The Relationship Between Price Volatility, Maturity and Volume of Trade of the Malaysian Bond Market

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Kajian ini cuba untuk membuat eksplorasi ke atas kesan tempoh matang dan volum dagangan ke atas kemeruapan pasaran bon Malaysia. Bon MGS, Cagamas dan Korporat yang aktif didagangkan merupakan data yang digunakan di dalam kajian ini. Perhubungan di antara pembolehubah-pembolehubah ini seterusnya dicerap dengan menggunakan analisa regresi. Tempoh kajian ini debahagaikan kepada tiga tempoh iaitu tempoh krisis (Mac 1996-Jun 1997), tempoh semasa krisis sebelum pegging (Julai 1997-Ogos 1998) dan tempoh krisis selepas pegging (September 1998-Mac 1999). Adalah didapati bahawa tidak wujud perhubungan di antara kemeruapan harga dan tempoh matang bagi bon MGS dan Cagamas tetapi bagi bon Korporat, perhubungan di antara pembolehubah tersebut adalah positif dalam semua tempoh masa. Keputusan kajian juga menunjukkan bagi bon Korporat apabila volum dagangan dimasukkan ke dalam persamaan regresi, perhubungan di antara tempoh matang dan kemeruapan harganya menjadi tidak signifikan kecuali bagi tempoh semasa krisis sebelum pegging.

Kata kunci: Kemeruapan, portfolio bon, harga bon, analisis matematik dan tempoh matang.
Key words: Volatility, bond portfolio, bond price, mathematics analysis and term to maturity

Introduction

A lot of previous studies discussed on the determinants of bond price volatility. One of the more common and accepted generalizations in the mathematics of bond prices is that for a given change in yield, the fluctuations in the market price will be greater the longer the term to maturity, Freund (1970). It will be useful to review Malkiel s (1962,1965) five theorems as these theorems are well-known preliminary relationship between yield changes and bond price movements. Theorem one states that bond price move inversely to bond yields. Theorem two states that for a given change in yield from the nominal yield, changes in bond prices are greater, the

longer is the term to maturity. Theorem three states that the percentage price changes described in theorem two increase at a diminishing rate as years to maturity increase. Theorem four states that results from an equal-sized increase or decrease in a bond's yield is asymmetrical or to be more specifically, for any given maturity, a decrease in yields causes a price rise that is larger than the price loss that results from an equal increase in yields. Theorem five states that the higher is the coupon carried by the bond, the smaller will be the percentage price fluctuation for a given change in yield except for one-year securities and consoles[1]. Mathematically, Malkiel had proven the theory. Similar statements may be found in almost every investment book discussing the mechanics of bond pricing. The study by Fuller and Settle (1984) investigates the relationship between duration and bond volatility. In their study, the volatility of bonds are determined by the bonds' coupon rate, term to maturity and yield to maturity. Results of an analysis of these issues include: the duration and volatility are inversely related to the coupon rate, short-term bonds can have a longer duration and be more volatile than long-term bonds under certain circumstances such as when the bonds are selling at a discount, there are certain longer-term discount bonds less sensitive to a given change in market interest rates than are shorter term bonds and a negative relationship exists between yield to maturity, duration and bond price volatility. Walls (1999) also examines the relationship between volatility, volume and maturity but not in bond market. He focuses his study in electricity futures market. He uses regression model in examining this relationship; volatility is considered as a dependent variable while maturity and volume as independent variables. The results show that the electricity future price volatility is negatively associated with maturity but positively associated with the contemporaneous volume of trade conditional on the term to maturity. The role of emerging market bonds in global investment portfolios is examined by Claude, Campbell and Tadas (1999). They concluded that volatility has been one of the characteristics in emerging market bonds throughout time. In relatively good times, the emerging market bonds seem to be unique in return characteristic. In the time of crisis, they are highly related with equity markets.

There is still not much research has been done on Malaysian bond market. There are only a few of it such as articles written by Muhammad Muda (1985) who looks at the behaviour of MGS's coupon rate and by Noniszura & Tan (1999) who investigate the financial risk of Malaysian Corporate bond.

