The J-value as the measurement tool of the bonds investor's behavior

Cite as: AIP Conference Proceedings **2331**, 020004 (2021); https://doi.org/10.1063/5.0041977
Published Online: 02 April 2021

Josep Ginting, and Lydia Anggraini

The J-Value as the Measurement Tool of the Bonds Investor's Behavior

Josep Ginting[1, a)] and Lydia Anggraini[2, b)]

[1]*Study Program of Accounting, Faculty of Business, President University, Jl. Ki Hajar Dewantara, Jababeka Education Park, Cikarang Baru, Bekasi 17550, Indonesia*
[2]*Study Program of Mechanical Engineering, Faculty of Engineering, President University, Jl. Ki Hajar Dewantara, Jababeka Education Park, Cikarang Baru, Bekasi 17550, Indonesia*

[a)]josepginting@president.ac.id
[b)]Corresponding author: lydia.anggra@president.ac.id

Abstract. For many years, mathematics has been used to solve the problem in economic and finance instead of natural science and engineering. This paper shows how accurate mathematics reads financial behavior. One of the financial areas using the mathematics approach is the bond valuation technique. Bond is one of the long term debt instruments. The finding in this research is that mathematics can be used to read the changes in the concept of a pricing model where the par value of bonds is always going to 100% at the maturity date. Theoretically, the bonds fair price is resulted by calculating the present value of future coupon interest of bonds, but not in practice, caused by the bonds investor behavior. The difference in price, resulted from both different approaches, in this paper is defined by a new mathematical concept to reflect the bonds' investor behavior. It is the aim of this research. To address the differences, we have evaluated the fair price of bonds calculation by creating new mathematics equations by combining the calculation of the present value of future coupon interest of bonds with the market concept models. The result is a new mathematical model called J-Value. To prove the eligibility of J-Value, a simulation was done. The mathematics model in this paper is found by combining the usage of a qualitative method and supported by a quantitative method.

INTRODUCTION

The idea of this research comes from the bonds trading case in Indonesia Capital Market, where the case also happened in many countries. The bond in this discussion is part of the debt securities paper issued by a company or government and sold to investors to have fresh money. The bond located in the financial statement of the company as the part of the long term liability side in the statement of financial position.

The investors invest their money in bonds instrument for the coupon interest and capital gain. The total coupon interest and capital gain are called the yield to maturity (YTM). From those concepts, it can be seen that there is a relationship between the interest rate and capital gain (to reflect the market) to yield to maturity. Mahajan and Fraser said that equilibrium yield relationships between otherwise similar dollar-denominated Eurobonds and U.S. bonds with the use of supply and demand conditions and the standard arbitrage argument [1]. This is predicted as one of the source of bonds pricing modeling. The model proposed by Mahajan and Fraser was also supported by Peterson and Stapleton [1, 2]. Peterson and Stapleton built a three factor term structure of interest rate models and use it to price corporate bonds [2]. Also, in accounting treatment, coupon interest and capital gain are recognized as the

The 2nd Science and Mathematics International Conference (SMIC 2020)
AIP Conf. Proc. 2331, 020004-1–020004-9; https://doi.org/10.1063/5.0041977
Published by AIP Publishing. 978-0-7354-4075-3/$30.00

income of investors, by using accrual accounting system and amortization process. The bond's coupon interest for some investors is a source of passive investment income with competitive yield compared to bank deposit rates.

