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A Financial Econometric Analysis of the Determinants of Interest Rate Risk in the US

Augustine Arize[1], Andreas Christofi[2], Ioannis Kallianiotis[3],
John Malindretos[4], Moschos Scoulis[5]

Abstract:
We introduce a macroeconomic system which we use for interest rate determination, after which we generate the interest rate risk premium. Considering this risk premium function, we investigate, test and determine the macro-variables which affect the interest rate risk premia by using a GARCH(p,q) and an ARCH-M model. The empirical results examine ten different interest rate risk premia and fifteen factors. Factors with significant effects on risk premia are: the real risk-free rate of interest, the inflation rate, the unemployment rate, the growth of GDP and industrial production, the growth of national debt and current account deficit, the money supply growth, the yield differentials on S-T and L-T securities and other variables. The conclusion is that, if we can decrease the volatility of the aforementioned determinants, we can also reduce interest rate risk and, consequently, the risk premium, thus, improving social interest.

Key Words: *Interest rate risk, risk premium, social interest*

JEL Classification : G10, G15, F37

[1] *Business Administration and MIS Department, College of Business and Technology, Texas A&M*

[2] *Chair, Department of Economics Finance and Real Estate, Leon Hess Business School, Monmouth University*

[3] *Economics/Finance Department, The Arthur J. Kania School of Management, University of Scranton,*
e-mail: jnk3533@scranton.edu

[4] *Economics, Finance and Global Business, Cotsakos College of William Business, Paterson University, e-mail: jnmalindre@optonline.net*

[5] *Economics and Finance, School of Business, Kean University*

1. Introduction

Capital in a market-oriented economy is allocated through the price system. The interest rate is the price of capital paid to borrow debt capital. The factors that affect supply of and demand for capital (funds) determine the cost of capital, too. The risk of capital losses to which suppliers and demanders of capital are exposed because of unanticipated changes of interest rates is called as the interest rate risk (Thalassinos *et al.,* 2010). This risk is measured by a component, added on the base rate (the real risk-free rate of interest), which is called the risk premium. The risk increases the risk premia on interest rates and it is reallocated among people in our economy, from the riskiest to the less risky ones. All agents of an economy, suppliers or demanders of funds, are exposed to interest rate risk. Everyone is sensitive to interest rate movements and this volatility has increased significantly. Since it is difficult to predict the direction and magnitude of interest rate changes, borrowers and lenders (especially shorter-maturity and variable-rate debts) face an interest rate exposure. There is a type of interest rate risk that affects every participant in the financial markets, the basis risk, which is the mismatching of interest rate bases for associated assets and liabilities.

A second type of risk is the gap risk (more typical of a nonfinancial firm) which arises from mismatched timing in repricing interest-rate-sensitive assets and liabilities. For financial institutions, portfolio managers, and investment on securities, there are also a price risk and a reinvestment risk. Another risk is due to the average expected inflation rate over the life of a loan. Inflation erodes the purchasing power of the dollar and causes capital losses (lowers the real rate of return). In addition, there is a risk that the borrower could default on a loan. Besides, a liquidity risk exists because the financial assets cannot be converted to cash quickly and at a "fair market value". Moreover, a maturity risk occurs due to high price sensitivity of long-term securities whenever interest rates rise. On the other hand, the reinvestment risk is the risk that affects more the short-term securities because a decline in interest rates will lead to lower income when financial instrument matures and funds are reinvested. Further, a foreign exchange risk (unexpected changes in exchange rates) can cause capital losses by altering the home currency value of foreign currency receipts or payments (Thalassinos, 2007). Likewise, a political risk may exist due to the possibility that political events in a particular country will cause some capital losses from expecting capital outflows from that country.

Given the interest rate risks, every participant in the financial market requires a compensation for undertaking these risks. This remuneration is called the interest rate risk premium. We are interested to determine the factors that affect the different components of risk premier. The intelligent supplier or demander of capital must have knowledge of these factors affecting risk premium (and then interest rate) and be able to anticipate possible future changes in those factors. We are defining as risk premium the difference between a market rate of interest and the real risk-free rate of interest.

$$IRRP_t \cong RP_t = i_t - r_t^* \qquad (1)$$

where, IRRPt = interest rate risk premium, RPt = risk premium, it = a nominal market rate of interest and rt* = the real risk-free rate of interest (3-month T-bill rate minus the expected inflation rate).

Consequently, risk premia are the prices of risk (components of the rate of return) built in financial assets priced (return) against the uncertainties related to the relevant state variables in our inherited risky economic system. As the uncertainties of the state variables (expected macro- variables) change over time, the risk related to the state macro-variables and hence the risk premia on interest rates vary over time. The current paper investigates the macroeconomic variables that affect the interest rate risk premium and makes it a time-varying component; therefore, constructing a changing interest rate risk and an altering market rate of interest.

We focus here on ARCH-M and GARCH (p, q) models to determine the volatility of our interest rates. Similar work has been done by Boscher, Fronk, and Pigeot (2000) who compared the forecast ability of GARCH (1,1) and stochastic volatility models for interest rates and found that forecasts based on stochastic volatility models are in most cases superior to those obtained by GARCH (1, 1) models.

The plan of the current paper is as follows. In section II the theoretical model has been developed. Section III provides the empirical results of the analysis. Next, section IV gives some policy suggestions for reducing the interest rate risk. The last section offers a few concluding remarks for this research.