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[1] Bond that has no specific maturity or unending cash flow stream

Background on Malaysian Bond Market

This study concentrates on Malaysia bond market, which includes government securities (represent public sector instruments), Cagamas bonds and Corporate Bonds (represent private sector instruments).

Malaysian Government Securities (MGS), which is generally known as government bond, is an established securities since it is guaranteed by the Malaysian Government. The issuance of MGS basically is for providing funds for any long-term development projects with interest payable semi annually. MGS are auctioned by the Central bank through the 23 primary dealer participants (banks, discount houses and merchant banks). Therefore, the coupon rate is determined by the weighted average of the successful yield. The central bank accepts no direct subscriptions for MGS from investors (except for two major government-related institutional investors, the Employees Provident Fund and the National Savings Bank). The tenor of MGS is normally above one year. The primary investors in MGS are tax-exempt pension funds, the Employees Provident Fund, insurance companies and commercial banks.

Cagamas bonds are securities issued by Cagamas Berhad, a Malaysian mortgage corporation, established in 1986 to foster growth in the Malaysian mortgage market, raises funds through the issuance of securities, and utilizes the proceeds to purchase residential mortgages from financial institutions. Ownership is currently held by a broad group of financial institutions, with Bank Negara Malaysia being the single largest shareholder. This is the reason why some may argue that Cagamas bond is actually a public sector instrument. One must not forget that despite the central bank's ownership, there is no explicit government guarantee attached to Cagamas bonds. Therefore, Cagamas bonds are considered private sector instruments.

Corporate bonds are long-term securities issued by the corporations to meet their financing needs. The issuer may issue these bonds based on Islamic or conventional principle, and with fixed or floating rate bonds or without interest (zero coupon bonds) attached. The interest may be payable on a quarterly, semi annually or annually depending on the cashflow of the issuer.

Although the range of products available to issuers and investors is broad, the Malaysian fixed income market is still hampered by limited secondary trading activity in certain sovereign and private sector issues and still-modest primary issuance by the private sector. A number of steps the Malaysian government has taken in order to alleviate some of these drawbacks, stated briefly, the key changes includes the establishment of the first credit rating, Rating Agency Malaysia Berhad which provides some guidance on the credit worthiness of the issuers in November 1990 and the second rating agency, Malaysian Rating Corporation Berhad in October 1995. Other steps taken by the Malaysian government are eliminating stamp duties and income taxes on

certain bond issues, ensuring greater access by the investing public to a series of government and private securities issues, creating a centralized clearing system for sovereign securities and introducing interest rate futures.

The objectives of this study is to analyze the relationship between price volatility, term to maturity and volume of trade of the Malaysian bond market by imposing Wall's (1999) model with a little modification to fit the nature of the bonds. Empirical assessment of the findings should prove useful to market participants and regulators since they need to understand the volatility of bonds' price to effectively employ fixed income portfolio strategies as mentioned by Fabozzi, Pitts and Dattatreya (1995).

Data and Methodology

Monthly actively traded Malaysian Government Securities (MGS), Cagamas Bond and Corporate Bond data published by RAM Bond Newsletter and Investors Digest is used in this study. The data set consists of term to maturity and volume of trade at the end of every month and the highest and lowest price in the month between March 1996 and March 1999. The time period is then divided into three periods. Data from March 1996 to June 1997 represent the period before the currency crisis, data from July 1997 to August 1998 represent the period during the crisis before pegging and data from September 1998 to March 1999 represent the period during the crisis after pegging.

Measure of volatility is as proposed by Parkinson (1980) and Garman and Klass (1980). All variables are transformed to logarithmic form.

The volatility is estimated as follows:

$$\text{Volatility}_t = \log \text{price}(\text{high}_t) - \log \text{price}(\text{low}_t)]^2/[4 \log 2] \quad (1)$$

where volatility is the fluctuation or variability of bond price over time. Statistically, volatility is a measure of the dispersion or spread of bond price around the mean of the bond price.