The risks that occur in bonds investment are credit risk, liquidity risk, and market risk. Credit risk occurs when a bond issuer becomes unable to pay either interest of the bonds or the principal of the bonds when the bonds matured. Liquidity risk occurs due to the illiquid funds in the issuer paid to the bondholders. The measurement of the risks to the bonds as mentioned is carried out with different approaches. Consider that risk is very critical and important for the investor, it is also the consideration for Peterson and Stapleton to develop the model based on risk where they built a three-factor term structure of interest rates model and use it to price corporate bonds [2]. The first two factors allow the risk-free term structure to shift and tilt. The third factor generates a stochastic credit-risk premium. The method of research approximates a correlated and lagged-dependent lognormal diffusion process. Peterson and Stapleton then price options on credit-sensitive bonds [2]. The recombining log-binomial tree methodology allows the rapid computation of bond and option prices for binomial trees with up to forty periods. Before Peterson and Stapleton, the model of bonds pricing developed based on the liquidity on bonds price by Kempf and Uhrig-Homburg [3]. Kempf and Uhrig-Homburg proposed a theoretical continuous-time model to analyze the impact of liquidity on bond prices [3]. This model prices illiquid bonds relative to liquid bonds and provides a testable theory of illiquidity induced price discounts. For advanced modeling, the bond pricing modeling was developed by Oberman and Zariphopoulou [4]. Oberman and Zariphopoulou proposed a utility-based methodology for the valuation of early exercise contracts in incomplete markets [4]. Oberman and Zariphopoulou found that a class of numerical schemes is developed for the variational inequalities and a general approach for solving numerically nonlinear equations arising in incomplete markets is discussed [4].

Bond's market risk is reflected by the volatility of bond prices occurring in the secondary market and also demonstrated in the absence of response on price movement as the impact of the change of interest rate in financial markets, either from the central bank or from commercial banks. The changes in interest rates, in both the central bank and commercial banks, should indirectly affect the price through changes in yield-to-maturity (YTM) expectations. The fact that investors judge percentage without the concept of present value, in terms of is not always in line with the movement of interest rates, even in the same trend. YTM's growth (□YTM) is not equal to the growth of market interest rate (□ market interest rate). In our observations directly in the capital market, this inconsistency occurs due to the different perceptions of investors on risk tolerance in the market. A long time before, this concept of risk was managed by Weeks and Kassicieh as the bond pricing models [5]. Weeks and Kassicieh developed the calculation of model prices involves three disjoint tasks: (1) estimation of the values of the real interest rate and the inflation rate (which we will refer to as state variables or sources of uncertainty) as well as the parameters of the state stochastic differential equations, (2) estimation of the market prices of risk associated with the two state variables, and (3) the solution of the valuation partial differential equation [5].

The risk in bonds market and the issuer of bonds also have a participation in building the models of bonds pricing. Ando developed the models based on a Bayenesian methods by formulating a corporate bond (CB) pricing model and credit default swap (CDS) premium pricing models to estimate the term structure of default probabilities and the recovery rate [6]. Previously, in 2011, a model in terms of risk was developed by formulating the influence of imperfect information developed by Agliardi and Agliardi [7]. Agliardi and Agliardi mentioned a computational method to implement the effect of imperfect information on the value of defaultable bonds [7]. Fuzzy modeling is adopted and the numerical experiments show that an imprecise value of the stochastic underlying asset and/or the barrier triggering default have a material impact on the qualitative shape of the term structures of credit spreads.

As the empirical data, in this paper, we observed some cases that happened in the bond market in Indonesia when interest rates in the central bank or in commercial banks decreased or increased, YTM did not move down or move up as the concept of bonds fair price. The concept said that if the interest rate in the central banks or in commercial banks changed it will cause the movement of yield to maturity of the bonds, automatically the price of bonds in the market also moves. But in fact, sometimes, when the bond prices rise, it is not caused by the declining of the YTM. This case happened in all capital markets in this world and supported by the research of Chiarella and Mackenzie [8]. Chiarella and Mackenzie said that specifically, it evaluates the assumed discrete version of the joint interest process for the short and long rates by estimating it for a series of sample periods under varying market conditions [8]. The implications of the specified form of these two interest rates within the context of hypotheses of interest rate behavior are also examined.

The different concept from market, risk, interest rates, there are two different models in bonds pricing. The first proposed by Branger, Mahayni, and Schneider, where the researcher tried to use the models of Black and Scholes to bonds pricing as they did for stock valuation [9]. Branger, Mahayni, and Schneider said that there is a cash settlement at maturity which depends on the lowest stock return. Thus, the products consist of a knock-out coupon bond and a knock-in claim on the minimum of the stock prices. In a Black-Scholes model setup, the price of the knock-out part can be given in closed (or semi-closed) form in the case of one or two underlying only. The newest models of bonds pricing proposed by Georgiopoulos, where he presents a method of pricing catastrophe bonds (cat bonds) using stochastic programming [10]. Stochastic programming is a method ubiquitous in operations research when decision problems involve uncertainty.