2. The Model

In a completely riskless environment (where, RP = 0) the nominal rate of interest (i) is equal to the real risk-free rate (r*). For a risk-averse individual or a risk-neutral firm

If the certainty equivalent of it = rt* is less than the expected value of it, E(it), they demand a positive risk premium (RP). This general risk premium depends on the objective functions of the agent (utility or profit functions), the distribution of it, and the factors (variables) that affect the interest rate. Private investment and consumption, government revenue and expenditures, and exports and imports will contribute to the aggregate supply and demand in our economy. Consequently, they will affect production, prices, employment, trade, capital flows, financial markets, demand for money, interest rates, exchange rates, profitability, income, taxes, wages, savings, consumption, investment, and of course, riskiness of our economy.

Through the interaction of all these markets participants and their subjectivity about risk, return, and the future of the state of our economy, they will affect all the macroeconomic variables and will make them very volatile (Thalassinos and Politis, 2011). This volatility will transfer to all prices and to the interest rates, the cost of capital and money, and will affect their interest rate risk premia. Then, we build a model whose purpose is to determine the interest rate risk premium which is the difference between the market rate of interest and the real risk-free rate of interest [eq. (1)]. The production function in our

Economy is:

$$Y_t = F(K_t, L_t) \tag{2}$$

where, Yt = the nominal output (GDP) of the economy, Kt = the capital input, and Lt = the labor input in our production process.

Firms maximize their profits (market values or shareholders' wealth) with respect to the employed capital and labour through the first-order conditions.

$$F_K = i_t - \pi_t \tag{3}$$

$$F_L = w_t / p_t \tag{4}$$

where, FK, FL = the marginal product of capital and labor (first-order condition), it = the nominal cost of capital, pt = the inflation rate, wt/pt = the real wage.

The aggregate demand comprises the following equations

$$C_t = f\left(Y_t, T_t, S_t, \pi_t, u_t, \frac{B_t + S_t}{p_t}, i_t - \pi_t, \sigma_t^2\right) \tag{5}$$

$$I_t = f\left(K_t, L_t, r_t^*, Y_t, u_t, \frac{w_t}{p_t}, ND_t, CA_t, TD_t, \frac{B_t + S_t}{p_t}, i_{RF_t}, XRI_t, \sigma_t^2\right) \tag{6}$$

$$NX_t = f\left(Y_t, Y_t^*, \pi_t, u_t, ND_t, CA_t, XRI_t, i_{RF_t}, \sigma_t^2\right) \tag{7}$$

where, Ct = consumption, Tt = taxes, St = saving, ut = unemployment rate, (Bt+St)/pt = Wt = households' real wealth (bonds' plus stocks' market value), it-pt = real interest rate, st2 = riskiness of the market, It = investment, rt* = the real risk-free rate of interest, NDt = national debt, CAt = current account, TDt = total credit market debt, iRFt = the risk-free rate of interest, XRIt = exchange rate index, NXt = net exports (X-M), and Yt* = foreign income.

Next equation describes the determination of the economy's output and the uses to which it is put

$$Y_t = C_t + I_t + G_t + NX_t \qquad (8)$$

where, Gt = government purchases of goods and services

The condition for portfolio equilibrium by equalizing supply and demand for money balances can be written as

$$\frac{M_t^s}{p_t} = \frac{M_t^d}{p_t} = f(Q_t, i_t, W_t) \qquad (9)$$

where, Mts = money supply, Mtd = money demand, Qt = real income, it = nominal interest rate.

Solving eqs. (2), (3), (4), (5), (6), (7) and (8) for it, we determine an IS curve.

Then, solving eq. (9) for it, the LM curve is depicted. The simultaneous solution of these two equations will give the interest rate as a function of all our variables incorporated in the above system. By utilizing eq. (1), we determine the IRRP in our economy which is a function of the macro-variables from our standard model above. So, the risk premium will be a function of the expected values of the following variables.

$$IRRP_t \cong RP_t = f(r^{*e}, \pi^e, t, g^e_{GDP}, g^e_{IP}, u^e, g^e_S, g^e_T, g^e_{w/p}, g^e_{ND}, g^e_{CA}, g^e_D, g^e_{DJIA}, g^e_{SP}, g^e_{M^s}, i^e_{RF}, YD_{GB}, YD_{Baa}, g^e_{XRI}, \ldots)$$

$$RP_{r^{*e}} > 0, RP_{\pi^e} > 0, RP_t > 0, RP_{g^e_{GDP}} < 0, RP_{g^e_{IP}} < 0, RP_{u^e} > 0, RP_{g^e_S} < 0,$$
$$RP_{g^e_T} > 0, RP_{g^e_{w/p}} < 0, RP_{g^e_{ND}} > 0, RP_{g^e_{CA}} > 0, RP_{g^e_D} > 0, RP_{g^e_{DJIA}} < 0,$$
$$RP_{g^e_{SP}} < 0, RP_{g^e_{M^s}} < 0, RP_{i^e_{RF}} > 0, RP_{YD_{GB}} > 0, RP_{YD_{Baa}} > 0, RP_{g^e_{XRI}} < 0 \qquad (10)$$

where, r*e = expected real risk-free rate of interest, pe = expected inflation, t = time trend, gGDP =growth of GDP, gIP = growth of industrial production, gS = growth of saving, gT= growth of taxes, gw/p = growth of real wages, u = unemployment rate, ND = national debt, CA = current account deficit, D = total debt of our economy, gDJIA = growth of the DJIA, gSP = growth of the S&P500 index, gMs = growth of the money supply, iRF = risk-free rate of interest (3-month T-bill rate), YDGB = differential in yields of long-term and short-term government securities, YDBaa = differential yields of long-term corporate bonds and T-bill rate, XRI = exchange rate index.

In the above conventional econometric model, the variance of the disturbance term is assumed to be constant, E(et2) = s2. However, many economic time series exhibit periods of assumption of a constant variance (homoskedasticity) is inappropriate. An accurate volatility forecast can allow a more precise estimation of the value at risk (the interest rate). We want to test the factors of eq. (10) if they exert any effect on the IRRPt. Then, the volatility of these factors will contribute to the RPt of interest rates.

