Identifying the Distortions of Market Relationships in Government Bond Markets using ARDL-Models

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Introduction

The relevance of the research. The post-crisis "new" reality with low or even negative interest rates (until the end of 2020) forced global investors to take more risk. Interest rate levels in developing countries remain attractive, as they provide real positive returns (for the Russian Federation, about 1.2% with a gradual decrease by December 2020). There are active flows to emerging market funds and carry trade. A number of developing countries, including Russia, are actively developing the market for government bonds (GB) in local currency. By 2019, the share of GB markets in the local currency (LCY GB) of developing countries reached 30% of the global public debt market. This motivates our research to identify the factors that determine the dynamics of interest rates in the bond markets of developing countries. Numerous studies focus primarily on the determinants of dollar or euro denominated GBs (Hartelius et al., 2008; Siklos, 2011; Silvapulle et al., 2016; Izadi and Hassan, 2018; Boysen-Hogrefe, 2017; Senga et al., 2018; Capelle-Blancard et al., 2019; Boubaker et al., 2019). The determinants of LCY GB are less studied (Rodionova, 2014; Moreno, 2008; Peiris, 2010; Jaramillo, Weber, 2013). Our research is motivated by identifying new trends after the 2008 global financial crisis and the 2014-2015 regional crises. Our results close the gaps in this area.

The aim of this study is to analyze the determinants of the nominal yields of GBs in large emerging markets (BRICS countries) based on the construction and selection of optimal ARDL models. We consider the influence of both global and specific national factors.

Our contribution to previous research is in two directions. First, we develop a methodology for analyzing pricing in financial markets. In modern econometric research, one of the most important aspects is the selection procedures for explanatory or predictive models and their evaluation. Many econometric methods were developed decades ago and have become classics in quantitative research. At the same time, the volume, variety and plenitude of the data grows, the calculation procedures are automated to reduce labor intensity. When studying time series, the volume of initial data can increase significantly, since it becomes possible to use lags and differences of explanatory variables. In such conditions, the problem is not the construction of a statistically adequate model itself, but the choice of the optimal model based on various criteria of optimality. The urgency of this problem is increasing, since classical information criteria or qualitative statistics often contradict each other and become the result of "fitting". In our paper, for each country under consideration, we use its own set of initial

variables and select its own optimal ARDL model, reflecting the relationships between various factors and the LCY GB yields. In total, about 3200 models are tested.

Second, for the first time for each BRICS market, we identify the dominant factors that determine the yields on LCY GB and compare them with regard to the term to maturity. For each optimal ARDL model, a VIM (variable importance measure) estimate is constructed, which allows ranking the contribution of each variable to the final value of the coefficient of determination of the model R^2.

Hypotheses

We put forward a number of hypotheses regarding the determinants of LCY GB yields. The first group of hypotheses concerns the influence of country factors, including the actions of the Central Bank, public debt and expenditure management policies, and characteristics of the stability of the macroeconomic situation. The second group of hypotheses concerns the influence of global market factors: risk tolerance, the dynamics of commodity markets and the US stock market.

The first group of hypotheses concerns the influence of national factors.

H1.1. The inflation rate has a significant positive effect on LCY GB yields. An important co-factor is the Central Bank (key rate) policy.

H1.2. The depreciation of the local currency relative to the US dollar raises LCY GB yields.

H1.3. The economic growth has a significant effect on LCY GB yields.

H1.4. The ratio of government debt to GDP significantly effects LCY GB yields.

H1.5. The balance of the state budget (% GDP) significantly effects LCY GB yields.

H1.6. The greater is the increase in the money supply, the lower are LCY GB yields.

The second group of hypotheses concerns the influence of the global market factors.

H2.1. The higher is the US market volatility index (VIX), the higher are LCY GB yields in the emerging markets. The VIX growth impacts differently the LCY GB markets of various countries.

H2.2. The growth of the S&P500 stock index has a significant impact on LCY GB yields in emerging markets.

H2.3. The oil price has a significant effect on LCY GB yields.

The control variables are yields of 10-year US Treasuries and 3-month US T-Bills (Hartelius et al., 2008).

Methodology

The research is based on ARDL-models (Pesaran, 1998, 2001), the use of which for cointegration analysis has recently become quite popular. Models of this class have a number of important advantages. First, they allow variables of different integration orders to be combined in one

model while maintaining the quality of the model. Secondly, ARDL allows you to use arbitrary variable lags and any combinations of them when building a model. In our work, for each country under consideration, we use its own set of initial variables and select its own optimal model. The choice is made for 4 explained variables, 5 different countries, about 200 models are tested for each explained variable and country (in total, about 4000 models are tested).

We can briefly describe the procedure as the following:

- ✓ We check time series for stationarity (Dickey-Fuller, Phillips-Perron, Elliott-Rothenberg-Stock tests) and implement the first differences approach.
- ✓ We test the co-integration between the YTM of LCY GB and inflation rate (ARDL-bounds tests, Johansen).
- ✓ To estimate the long-term relationship between the model variables, the ARDL model is used in the form of error correction:

$$\Delta YTM_{i,t} = \alpha_i + \theta_i t + \sum_{k=1}^{p\in(1:K^*)} a_{i,k}\Delta YTM_{i,t-k} + \sum_{k=1}^{q\in(1:K^*)} b_{i,k}\Delta {\pi^e}_{t-k} + \gamma_i YTM_{i,t-1} + \mu_i {\pi^e}_{t-1} + \varepsilon_{i,t}$$

where $YTM_{i,t}$ is the nominal yield to maturity of a GBLCY with i years to maturity (i = 1, 3, 5, 10), $\alpha, \gamma, \mu, \theta, a, b$ are model parameters, π^e is inflation rate, K^* is the optimal lag of the model variables.

- ✓ To choose the optimal model, we analyze the models with all possible configurations of $\{p; q\}$. After estimating a model, we test its residuals for the normality (Jacques-Burr test) and for autocorrelation (Brousch-Godfrey test), and compute the Akaike (AIC) and Schwartz (BIC) criteria.
- ✓ The following component is used to account for the long-term relationship:

$$ECT_t = \gamma_i YTM_{i,t-1} + \mu {\pi^e}_{t-1}$$

It is estimated with the help of the Δ-method (Oehlert, 1992).

- ✓ A complex factorial ARDL model is built:

$$\Delta YTM_{i,t} = c_i + d_i t + \sum_{k=1}^{p\prime\in(1:K^*)} a_{i,k}\Delta YTM_{i,t-k} + \sum_{j=1}^{n}\sum_{k=1}^{q_j\prime\in(1:K^*)} b_{i,k}\Delta X_{j,t-k} + \lambda_i ECT_{i,t-1} + \varepsilon_{i,t}$$

where X is a vector of repressors. The models are built with an individual lag for every explanatory variable of the vector X.

