macroeconomic aggregates than previously recognized. Vieira et al. (2017) also proposes a forecasting model that combines a factor augmented VAR methodology with the Nelson and Siegel (NS) parametrization of the yield curve in order to predict the Brazilian term structure of interest rates, concluding that their model improves on the predictive accuracy particularly at short term. Also, Paccagnini (2016, 2017) studied the impact of the macroeconomic determinants on the USA term structure during the Great Moderation period using macroeconomic variables and factor augmented VAR methodology.

The purpose of our study is to evaluate the information implicit in the components of the term structure regarding the future evolution of fundamental macroeconomic variables. There are some points that allow us to distinguish our work from previous studies. On the one hand, we chose not to consider only individual macroeconomic variables but to incorporate a broader set of macroeconomic

information from which we extract macroeconomic factors. We seek to analyze the existence of a bidirectional relationship between the factors that determine the yield curve and the macroeconomic factors. For this purpose, we first study changes in the factors of the yield curve resulting from the reaction of the bond market to shocks in macroeconomic factors. Indicators of activity, prices and confidence grouped under the macroeconomic variables. In a second phase, we analyze which information transmitted by shocks in the three components of the yield curve have an effect on the future behavior of macroeconomic factors.

2. **Data and Methodology**

In our study, the yield curve latent factors and the macroeconomic variables are model by FAVAR (Factor-Augmented vector autoregressive) macro-finance model, seeking to characterize the relationship among estimated yield factors and the macroeconomic factors.

We started our study with the extraction of the components of the yield curve through the dynamic model of Nelson and Siegel (1987) proposed by Singh & Hatekar (2018). We estimate the model using monthly data for the two Iberian countries: Portugal (PT) and Spain (SP) from January 1990 until December 2011. The data refers to zero-coupon yields, for several different maturities (from 3-months to 120 months) and was obtained from the Central Banks of Portugal and Spain. In total, we obtained 264 monthly observations for each country. The choice of Spain and Portugal as the subjects of study for this research can be attributed to their recent economic recoveries. Most researchers have shifted focus in studying the economic activities of these countries because they want to understand how they were able to turn the economic situations of their countries in their favor.

For the macroeconomic factors, we collected data for tree different groups of macroeconomic variables including indicators of activity, prices and confidence, in total, 50 for each country were collected individually from the OECD, IMF, Eurostat and Central Banks of Portugal and Spain. These three variables were selected because they are the best reflectors or indicators of macroeconomic activities. We conduct a probabilistic analysis of principal components extracting the main element for each of the groups of macroeconomic variables considered.

Then, we combine the macroeconomic factors and the latent factors of the term structure of interest rates in the FAVAR model and we analyze the interactions between factors using the variance decomposition and the impulse response functions as in Almeida et al. (2016), Hüseyin (2017), Lange (2017), Laumer (2020), and Borağan Aruoba (2020).

3. **Empirical Results**

In order to estimate the effect of an exogenous shock of the yield curve factors over the macroeconomic factors and of an exogenous shock of macroeconomic factors over the yield curve factors, we used the forecast error variance decomposition and impulse response function analysis.

3.1 Forecast Error Variance Decompositions

The forecast error variance decompositions allow us to measure how much of the forecast error variance for any factor is explained by shocks to each explanatory factor, over a series of time horizons. In table 1 we present the results of this decomposition, the sum of macroeconomic effects and the sum of yield effects for the 24 months forecasting horizon.

Analyzing the table 1, and for a time horizon of 24 months, we can conclude that in both countries the effect of macroeconomic factors shocks on term structure factors is stronger than the inverse. For

Spain we can observe that percentage of the variance of the error made in forecasting macroeconomic factors due to macroeconomic shocks in 24 months is of 90,4%, 87,4% and 88,4% for activity, prices and confidence, respectively. In the Portuguese case, these reach percentages in the order of 95,9%, 64,5% and 77,1%.

The effect of shocks of macroeconomic factors on term structure factors is more visible in the slope in both countries, being the shocks in the term structure factors generally stronger in Spain than in Portugal. The percentage of the variance of the error made in forecasting term structure factors due to macroeconomic shocks in 24 months is 13,1%, 20,7% and 14,7% for level, slope and curvature, respectively, in Spain and of 5,2%, 22,1 % and 4,1% in Portugal.