According to Wall (1999), to quantify the effect of time until maturity on price volatility, the following linear regression equation is used:

$$\text{Volatility}_t = \alpha_t + \beta \log(\text{maturity})_t + \mu_t \quad (2)$$

where time until maturity refers to the number of month to the date the contract between the firm and bondholder expires and the firm repays a bond's principal to the bondholder.

Table 1

Number of data and issue of bond involved.

Overall Period (March 1996- March 1999)	Number of data	Number of issue
MGS	96	15
Cagamas	58	36
Corporate bond	1 367	55
Before Crisis (March 1996-Jun 1997)		
MGS	29	5
Cagamas	35	14
Corporate bond	542	39
During crisis before pegging (July 1997 – August 1998)		
MGS	26	7
Cagamas	23	14
Corporate bond	626	54
During crisis after pegging (Sept 1998 – March 1999)		
MGS	41	11
Cagamas	Data not available	Data not available
Corporate bond	199	41

The coefficient on maturity (β) reflects the extent to which the time until maturity effects price volatility. According to conventional wisdom, β has to be positive so that price volatility decreases as the number of months to maturity decreases. This study also investigates maturity effects in a second regression to explicitly control the volume of trade. By controlling the volume of trade, it will enables inference on the presence of maturity effects that are not associated with the trading volume be made. For example, in Serletis's (1992a) study of crude oil, heating oil and unleaded gasoline futures, he found that including the volume of trade as an explanatory variable significantly reduced the explanatory power of time until maturity. 'What this means is that it is probably not maturity *per se* which affects volatility, but rather one or more factors which simultaneously affect the volume of trade and volatility'. (Serletis, 1992a, p. 151).

$$\text{Volatility}_t = \alpha_t + \beta \log(\text{maturity})_t + \gamma \log(\text{volume})_t + \mu_t \quad (3)$$

where volume is the number of bonds traded on the particular month.

Findings

Descriptive Summary

Table 2A, 2B and 2C presents the summary statistics, respectively, on volatility, maturity and volume for MGS, Cagamas and Corporate bonds respectively for the overall , before the crisis, during the crisis before pegging and during the crisis after pegging period.

The high level of volatility is demonstrated by the high level of mean value from table 2A. It is clearly shown that the volatility for MGS, Cagamas and Corporate Bond is higher during the crisis compared before the crisis. In the overall and during the crisis before pegging period, the price of Cagamas is the most volatile while the price of MGS is the least volatile. Before the crisis, it is found that price of the Corporate bond is the most volatile while the price of Cagamas is the least volatile.

From table 2B, it could be seen that the volume of trade for MGS is the highest while Corporate bond is the lowest not only before the crisis and during the crisis before pegging but also in the overall period. During the crisis before pegging, the volume of trade for Cagamas and Corporate bond is higher compared to before the crisis but for MGS the result is different since its volume of trade decrease during the crisis before pegging compared to before the crisis.

Table 2C indicates that MGS has the longest term to maturity in all period. Before the crisis, Cagamas bond has the shortest term to maturity while during the crisis before pegging, Corporate bond has the shortest term to maturity. The result for the period during the crisis after pegging is not discussed here because the data for Cagamas is not sufficient.

Regression Summary

The empirical analysis begins by first investigating the time series properties, i.e., volume and volatility. Data generated in financial markets are often nonstationary. If the data are nonstationary the standard statistical procedures, including the usual t- and F-tests in the regression analysis, will give misleading results. Therefore, volatility and logvolume are tested for nonstationary using ADF unit root test. The results of the unit root tests displayed in Table 3, indicate a clear rejection of the hypotheses that volume and volatility contain a unit root. For all types of bonds, the hypothesis of a unit root is rejected at the 1% significanse level. In other words, the unit root test results indicate that the series have a constant unconditional variance across time. Given the strong evidence that the time series data to be analysed are stationary, we will proceed using standard statistical methods. Correlation

test is also conducted in order to examine the existance of multicollinearity. Table 4 shows the correlation test results for each period studied.