- ✓ The original DEA methodology is used to optimize the model selection procedure. The AIC and BIC criteria are used as inputs in the DEA procedure, and the adjusted R2 as an output.
- ✓ A variable importance measure (VIM) is estimated for the optimal model. The LMG metric is used to assess the VIM (Lindeman et al., 1980). This metric allows us to estimate the contribution of every variable to the value of the model coefficient of determination R^2.

- ✓ Also, ARDL models are built on the basis of the shorter subsamples (for different moving time "windows" / periods) to analyze the changes in the factor effect on the YTM.

In our study, in addition to the ARDL models built on the basis of the entire sample (169 observations), models were built using shorter sliding subsamples for a more detailed analysis of changes in the influence of factors on LCY GB yields. To analyze the dynamics of changes in the influences of factors, the method of "dynamics in statics" was used.

For each of the obtained subsamples, the procedure for constructing an optimal ARDL model, described above in this study, was applied. For the obtained optimal models, VIM estimates were constructed.

The model variables are shown in Table 1.

Table 1. The model variables

Variable	Description
KeyRate	The Central Bank key rate, %
Inflation	The inflation rate, year on year, %
USD_LCY_Return	A change in the exchange rate of the US dollar to the local currency (per month),%
Budget_to_GDP	The state budget balance,% of GDP
Debt_to_GDP	The government debt,% of GDP
M2_Change	A change in the money supply M2 (per month),%
Output_Change	The industrial production growth rate,%
PMI	Purchasing Managers' Index
SnP_500_Return	S&P 500 Index return (per month),%
CBOE_VIX_Return	VIX index change in the US market (per month),%
BrentReturn	A change in the Brent oil price (per month),%
USA_10Y_YTM	YTM of 10-year US Treasuries,%
USA_3M_YTM	YTM of 3-month US T-Bills,%
Y10_GB_YTM, Y5_GB_YTM, Y3_GB_YTM, Y1_GB_YTM	YTM of 10, 5, 3, 1-year GBLCY,%

The sample of our study

The sample includes 169 monthly observations for each BRICS country from January 2007 to January 2021. To study the dynamics of the influence of factors, the sample was divided into subsamples (the so-called "windows") of 48 observations in each with a step between the nearest

subsamples equal to 4 periods. A total of 31 subsamples were analyzed (the last subsample included the observations remaining until the end of the main sample).

The results

The calculation results are shown in Fig. 2-5 and in Appendix 1. They indicate the existence of cross-country differences in the key factors affecting yields of LCY GB. The sets of the most significant factors by maturity of LCY GB are also different.

First, consider the determinants of long-term (10-year) LCY GB yields. In the Russian market, the main factor determining the YTM of long-term LCY GB is the key rate (the influence of the factor is significant at the 1% level and is positive, Fig. 2). The key rate contribution to the determination coefficient R^2 is 47%. This conclusion confirms Hypothesis 1.1. Such a high explanatory power of the key rate, in our opinion, is due to the fact that in the Russian bond market, OFZ purchases are carried out mainly by government-owned banks, and the Bank of Russia rate gives them a benchmark. Thus, regulation by the Bank of Russia prevails over market factors.

We obtained an original result on the existence of a direct relationship between the government budget balance (% of GDP) and the yields of LCY GB: the higher the surplus (or lower the deficit) of the budget, the higher the YTM. We explain this by the large role of the regulator in the LCY GB market: with an increase in the surplus or a reduction in the budget deficit, the incentives for LCY government-owned banks to buy OFZs decrease, as a result of which the demand for OFZs decreases, and the yields increase.

With a lag of 2 months, the growth rate of industrial production has a significant negative effect, which proves Hypothesis 1.3. The Russian Federation is characterized by low rates of economic growth in general, and an increase in the rate of growth of industrial production signals an improvement in the economic situation, and interest rates are decreasing.

With a lag of 4 months, the growth of the money supply has a significant effect: the higher the growth of M2, the lower the YTM, which corresponds to the Hypothesis 1.6. We conclude that the effect of increasing liquidity is significant for the developing Russian bond market (Fig. 2).

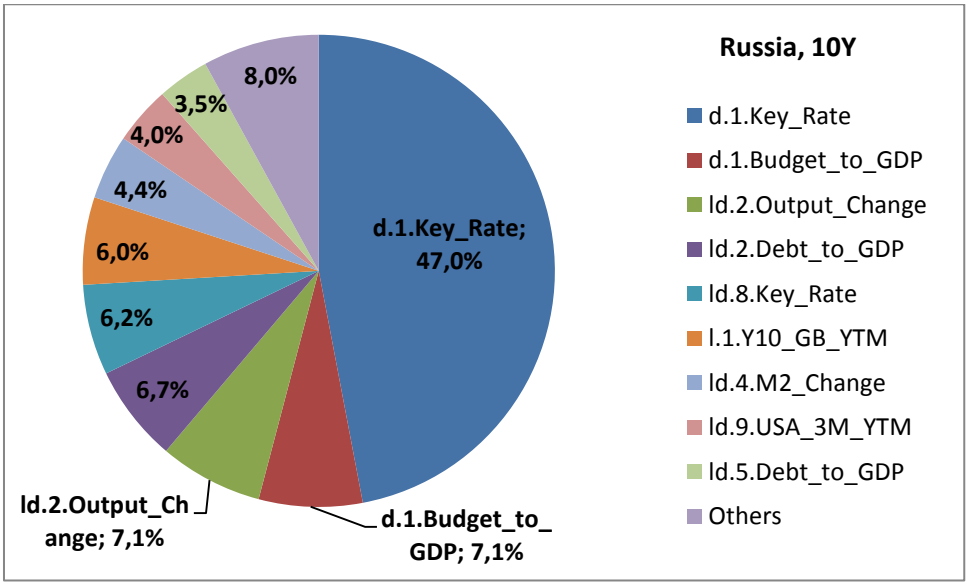

Fig. 2. Russia, 10-year LCY GB. Contribution of factors to the coefficient of determination R^2

For the Chinese market (Fig. 3), the YTM of long-term LCY GB is significantly positively influenced by the key rate, but its contribution to the final value of the determination coefficient is lower than for the Russian Federation and amounts to 20.9%. The yield on short-term (3-month) US T-bills has a significant positive impact in the current month and with a lag of 1 month. YTM of 10-year US Treasuries has a significantly negative effect with a lag of 4 months. We explain this by the fact that China is one of the largest holders of US Treasuries (worth about $ 1.1 trillion at the end of 2020). The People's Bank of China sells US Treasury bonds to support the local currency. As a result, yields on US Treasuries increase as a result of increased supply (and a corresponding decrease in prices). On the contrary, with the strengthening of the local currency, investors benefit from investments denominated in LCY (as compared to investments in dollar-denominated securities), the demand for LCY GB grows, and the yields decrease.

