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VALUATION OF GOVERNMENT BONDS: THE EXCHANGE RATE IS AN IMPORTANT ASPECT

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Abstract

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Interest rates are currently very low in the countries. In these countries bonds are issued with low or negative yields. In this paper, I empirically investigate the factors that affect the price of bonds. I follow international arbitrage pricing theory to determine the relationship between factors and the price of bonds. The international arbitrage pricing theory applies a multi-linear regression model. The regression model is used for emerging markets and developing markets separately. I have a unique data set of 46 countries. The main data are the monthly returns on government bonds in the period 2010–2015. Exchange risk influences the bond prices. Currency movements can bring further yield for investors.

Keywords: bonds, exchange rate, asset pricing, risk premium

INTRODUCTION

During the financial crisis of 2008 and the following years, many central banks reduced their target interest rates as the traditional tool of monetary policy. Interest rates were at their lower bounds. Interest rates and inflation influence prices and yields of bonds (Huang and Kong, 2002; Elton, 2004). In times of financial crisis when interest rates and inflation decline to their lower limits, bond prices increase.

The aim of my research is to investigate the impact of exchange rate movements on movements in bond prices. My study builds on the asset-pricing literature and my goal is to investigate factors affecting the bond prices. Nominal bond yields have been constrained by interest rate lower bounds in different countries. Exchange rates are an important factor that affects bond prices.

Following the seminal paper by Elton (2004) who solved the question of what factors affects bond prices. He defined five factors: default risk, liquidity, different tax treatment, different recovery rate and the maturity of bonds. The factors affect price of bonds in a rating class of country differently. Huang and Kong (2002) used default rates, the risk-free interest rate, return and volatility of the equity market, liquidity indicators from bonds, and the state of the economy.

Huang and Kong (2002) used the model price of corporate bonds. They apply an empirical model for pricing corporate bonds. Moreover, the authors used the Fama-French high-minus-low factor in the equity market. High-yield bonds are more closely related to the interest rate and equity market factors. Brennan (2001) applied intertemporal asset pricing and the Fama-French portfolio. The Fama-French model has been found to be associated with HML and SMB portfolio returns. The Fama-French portfolio does predict the real interest rate and the Sharpe ratio. Investors diversify their portfolios across international markets. Exchange rate risks affect returns of international investments (Sirr, 2011, Liu, 2012, Panda, 2013).

Solnik (1983) first applied international arbitrage pricing theory. The form of the international arbitrage pricing theory model is unchanged by investors with different home currencies, while risk premiums very much depend on the investor's home currency. Armstrong (2011) disentangled

underlying asset values and currency values. Cross-sectional regress analysis is used indicating that currency movement influences prices of U.S. stocks. Huang and Kong (2002) determined the risk of investment in bonds for investors: default loss, credit risk premium, liquidity and the tax premium. The extra yield offered to compensate investors for the risks. Arbitrage pricing theory has been applied for various commodities and markets (Malhotra, 2010, Middleton, 2001, Geambasu, 2014, Cho, 1986)

I apply this universal return decomposition to Solnick's international arbitrage pricing theory. In this paper, I look at the proposition that currency movements affect systematic risk factors themselves in addition to the residual exchange rate risk.

International asset pricing theory decomposes asset returns into portions due to currency returns and non-currency returns. Armstrong (2011) defined changes in underlying asset values (non-currency) and random currency movements (i.e., exchange rate risk). Non-currency returns are earned by all investors regardless of their home currency. The exchange risk is associated with random changes in currency values and changes in the asset returns of investors with different home currencies. Currency movements affect risk factors and addition residual exchange risk. The main assumptions of IAPT are purchasing power parity, efficient markets and the possibility of arbitrage.

I use data on government bonds to test the theory between 2010 and 2015. My data source is internal databases of the company Thomson Reuters for bond prices. A further data source is the International Money Fund. The interest rate is represented by the policy rate. Inflation is defined as the producer price index. The exchange rate is determined as the value of national currency per SDR. Monthly data is processed using a panel analysis. My analysis includes 46 countries. The rest of the article is structured as follows: Section 2 discusses the data. Section 3 presents the methodology used to measure factors affecting bond prices. Section 4 displays the findings, and section 5 is the conclusion.

Data

According to Brennan *et al.* (1998), risk factors should explain the variation of returns in a large well-diversified portfolio. As such I estimate panel regress analyses with time-series data. The definitions of the variables are given in Tab. I.

The bond data is extracted from the database of the company Thomson Reuters. This database contains the monthly price and coupon rate of government bonds. I excluded some of the 60 countries because the data was incomplete. Several independent variables were selected.