In respect to the effect of term structure factors shocks in macroeconomic factors, the effect is more noticeable in prices for Portugal and for Spain. As in the case of macroeconomic shocks, the effect of term structure factors shocks in macroeconomic factors is also stronger in Portugal, with the exception of the activity.

Our results reach the ones obtained by Borağan Aruoba (2020)for the USA economy. They found that macroeconomic variables effects over the yield curve are more important than in the other direction. However, they point in the opposite direction of Lange (2017) in a study for Canada.

Table 1: Forecast error variance decompositions under the FAVAR model for a time horizon of 24 months

	FEDV of Macro factors decompositions			FEDV of Yield curve decompositions		
Spain	Activity	Prices	Confidence	Level	Slope	Curvature
Activity	0,482	0,099	0,035	0,047	0,055	0,085
Prices	0,359	0,751	0,409	0,016	0,044	0,026
Confidence	0,063	0,025	0,441	0,067	0,108	0,036
Macro effect	0,904	0,874	0,884	0,131	0,207	0,147
Level	0,087	0,076	0,090	0,714	0,447	0,498
Slope	0,003	0,016	0,017	0,116	0,214	0,063
Curvature	0,006	0,034	0,008	0,040	0,132	0,292
Yield effect	0,096	0,126	0,116	0,869	0,793	0,853
Portugal	Activity	Prices	Confidence	Level	Slope	Curvature
Activity	0,731	0,065	0,005	0,040	0,034	0,010
Prices	0,026	0,573	0,037	0,008	0,150	0,022
Confidence	0,202	0,007	0,728	0,005	0,037	0,009
Macro effect	0,959	0,645	0,771	0,052	0,221	0,041
Level	0,020	0,023	0,064	0,186	0,100	0,032
Slope	0,002	0,020	0,008	0,003	0,241	0,093
Curvature	0,019	0,312	0,158	0,759	0,438	0,834
Yield effect	0,041	0,355	0,229	0,948	0,779	0,959

This table contains the absolute values of the variance of the error made in forecasting a given factor due to a specific shock in another factor at the time horizon of 24 months, and the sum of macroeconomic effects and the sum of yield curve factors effects for the same time horizon. The table should be read as the effect of the variables in the vertical axis (the lines) over the variables in the horizontal axis (the columns).

In order to complement our analysis, we present in table 2, the major sources of randomness and its tendency for each factor for Portugal and Spain and for a 4 and a 20 months horizon.

For Spain, the main sources of randomness for activity in a short-term horizon are prices, confidence and curvature, but in the long run, the prices, slope and curvature are the main source of randomness. An important source of randomness for prices is the confidence, followed by activity and level in the short term, and activity and slope in the long term. Confidence depends on activity, level and slope, with the effect of term structure factors following an increasing tendency. As to the term structure components, the level is affected by confidence, slope and curvature. Slope is affected by activity, confidence and curvature in short-term and confidence, level and curvature in long-term. The curvature is affected by prices, level and slope in both the short and the long term, but the level has a symmetric effect between the short and long term.

For Portugal, we note that activity is fundamentally affected by prices, level and slope, both in the short and long term. Confidence is affected by activity and by level and curvature in short-term and slope and curvature in long-term. In the short term, prices are affected by activity, slope and curvature and in the long term by activity, confidence and slope. As to the major sources of randomness in the term structure factors, level is affected by confidence, slope and curvature and the curvature is affected by prices, level and slope. The slope is affected by prices, confidence and curvature.

In both countries, we note that confidence is an important factor in explaining all macroeconomic factors, as well as term structure factors, but there are some marked differences in the impact in each country. As for the level factor, we can see that this explains a significant percentage of prices and confidence in Spain, with a growing tendency in the long run. In Portugal is a major source of randomness of the activity and confidence.

Table 2: Forecast error variance decompositions for 4 and 20 months – summary of FEDV for FAVAR models – Spain (SP) and Portugal (PT)