Note that the impact of the return of the S&P 500 index on the YTM of LCY GB in China is positive, although the statistical significance is not high. This conclusion refutes Hypothesis 2.2. We explain the direct dependence by the effects of capital flow from the Chinese market to the growing US stock market. Demand for China's LCY GB declines, and yields rise (Fig. 3).

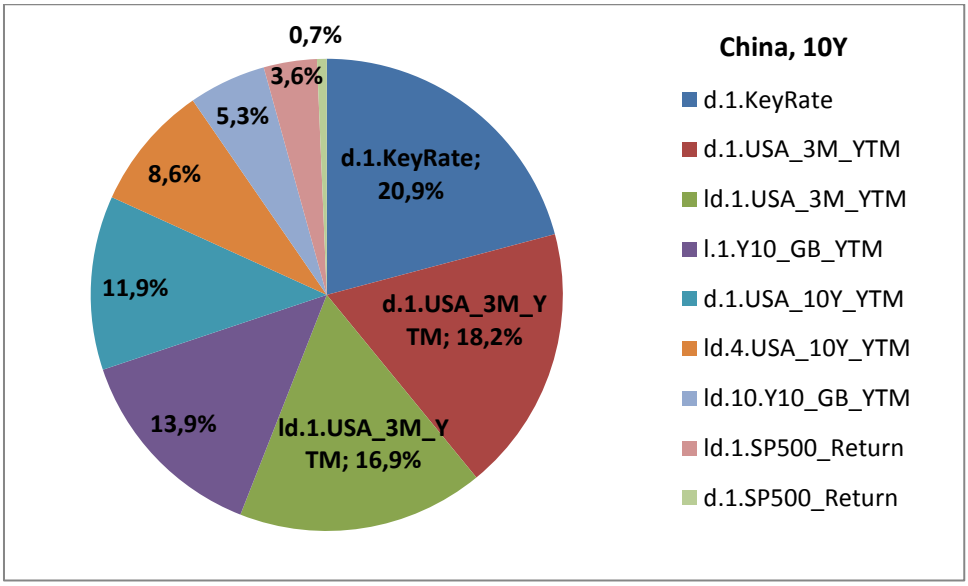

Fig. 3. China, 10-year LCY GB. Contribution of factors to the coefficient of determination R^2

In the Indian market (Fig. 4), yields of 10-year LCY GB are most strongly influenced by the third lag of the dependent variable itself: the contribution to the determination coefficient is 17% (note that the first and fourth lags are also significant), as well as the current yields of 10–year US Treasuries and 3-month US T-Bills with a lag of 1 month (the influence of the yields of US government bonds is significant at the 1% level and positive). The explanatory power of the key rate of the Central Bank of India is less than that of China and the Russian Federation. We note that the direction of influence of the key rate in the current month is positive (and the factor is significant at the 1% level), which supports Hypothesis 1.1.

Nevertheless, for a number of other factors, market distortions were revealed (for example, with an increase in the M2 aggregate YTM of LCY GB does not decrease, the state budget balance has a positive effect on the YTM of LCY GB), which contradicts our hypotheses. We explain these distortions by the fact that the Central Bank plays an important role in the Indian LCY GB market, which actively conducts transactions for the purchase and sale of LCY GB in the open market in order to maintain the target level (corridor) of yields.

A striking example is the situation in the first two quarters of 2020, when a record outflow of foreign capital was observed in the Indian LCY GB market. Foreign funds reduced their investments in LCY GB by 1.5 times (from 1.9 to 1.1 billion Indian rupees, Bloomberg). However, this did not lead to an increase in YTM (see Fig. 5 for 10-year LCY GB) even against the background of the growing government budget deficit (from 5.48% of GDP in January 2020 to 10.2% of GDP in June 2020; CEIC data), because the Central Bank of India carried out transactions for the purchase of LCY GB.

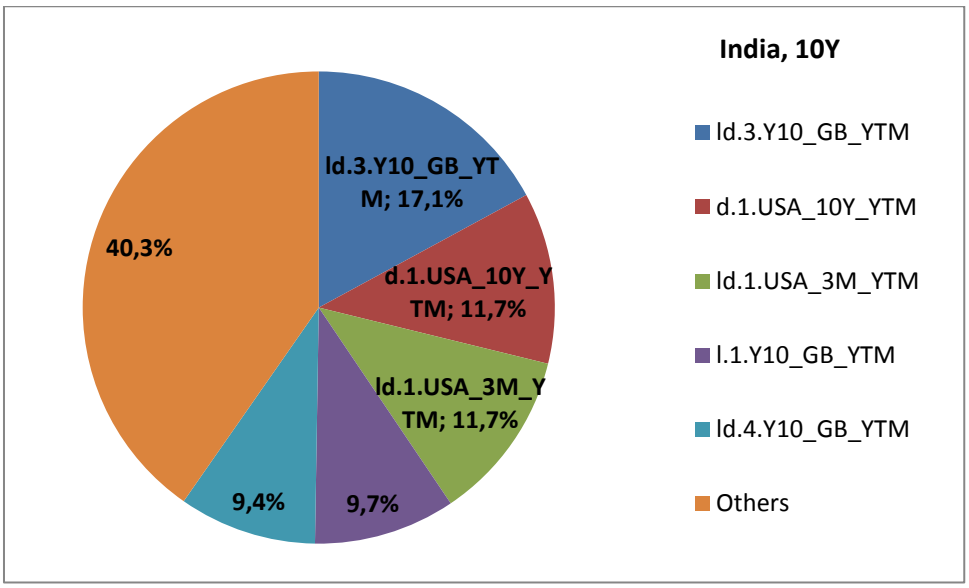

Fig. 4. India, 10-year LCY GB. Contribution of factors to the coefficient of determination R^2

