Soochow Journal of Economics and Business
No.109 (December 2024)：35-62.

The Impact of Inflation and Interest Rate Cycle on the Bond Market

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Abstract

This study investigates the relationship between inflation and bond yields, focusing on 2-year and 10-year maturities, and analyzes bond spreads. To understand the influence of rate hike cycles, interbank rates are also incorporated. We use monthly panel data from developed and emerging markets, spanning January 2002 to December 2022. The panel data regression model results reveal that during rate hikes, both 2-year and 10-year bond yields tend to increase, after controlling for fixed effects. Conversely, rate hikes are associated with a decrease in bond spreads. Additionally, high inflation environments may lead to the undervaluation of certain high-quality bonds. Based on these findings, we recommend that investors closely monitor monetary policy changes, particularly rate hike cycles, and consider investing in bonds with longer maturities.

Keywords: Panel Data, Inflation, Bond Market, Monetary Policy, Covid-19

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1. INTRODUCTION

The sudden onset of the Covid-19 forced people to stay home compulsorily since the end of 2019. People cut down economic activity drastically, causing an imbalance between supply and demand in the market, which combined with the use of extreme measures such as city closures by governments to control the epidemic, led to a significant economic downturn in all countries. Moreover, before the epidemic, most countries in the world were implementing quantitative easing monetary policies. For example, the U.S. lowered interest rates to 0%, and Europe even had negative interest rates, leaving a large amount of money scattered in the market. In response to inflation, the Federal Reserve Board announces that it will continue to raise interest rates, countries are advancing rapidly. For instance, Taiwan's central bank announces a half-yard (0.125%) rate increase, the Central Bank of Japan decided to keep its benchmark interest rate at -0.1%, Indonesia, Vietnam and the Philippines also raised interest rates by 2 yards (0.5%), 3 yards (0.75%) and 2 yards (0.5%) respectively. In contrast, the People's Bank of China proclaims a reduction in the Required Reserve Ratio. From the above, we can see that raising interest rates is a necessary policy tool when facing the risk of inflation. Rate hikes continue to exert influence on stock and bond markets. Due to the relevance of stock and bond markets strongly, when the world is in a cycle of rising interest rates, higher interest rates are responsible for lower bond prices. Conversely, for the stock market, higher interest rates represent a rebound in the boom and a tightening of monetary policy. The assumption is that when companies start to make profits in the future, the impact on the stock market will be positive. Simply stated, bonds outgo stocks in a declining interest rate cycle and stocks outperform bonds in an increasing interest rate cycle. Concurrently, rising of interest rate also has an indirect impact on total imports and exports. Therefore, we can use long-te rm investments during this time.

This study investigates how inflation affects short-term (2-year) and long-term (10-year) bond yields, as well as bond spreads, particularly in relation to interest rate hike cycles. Specifically, we employ a panel data regression model to examine whether the relationship between inflation and bond yields is positive or negative. We then compare these findings

to existing literature to assess the consistency of our results. In addition, we add Covid-19 as a dummy variable to reflect the impact of the epidemic on the bond market. In conclusion, we will re-estimate the linkage between inflation and bond yields during the period of negative interest rates and compare these results with those obtained for the full period. Should there be any discrepancies observed between these two empirical findings, a comprehensive examination will be undertaken to investigate the causative factors.

There are three main contributions we are striving to make with our study. First, we leverage the latest data to provide empirical findings that can update related research topics. Second, we estimate the correlations between Covid-19 and both bond yields and bond spreads. Finally, we analyze the relationship between inflation and rising interest rates in the bond markets of both developed and emerging economies. We also investigate how this relationship changes when interest rates are negative.

The remainder of the paper is organized as follows. The section 2 shows the inflation theory and literature review. After which research methodology is presented, with full details of data collection in the research, and of the description of the variables and model used. Results are then presented, including a thorough description of the impact of inflation and interest rate cycle on the bond market in the developed countries or developing countries. To conclude, this section presents a summary of the study's key findings and recommendations.

2. THEORY AND LITERATURE REVIEW

2.1 Inflation Theory

Before going any further, I would like to define the most significant key which will be using in this paper. Inflation is defined as "a phenomenon that in an economy, due to the price of goods and service is increasing steadily, the circulation of money is rise, people's purchasing power has decreased, supply far exceeds demand. Fisher (1930) suggested that the inflation rate is the nominal interest rate minus the real interest rate, called "Fisher Effect". The Fisher equation is described as follows:

$$r = i - \pi^e \tag{1}$$

The Fisher equation with compound interest is represented below:

$$(1+i) = (1+r) \times (1+\pi^e) \tag{2}$$

According to the Fisher's hypothesis, when r is controlled, π^e is increasing or decreasing, i is changing point-for-point. Under conditions of fixed real interest rates, nominal interest rates will be adjusted one-to-one with expected inflation rates. However, other academics point out that the Fisher effect may be failure when the financial institutions carry out the quantitative easing or fund restructuring. Under the quantitative easing policy, the nominal and real interest rate could fall to zero or even a negative interest rate, which result in the Fisher effect does not valid. (Okina and Shiratsuka, 2006)