In observations on bond trading data as of September 26, 2015, in the Indonesia Capital Market, there were some government bonds (should be more stable than private corporate bonds), reacted in the extreme movement as mentioned above, against the movement of interest rate (for example when interest rate decreased theoretically followed by the decreasing of YTM but the fact the market price of bonds did not move significantly then should be (low response). Some examples in this paper taken from the direct observation on Indonesian Capital Market, the fact was found that fixed-rate (FR) government bond series 70, which will due on March 15, 2024 (8.48 years) with a coupon rate of 8.375% per annum traded on September 26, 2015, at the price of 93.45% (discount) with the YTM was of 9.52% when the market interest rate was down below 8.375% but it should be above 100%, theoretically. The government bond of FR 71 with the maturity date of March 15, 2029 (13.48 years) with a coupon rate of 9% per annum, traded at 97.25% where the YTM was of 9.36% where the interest rate was down below 9%, it should be above 100%. FR 72 with the maturity date of May 15, 2036 (20.65 years) with a coupon rate of 8.25% traded at 88% with the YTM was 9.59% when the interest rate was below 8,25%, it should be above 100%. Similar to FR 73 which due on May 15, 2031 (15.65 years) with a coupon rate of 8.75% traded at 93.15% with YTM was 9.6% should be followed by the price above 100%. The fact, all bond prices were still below 100% although interest rates from the central bank and commercial banks interest rate declined below 7% per annum. By observing that condition, we found that something abnormally happened with the behavior of the investors.

Similar things happened to the bonds issued by private companies, bond prices also did not refer to the calculation of price sensitivity of bonds towards the changes of market interest rates. Astra Leasing Company's bond (ASDF 01CCN1) bonds due on February 21, 2017 (1.41 years) with a coupon rate of 8.6% traded at the price of 93% with YTM was of 14.23%, Bank Central Asia's Bond, BCAF02ACN1 due on March 30, 2015 (0.51 years) with a coupon rate of 8.25% per annum was traded at 99.97% with YTM was of 8.31%. Not so different from the government bonds that the bonds market price is less sensitive to the movement of bonds' YTM and very sensitive to supply and demand mechanism only. It confirms us that the yield movement is unpredictable.

Referring to the issues that the yield of bonds movement was not followed by the movement of bonds market price as mentioned in the theory of bonds price. Some investigations showed that the bonds yield spread was affected by macroeconomics indicators, case in Malaysia [11]. In previous years, Bhojraj and Sengupta said that an effective corporate governance mechanism can affect bonds yield and rating through effective monitoring of their activities [12]. In this study, we argue that both macroeconomic and corporate governance mechanisms influence bondholder behavior. Bondholders will react to changes in interest rates, bondholders respond to the effectiveness of ineffective corporate governance on the issuer, both government and companies, in this study it is defined as the behavior of bondholders.

Considering the real condition in the capital market (as mentioned in cases), we are interested to see further, what happened to the bonds market related to the behavior of the investors. In this paper, the research was focused on how to look at investor behavior in the bonds market by creating new mathematics models. The basic theories and previews research like proposed from 1986 until 2017, we can see that there is no solution to read the behavior of bonds investor [13–17]. The market concept or the interest rates concept as mentioned even the modern one such as stochastic models could not answer the question of why there is no linear relationship between the movement of interest rate and the price of bonds in the capital market. So in this study, we assumed the answer may be the behavior of bonds investors can be read from the similarity of the component in the previews formula. All assumptions that have been formulated is discussed in this paper in detail.

METHOD

The research process in this paper is released by using a qualitative and quantitative method where the conclusion in the research process is resulted by combining the concept of the present value of the bond's coupon interest and the concept of valuation based on market perception. The result of this process is in a single equation. This single equation, then, is used to measure the behavior of bonds' investors. We notified this as the adjusted par value because it was predicted that the fair par value changed due to the changes in investor behavior. In this paper, the adjusted par value is identified as J-Value. The last process in this research is to generate simulation on the new mathematics formula (J-Value) to prove whether J-Value is eligible and applicable to explain the behavior of bonds investors.