Table 2A

Summary statistics for volatility

Overall Period (March 1996 – March 1999)	MGS	CAGAMAS	CORPORATE BOND
MEAN	0.0000319	0.013389	0.001340
MEDIAN	0.00000213	0.0000000626	0.000178
MAXIMUM	0.000829	0.829963	0.068784
MINIMUM	0	0	0
Before crisis (March 1996 – Jun 1997)	MGS	CAGAMAS	CORPORATE BOND
MEAN	0.00000347	0.000000162	0.000486
MEDIAN	0.000000756	0	0.0000517
MAXIMUM	0.0000338	0.00000378	0.068784
MINIMUM	0	0	0
During crisis before pegging (July 1997 – August 1998)	MGS	CAGAMAS	CORPORATE BOND
MEAN	0.0000159	0.036091	0.001940
MEDIAN	0.00000138	0.000000156	0.000472
MAXIMUM	0.000173	0.829963	0.032111
MINIMUM	0	0	0
During crisis after pegging (Sept 1998 –March 1999)	MGS	CAGAMAS [a]	CORPORATE BOND
MEAN	0.0000883		0.001832
MEDIAN	0.0000326		0.000601
MAXIMUM	0.000829		0.037375
MINIMUM	0.000000506		0

Note: [a] Data not available

Table 2B

Summary statistics for volume (in units)

Overall Period (March 1996 – March 1999)	MGS	CAGAMAS	CORPORATE BOND
MEAN	66803990	5592664	2483501
MEDIAN	16481870	1994516	345000
MAXIMUM	476000000	60726928	176000000
MINIMUM	301204.8	90895.87	730000
Before crisis (March 1996 – Jun 1997)	MGS	CAGAMAS	CORPORATE BOND
MEAN	60562077	2807055	1772057
MEDIAN	13478434	1500300	210500
MAXIMUM	362000000	15978429	58374000
MINIMUM	494071.1	498603.9	730000
During crisis before pegging (July 1997 – August 1998)	MGS	CAGAMAS	CORPORATE BOND
MEAN	25855923	10299559	3144166
MEDIAN	5846470	4000000	489500
MAXIMUM	191000000	60726928	176000000
MINIMUM	301204.8	90895.87	1000
During crisis after pegging (Sept 1998 – March 1999)	MGS	CAGAMAS [a]	CORPORATE BOND
MEAN	123000000		2257186
MEDIAN	61974441		586000
MAXIMUM	476000000		36672000
MINIMUM	1463772		1000

Note: [a] Data not available

Table 2C

Summary statistics for maturity (in months)

Overall Period (March 1996 – March 1999)	MGS	CAGAMAS	CORPORATE BOND
MEAN	72.96623	32.47258	29.34616
MEDIAN	60.00000	34.08000	29
MAXIMUM	119.6000	47.64000	74
MINIMUM	9.500000	15.78000	0.29
Before crisis (March 1996 – Jun 1997)	MGS	CAGAMAS	CORPORATE BOND
MEAN	74.08621	30.87771	31.44855
MEDIAN	74.50000	31.08000	29
MAXIMUM	119.000	47.52000	74
MINIMUM	26.5	20.16	0.29
During crisis before pegging (July 1997 – August 1998)	MGS	CAGAMAS	CORPORATE BOND
MEAN	76.16923	35.10261	28.57668
MEDIAN	59.10000	34.92000	26.00000
MAXIMUM	119.5000	47.64000	59.00000
MINIMUM	9.500000	17.28000	1.00000
During crisis after pegging (Sept 1998 – March 1999)	MGS	CAGAMAS[a]	CORPORATE BOND
MEAN	67.70455		23.88442
MEDIAN	57.00000		29.00000
MAXIMUM	119.6000		47.00000
MINIMUM	27.50000		1.00000

Note: [a] Data not available

Table 3

Unit root test results

Subject	Volatility	logVolume
MGS	-4.072008***	-3.511991***
CAGAMAS	-4.899041***	-4.827710***
Corporate bond	-12.53808***	-7.239526***

Note: ***Significant at 1% level

Table 4

Correlation results between logmaturity and log volume for MGS, Cagamas and Corporate bond