The monthly treasury bill rate is used as the risk-free rate. The interest rate is represented by the monthly long-term fixed government bond yield as a percentage per annum. Inflation is defined as the producer price index. The exchange rate is determined as the national currency per SDR index. The basket of currencies that determines the value of the SDR consists of the U.S. dollar, the euro, the Chinese renminbi, the Japanese yen and the pound sterling. The coupon rate is the payments

I: *Definition of the variables*

Variable	Description	Source
Price of bonds	Prices of government bonds with ten years maturity	Thomson Reuters
Risk free rate	Treasury bill rates	International Monetary Fund
Interest rate	Bond yield of government bonds	International Monetary Fund
Inflation	Producer price index	International Monetary Fund
Exchange rate	National currency per SDR	International Monetary Fund

II: *List of Countries*

Continent	Countries	Number of Countries
Europe	Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Georgia, Croatia, Ireland, Iceland, Italy, Israel, Cyprus, Hungary, Malta, Germany, Netherlands, Norway, Poland, Portugal, Austria, Greece, Slovakia, Slovenia, United Kingdom, Spain, Sweden, Switzerland, Turkey	29
America	Argentina, Brazil, Chile, Colombia, Mexico, United States of America, Venezuela	7
Asia	Bangladesh, China, Philippines, Hong Kong, India, Indonesia, Japan, South Korea, Malaysia, Pakistan, Singapore, Thailand, Taiwan, Vietnam	14
Africa	Botswana, Egypt, South African Republic, Kenya, Morocco, Namibia, Nigeria, Tanzania, Uganda, Zambia	10

of the bond per year. The macroeconomic data are from database of the International Monetary Fund.

My monthly panel dataset covers the period from 2010 to 2015. Taking all the restrictions on the different data sources into account I end up with a dataset that contains over 3,312 observations for 46 countries available for the estimations.

The descriptive statistics of the main variables are given in Tab. III. Each variable includes 72 monthly observations from January 2010 to December 2015.

The correlations between variables are displayed in Tab. IV. There is a strong correlation between bond yield and the bond coupon rate. The bond coupon rate was eliminated from the regression analysis.

Methodology

I use a multifactor linear regression model for defining the relationship between the volatility of factors and the movement of bond prices. I estimate time-series international arbitrage pricing theory regression models.

The 1st step is to calculate the return of government bonds. We write the log of the gross rate of return on the i-th asset in period *t* as:

$$R_{it} = ln(P_t) - ln(P_{t-1}), \quad (1)$$

where
P.....the price,
t.....the period.

The 2nd step is the application of international arbitrage pricing theory. Arbitrage pricing theory is a multivariate linear regression. This theory specifies an m-factor model of random returns arbitrarily over periods of time as:

$$R_{it} = E(R_{it}) + b_{1i}\delta_{1i} + \ldots + b_{im}\delta_{im} + \varepsilon_{it}, \quad (2)$$

where
$E(R_{it})$...the expected return on the i-th asset in period t,
δ_{mt}.....the m-th zero mean common factor capturing systematic risk,
b_{im}.....the sensitivity of the ith asset to the factor m,
ε_{it}.....is the random idiosyncratic error term.

The 3rd step is the definition of the following model which helps us to understand the basic relationship among the variables. The author can produce the following regression:

$$R^j_{it} - R^j_{ft} = \alpha^j_{it} + b_0\left(R^j_{mt} - R^j_{ft}\right) + b_1 X^j_{0t} + \varepsilon_{it}, \quad (3)$$

where
$\left(R^j_{it} - R^j_{ft}\right)$....the return in excess of the risk free rate of return,
α^j_{it}.....the pricing error,
b_0.....the coefficient corresponding to the universal component of factor loadings,
the b_1.....coefficient captures the exchange risk component of factor loadings arising from home currency,
$\left(R^j_{mt} - R^j_{ft}\right)$..the excess market return factor,
X^j_{0t}.....the scaled excess market return using a currency return instrument containing time t information.

III: *Descriptive statistics for the main variables*

Variable	Obs.	Mean	Std. Dev.	Min	Max
Bond price	3,007	122.8850	122.7423	42.3100	1 083.2850
Risk free rate	2,066	3.7830	4.3259	–1.2700	23.1375
Bond yield	2,297	4.3343	3.3228	–0.3100	18.0900
Inflation	2,235	107.3412	7.9885	80.2966	147.0110
National currency per SDR	1,648	738.4821	3 259.3740	0.8948	20 574.6200
Coupon rate of bond	2,808	4.1503	3.8119	0.0000	14.2000
Excess market return, or $R_m - R_f$	1,592	1.3454	2.8784	–13.1000	11.5188
Excess return of bonds, or $R_j - R_f$	1,853	–3.3323	4.0698	–21.1912	1.2741