In this research, the researcher used a single sample, which is any fixed-rate bond with a certain interest rate. As the standard of comparison, the coupon is put into the J-Value formula to calculate J-Value and trend of the chart. We used this as the standard to know the difference if the YTM moved above or below the coupon rate of the bond. After that, we put the YTM above and below the coupon rate into the formula to know the J-Value and trend. In the simulation, the increasing and decreasing of YTM was 100 basis points and 200 basis points. There is no previews research about the number, but in this research, we used 100 basis points and 200 basis points to simplify the calculation.

Conceptually, the bond price at maturity will return to 100% (par value), considering that the issuer will repay its debt in the amount of principal plus interest for the last payment period. The price will rise towards 100% for the discounted bond and fall towards 100% for the premium price of bonds. In the observations on the bond market in Indonesia, the fundamental concept is that when the interest rate in the market increased then followed by YTM increased and caused the market price increased fit to the formula is not always true except for one thing that is at maturity the bond price will return to 100%. This thought underlies our assumption in asking about some important things in research is that what mathematical models can prove that in the bonds market sometimes found that the market price is less responsive to the changes of interest rate in the central bank and commercial banks as the tools to answer next two questions in the market is that how is the behavior of bonds holder to give the response on the interest rate movement.

To answer the above conceptual question, we created the new mathematical tools by combining two existing different price calculation models based on the present value of the coupon interest of bonds market approach models. The first concept or the assumption is that the market price based on the present value of the coupon interest (denoted by PV_{cf}) is equal to the price calculated based on the market approach (denoted by MP) as follows:

$$PV_{cf} = MP \tag{1}$$

The first concept assumes that the MP number is derived from the formulation of the following market approach:

$$YTM = \frac{C + \frac{P - MP}{n}}{\frac{P + MP}{2}}$$

Where P is par value, MP is market price of bond, C is coupon rate, YTM is yield to maturity, $\frac{C}{(P+MP)/2}$ is coupon yield, and $\frac{(P-MP)/n}{(P+MP)/2}$ is capital gain yield. Therefore, $YTM \times \left[\frac{P+MP}{2}\right] = C + \frac{P-MP}{n}$

$$\left[\frac{YTM \times (P+MP)}{2}\right] - \left[\frac{P-MP}{n}\right] = C$$

$$\frac{n \times YTM \times [P+MP] - 2 \times [p-MP]}{2 \times n} = C$$

$$MP \times (n \times YTM + 2) = [2 \times n \times C] + [2 \times P] - [n \times YTM \times P]$$

$$\boldsymbol{MP} = \frac{[2 \times \boldsymbol{n} \times \boldsymbol{C}] + [2 \times \boldsymbol{P}] - [\boldsymbol{n} \times \boldsymbol{YTM} \times \boldsymbol{P}]}{[(\boldsymbol{n} \times \boldsymbol{YTM}) + 2]} \qquad (2)$$

The second concept is assumed that the price of a bond based on the present value of the coupon interest and principal at maturity date is equal to the price of the bond calculated with the market approach, $PV_{cf} = MP$ [4]. Thus, if we assumed that $PV_{cf} = MP$, then the second concept is prepared as follows:

$$PV_{cf} = \frac{[2 \times n \times C] + [2 \times P] - [n \times YTM \times P]}{[(n \times YTM) + 2]} = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} + \frac{VMD}{(1+r)^n}$$

If we assumed that the price based on the present value of the coupon interest (right side of the equation above) is the δ, then:

$$\frac{[2 \times n \times C] + [2 \times P] - [n \times YTM \times P]}{[(n \times YTM) + 2]} = \delta$$

written as,

$$P(2 - [n \times YTM]) = \delta[(n \times YTM) + 2] - [2 \times n \times C]$$

then we have:

$$P = \frac{\delta[(n \times YTM) + 2] - [2 \times n \times C]}{2 - [n \times YTM]} \qquad (3)$$