Subject/Period		Pearson correlation coefficient
MGS	Overall period	0.250** (0.014)
	Before crisis period	0.528*** (0.003)
	During crisis before pegging	0.152 (0.459)
	During crisis after pegging	0.219 (0.169)
Cagamas	Overall period	0.164 (0.161)
	Before crisis period	0.173 (0.321)
	During crisis before pegging	0.214 (0.328)
	During crisis after pegging	0.025 (0.923)
Corporate bond	Overall period	0.334***(0.000)
	Before crisis period	0.400***(0.000)
	During crisis before pegging	0.406*** (0.000)
	During crisis after pegging	0.207*** (0.003)

Note: p-value is in the parentheses
** Significant at the 0.05 level
*** Significant at the 0.01 level

From table 4, it could be seen that the correlation between log maturity and log volume is significant at 0.05 levels for MGS in the overall and before crisis period. While for the Corporate bond the correlation between the same variables is significant at 0.01 level in all periods.

Table 5 reports the estimated parameter and hypotheses testing results for the regression model specified in equation (2), i.e, the effect of term to maturity on bond price volatility for MGS, Cagamas and Corporate Bond.

From table 5, it is found that the term to maturity is significantly related to bond price volatility only for Corporate bond and the relationship is positive in all period of study. From the R^2 value, the term until maturity does not appear to have a great deal of explanatory power in the regression. Maturity effects explained at the most only 4.65% of the variation in corporate bond price volatility, which occurred in the period during the crisis before pegging.

Table 5

Regression results: Volatility$_t$ = α_t + β log(maturity)$_t$ + μ_t

Overall period: March 1996-March 1999					
	α	t_α	β	t_β	R^2
MGS	0.0000844	1.343484	-0.0000289	-0.938104	0.003892
CAGAMAS	-0.0613540	-0.942299	0.049879	0.956675	0.002725
CORPORATE BOND	-0.0000312	-0.120197	0.001012	5.294932**	0.011848
Before crisis: March 1996-June 1997					
	α	t_α	β	t_β	R^2
MGS	-0.00000977	-0.682	0.00000722	0.929	0.031
CAGAMAS	-0.000000543	-0.308	0.000000476	0.400	0.005
CORPORATE BOND	-0.000316	-1.533324	0.000122	4.659017**	0.004054
During crisis before pegging: July 1997-August 1998					
	α	t_α	β	t_β	R^2
MGS	0.0000423	1.057040	-0.0000145	-0.733841	0.011355
CAGAMAS	-0.011677	-0.123941	0.031182	0.450195	0.000440
CORPORATE BOND	-0.000784	-1.908048	0.002034	6.201391**	0.046523
During crisis after pegging: Sept 1998-March 1999					
	α	t_α	β	t_β	R^2
MGS	0.000154	0.891975	-0.0000366	-0.425705	0.001870
CAGAMAS					
CORPORATE BOND	0.000812	1.221997	0.000840	1.721553*	0.009496

Note: ** Significant at 5% level

*Significant at 10% level

[a] data not available

Table 6 reports the estimated parameter and hypotheses testing results for the regression model specified in equation (3,) i.e., the effect of term to maturity and volume of trade on price volatility of MGS, Cagamas and Corporate Bond. The volume of trade is significantly and positive related to price volatility for Corporate bond in all periods but the most important things that could be observed from Table 5 is the significance of the relationship between term to maturity and Corporate bond price volatility deteriorate when the volume of trade is included as one of the independent variables except for the period during the crisis before pegging. For MGS and Cagamas the volume of trade is also significantly related to price volatility but only in certain periods. The R^2 value increase compared to the previous regression model. Thus the inclusion of volume of trade can explain better the variation of bond price volatility.