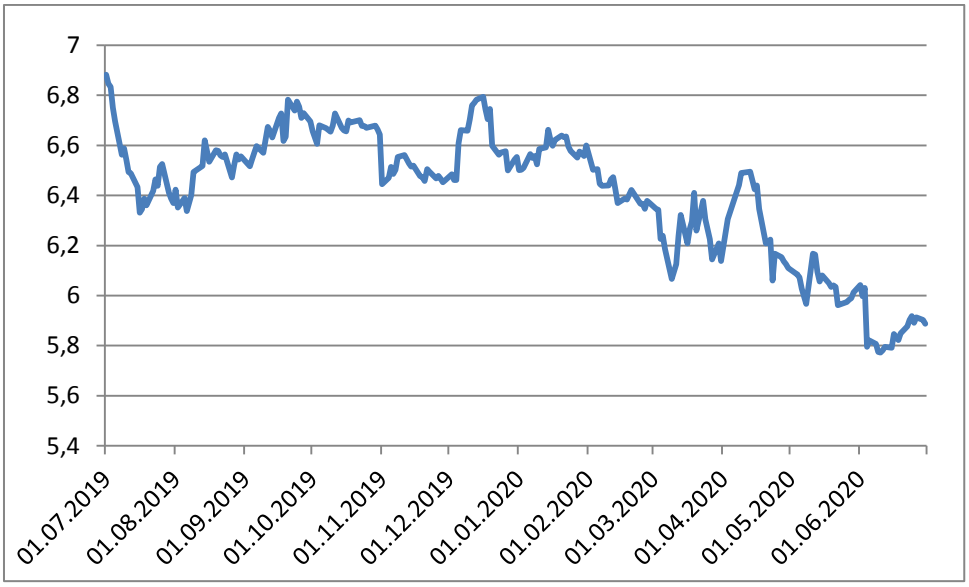

Fig. 5. Dynamics of YTM of 10-year LCY GB in India

Source: Investing.com

The most significant factor determining YTM on Brazil long-term LCY GB is the yield on 10-year US Treasuries in the current month (Fig. 6). The influence of this factor is positive and significant at the 1% level, as we expected. The next most influential factor is the exchange rate (in the current month and with a lag of 1 month): the depreciation of the Brazilian real against the US dollar leads to an increase in YTM in Brazilian LCY GB, which confirms Hypothesis 1.2.

Note that the impact of yields on 3-month US T-Bills in the current month is negative (Fig. 6). We explain this by the fact that there are close economic ties between the countries, and capital flows actively take place between the US and Brazilian GB markets. According to the IMF, total portfolio foreign investment from the United States to Brazil at the end of 2019 was $ 204 bln (or 1% of US

GDP), while portfolio foreign investment from Brazil to the United States was $ 19.7 bln (or 1.1% of Brazilian GDP). The US accounts for 23% of the total FDI in Brazil. As risk appetite grows, regional investors sell off T-bills and buy Brazilian LCY GB, as a result of which yields on T-bills rise, while Brazilian LCY GB yields fall.

Macroeconomic factors also affect YTM of 10-year LCY GB in Brazil: for example, the growth of industrial production with a lag of 2 months leads to an increase in YTM. We explain this by the fact that companies' demand for cash to finance production growth increases, and rates of return on borrowed capital may increase. Thus, Hypothesis 1.3 is confirmed. The influence of the inflation rate is significantly positive, which confirms Hypothesis 1.1. We obtained a paradoxical result that an increase in money supply M2 with a lag of 6 months leads to an increase in YTM of long-term LCY GB, which contradicts Hypothesis 1.6. We explain this by the fact that when M2 grows, investors' money does not go to the LCY GB market, but can go to other markets (for example, the US market), the Brazilian stock market or the foreign exchange market (Fig. 6). Thus, from 2011 to 2021, the rate of the Brazilian real against the US dollar demonstrates a tendency to a steady decline, which makes Brazilian LCY GB not very attractive for investors.

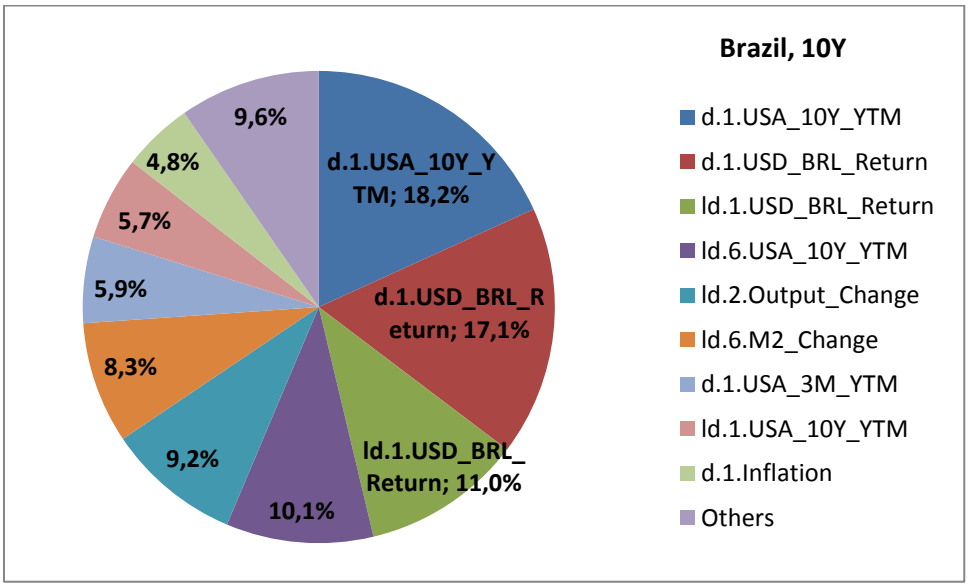

Fig. 6. Brazil, 10-year LCY GB. Contribution of factors to the coefficient of determination R^2

Finally, we consider the LCY GB market of South Africa (Fig. 7). The influence of the factors of the global market is the strongest. The growth of the S&P 500 stock index (in the current month and with a lag of 2 months) leads to a decrease in the yield on YTM (the factor is significant at the 1% level), which confirms Hypothesis 2.2. We conclude that the growth of the S&P 500 is perceived positively by LCY GB holders in Brazil, since signals a decrease in global credit risks. In second place in terms of explanatory power is the yield of 10-year US Treasuries; the direction of this factor influence is positive and significant at the 1% level, which is in line with our assumptions. In contrast, the impact of US 3-month T-bills yield (current month) is negative. As in the case of Brazil, we

explain this by a common investor base and a relatively high amount of portfolio foreign investment: investments from South Africa in the US amount to $ 20.7 billion (or 5.9% of South African GDP).

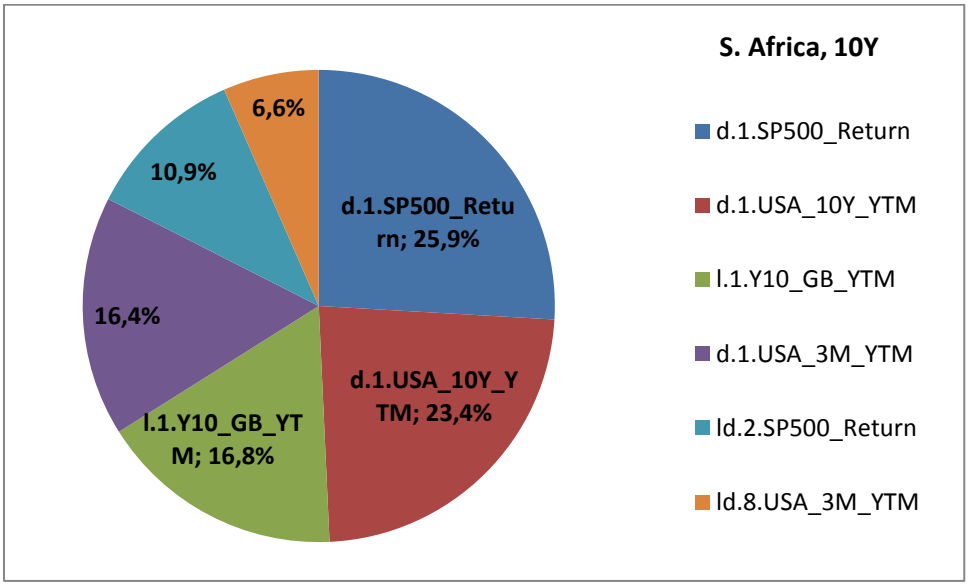

Fig. 7. S. Africa, 10-year LCY GB. Contribution of factors to the coefficient of determination R^2