Because we have assumed that the price based on the present value of the cash flow (right side of the equation above) is δ then:

$$\delta = \sum_{t=1}^{n} \left(\frac{C_t}{(1+r)^t}\right) + \frac{VMD_n}{(1+r)^n} = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} + \frac{VMD_n}{(1+r)^n} \qquad \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} = \frac{C_1}{(1+r)} + \frac{C_2}{(1+r)^2} + \ldots + \frac{C_n}{(1+r)^n} \qquad (4)$$

where $C_1 = C_2 = \ldots = C_n = C$ $$\sum_{t=1}^{n} \frac{C_t}{(1+r)^t} = \frac{C}{(1+r)} + \frac{C}{(1+r)^2} + \ldots + \frac{C}{(1+r)^n} = C \times \left[\frac{1 - \frac{1}{(1+r)^n}}{r} \right] \quad (5)$$

$$\delta = C \times \left[\frac{1 - \frac{1}{(1+r)^n}}{r} \right] + \frac{VMD_n}{(1+r)^n} = C \times \left[\frac{(1+r)^n - 1}{r(1+r)^n} \right] + \frac{VMD_n}{(1+r)^n} = \frac{1}{(1+r)^n} \times \left[\frac{C}{r}\left((1+r)^n - 1\right) + VMD_n \right] \quad (6)$$

More details, $$P = \left[C \left[\frac{1 - \frac{1}{(1+r)^n}}{r} \right] + \frac{VMD_n}{(1+r)^n} \right] \times \left[\frac{\left[(n \times YTM) + 2\right] - 2 \times n \times C}{2 - [n \times YTM]} \right]$$

or $$P = \frac{1}{(1+r)^n} \times \left[\frac{C}{r}\left((1+r)^n - 1\right) + VMD_n \right] \times \left[\frac{\left[(n \times YTM) + 2\right] - 2 \times n \times C}{2 - [n \times YTM]} \right] \quad (7)$$

Consider that the market rate (r) fluctuates then YTM is expected to fluctuate, r is equal to YTM, the P (denominated as J-Value) becomes :

$$P = \frac{1}{(1+YTM)^n} \times \left[\frac{C}{YTM}\left((1+YTM)^n - 1\right) + VMD_n \right] \times \left[\frac{\left[(n \times YTM) + 2\right] - 2 \times n \times C}{2 - [n \times YTM]} \right] \quad (8)$$

where P is assumed as the J-Value to measure the behavior of bonds holders, YTM is the yield to maturity, VMD is the principal amount at maturity, n is the maturity period.

This formula is determined because the purpose of this paper is to generate a new concept to analyze the bond in the capital market by introducing new formula; we did not use the statistical test to have the accuracy of the result, but from the trend, number and chart. For further research in finance, this concept will be tested by interviewing the users in the capital market and banking sector.

RESULT AND DISCUSSION

The formula of J-Value (P), as a finding, was tested as shown in simulation between C and YTM with the criteria of 1) C = YTM; 2) C < YTM; and 3) C > YTM, when C is assumed equal to YTM, the J-Value calculation result shows in a smooth line is going back to 100% which is also shown in FIGURE 1. The trend line shown by the trend line that is y = 0.0658lnx + 0.8919, which means that the line is almost a straight line. In condition of C = YTM, there is no speculation found in bond trading, then par value = J-Value = 100%, as well as a price based on PV_{cf}= price based on market (see the exhibit of TABLE 1 and FIGURE 1). In the TABLE 1, can be seen that the different of J-Value and trend of price is almost not significant from 1 year to 5 year.

TABLE 1. J-Value of bond (case = Indonesian Government Bond FR 72) for the period of 1st - 5th year

J-Value at YTM = C (%)	PAR (%)	Trend of Price (%)
189.28	100.00	89.28
193.48	100.00	93.48
196.50	100.00	96.50
198.52	100.00	98.52
199.65	100.00	99.65