Furthermore, an Autoregressive Conditional Heteroskedastic in Mean (ARCH-M) Model can be used here to determine the excess return above the real risk-free rate due to the riskiness of interest rate. This model is an extension of the basic ARCH framework to allow the mean of a sequence to depend on its own conditional variance. Risk adverse agents will require, as we have mentioned above, compensation (RP) for holding a risky asset. Given that an asset's riskiness can be measured by the variance of returns, the risk premium will be an increasing function of the conditional variance of returns.

The excess return from holding a risky asset (being in a market that pe > 0 and Risk > 0) can be written as:

$$EXR_t \equiv IRRP_t \equiv RP_t + \varepsilon_t \tag{11}$$

where, EX Rt = excess return from holding an asset in our financial market relative to the real risk-free rate of interest, RPt = risk premium necessary to induce the risk-averse agent to hold an asset in an economy with positive inflation and risk, et = unforecastable shock to the excess return on the asset.

The expected excess return from holding an asset must be equal to the risk premium

$$E_{t-1} IRRP_t = RP_t \tag{12}$$

We assume that the risk premium is an increasing function of the conditional variance of et. The greater the conditional variance of returns, the greater the compensation necessary to induce the agent to hold an asset. Mathematically, if st2 is the conditional variance of et, the risk premium can be expressed as:

$$RP_t = \beta + \delta \sigma_t^2$$
$$\delta > 0 \tag{13}$$

where, st2 is the ARCH (q) process:

$$\sigma_t^2 = \alpha_0 + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 \tag{14}$$

Equations (11), (13), and (14) constitute the basic ARCH-M model. As we can see from eqs. (11) and (13), the conditional mean of IRRPt depends on the conditional variance st2 which is an ARCH (q) process, [eq. (14)].

If the conditional variance is constant (a1 =a2 = ... = aq = 0), the ARCH-M model degenerates into the more traditional case of a constant risk premium.

In our case, one approach to forecasting the variance of the interest rate risk premium is to explicitly introduce and test all the independent variables that will help to predict the interest rate volatility, as we have mentioned them in eq. (10).

Then

$$IRRP_{t+1} = \varepsilon_{t+1} g_{M_t^s} \quad (15)$$

where, IRRPt+1 = the interest rate risk premium, et+1 = a white-noise disturbance term with variance s2, and gMst = the growth of money supply that is observed at period t.

The variance of IRRPt+1 conditional on the observable value of gMst is:

$$Var(IRRP_{t+1} \mid g_{M_t^s}) = g_{M_t^s}^2 \sigma_t^2 \quad (16)$$

$$IRRP_t = \alpha_0 + \alpha_1 g_{M_{t-1}^s} + \varepsilon_t \quad (17)$$

$$IRRP_t = \alpha_1 X_t + \varepsilon_t$$

$$\sigma_t^2 = \mu + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (18)$$

We modify the basic model by introducing the coefficients a0 and a1 and estimating the following regression equation

$$IRRP_t = \alpha_0 + \alpha_1 g_{M_{t-1}^s} + \varepsilon_t \quad (19)$$

where, et = the error term (assumed to have a constant variance).

The standard GARCH (1, 1) specification is:

$$IRRP_t = \alpha_1 X_t + \varepsilon_t \quad (20)$$

$$\sigma_t^2 = \mu + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \quad (21)$$

The mean equation given in (18) is written as a function of exogenous variables Xt's [those mentioned in eq. (10)] with an error term et. Since st2 is the one-period ahead forecast variance based on past information, it is called the conditional variance. The conditional variance equation specified in (19) is a function of three terms, the mean (m); news about volatility from the previous period, measured as the lag of the squared residual from the mean equation (e2t-1) the ARCH term; and last period's forecast variance (s2t-1), the GARCH term.

Equation (21) may be extended to allow for the inclusion of exogenous or predetermined regressors, Zt, in the variance equation:

$$\sigma_t^2 = \mu' + \alpha'\varepsilon_{t-1}^2 + \beta'\sigma_{t-1}^2 + \gamma' Z_t \tag{22}$$

In addition, the Xt's in eq. (18) represent exogenous or predetermined variables that are included in the mean equation. If we introduce the conditional variance into the mean equation, we get the following ARCH-in-Mean (ARCH-M) model:

$$IRRP_t = \alpha_1' X_t + \alpha_2' \sigma_t^2 + \varepsilon_t \tag{23}$$

Higher order GARCH models, denoted GARCH (p, q), can be estimated by choosing either p or q greater than 1. The representation of the GARCH (p, q) variance is:

$$\sigma_t^2 = \mu + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \tag{24}$$

where, p is the order of the GARCH terms and q is the order of the ARCH terms Our objective is to run two different models, here. The first one is a GARCH (1, 1) with mean equation specification, and variance equation specification .The second model is the ARCH-M one, with mean equation, and variance equation. From this analysis, we can see if the variance of the IRRPt is affected by those tested macroeconomic factors and how this volatility contributes to mean value of the IRRPt.

3. Empirical Results

Using monthly data from 1959:06 to 2000:12, we construct the excess return (IRRPt) on ten different interest rates; the federal funds rate (iFF), the 3-month T-bill rate (i3TB), the 1-year T-bill rate, secondary market (i1TBS), the 1-year T-bill, auction average (i1TBA), the 5-year T-note rate (i5TN), the 30-year T-bond rate (i30TB), the Moody's corporate Aaa bond rate (iAaa), the Moody's corporate Baa bond rate (iBaa), the growth of DJIA market index (gDJIA), and the growth of the S&P500 index (gSP). The most of the data are coming from Economic Time Series Page by Evelina Tainer at www.economagic.com and a few series from http://chart.yahoo.com/t?a.