Now let us look at the determinants of yields on *medium-term* (3-year) LCY GB. In the Russian market, the main factor determining the YTM of medium-term LCY GB, as well as long-term ones, is the key rate (the influence is significant at the 1% level and is positive, Fig. 8). The contribution of this factor to the value of the coefficient of determination is 62%. This conclusion confirms Hypothesis 1.1. The next in terms of explanatory power is the exchange rate: the more the Russian ruble depreciates against the US dollar, the higher LCY GB yields, which confirms Hypothesis 1.2.

The balance of the state budget (in% of GDP) in the current month and with a lag of 1 month is significant: the higher the surplus (or lower the deficit) of the budget, the higher the YTM of medium-term LCY GB (as well as for long-term ones). We explain this by the large role of the regulator in the LCY GB market: with an increase in the budget surplus or a reduction in its deficit, the incentives for state-owned banks to buy OFZs decrease, as a result of which the demand for OFZs decreases, and the yield increases. The volume of industrial production has a significant effect (in the current month and with a lag of 1 month): the higher its growth rate, the lower YTM, which corresponds to Hypothesis 1.3 (Fig. 8).

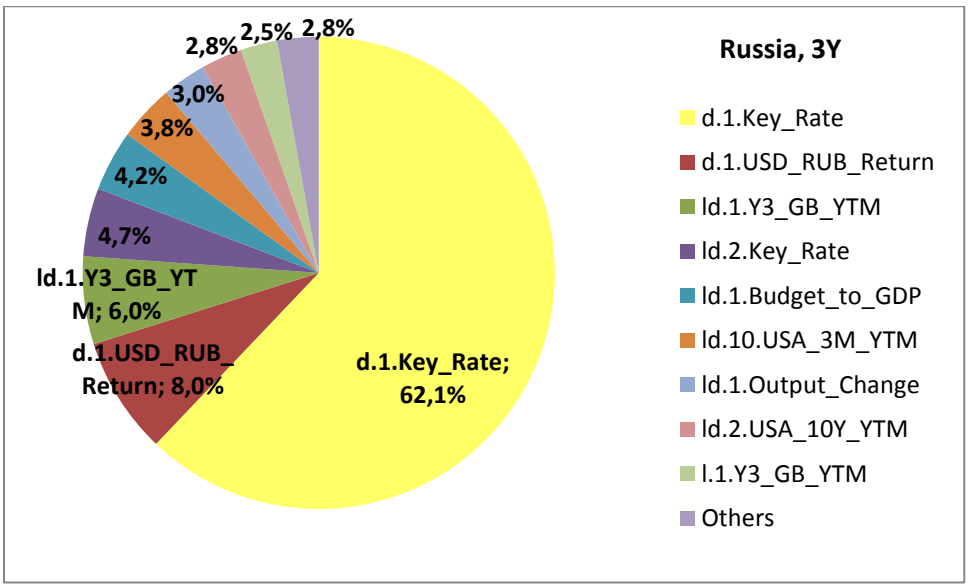

Fig. 8. Russia, 3-year LCY GB. Contribution of factors to the coefficient of determination R^2

In the Chinese market (Fig. 9), the YTM of medium-term LCY GB is the most strongly influenced by yields on 3-month US T-bills (the factor is significant at the 1% level, the direction of influence is positive). The key rate is in second place in terms of explanatory power; its influence is also significant at the 1% level and is positive. This is followed by the growth rate of industrial production (in the current month and with a lag of 2 months): the higher the growth in production, the higher the YTM. We explain this by the fact that in the context of increasing production volumes, companies' demand for cash to finance this growth is growing, and rates of return on borrowed capital may increase. But the effect of the growth rate of industrial production with a 5-month lag, on the contrary, is significantly negative. Investors in LCY GB perceive the increase in industrial production growth rate as a positive signal.

Yields on 10-year US Treasuries influence YTM on the 3-year LCY GB of China significantly positively with a lag of 1 month. The higher the volatility in the global market, the higher the yield on medium-term LCY GB in China, which confirms Hypothesis 2.1 (Fig. 8).

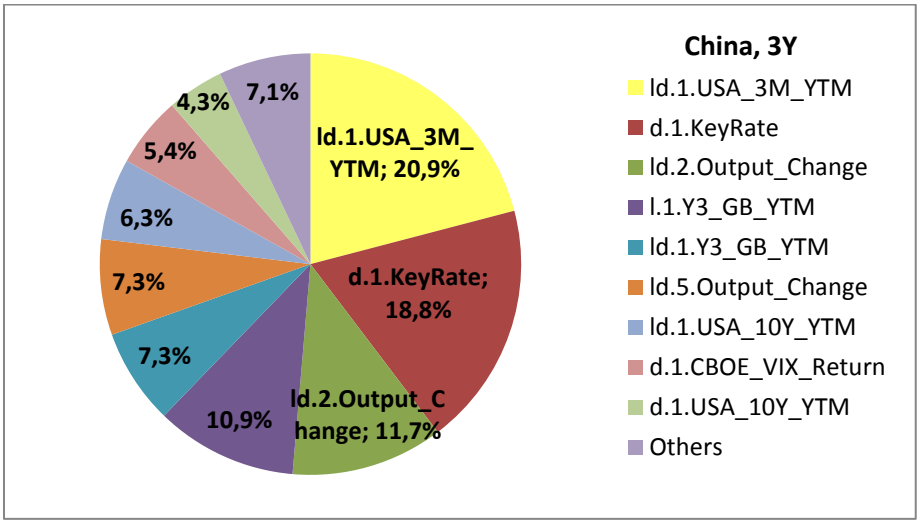

Fig. 9. China, 3-year LCY GB. Contribution of factors to the coefficient of determination R^2

In the Indian market, the yield on 3-year LCY GB is most strongly influenced by the current yield on US 3-month T-Bills (the influence of the factor is significant at the 1% level and positive). The yield on 10-year US Treasuries has a positive and significant 10% impact on YTM on LCY GB of India. The direction of influence of the key rate in the current month is positive and significant at the 10% level, which corresponds to Hypothesis 1.1.