Spain	H	AT	T	PR	T	CF	T	L	T	S	T	C	T
AT	4	**94,7%**	↘	2,2%	↗	5,9%	↗		↗		↗	3,7%	↗
	20	**52,8%**	↘	10,1%			↘		↗	5,1%	↗	8,6%	↘
PR	4	0,7%	↗	**97,0%**	↘	5,5%	↗	0,9%	↘		↗		↘
	20	32,9%	↗	**78,5%**	↘	38,1%	↗		↗	2,7%	↗		↗
CF	4	3,9%	↗		↗	**86,9%**	↘	3,8%	↗	5,0%	↗		↗
	20	6,6%				**48,3%**	↘	6,5%	↗	10,3%	↗		
L	4		↘		↗	0,2%	↗	**90,4%**	↘	48,7%	↗	62,6%	↘
	20		↗		↗	7,2%	↗	**74,0%**	↘	46,3%	↘	49,7%	
S	4	0,2%	↘		↘	1,2%	↗		↗	**41,5%**	↘	4,3%	
	20		↗		↗	1,9%	↘	9,7%	↗	**22,2%**		6,4%	
C	4		↗	0,6%	↗			3,5%	↗	4,3%	↗	**26,9%**	↗
	20			3,4%			↗	4,1%	↘	13,3%		**30,0%**	↘
Portugal	H	AT	T	PR	T	CF	T	L	T	S	T	C	T
AT	4	**93,7%**		3,8%	↗			0,7%	↗	0,4%	↘		
	20	**76,2%**	↘	7,0%				3,9%	↗	2,7%	↗		↗
PR	4	3,2%		**93,6%**			↗		↗	0,32%	↗	0,4%	↘
	20	2,7%	↘	**61,6%**		3,0%	↘			13,0%	↗		↗
CF	4	2,1%	↗			**97,9%**		0,6%	↘		↗	0,6%	
	20	17,5%	↗			**76,1%**			↗	3,6%	↗	0,6%	↗
L	4				↗	1,1%	↗	**78,5%**	↘	44,2%	↘	4,8%	

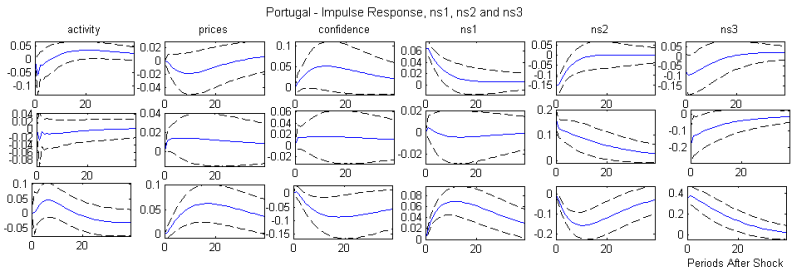
	20	↗			6,1%	↗	**21,3%**		11,4%		3,3%		
S	4	↗	1,0%	↗	0,5%	↗			**46,5%**	↘	12,8%	↘	
	20		1,9%	↗	0,8%				**25,8%**	↘	9,4%		
C	4	↗	1,2%	↗		↗	19,8%	↗	8,2%	↗	**81,4%**	↗	
	20		26,7%	↗		↗	73,5%	↗	43,5%		**84,0%**		

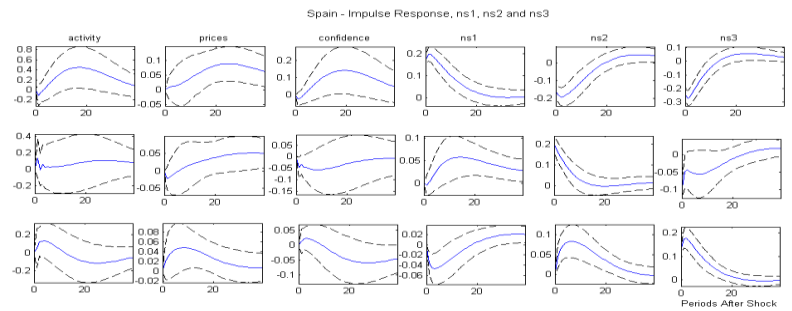
This table contains percentage values of the variance of the error made in forecasting a given factor due to a specific shock in another factor at the time horizon of 4 and 20 months for Spain (SP) and Portugal (PT) and factors trend behavior through the forecasting horizons considered in total (1 to 24 months). Besides the own factor impact , only three major sources of randomness for each factors have been accounted for. The table should be read as the effect of the variables in the horizontal axis (the columns) over the variables in the vertical axis (the lines). AT stands for activity, PR for prices, CF for confidence, L for level, S for slope and C for curvature. H stands for horizon and T for tendency.

Regarding the slope factor, our results show that slope is a good predictor for economic activity essentially in the long run. This conclusion is in line with the literature that documents that the slope of the yield curve is a good predictor of future economic growth (Borağan Aruoba (2020)). In addition, curvature (the medium-term component) reveals to be important in explaining activity for Spain and prices and confidence for Portugal. Borağan Aruoba (2020)associate the level and slope of the yield curve with inflationary expectations and cyclical variation of output, respectively.