3.1 Group Statistics

We started our analysis by presenting some descriptive statistics of the different interest rate premia (Table 1) and the factors that might contribute to the volatility of our IRRP (Table 1a). From these distributions, we can see their high standard deviations (s's) which donate to the riskiness of our economy through the interest rate volatility. Next, we gave the variance-covariance matrix of all IRRP and of our independent variables from eq. (10) in Table 2. The highest variances are: sRP1TBA= 8.488 and sRPDJIA=2,834; the lowest is sRP3TB= 6.243. From the independent variables, the highest ones are: gDJIA= 2,864 and gND = 670.353. By observing Table 2, we can see the covariances of the risk premia with respect to the other factors from our economy. We expect these variables with the high covariances to contribute drastically to the volatility of the different risk premia. Lastly, Table 3 provides the correlation coefficients of all our variables (dependents and independents).

3.2 GARCH and ARCH-M Models Estimation

The results from regressing the excess return, risk premia (RP) of the different interest rates and rates of growth on the exogenous or predetermined variables of eqs. (18) and (20) appear in Table 4 under the column "GARCH". Then, the introduction of the conditional variance into the mean equation of the RP's, the ARCH-in-Mean model of eqs. (21) and (20) seems underneath the indication "ARCH-M".

The factors that significantly affect the risk premia (RP) of the different interest rates, considering the mean equation specification are: the real risk-free rate of interest (r*), the inflation rate (p), time trend (t) has some effects, too, the unemployment rate (u), the yield differentials on government (YDGB) and Baa (YDBaa) bonds affect positively the RP, and the variances (s2) of the RP, (ARCH-M), too. In the variance equation specification, the results show that the lag of the squared residual, e2t-1 [ARCH(1)] and last period's forecast variance, s2t-1 [GARCH(1)] have a highly significant effect on RP's. Also, the variance of some other factors, like r*, p, gGDP, gIP, gND, gCA, gMs, YDGB, and gXRI, affect the volatility of RP.

Table 1: Descriptive Statistics of the Interest Rate Risk Premia

Statistics	RPFF	RP3TB	RP1TBS	RP1TBA	RP5TN	RP30TB	RPAaa	RPBaa	RPDJIA	RPSP
Mean	3.594	3.241	3.281	3.315	2.831	3.068	6.027	7.050	12.084	12.936
Median	3.301	3.192	3.284	3.353	3.922	4.446	5.992	7.088	13.885	14.597
Maximum	14.756	13.686	13.176	12.776	11.559	11.699	14.866	17.526	167.800	160.097
Minimum	-5.861	-6.581	-6.751	-6.731	-11.659	-11.339	-3.671	-2.841	-281.830	-264.375
Std Dev.	2.440	2.344	2.298	2.303	4.125	4.429	2.433	2.571	52.620	51.613
Skewness	.711	.436	.168	.113	-1.067	-.909	-.038	.158	-.880	-1.043
Kurtosis	6.880	7.108	6.911	6.678	3.700	3.142	4.762	4.904	7.531	7.486
J-B Statistic	154.367	159.444	139.305	122.759	45.611	30.052	27.982	33.522	213.634	189.653
N	217	217		217	217		217	217		216

Note: IRRP = interest rate risk premium, RP_{XYZ} = risk premium of XYZ security, i = nominal market rate of interest or growth of index, r^* = real risk-free rate of interest (i_{3TB} - p^e), FF = federal funds, 3TB = 3-month T-bill, 1TBS = 1-year T-bill in the secondary market, 1TBA = 1-year T-bill auction average, 5TN = 5-year T-note, 30TB = 30-year T-bond, Aaa = Moody's corporate Aaa bond, Baa = Moody's corporate Baa bond, DJIA = Dow Jones Industrial Average index, SP = Standard & Poor's 500 index, J-B Statistic = Jarque-Bera test statistic for normal distribution of the series (all series here are normally distributed), and N = number of observations (1982:01 - 2000:01). ***Source***: www.economagic.com and http://chart.yahoo.com/t?a

Table 1a: Descriptive Statistics of Factors affecting the Interest Rate Risk Premia [from eq. (10)]

Statistics	r^*	p	g_{GDP}	g_{IP}	u	g_{ND}	g_{CA}	g_{TD}	g_{DJIA}	g_{SP}	g_{M2}	i_{RF}	YD_{GB}	YD_{Baa}	g_{XRI}
Mean	1.27	3.94	7.08	3.46	5.67	7.07	17.65	2.53	7.60	12.25	6.82	5.20	1.74	2.85	-.15
Median	1.59	3.61	.00	4.41	5.60	.00	.00	.00	10.90	15.40	7.91	4.97	1.82	2.53	1.37
Maximum	13.95	21.48	71.09	71.97	10.80	194.16	2,877	12.14	161.63	148.54	30.64	16.30	4.67	7.71	60.39
Minimum	-17.71	-9.09	-19.38	-50.96	2.50	-25.07	-1,704	.00	-317.04	-294.51	-18.55	.64	-3.09	-.75	-64.95
Std Dev.	3.68	4.08	12.52	10.47	1.58	21.12	360.55	3.80	49.63	53.97	7.18	2.85	1.49	1.50	20.30
Skewness	-.60	.77	1.73	-.09	.50	4.30	1.53	1.04	-.68	-1.24	-.41	1.06	-.59	.38	-.21
Kurtosis	5.36	4.26	5.95	9.05	3.22	27.44	23.74	2.49	6.37	8.12	3.46	4.58	3.36	2.35	3.21
J-B Statistic	178.91	101.94	525.60	768.17	26.95	14,093	7,085	31.74	337.23	270.22	18.44	178.54	18.16	25.63	3.09
N	613	613	611	504	615	504	387	167	614	200	506	615	290	615	