We conclude that the rate of change in oil prices with a lag of 4 months has a positive and significant effect on the yield on LCY GB in India at the 5% level. We explain this by the fact that for the oil importing countries, the rise in oil prices is an unfavorable factor, as a result, the risks and yields on LCY GB grow.

As for the long-term LCY GB of India, for the medium-term LCY GB we conclude that the state budget balance (to GDP) has a positive effect on the yield of the LCY GB with a lag of 7 months, which contradicts Hypothesis 1.5. We explain this non-market dependence by the result of the actions of the Central Bank of India.

For the Brazilian medium-term LCY GB (Fig. 10), the main factor influencing YTM is the yield on 10-year US Treasuries (in the current month and with lags of 1 and 6 months). The influence of this factor is positive and significant at the 1% level. As for long-term LCY GB, the influence of YTM on 3-month US T-Bills is significant at the 5-10% level (for the current month and with a lag of 7 months), but negative; which we attribute to capital flight effects due to strong linkages between the US and Brazilian bond markets and the common investor base.

Macroeconomic factors are also important: the inflation rate has a significant positive effect on the yield on 3-year LCY GB in Brazil (Fig. 10), which corresponds to Hypothesis 1.1. The influence of the growth rate of industrial production is significant at the 5% level and positive (with 2 lag). We explain this by the fact that the expansion of production requires borrowed funds, and interest rates in the developing economy grows. The more the local currency depreciates against the US dollar, the higher the yield on 3-year LCY GB (the factor is significant at the 10% level).

As the US stock market index rises, the Brazilian LCY GB YTM declines. We explain this by the fact that the growth of the US stock market index indicates an improvement in global macroeconomic conditions, which is positively perceived by holders of LCY GB in developing countries, and signals a decrease in credit risks. The impact of the volatility index VIX with 7 month lag on YTM for 3-year GONV in Brazil is negative and significant at 10% level.

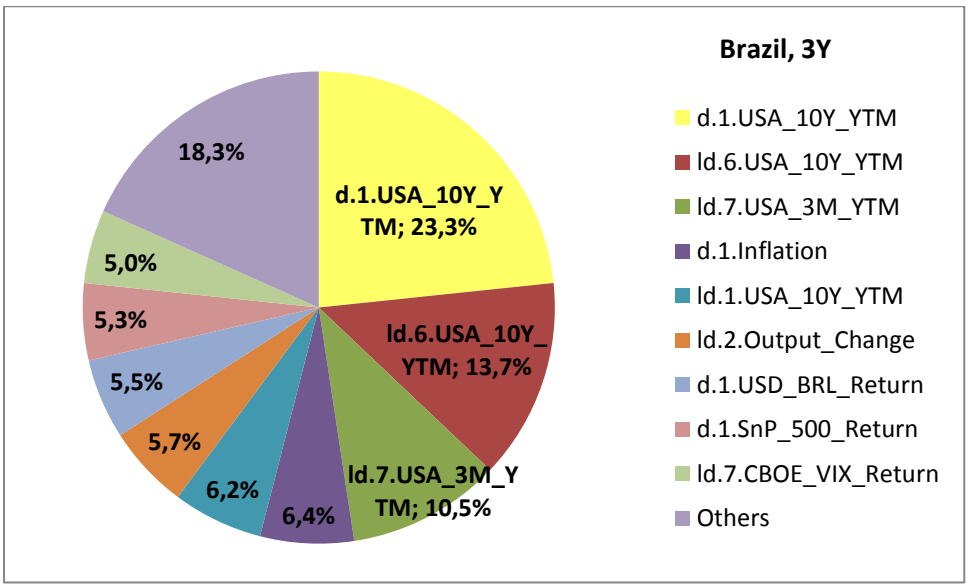

Fig. 10. Brazil, 3-year LCY GB. Contribution of factors to the coefficient of determination R^2

We also analyzed the dynamics of the contribution of various factors to the formation of YTM on LCY GB. Fig. 11 presents the results: VIM metrics by factors for 3-year LCY GB. The correspondence of moving time periods to the time scale is shown in Appendix 2.

Based on Fig. 11, we can conclude that up to the third quarter of 2014, in the Russian market, the dominant factors influencing 3-year LCY GB on YTM were the change in the exchange rate and the growth rate of industrial production. Further, up to the third quarter of 2016, the key rate, which was sharply increased by the Central Bank of the Russian Federation in December 2014, began to play the most important role in the formation of YTM on medium-term LCY GB. Then the role of the key rate in the formation of YTM decreased, but the role of the yields on the 3-month US T-Bills and the exchange rate increased.

As can be seen from Fig. 11, for the Indian market before the second quarter of 2015, YTM on 3-year LCY GB was most strongly influenced by the yields on short-term US government bonds, as well as the yields on 3-year LCY GB that formed in the national market in previous periods, which may indirectly reflect the fact that the yields of LCY GB are formed under the influence of the Central Bank. Further, until the end of 2016, the role of the yields on LCY GB in previous periods and the yields on 10-year US Treasuries increased even more. From 2018 to the third quarter 2020, YTM began to be dominated by the state budget balance (% of GDP) and the key rate.

As shown in Fig. 11, for the Chinese market until the end of 2013, the YTM of 3-year LCY GB were most strongly influenced by the yields of short-term and long-term US Treasuries, as well as the dynamics of oil prices. In 2014 and early 2015, the role of the yields on 10-year US Treasuries sharply increased. Further, two more periods can be distinguished: 2016-2017 and 2018-2020. During the period 2016-2017, the most significant factors were the return of the S&P 500 stock index and the key

rate. In 2018-2020, these factors are inferior to the rate of growth of industrial production and the yields of short-term and long-term US GB.

As shown in Fig. 11, for the Brazilian market, throughout almost the entire period under review until the II quarter of 2019, the yields of 10-year US Treasuries played an important role in forming the yields on 3-year LCY GB. In 2014-2015, the VIX volatility index had a significant impact. In 2020, the industrial production growth rate and the VIX volatility index played a significant role.