3.2 Impulse Response Functions

Next, we used impulse response function analysis to estimate the effect of an exogenous shock of the yield curve factors over the macroeconomic factors and of an exogenous shock of macroeconomic factors over the yield curve factors.





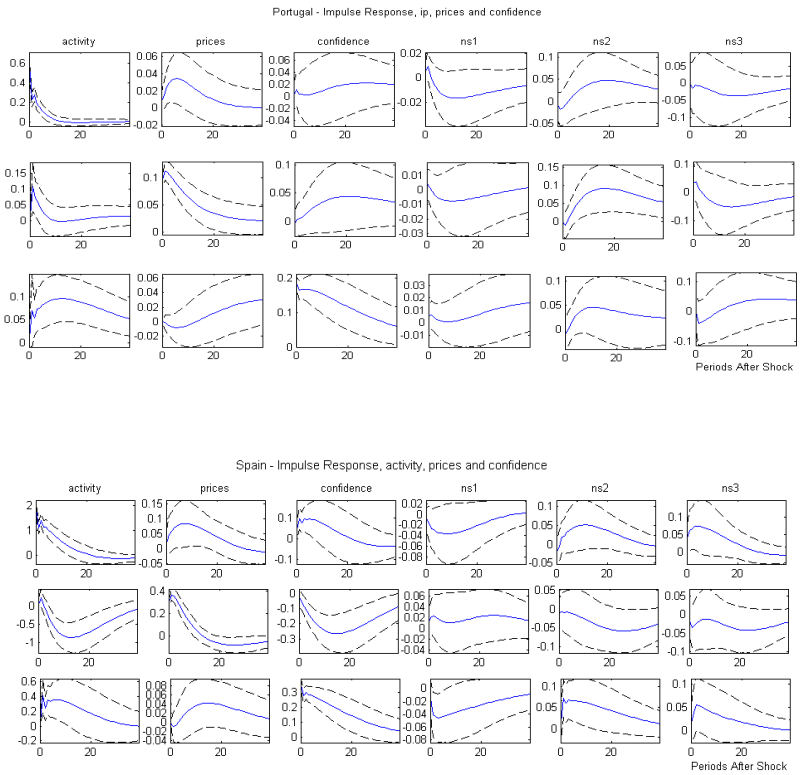


Figure 1: Impulse responses for the macro-yield components FAVAR model

These graphs show the impulse responses of activity, prices, confidence and yield factors (ns1, ns2 and ns3) to innovations in the yield curve factors for Portugal (first panel) and Spain (second panel) and to innovations in activity, prices and confidence for Portugal (third panel) and Spain (fourth panel). The bold lines are the impulse responses. The dashed lines are standard error bands.

Figure 1 presents the impulse response function plots obtained for Portugal and Spain showing the effect of a 1% change in each factor due to a shock in one other macroeconomic or term structure factor, along with 90 percent confidence.

4. Discussion

Our results show strong evidence of macroeconomic effects on the future yield curve, but a weaker evidence of yield curve effects on future macroeconomic developments. For both countries, all macroeconomic factors seem to show significant persistence's and the yield curve components add some interesting elements to the macroeconomic responses.

We start with the analysis of the macroeconomic responses to macroeconomic shocks in figure 1. As in Borağan Aruoba (2020), an increase in the activity is followed by a positive response in prices. In Spain, we can see a slight increase in prices and confidence, which decreases in 8/9 months horizon. In Portugal, it leads to a positive response in prices and confidence.

Turning to our main purpose of evidencing what information innovations of the term structure level, slope and curvature convey about the economy future evolution, now we explore the macroeconomic

responses to yield curve shocks. The increase in level raises the activity and confidence in Spain and raises the activity (short-term), prices and confidence in in Portugal. As in Hüseyin (2017) and Lange (2017), an increase in the level factor raises activity and prices, confirming the interpretation of Borağan Aruoba (2020) that the level factor as the bond market's perception of long-run inflation. As such, an increase in future perceived inflation lowers the ex-ante real interest rate, followed by an increase in economic activity and this in turn increases confidence. This effect is observed for both countries.