Note: r* = the real risk-free rate of interest, p = inflation rate, gGDP = growth of GDP, gIP = growth of industrial production, u = unemployment rate, gND = growth of National Debt, gCA = growth of Current Account, gTD = growth of total debt of the economy, gDJIA = growth of DJIA index, gSP = growth of S&P500 index, gM2 = growth of M2 Money stock, iRF = risk-free rate of interest (3-month T-bill rate), YDGB = yield differential on government bonds (L-T 30-year T-bond rate minus S-T 3-month T-bill rate), YDBaa = yield differential on corporate bonds (L-T Moody's Baa bond rate minus S-T 3-month T-bill rate), gXRI = growth of the exchange rate index, I = insignificant at 10% (series is not normally distributed), and N = number of observations (1950:01- 2001:03). ***Source***: Table 1.

Table 2: Variance-Covariance Matrix of Interest Rate Risk Premia and of Factors affecting IRRP

	RP3TB	RP_{3TB}	RP_{1TBS}	RP_{1TBA}	RP_{5TN}	RP_{30TB}	RP_{Aaa}	RP_{Baa}	RP_{DJIA}	RP_{SP}	r^*	p	g_{GDP}	g_{IP}	u
RP_{FF}	**6.707**														
RP_{3TB}	6.408	**6.243**													
RP_{1TBS}	6.361	6.227	**6.300**												
RP_{1TBA}	6.714	6.575	6.737	**8.488**											
RP_{5TN}	6.437	6.366	6.554	7.236	**7.270**										
RP_{30TB}	6.239	6.233	6.455	7.298	7.371	**7.704**									
RP_{Aaa}	6.075	6.031	6.207	6.838	7.000	7.263	**6.967**								
RP_{Baa}	6.293	6.207	6.396	7.042	7.255	7.509	7.185	**7.498**							
RP_{DJIA}	-10.645	-11.245	-13.309	-8.063	-15.939	-14.933	-13.096	-14.343	**2,834**						
RP_{SP}	-9.271	-9.757	-11.200	-.897	-13.215	-12.739	-11.006	-12.616	2,622	**2,707**					
r^*	-5.104	-5.299	-5.400	-5.810	-5.676	-6.048	-5.786	-5.774	11.609	10.882	**6.788**	-5.104			
u	6.408	6.243	6.227	6.575	6.366	6.233	6.031	6.207	-11.245	-9.757	-5.299	6.243			
p	2.724	2.590	2.827	2.837	3.055	3.123	2.910	3.100	5.612	-8.115	-2.776	2.590	**76.684**		
g_{IP}	-.423	.048	.649	.955	.824	.817	.532	.390	-76.595	-67.146	-2.317	.048	.883	**37.576**	
g_{GDP}	-.034	.011	.093	.527	.718	1.046	.899	1.003	1.710	1.361	-.095	.011	-.123	-.826	**1.164**

Table 2 (cont.): Variance-Covariance Matrix of Interest Rate Risk Premia and of Factors affecting IRRP

	RP_{FF}	RP_{3TB}	RP_{1TBS}	RP_{1TBA}	RP_{5TN}	RP_{30TB}	RP_{Aaa}	RP_{Baa}	RP_{DJIA}	RP_{SP}	r^*	p	g_{GDP}	g_{IP}	u
g_{ND}	.992	.247	.399	1.946	1.751	1.211	.592	1.191	-62.782	-78.661	3.794	.247	80.470	-11.195	2.000
g_{CA}	-33.37	-19.73	-15.76	-11.63	4.39	16.54	10.53	4.03	513.92	263.49	-34.12	-19.73	247.81	157.75	16.48
g_{DJIA}	-15.74	-16.54	-18.79	-13.87	-21.61	-20.98	-18.88	-20.11	2,84	2,63	18.39	-16.54	2.83	-78.91	1.614
g_{SP}	-14.37	-15.05	-16.59	-6.707	-18.89	-18.78	-16.79	-18.39	2,63	2,71	17.67	-15.05	-10.89	-69.46	1.266
g_{M2}	-1.899	-2.405	-2.776	-3.174	-3.612	-4.063	-3.458	-3.258	-3.130	-9.477	3.981	-2.405	7.415	-3.872	-.753
i_{RF}	1.304	.944	.827	.765	.690	.185	.246	.433	.364	1.126	1.490	.944	-.186	-2.269	-.085
YD_{GB}	-.169	-.010	.228	.723	1.005	1.471	1.232	1.302	-3.687	-2.982	-.749	-.010	.533	.768	1.035
YD_{Baa}	-.116	-.036	.169	.467	.888	1.276	1.154	1.291	-3.098	-2.859	-.475	-.036	.509	.341	.992
g_{XRI}	-2.792	-1.383	-1.458	-4.860	-2.408	-3.787	-4.413	-4.950	-82.349	-73.729	.465	-1.383	-17.660	29.482	-3.068

Note: Table 1 and 1a. **Source:** Table 1

Table 2 (cont.): Variance-Covariance Matrix of Interest Rate Risk Premia and of Factors affecting IRRP

	g_{ND}	g_{CA}	g_{DJIA}	g_{SP}	g_{M2}	i_{RF}	YD_{GB}	YD_{Baa}	g_{XRI}
g_{ND}	**670.353**								
g_{CA}	1,031	**68,168**							
g_{DJIA}	-58.987	479.800	**2,864**						
g_{SP}	-74.867	229.374	2,651	**2,736**					
g_{M2}	24.479	3.127	.852	-5.495	**44.030**				
i_{RF}	4.041	-53.856	1.853	2.615	1.576	**2.434**			
YD_{GB}	.964	36.274	-4.436	-3.731	-1.657	-.759	**1.481**		
YD_{Baa}	.945	23.762	-3.574	-3.335	-.852	-.512	1.312	**1.327**	
g_{XRI}	-12.932	-394.84	-81.884	-73.264	-4.335	-.918	-2.404	-3.567	**436.244**