Gavriilidis and Kagri (2016) mentioned some papers on texting the Fisher effect at different times. They also pointed out that based on the Fisher's hypothesis, the predicted nominal returns on assets ought to offer a total inflation hedge. Therefore, inflation has a significantly positive correlation with the predicted nominal returns. If this finding is not shown in empirical research, we can say that the Fisher's hypothesis does hold. In some previous literatures, to establish the validity of the Fisher hypothesis, the researcher employs an empirical model to investigate the link between stock returns and inflation. During the 1970s, Nelson (1976) displays that the significant negative correlation between inflation and stock return is shown, which means that the fisher's hypothesis does not valid. From 1980s to 1990s, different results have been illustrated in the empirical paper, such as Fama (1981), Kaul (1987) etc. More detail, Fama (1981) adds an important factor called real activity and argu es that stock returns have a negative relationship with inflation since real activity measurements have a negative relationship with inflation and stock returns have a positive relationship with real activity approved this views that inflation and stock return are positively correlated, which is constant with Fisher effect. Recently, Uribe (2022) finds a neo-Fisher Effect in the empirical and optimizing model. According to the neo-Fisher effect, a continuous rise in the nominal interest rate raises inflation both in the short and long terms. Over 40% of variations in inflation may be explained by permanent monetary shocks.

In addition to Fisher's theory, economists are divided into two camps, each with their own believes regarding what drives inflation. Some economists point out that money has a powerful impact on our present understanding of inflation, others claim the fact that the interaction of interest rates and money is the most important factor. Aside from above-mentioned, Austrian School of Economics come up with the conclusion that issuing currency by central bank may have contributed to the inflation. Besides, wage-related variables also continue to exert influence on inflation. In macroeconomics, a famous theory called "Price/ Wage Spiral", which it means that inflation will be due largely to the spiral growth of wage and price. In detail, higher earnings boost disposable income, which raises the demand for commodities and driver up prices. When the price is up, producers need higher production cost and additional price increases, resulting in a price spiral and inflation.

Several studies have examined the relationship between stock-bond correlation and inflation, given the strong linkages between bond and equity markets. We review this literatures in section 2.2, focusing on empirical papers that test the Fisher effect. Including this review strengthens the overall completeness of our paper.

2.2 Literature Review

In this section, the related works report in the literature can be classified into four major categories, which are the development of bond yield and spread, the study of inflation and bond market risk, the relationship between inflation and bond yield, the correlation of monetary policy, bond yield and bond spread.

In this paragraph, we first review previous literatures regarding the development of bond yields and spreads. The purpose of Duffee (1998) studies the relation of Treasury yields and corporate bond yield spreads. Author divides corporate bond into two categories: callable bonds and noncallable bonds and focuses on the difference of callable and noncallable bonds. Using the monthly data during January 1985 to March 1995, Duffee (1998) reports that the relationship between Treasury Yields and Corporate Bond Yield Spreads is significant negative correlated on noncallable bond by means of VAR and OLS model. On callable bonds, however, the relationship between Treasury yields and yield spreads is significantly stronger in the negative direction than it is for noncallable bonds. In addition, Duf-

fee (1998) confirm this hypothesis for investment grade bond that the relationship between noncallable Treasury yields and spreads of corporate bond yields above Treasury rates should rely on the callability of the co rporate bond as the option to call a bond should increase in value when bond yields decline. Chen *et al*. (2007) has pointed out that bond liquidity is a key factor to affect bond yield. And they measure the bond liquidity by LOT model and suggest that the yield spreads significantly fall when the bond liquidity rise. They also provide strong evidence of the fact that the bond volatility can explain bond liquidity. Besides, other literature like Hull *et al*. (2004) estimates the relationship between bond yields and credit default swap spreads as a benchmark risk-free used in credit derivative market, which add the other factor called credit rating announcements. The authors discover that negative rating changes cause CDS spreads to rise in response to Moody's credit rating releases, which have a major effect on the CDS market. According to the study, there is a strong correlation between bond yields and CDS spreads. Additionally, the benchmark risk-free rate in the credit derivatives market is higher than th e risk-free rate in the bond market.