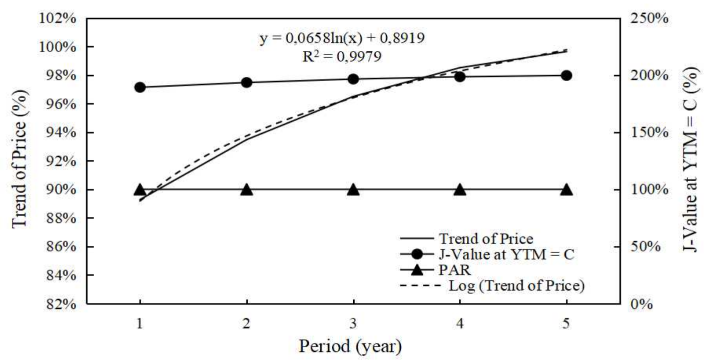

FIGURE 1. J-Value of bond when YTM = C for the period of 1st - 5th year

The different result showed by TABLE 2 and supported by Fig. 2, when the bond coupon is less than YTM (C < YTM) the J-value reacts very significant (see the exhibit, TABLE 2 and FIGURE 2). Trend line denotes negative coefficient number, $y = -0.059x + 0.1315$ with $R^2 = 0.9483$ means that there is a tendency toward price direction to fall down when YTM is greater than the bond's coupon. This indicates the tendency of bond price behavior to lead down when market interest rates rise, but the graphs and figures do not exactly form a straight line, meaning there is speculation of either YTM or fair market prices. Speculations of YTM quantity and the fair price indicate that the value of the bond is not like previous estimation, 100%, but shifted from 100%. This is a clear parameter of speculation and inconsistency on the part of investors or analysts in viewing and analyzing YTM and the fair market price of bonds. It is also the evidence that at the condition of C < YTM, adjusted par value may indicate a speculative behavior, concluded that adjusted par value can give the real explanation in the bond's trading.

TABLE 2. J-Value when YTM increased above 100 and 200 bp for the period of 1st - 5th year

YTM +100 bp (%)	YTM +200 bp (%)	Trend of Price (%)
193.44	181.04	12.40
196.82	186.91	9.91
199.05	191.53	7.52
200.25	195.12	5.13
200.54	197.90	2.64

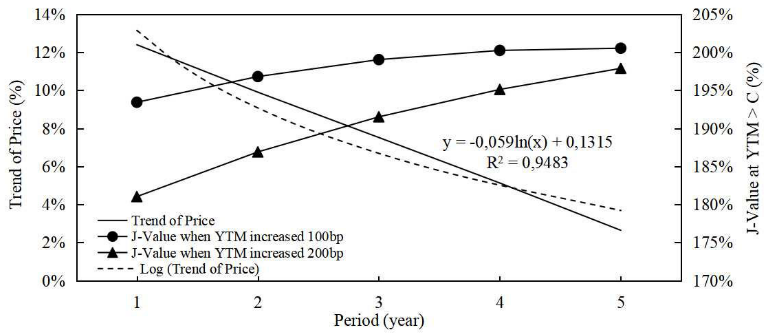

FIGURE 2. J-Value of bond when YTM moved up (C < YTM) 100 and 200 bp for the period of 1st - 5th year

Meanwhile, when C > YTM, the result shows that the speculation happened. The J-Value moved down before the maturity date (5 years). This means that there is a signal of speculative condition. In the increasing and decreasing of YTM, there are speculation movements shown by J-Value, that are not in a linear line. And for the 200 basis point decrease of the YTM, J-value tends to go down before the maturity date 5 years (see TABLE 3 and FIGURE 3). In this case when YTM moves down without a certain limit. The investors or analysts can judge the spread between YTM and coupon by their perception. This analysis is proved by the number of J-Value that is different as predicted and shown by the nonlinear curve of adjusted par value until the maturity date of bonds.

From three simulations above, proved that if the YTM moves then fair market price of bond also moves in accordance with market perception, where the J-Value of bond is not 100% in the market and the trend of line is not 1 before maturity date (5 years). If it is a flat at 100% and trend line is 1 then the bond price will be easily predictable and indicates no speculative price. Empirically, the price is not easy to predict because the YTM is the true perception of the market, and the market price or YTM certainly is the right of the investors or analysts to determine. Then the behavior of the bond market against the par value of the bond can be inconsistent. The investors and analysts appropriately used the J-Value.