Table 6

Regression results: $Volatility_t = \alpha_t + \beta\, log(maturity)_t + \gamma\, log(volume)_t + \mu_t$

Overall period: March 1996-March 1999							
	α	t_α	β	t_β	γ	t_γ	R^2
MGS	-0.0000744	-1.699697	-0.0000718	-2.012332**	0.0000330	3.179245**	0.083767
CAGAMAS	0.269767	1.086735	0.151387	1.050854	-0.075685	-1.126972	0.140445
CORPORATE BOND	-0.003006	-8.452721	0.000354	1.605026	0.000705	8.351157**	0.05288
Before crisis: March 1996-June 1997							
	α	t_α	β	t_β	γ	t_γ	R^2
MGS	-0.0000149	-1.07	-0.00000127	-0.14	0.000002.96	1.83	0.142
CAGAMAS	-0.00000171	-0.74	0.00000031	0.26	0.000000226	0.79**	0.024
CORPORATE BOND	-0.001334	-5.215719	0.000181	1.436249	0.000297	4.822236**	0.012927
During crisis before pegging : July 1997-August 1998							
	α	t_α	β	t_β	γ	t_γ	R^2
MGS	-0.000107	-1.363364	-0.0000252	-1.411517	0.0000246	1.696703	0.274516
CAGAMAS	0.634514	1.190114	0.205259	0.957421	-0.138581	-1.301971	0.287173
CORPORATE BOND	-0.003440	5.878134	0.001286	3.723170**	0.000652	6.069666**	0.078389
During crisis after pegging : Sept 1998-March 1999							
	α	t_α	β	t_β	γ	t_γ	R^2
MGS	-0.000124	-0.832276	-0.000151	-1.427723	0.0000625	2.882173**	0.047147
CAGAMAS							
CORPORATE BOND	-0.004004	-2.129767	0.000439	0.719630	2.125417**	0.000940	0.057794

Note: ** Significant at 5% level

[a] data not available

Conclusion

The results of this study implies that volatility for MGS, Cagamas and Corporate Bond is higher during the crisis before pegging compared to before crisis. This could be due to the instability of interest rate during the crisis period and the most preferable bond to risk adverse investors during the crisis could be MGS since the price of MGS is the least volatile during the period. The volume of trade is higher for the period during the crisis before pegging compared to before the crisis for Cagamas and Corporate bond but for MGS the result between the two periods is the opposite. Changes in economic situations during the crisis may altered investors behaviour. Some investors are worry if they are holding bonds with high probability of going default. Therefore, there is a high possibility that they actively changing their portfolio of Cagamas and Corporate bond but at the same time they may choose to keep holding MGS since its default risk is zero. On average, MGS has the longest term to maturity while Corporate bond has the shortest term to maturity. It is discovered that the higher the term to maturity the more volatile the Corporate bond price but the relationship between price volatility and maturity for MGS and Cagamas bond do not exist. Therefore, result for the Corporate bond is consistent with the statements made by Livingstone (1993, p. 297) which similar to the statement made by Malkiel in his theorem two which stated that for a given change in yield from the nominal yield, changes in bond prices are greater, the longer the term to maturity. The results also suggest that for Corporate bond investors who are concern with the stability of the bond price are advised to choose Corporate bonds with shorter maturity. How reliable are the results of Corporate bond is quite difficult to be confirmed since correlation between its log maturity and log volume is significant. In addition, when volume of trade is included into the regression equation, the relationship between term to maturity to price volatility become insignificant except for the period during the crisis before pegging. Anyway, the higher the volume of trade, the more volatile the Corporate bond price and the relationship is significant in all period. For MGS and Cagamas, the volume of trade is significantly related to price volatility but only in certain period of study. According to Brailsford (1996), there are three types of volume measurement i.e. number of transactions, number of shares traded and value of shares traded. In this study, the number of shares traded is used. Maybe in the future, the other two measurements for volume could be used to measure the relationship between bond volatility and volume. Since the R^2 value increased in the second regression model, the study concludes that the volume of trade helps to explain better the variation of bond price volatility. Although the R^2 value increased but the value it is still low and this phenomenon suggest that other factors such as interest rate, duration and coupon rate can explain the bond price volatility better. The difference between interest rate and coupon

rate is that interest rate is the cost of fund that prevails in the financial market while coupon rate is the stipulated interest rate to be paid on the face value of a bond. It represents a fixed annual dollar amount that is paid as long as the debtor is solvent. Duration may be defines as the weighted average number of period until the cashflows occur, with the relative present values of each cash flow used as the weight. Further empirical work should seek to investigate these factors.

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