IV: *Correlation matrix for the main variables*

Variable	Bond price	Risk free rate	Bond yield	Inflation	National currency per SDR	Coupon rate of bond
Bond price	1					
Risk free rate	0.3147	1				
Bond yield	–0.4993	0.6851	1			
Inflation	–0.2751	0.4423	0.2878	1		
National currency per SDR	–0.0493	0.2873	0.3441	0.2974	1	
Bond coupon rate	–0.2602	0.6268	0.8514	0.3077	0.5084	1

In the estimate of (3) compared the regress analysis for OLS, fixed effects model and the random model. These regressions are used particularly for developing and emerging countries.

RESULTS

This section presents the results for the impact of factors on the prices of government bonds. Tab. V and Tab. VI set out the main results. Time-series regression results for the international arbitrage pricing theory are presented with the results for fixed effects and random effects. It provided regression analysis for all countries in the dataset. Time-series regression results for fixed effects are presented in Tab. V. Inflation is excluded for emerging markets and developing countries due to it not being significant. The bond yield has the same effect for emerging and developing countries. Exchange rate risk affects emerging markets more than developing countries. The bond yields affect the bond price more than the exchange rate.

Time-series regression results for random effects are given in Tab. VI. Inflation is not significant. The independent variables affect the price of bonds in emerging markets more than in developing countries. All variables are significant at the 5 percent level. There is a positive coefficient for the exchange rate risk and for bond yield as well.

The results of the Hausman test are seen in Tab. VII.

I used the panel regression analysis for time series for testing International Arbitrage Pricing Model. In this case, the best model is that with random effects. Taking this into account, we interpret our results as providing strong support for a positive relationship between exchange rate and the price of government bonds. The bond price is also influenced positively by bond yield. The bond yield affects the bond price more than the exchange rate. These factors have more influence in emerging markets than in developing countries.

V: *Main estimation result for fixed effects. Note: Robust standard errors in parentheses. ***, **, * denote significance at 1 %, 5 % and 10 % level.*

Variable	All countries	Emerging markets	Developing countries
Cons	–3.4219***	–7.2491***	–2.7178***
	(0.5390)	(0.3122)	(0.1605)
National currency per SDR	0.0363***	0.0391***	0.0176***
	(0.0028)	(0.0036)	(0.0042)
Bond yield, or R_m - R_f	0.7215***	0.0.6846***	0.7412***
	(0.0206)	(0.0440)	(0.0176)
Inflation	–0.0106**		
	(0.0052)		
R^2	0.6276	0.4879	0.7193
N	991	440	702

VI: *Main estimation result for random effects. Note: Robust standard errors in parentheses. ***, **, * denote significance at 1 %, 5 % and 10 % level.*

Variable	All countries	Emerging markets	Developing countries
Cons	–4.4359***	–6.1204***	–2.4145***
	(0.4339)	(0.6079)	(0.3316)
National currency per SDR	0.0233***	0.0216***	0.0091***
	(0.0022)	(0.0031)	(0.0032)
Bond yield, or R_m – R_f	0.7324	0.7012***	0.7469***
	(0.01873)	(0.0460)	(0.0175)
R^2	0.6081	0.4638	0.7176
N	1,142	440	702

VII: *Hausman test*

Variable	All countries		Emerging markets		Developing countries	
	Fixed	Random	Fixed	Random	Fixed	Random
National currency per SDR	0.0363	0.0233	0.0391	0.0216	0.0176	0,0091
Bond yield, or $R_m - R_f$	0.7215	0.7324	0.6846	0.07012	0.7412	0.7469
Prob > chi2	0.0000	0.0000	0.0001			

CONCLUSION

In this study, I investigate the impact of factors on bond prices in countries that issued the government bonds. The results were obtained by a panel regression analysis of time series for the period from January 2010 to December 2015.

It was found some evidence that the exchange rate risk influence on price of bond. Exchange rate risk is positively associated with bond price. It is also shown that price of bonds is not influenced on exchange rate more than bond yield. Bond yield also affects bond prices positively. Exchange rates and bond yields have more influence in emerging markets than in developing countries.

My findings have two implications. Firstly, they contribute to the literature on asset pricing by displaying the influence of factors on bond prices. While several studies have looked at the determinants and measures of factors affecting bond prices, to the best of my knowledge my work is the first to bring out the impact of exchange rates on bond prices across several countries. Second, my results provide more insights into the impact of factors on bond prices for several countries. As such, my results suggest that exchange rates contribute to bond prices.

In any case, to deepen our understanding of the relationship between exchange rate and the price of bonds this topic needs to be further explored.

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