As to the curvature, our results are contrary to those of Borağan Aruoba (2020) but are in line with the conclusions of Hüseyin (2017), Lange (2017) and Levant and Ma (2016), suggesting that macroeconomic factors react to curvature shocks. An increase in curvature as a strong impact in all macroeconomic factors in Spain and in Portugal, implying an increase in activity stronger in Portugal than in Spain. This curvature shock implies an initial rise of activity, which slowly reverts, significantly falling towards zero about approximately 3 and 8 months.

The analysis of yield curve responses to macroeconomic shocks show that all yield curve factors respond to macroeconomic factors. However, this response is stronger for slope and curvature than for the level factor. In both countries, an increase in the activity lowers the level and rises the slope as in Lange (2017) and Levant and Ma (2016).

In terms of shocks to confidence factor, a surprise in confidence leads to an increase in the level factor in median and long-term horizons. In face of these confidence positive shocks, we see that also the slope increases through the response of the monetary policy, which is be forced to move interest rates and this is verified through the observed decrease felt in level after these confidence rise in all both countries.

As such, the confidence factor which were initially identified as being highly correlated to activity components, and as being one of the major sources of randomness for these variables, through IRFs, reveal an important factor that needs to be accounted for when we try to explain the relation between yield curve components and the macroeconomy (Slavinskaite, 2017;Hasanov & Akbulaev, 2020). Moreover, the reason we chose to include confidence factor into the macro-yield components analysis here performed, was because confidence reflects the confidence sentiment in the economy (Sandu, & Gide 2019). When confidence rises, economic activity increases, thus raising output, and this is verified by the positive impact obtained over activity. After, the pressure felt through output rises, and leads to a rise price reaction.

Now assessing the effects of yield curve responses to yield curve shocks, an increase in level is followed by hump-shaped response of slope and of curvature factors in Spain and Portugal. In the months following a level surprise, and consistent with Hüseyin (2017) results, short and medium-run maturities rise more than longer maturities.

5. **Conclusions**

This paper analyses the bidirectional relation between the yield curve factors and macroeconomic factors. Our results show that in both countries the effect of macroeconomic factors shocks on term structure factors is stronger than the inverse. Using monthly observations of macroeconomic data and yield curve observations for Spain and Portugal, we tested this relationship for the period January 1990 until December 2011, to include moments of instability. We also included a new macroeconomic factor representing the agent's confidence and use macroeconomic factors representing activity and prices when inferring the relationship between the economy and yield curve information.

The results show strong evidence of macroeconomic effects on the future yield curve, but a weaker evidence of yield curve effects on future macroeconomic developments in Spain and Portugal. However, yield curve components add some interesting elements to the macroeconomic responses. Studding the

results of the Forecast Error Variance Decompositions, we note that confidence revels herself to be an important factor in explaining all macroeconomic factors, as well as term structure factors. The level factor explains a significant percentage of prices and confidence in Spain and the activity and confidence in Portugal. The slope factor is a good predictor for economic activity essentially in the long run. This conclusion is in line with the literature that documents that the slope of the yield curve is a good predictor of future economic growth.

The Impulse Response Functions analysis also shows that an increase in level raises the activity and confidence in Spain and raises the activity, prices, and confidence in in Portugal. An increase in the level factor raises activity and prices, that the level factor as the bond market's perception of long-run inflation.

As regards to the confidence factor, Impulse Response Functions analysis shows that is an important factor to be accounted for when we try to explain the relation between yield curve components and the macroeconomy. A shock in confidence leads to an increase in the level factor in median and long-term horizons. When confidence rises, economic activity increases, thus raising output, and this is verified by the positive impact obtained over activity. After, the pressure felt through output rises, it leads to a rise price reaction.

Our results suggest that yield curve components contain information about future macroeconomic dynamics, also that the confidence factor it is important to explain the relation between yield curve components and the macroeconomy.

6. Recommendations

This research sought to analyze the bidirectional relation between the term structure of interest rates components and macroeconomic factors using three main variables: indicators of activity, prices, and confidence. Even though these macroeconomic variables are viable and the best measure of the studied relationship between structure of interest rates components and macroeconomic factors, there are other factors that equally measure this relationship. The research therefore suggests that future researchers investigate other macroeconomic variables that can be studied in order to make the debate in this topic complete.

Economists in Spain and Portugal can apply the results of this research in their decision making and policies in order to improve the economy of their countries. Other countries could also compare the results of this result to their economies to understand the relationship between term structure of interest rates components and macroeconomic factors.

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