TABLE 3. J-Value when YTM decreased 100 and 200 bp for the period of 1st - 5th year

YTM -100 bp (%)	YTM -200 bp (%)	Trend of Price (%)
193.44	197.62	4.18
196.82	200.19	3.37
199.05	201.63	2.58
200.25	202.02	1.77
200.54	201.46	0.91

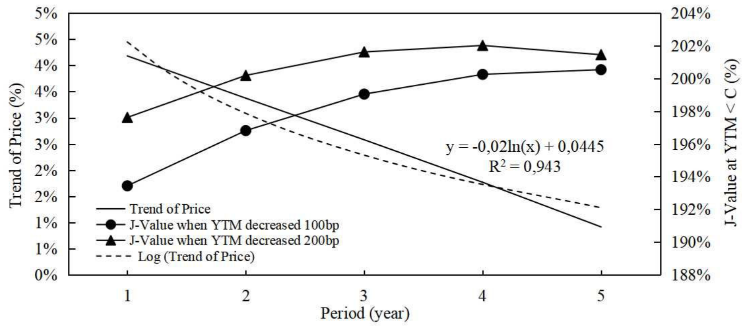

FIGURE 3. J-Value of bond when YTM moved down (C > YTM) 100 and 200 bp for the period of 1st - 5th year

CONCLUSION

This research results in the new mathematics formula mention as J-Value to the capital market industry in analyzing the bonds investor behavior shown as the adjusted par value. It is proven that there is a different price that resulted from the present value of the coupon payment concept and the market approach concept. Based on the calculations and simulations on J-Value with three different conditions between C and YTM of the bonds as mentioned above, we summarize the findings as follows:

1. The J-Value can show that the bonds market price moves irrationally during the periods between issuance date and maturity date especially when C > YTM or C < YTM.
2. The J-Value shows us that when interest rate in the market moves, then YTM moves irrationally during the periods issuance date and maturity date especially when C > YTM or C < YTM.
3. The J-Value is valuable to help the fund manager, investor and analyst to read the market risk of bonds in the trading day.

REFERENCES

1. A. Mahajan and D. Fraser, *J. Int. Buss. Stud.,* **17** (2), pp. 21–36, (1986).
2. S. Peterson and R.C. Stapleton, *Schmalenbach Buss. Rev.*, **55** (3), pp. 178–193, (2003).
3. A. Kempf and U. Homburg, *Schmalenbach Buss. Rev.*, **52**, pp. 26–44 (2000).
4. A. Oberman and T. Zariphopoulou, *Comput. Manag. Sci.,* **1** (1), pp. 75–107 (2003).
5. D. Weeks and S. Kassicieh, *Ann. Oper. Res.*, **45** (1), pp. 405–431 (1993).
6. T. Ando, *Oper. Res. Soc.,* **65** (3), pp. 454–465 (2014).
7. E. Agliardi and R. Agliardi, *Operational Research*, **11** (3), pp. 299–309 (2011).
8. C. Chiarella, D. Mackenzie and T.M., *Asia Pacific J Manag.*, **7** (22), pp. 1–24 (1990).
9. N. Branger, A. Mahayni and J.C. Schneider, *Review of Managerial Science*, **5** (4), pp. 309–336 (2011).
10. N. Georgiopoulos, *Comput. Manag. Sci.,* **14** (3), pp. 297–312 (2017).
11. N. Ahmad, J. Muhammad and T.A. Masron, *Asian Acad. Manag. J.*, **14** (2), 95–114 (2009).
12. S. Bhojraj and P. Sengupta. *The Journal of Business,*: **7** (6), pp. 455–75 (2003).
13. F.X. Diebold and C. Li, *Journal of Econometrics*, **130** (2), pp. 337–64 (2005).
14. F.J. Fabozzi and S.V. Mann, *The Handbook of Fixed Income Securities* (McGraw-Hill Education, United States, 2012).
15. C.P. Jones, *Investments. 8th Edition* (John Wiley & Son, Inc, 2002).
16. R. Zipf, *Fixed Income Mathematics* (Academic Press, San Diego, 2003).
17. N. Rokkanen, *Fin. Mark Portf. Manag.*, **23** (1), p. 23 (2009).