Note: Table 1 and 1a. **Source:** Table 1

Table 3: Correlation Coefficients Matrix of Interest Rate Risk Premia and their Factors

	RP_{FF}	RP_{3TB}	RP_{1TBS}	RP_{1TBA}	RP_{5TN}	RP_{30TB}	RP_{Aaa}	RP_{Baa}	RP_{DJIA}	RP_{SP}	r^*	p	g_{GDP}	g_{IP}	u
RP_{FF}	1.000														
RP_{3TB}	.990	1.000													
RP_{1TBS}	.979	.993	1.000												
RP_{1TBA}	.890	.903	.921	1.000											
RP_{30TB}	.922	.945	.968	.921	1.000										
RP_{5TN}	.868	.899	.927	.902	.985	1.000									
RP_{Baa}	.889	.915	.937	.889	.984	.991	1.000								
RP_{Aaa}	.887	.907	.931	.883	.983	.988	.994	1.000							
RP_{DJIA}	-.077	-.085	-.100	-.052	-.111	-.101	-.093	-.098	1.000						
RP_{SP}	-.069	-.075	-.086	-.006	-.094	-.088	-.080	-.089	.947	1.000					
r^*	-.756	-.814	-.826	-.765	-.808	-.836	-.841	-.809	.084	.080	1.000				
P	.990	1.000	.993	.903	.945	.899	.915	.907	-.085	-.075	-.814	1.000			

g_{GDP}	.120	.118	.129	.111	.129	.128	.126	.129	.012	-.018	-.122	.118	1.000		
g_{IP}	-.027	.003	.042	.053	.050	.048	.033	.023	-.235	-.211	-.145	.003	.016	1.000	
u	-.012	.004	.034	.168	.247	.349	.349	.339	.030	.024	-.034	.004	-.013	-.125	1.000

Note: Table 1 and 1a. **Source:** Table 1

Table 3 (cont.): Correlation Coefficients Matrix of Interest Rate Risk Premia and their Factors

	RP_{FF}	RP_{3TB}	RP_{1TBS}	RP_{1TBA}	RP_{5TN}	RP_{30TB}	RP_{Aaa}	RP_{Baa}	RP_{DJIA}	RP_{SP}	r^*	p	g_{GDP}	g_{IP}	u
g_{ND}	.015	.004	.006	.026	.025	.017	.017	.017	-.046	-.058	.056	.004	.355	-.071	.072
g_{CA}	-.049	-.030	-.024	-.015	.006	.023	.023	.006	.037	.019	-.050	-.030	.108	.099	.059
g_{DJIA}	-.114	-.124	-.139	-.089	-.150	-.141	-.141	-.137	.999	.945	.132	-.124	.006	-.241	.028
g_{SP}	-.106	-.115	-.126	-.044	-.134	-.129	-.129	-.128	.946	.999	.130	-.115	-.024	-.217	.022
g_{M2}	-.111	-.145	-.167	-.164	-.202	-.221	-.221	-.179	-.009	-.027	.230	-.145	.128	-.095	-.105
i_{RF}	.323	.242	.211	.168	.164	.043	.101	.101	.004	.014	.366	.242	-.014	-.237	-.050
YD_{GB}	-.054	-.003	.075	.204	.306	.435	.435	.391	-.057	-.047	-.236	-.003	.050	.103	.788
YD_{Baa}	-.039	-.013	.058	.139	.286	.399	.399	.409	-.051	-.048	-.158	-.013	.050	.048	.798
g_{XRI}	-.052	-.027	-.028	-.080	-.043	-.065	-.065	-.087	-.074	-.068	.009	-.027	-.097	.230	-.136

Note: Table 1 and 1a. **Source:** Table 1

Table 3 (cont.): Correlation Coefficients Matrix of Interest Rate Risk Premia and their Factors

	g_{ND}	g_{CA}	g_{DJIA}	g_{SP}	g_{M2}	i_{RF}	YD_{GB}	YD_{Baa}	g_{XRI}
g_{ND}	1.000								
g_{CA}	.153	1.000							
g_{DJIA}	-.043	.034	1.000						
g_{SP}	-.055	.017	.947	1.000					
g_{M2}	.142	.002	.002	-.016	1.000				
i_{RF}	.100	-.132	.022	.032	.152	1.000			
YD_{GB}	.031	.114	-.068	-.059	-.205	-.400	1.000		
YD_{Baa}	.032	.079	-.058	-.055	-.111	-.285	.936	1.000	
g_{XRI}	-.024	-.072	-.073	-.067	-.031	-.028	-.095	-.148	1.000

Note: Table 1 and 1a. **Source:** Table 1

Table 4.GARCH and ARCH-M Estimations of IRRP, Models (18)-(20) and (21)-(20)