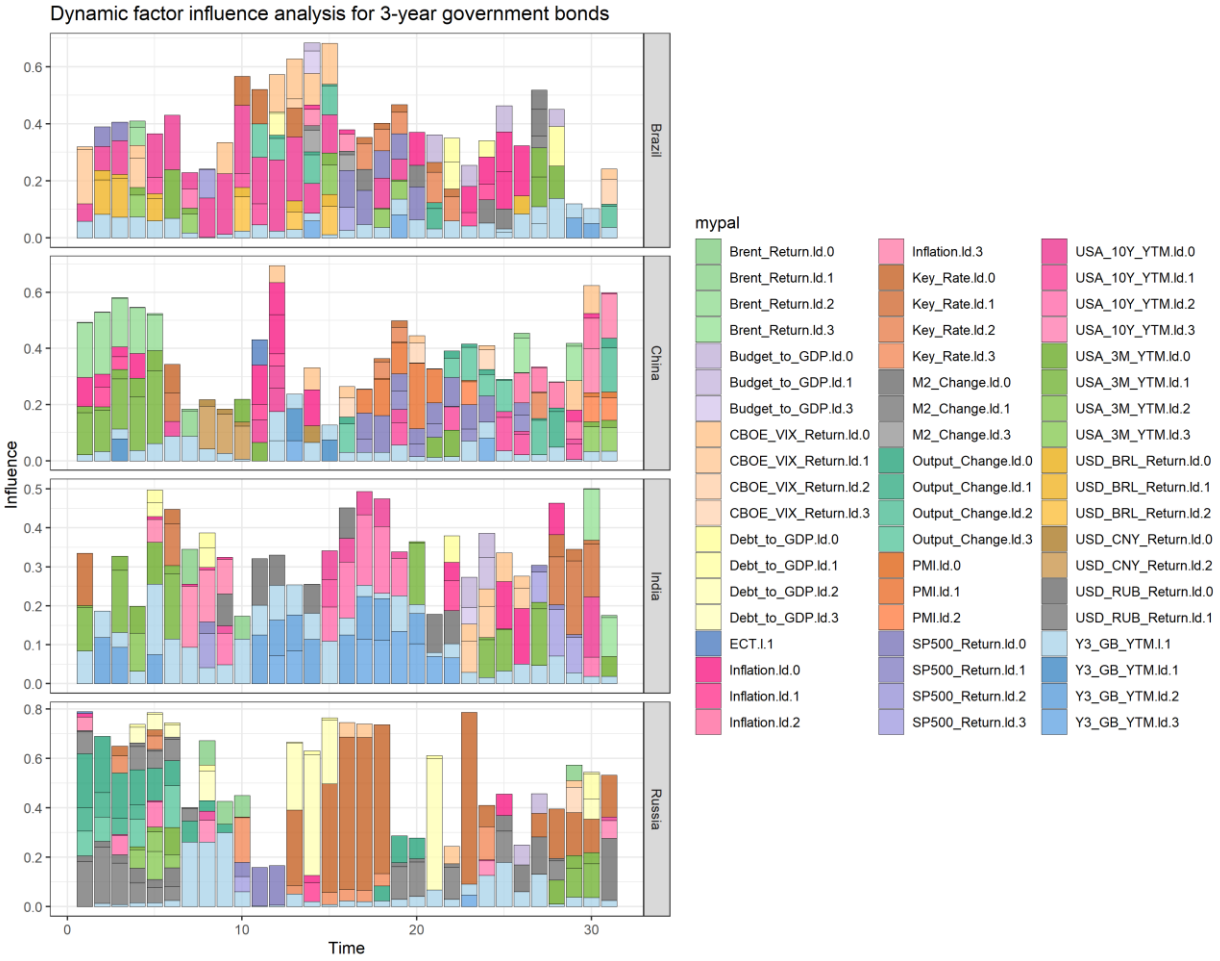

Fig. 11. The dynamics of the contribution of various factors to the formation R^2

Appendix 1. The results: The determinants of YTM of GB of the BRICS countries

Table 1. The determinants of YTM of GB of Russia

	YTM_Y1		YTM_Y3	YTM_Y5	YTM_Y10
(Intercept)	0.192	0.217	0.198	0.267	0.554**
d.1.Budget_to_GDP			0.028*	0.071***	0.05**
d.1.CBOE_VIX_Return		0.002		-0.003	
d.1.Debt_to_GDP		0.033			-0.093
d.1.Key_Rate	0.545***		0.534***	0.467***	0.372***
d.1.M2_Change					0.001
d.1.Output_Change		-0.013	-0.025		-0.014
d.1.SnP_500_Return				-0.031***	
d.1.USA_10Y_YTM			0.21	0.273	
d.1.USA_3M_YTM	-0.074		-0.065	0.121	0.31
d.1.USD_RUB_Return			0.031***		
l.1.Y10_GB_YTM					-0.059**
l.1.Y1_GB_YTM	-0.029	-0.034			
l.1.Y3_GB_YTM			-0.027		
l.1.Y5_GB_YTM				-0.035	
ld.1.Budget_to_GDP			0.05**		
ld.1.Output_Change			-0.018		
ld.1.USA_10Y_YTM				-0.817***	
ld.1.USA_3M_YTM	-0.343*				
ld.1.Y3_GB_YTM			0.171***		
ld.2.Debt_to_GDP		0.505***			0.132
ld.2.Key_Rate			0.142***		
ld.2.Output_Change					-0.051***
ld.2.SnP_500_Return				0.018**	
ld.2.USA_10Y_YTM			-0.246	-0.17	
ld.3.USA_10Y_YTM				0.315	
ld.4.CBOE_VIX_Return		-0.006***			
ld.4.Debt_to_GDP		-0.364***			
ld.4.M2_Change					-0.017*
ld.5.Debt_to_GDP					-0.179
ld.6.Debt_to_GDP					-0.109
ld.6.Output_Change		-0.055***			
ld.8.CBOE_VIX_Return				0.005**	
ld.8.Key_Rate					0.154***
ld.9.USA_3M_YTM					-0.338*
ld.10.USA_3M_YTM			-0.445***	-0.485**	
trendvar	0				-0.001
R^2	0.604	0.506	0.502	0.501	0.6
F-stat	18.467	11.364	10.289	11.119	16.601
Adj. R^2	0.572	0.462	0.453	0.456	0.564

Table 2. The determinants of YTM of GB of China

	YTM_Y1	YTM_Y3	YTM_Y5	YTM_Y10
(Intercept)	0.189**	0.249***	0.315***	0.312***
d.1.Budget_to_GDP		-0.034		
d.1.CBOE_VIX_Return		0.001		
d.1.KeyRate	0.494***	0.408***	0.305**	0.283***
d.1.Output_Change		0.001		
d.1.PMI			0.009	
d.1.SP500_Return			-0.002	0.0001

	YTM_Y1	YTM_Y3	YTM_Y5	YTM_Y10
d.1.USA_10Y_YTM		0.073		0.077
d.1.USA_3M_YTM	0.093	0.032	0.134*	0.152**
l.1.Y10_GB_YTM				-0.078***
l.1.Y1_GB_YTM	-0.064**			
l.1.Y3_GB_YTM		-0.072***		
l.1.Y5_GB_YTM			-0.084***	
ld.1.KeyRate		0.109	0.293**	
ld.1.SP500_Return			0.003	0.002
ld.1.USA_10Y_YTM		0.085		
ld.1.USA_3M_YTM	0.465***	0.232***	0.203***	0.162***
ld.1.Y3_GB_YTM		0.103		
ld.2.KeyRate	0.379**			
ld.2.Output_Change		0.016**		
ld.2.PMI			0.01	
ld.3.USA_3M_YTM	-0.31***			
ld.4.USA_10Y_YTM				-0.094**
ld.4.USA_3M_YTM			-0.202***	
ld.5.Output_Change		-0.014**		
ld.8.KeyRate	-0.186			
ld.9.Budget_to_GDP		-0.068		
ld.10.Y10_GB_YTM				-0.101
trendvar	0	0	0	0
R^2	0.375	0.337	0.385	0.332
F-stat	6.692	6.405	6.426	6.881
Adj. R^2	0.319	0.285	0.325	0.284