Variables	RP_{FF} GARCH	ARCH-M	RP_{3TB} GARCH	ARCH-M	RP_{1TBS} GARCH	ARCH-M	RP_{1TBA} GARCH	ARCH-M	RP_{5TN} GARCH	ARCH-M
$GARCH^2$	-166	- (.083)	.038	- (.025)	.133	- (.064)	-1.021	- (.211)	-257 (.140)	
C	-	-	16.171* (3.999)	22.750* (10.133)	-	-335 (.343)	20.796 (2.648)	12.024 (2.538)	-869 (.216)	-863
r*	-.051 (.023)	-.144 (.041)	-.994 (.003)	-.994 (.002)	.079 (.019)	.050 (.017)	-.382 (.078)	-.164 (.081)	.154 (.014)	.142 (.008)
p	.969(.023)	.863 (.041)	-	-	1.077 (.019)	1.048 (.017)	.591 (.080)	.819 (.082) (.015)	1.153 (.008)	1.142
t	-	-	-.015 (.008)	-.021 (.015)	-	-	-.024 (.003)	-.013 (.003)	-.088 (.025)	.0004 (.0003)
u	-	-.179 (.081)	-	-	-	-	-.650 (.137)	-.620 (.113)	-	-.091 (.025)
g_{DJIA}	-	-	-	-	-	-	-.013 (.003)	-.007 (.002)	-.0001 (.00007)	-.0001 (.00007)
g_{SP}	-	-	-	-	-	-	.014 (.003)	.007 (.003)	-	-
YD_{GB}	-.425 .092)	-.375 (.086)	.240 (.080)	.290 (.082)	.434 (.022)	.397 (.021)	1.620 (.199)	1.196 (.131)	.820 (.037)	.878 (.031)
YD_{Baa}	.418 (078)	.365 (.089)	-.952 (.083)	-1.036 (.076)	-	-	-1.539 (.219)	-.766 (.167)	.094 (.036)	.019 (.033)
g_{XRI}	-	-	.002 (.0004)	.001 (.0004)	-	-	-	-	.0004 (.0002)	.0005 (.0003)
AR(1)	.810 (.041)	.903 (.037)	1.453 (.063)	1.485 (060)	1.144 (.059)	1.119 (.054)	.417 (.111)	.287 (.091)	1.193 (.070)	1.068 (.072)
AR(2)	-	-	-.468 (.062)	-.497 (.060)	-.146 (.059)	-.165 (.053)	-	-	-.385 (.074)	-.301 (.073)
AR(5)	.110 (.042)	.076 (.037)	-	-	-	-	-	-	-	-
C	-.001 (.001)	.001 (.001	.001 (.0009)	-.044 (.014)	.003 (.0007)	.004 (.0008)	.366 (.141)	.327 (.082)	.002 (.0007)	.003 (.0008)
ARCH(1) .130*	.297 (.029)	.203 (.087)	.323 (.046)	.565 (.099)	.547 (.108)	.377 (.093)	.608 (.167)	.253 (.194)	.216 (.080)	(.072)

GARCH(1)	.842 (.029)	.649 (.089)	.783 (.044)	-.060 (.035)	.362 (.073)	.342 (.066)	.419	.107	.628	.607
r*	-	-	-	.001 (.007)	-	-	-.023 (.009)	-.037 -(.009)	-	-
g_{GDP}	.0004	-	-	-	-	-.008	-.006			
u	-	-	-	-	-	-	-.020	-	-	-
g_{ND}	.0002 (.0009)	-	-	-	-.0004 (.00002)	-.00005 (.000009)	-	-	-	-
g_{CA}	-.00001 (.000006)	-	-	-	-	-	-	-	-	-
g_M^s	-	.0008 (.0002)	-	-	-	-	-	-	-	-
i_{RF}	-	-	-	.010 (.002)	-	-	-	-	-	-
YD_{GB}	-	-	-	.007 (.002)	-	-	-	-	-	-
R^2	.993	.992	.995	.996	.999	.999	.943	.950	.999	.999
SSR	38.293	41.119	20.704	19.096	5.507	5.471	94.654	83.324	4.142	4.265
log L(.)	18.551	22.079	63.930	61.874	214.606	215.250	-138.330	-110.433	233.215	230.525
D-W	1.979	1.901	1.825	1.899	1.909	1.879	1.682	1.4982	2.141	1.922
N	282	284	287	287	286	286	196	196	285	285

Note: See, Table 1 and 1a; AR(k) = autoregressive process of order k, R^2 = R-squared, SSR = sum of squared residuals, Log L(.) = log of likelihood function, D-W = Durbin-Watson statistic, N = number of observations, * = significance at more than 5%.

Table 4 (continued).GARCH and ARCH-M Estimations of IRRP, Models (18)-(20) and (21)-(20)

Variables	RP_{30TB} GARCH	ARCH-M	RP_{Aaa} GARCH	ARCH-M	RP_{Baa} GARCH	ARCH-M	RP_{DJIA} GARCH	ARCH-M	RP_{SP} GARCH	ARCH-M
$GARCH^2$	-.519	-(.098)	-.685	-(.238)	.072	-(.024)	-1.006	-	-.689 (.355)	(.264)
C	1.782 (.365)	-	-.718 (.406)	-.990 (.164)	-1.920 (.375)	5.486 (.607)	-	-	-	-
r*	-.193	-.131	-	-	.090	-.453	-.816	.040	-	- (.444)
p	.811 (.016)	.882 (.003)	.995 (.004)	.990 (.004)	1.087 (.015)	.546 (.015)	-	-	.431 (.249)	1.009 (.439)
t	0.003 (.005)	-.0005 (.00004)	.001	.002 (.0005)	(.003)	.003	- (.005)	-	.023	.017 (.011)
g_{GDP}	-	-	-	-	-	-	.163 (.103)	.270 (.141)	-	-
g_{IP}	.009 (.003)	.003 (.001)	-	-	-.005 (.002)	-	-	-	-	-
u	-	-	-.037 (.043)	-	.277 (.026)	-	-	-	-	.620 (.705)
g_{ND}	-	-	-	-	-.0005 (.0003)	-	-	-	-	-
g_{DJIA}	-	-	.0003 (.0002)	-	-	-	-	-	.923 (.021)	.930 (.023)