Table 3. The determinants of YTM of GB of India

	YTM_Y1	YTM_Y3	YTM_Y5	YTM_Y10
(Intercept)	0.598***	0.881***	0.9***	1.039***
d.1.BrentReturn		0.002		
d.1.Budget_to_GDP	-0.045	-0.071	0.015	0.037
d.1.KeyRate	0.299**	0.194*	0.293**	0.3***
d.1.M2_Change			0.001	-0.001
d.1.USA_10Y_YTM	0.171	0.157*	0.272***	0.243***
d.1.USA_3M_YTM	0.015	0.068	0.025	-0.018
l.1.Y10_GB_YTM				-0.118***
l.1.Y1_GB_YTM	-0.07***			
l.1.Y3_GB_YTM		-0.098***		
l.1.Y5_GB_YTM			-0.098***	
ld.1.KeyRate	0.447***			
ld.1.USA_10Y_YTM	0.155		0.124	0.062
ld.1.USA_3M_YTM	0.368**	0.519***	0.351***	0.322***
ld.3.Y10_GB_YTM				-0.246***
ld.3.Y5_GB_YTM			-0.236***	
ld.4.BrentReturn		0.003**		
ld.4.Budget_to_GDP	0.538**			
ld.4.KeyRate		-0.152	-0.058	-0.174*
ld.4.Y10_GB_YTM				0.211***
ld.7.Budget_to_GDP		0.866***	0.593***	0.513***
ld.8.M2_Change			0.01**	0.01**
ld.10.M2_Change			0.009**	
trendvar	-0.001*	-0.002***	-0.002***	-0.001***
R^2	0.382	0.303	0.407	0.406

	YTM_Y1	YTM_Y3	YTM_Y5	YTM_Y10
F-stat	7.636	6.618	7.063	7.085
Adj. R^2	0.332	0.257	0.349	0.349

Table 4. The determinants of YTM of GB of Brazil

	YTM_Y1	YTM_Y3	YTM_Y5	YTM_Y10
(Intercept)	0.256	0.499	0.956**	0.723*
d.1.CBOE_VIX_Return		-0.001	0	0
d.1.Debt_to_GDP	0.078*			
d.1.Inflation	0.652***	0.418***	0.491***	0.372**
d.1.Key_Rate	0.355***			
d.1.M2_Change			-0.03	-0.027
d.1.Output_Change		-0.017	-0.02	-0.012
d.1.SnP_500_Return	-0.01*	-0.016*		
d.1.USA_10Y_YTM	0.604***	1.088***	0.987***	1.035***
d.1.USA_3M_YTM	-0.298	-0.63**		-0.657***
d.1.USD_BRL_Return		0.012*	0.027***	0.039***
l.1.Y10_GB_YTM				-0.048*
l.1.Y1_GB_YTM	-0.015			
l.1.Y3_GB_YTM		-0.036		
l.1.Y5_GB_YTM			-0.061**	
ld.1.Debt_to_GDP	-0.06			
ld.1.Inflation	-0.359			
ld.1.USA_10Y_YTM		0.43**		0.459**
ld.1.USD_BRL_Return				0.031***
ld.1.Y1_GB_YTM	0.052			
ld.2.Output_Change		0.028**	0.04***	0.037***
ld.3.USA_3M_YTM	0.568***			
ld.3.Y1_GB_YTM	0.037			
ld.3.Y3_GB_YTM		0.044		
ld.6.CBOE_VIX_Return			0.006***	
ld.6.M2_Change			0.064**	0.057**
ld.6.USA_10Y_YTM		0.871***	0.78***	0.744***
ld.7.CBOE_VIX_Return		-0.003*		-0.002
ld.7.USA_3M_YTM	-0.232	-0.389*		
ld.8.Key_Rate	-0.216**			
ld.8.USA_10Y_YTM		-0.244		
trendvar	-0.002	-0.001	-0.003**	-0.002
R^2	0.429	0.469	0.442	0.464
F-stat	7.83	8.531	7.089	8.383
Adj. R^2	0.374	0.414	0.38	0.409

Table 5. The determinants of YTM of GB of S. Africa

	YTM_Y5	YTM_Y10
(Intercept)	0.735***	0.734**
d.1.BrentReturn	-0.004*	

	YTM_Y5	YTM_Y10
d.1.CBOE_VIX_Return	0.002	
d.1.Debt_to_GDP	-0.114**	
d.1.Output_Change	0.007	
d.1.SP500_Return	-0.011*	-0.015***
d.1.USA_10Y_YTM	0.379***	0.487***
d.1.USA_3M_YTM		-0.573***
l.1.Y10_GB_YTM		-0.09**
l.1.Y5_GB_YTM	-0.091***	
ld.1.USA_10Y_YTM	0.026	
ld.2.SP500_Return	0.003	0.009*
ld.7.CBOE_VIX_Return	-0.002**	
ld.8.USA_3M_YTM		0.257*
trendvar		0
R^2	0.287	0.279
F-stat	6.747	8.395
Adj. R^2	0.244	0.246

Appendix 2. Periods for sliding subsamples

№	Beginning	End
1	Jan. '07	Dec. '10
2	May '07	Apr. '11
3	Sep. '07	Aug. '11
4	Jan. '08	Dec. '11
5	May '08	Apr. '12
6	Sепт. '08	Aug. '12
7	Jan. '09	Dec. '12
8	May '09	Apr. '13
9	Sep. '09	Aug. '13
10	Jan. '10	Dec. '13
11	May '10	Apr. '14
12	Sep. '10	Aug. '14
13	Jan. '11	Dec. '14
14	May '11	Apr. '15
15	Sep. '11	Aug. '15
16	Jan. '12	Dec. '15
17	May '12	Apr. '16
18	Sep. '12	Aug. '16
19	Jan. '13	Dec. '16
20	May '13	Apr. '17
21	Sep. '13	Aug. '17
22	Jan. '14	Dec. '17
23	May '14	Apr. '18
24	Sep. '14	Aug. '18
25	Jan. '15	Dec. '18
26	May '15	Apr. '19

27	Sep. '15	Aug '19
28	Jan. '16	Dec '19
29	May '16	Apr '20
30	Sep. '16	Aug '20
31	Jan. '17	Dec '20