g_{SP}	-	-	-	-	-	-	.980 (.017)	-	.985 (.019)	-
gm5	-.014 (.004)	-.003 (.001)	-	-	.006 (.002)	-	-	-	- (.159)	.482
YD_{GB}	-	-	.326	.263 (.061)	(.054)	.899	- (.025)	-	-	-
YD_{Baa}	.778 (.026)	.885 (.005)	.647 (.065)	.690 (.055)	-	-	-	-	-	-
g_{XRI}	-	-	-.001 (.007)	-.001 (.007)	-.002 (.007)	-	-	-	-	-
AR(1)	-	-	.562	.459	- (.059)	.775 (.070)	-	- (.035)	-	-
AR(2)	-	-	-	-	-	.173	-	-	-	- (.034)
C	.080 (.040)	.002 (.002)	.002 (.0009)	.004 (.002)	.093 (.004)	.055 (.005)	13.094 (9.398)	188.460 (59.169)	87.864 (22.946)	3.134 (9.840)
ARCH(1)	.740 (.074)	.136 (.171)	.253 (.036)	.196 (.055)	.182 (.041)	.100 (.026)	-.050 (.047)	.126 (.018)	.168 (.053)	(.064)
GARCH(1)	.573 (.204)	.350 (.067)	.870 (.031)	.737 (.050)	.605 (.71)	-.109 (.027)	.884 (.064)	1.007 (.052)	.688 (.013)	.761 (.064)
r*	-	-	-.0005 (.0002)	-	-	-	-	-8.454 (2.133)	-	-
p	-.004 (.002)	.0009 (.0004)	-	-	-	-	-	-14.071 (2.779)	-9.429 (5.238)	-
t	-	-	-	-	-.001 (.000006)	-	-	(.097)	-.087	-
g_{GDP}	-	-	-	-	-.0006	-	(.0002)	-	-	1.777 (2.713)
g_{IP}	-.002 (.0006)	-.0005 (.0003)	-.0002 (.0002)	-.0005 (.0003)	-	-	-	-3.005 (1.362)	-	-
u	-	-	-	-	-	-	-	-11.945 (2.242)	-	-
g_{ND}	-	-	-	-	-	-	- (.303)	-	-	.869
g_{DJIA}	-	-	-	-	-	-	-.309 (.289)	-.454 (.170)	-	-
YD_{GB}	-	-	-	-	-.004 (.0007)	-	-	-	-	-
g_{XRI}	-	-	-	-	-	-.0007	-	-	-	1.232
R^2	.987	.987	.994	.994	.979	.992	.897	.895	.892	.890
SSR	47.013	46.088	19.890	18.582	74.071	35.344	17.422	17.987	17.391	17.890
log L(.)	-105.206	-11.853	34.415	32.830	-63.419	-102.897	-823.571	-808.455	-821.364	-830.009
D-W	.264	.173	1.878	1.836	.132	.923	1.770	1.750	1.826	1.865
N	288	288	287	287	287	337	197	197	198	199

4. Conclusion

It is known that a risk averse investor demands a higher expected return for exposure to extra market risk. The objective is to find the determinants which contribute to market risk and stabilize them, so that we can reduce the interest rate premiums in the economy. We used a variety of definitions of interest rates and determining variables in this study. The results suggest that the interest rates and the risk premia are not stationary; the sample means do not seem to be constant and there is heteroscedasticity (their variance is not constant.) For these series the positive trend is interrupted by a market decline, followed by a resumption of the positive growth. They have not a time-invariant mean; they are not stationary. The real risk-free rate of interest (r*) and other interest rates show no particular tended decrease. It seems to go through sustained periods of increase and then decreases with no tendency to revert to a long- run mean.

This type of random walk behaviour of interest rates is typical of non stationary series. Any shock to these series displays a high degree of persistence. For example, most interest rates experienced a strong upward surge in 1979-1980 and stayed at the higher levels for nearly two additional years. The volatility of many series is variable intertemporally. During the 1970s and early 1980s the risk free rate fluctuated wildly as compared with the1960s and 1990s. Such series is conditionally heteroscedastic, if the unconditional variance is constant, but there are periods in which the variance is relatively high. Almost all series share co-movements with the others. Short term interest rates and their risk premia track each other closely, as we can see from their covariances and correlation coefficients. One way to estimate the coefficients of the factors affecting risk premia is to model conditional variances and covariances of the different factors presented in eq. (10). Among existing models of heteroscedasticity, the model of autoregressive conditional heteroscedasticity into the mean equation, ARCH-in-Mean (ARCH_M) and the generalized version (GARCH) have proven useful in modelling the risk premia.

Tables 1, 2, and 3 contain basic summary statistics such as means, variances, covariances, and correlation coefficients. They also contain the correlation structure for the risk premia and many other macro variables in the economy. The average risk premium is positive and high for all the different interest rates. The most notable feature is the high variability of the RP and the other factors that affect the RP. Table 4 shows the GARCH and ARCH-M estimations of two different specifications, the mean and the variance specifications. The results reveal that conditional variance of real risk-free rate of interest, growth of national debt and money supply, T-bill rate and differential in yields of government securities, or risk measurement, have significant positive effects on IRRP. The empirical results find that the above macro-variables, fiscal and monetary policy uncertainties and last period's squared residual from the mean equation e2t-2 and variance are important sources of time varying risk premia of interest rates.

The conditional variances of growth of S&P 500 and the yield differential of Baa bonds were not significant in any of the risk premium equations, but their mean values were highly significant. We can also see from the correlation statistics the opposite relationships between risk premia and growth DJIA, S&P 500, money supply, exchange rate index and real risk-free rate of interest.

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