Secondly, we discuss some literatures on the inflation and bond risk. Giesecke *et al*. (2011) collect 150-year data (1866-2008 period) to estimate the corporate bond default risk. Using the regime-switching model, Giesecke *et al*. (2011) suggest that the corporate bond default risk can be forecasted by other macroeconomic variables. However, because of the insignificance of the inflation rate, this variable does not forecast subsequent default rate. Kang and Pflueger (2015) analysis inflation risk in corporate bonds from the perspective of the liabilities. And they think that unexpected low inflation results in the growth of real liabilities and default risk. The authors classify firms into three types: young, seasoned and old. Under the dynamic and real business cycle model, use the panel data from six developed countries, they got the following conclusions: a) high inflation cyclicality makes investors realize the high level of the bond spreads easily. b) authors reveal the reason why some corporate bo nd investors estimate the risk of debt deflation and inflation to select the better corporate bond. c) from the policy side, make policymakers more aware of the importance of the debt deflation and repercussion in the economy. Song (2017) studies the macroeconomic and monetary policy risk in the bond market. The author supposes that inflation is procyclical and divides monetary policy into two categories: Active Monetary Policy or Passive

Monetary Policy. Song (2017)'s table 4 reports that the longer the life of the bond, the higher the average bond yield both active monetary policy and passive monetary policy using regime-switching model or fixed-regime model. Another way to phrase this finding would be when the monetary policy risk has positive correlation with average bond yield. However, average one-period bond risk premium decreases if monetary policy risk become high.

Part three of this section, we discuss some literatures on studying the relationship between inflation, bond yield, monetary policy and bond spread. Hsing (2015) created the loanable fund model to examine the government bond yield in Spain. And author illustrated that the government bond yield was positive related to expected inflation from 1999Q1 to 2014Q2. Besides though the EGARCH model, they demonstrated whether the volatility caused positive or negative value in bad or good news. It has been argued, by Duffee (2018), that it is possible to assess the degree to which inflation influences bond yields. In this paper, variations in predicted inflation news are responsible for 10% to 20% of yield shock variations on a quarterly frequency. In a similar way, Yusuf and Prasetyo (2019) researched inflation, bond yield in Indonesia and US bond yield, whose conclusions indicate that these variables have co-integration and influence each other from January 2009 until December 2018. Meanwhile, in this paper, they also think that inflation is important factors contributing to change the bond yield. As Siahaan and Panahatan (2019) emphasizes, countries in the emerging markets have been strongly shaped by the U.S. monetary policy. In this paper, they collect the data from November 2013 to October 2016, which divides into three periods. The findings from this study seem to indicate that all variables are insignificant for Indonesian government bond price in all periods expect for the BI rate, however, the BI rate, Fed rate and inflation rate may be negatively affected by bond prices during some periods.

In addition, the research question that guides this study are as follows, what effect do inflation expectation have on the nominal yield curve? (Gomez-Crom and Yaron, 2021). They build and evaluate a model with non-neutral inflation and performance shocks. And then they collect one, three, five, seven, and ten-years bond that make up the imbalanced panel data runs 1962 January to 2018 December. According to the empirical results, preference shocks are closely connected with market distress variables, and real rate news is the primary cause of nominal yield shocks. Hoang Le Trang Nguyen and Phuong Anh Nguyen

(2022) select 3-year and 5-year and 10-year Vietnam Government Bond to analyze the effect of some macroeconomic factors by use of GARCH-types model. Their results display that all three categories of bond rates are impacted by inflation, especially long-term bond yields are most affected.

Besides, there are some literatures on Treasury Inflation-Protected Securities. A definition of the TIPS is a statement that issued by the US Treasury department and combat the inflation. To take a case in point, Wang (2013) study the correlation between the Treasury bill and Treasury Inflation-Protected Securities to forecast the Break-even inflation rate. In this article, the data is composed of the five-year and ten-year Treasury bill yield and TIPS yield, which is monthly data from Jan. 2003 to July,2012. By mean of Granger causality, the impulse response function and analysis of Variance, author indicate that the research result shows significant gains over the desired outcome when adding the break-even inflation rate. According to the Granger causality test, author has pointed out that those variables exit causation each other.

Finally, Researchers frequently utilize stock-bond correlation as a research variable when examining how inflation affects the bond market. Humper and McMillan (2018) contend that the change in correlation behavior is what causes the conflicting empirical results for the Fed model. Authors provide some evidence that the equity/bond yield dynamic conditional correlation has been shown to be positively associated with the real bond yield from the G7 market data during Jan.1986 to Jan.2014 by panel regression and DCC model. Besides, Campbell *et al*. (2020) studies the impact of inflation in the stock-bond correlation. According to their estimation, in 2001 there was a change in the association between inflation and the production gap from negative to positive based on their new framework and new model. To go a step further, because greater inflation reduces real bond returns and higher output increases stock returns, stock-bond return correlation shifted from negative to positive. Other paper also mentions the effect of macroeconomic announcement for the stock-bond correlation such as Christiansen and Ranaldo (2007). They use the high-frequency bond and stock data from CME and CBOE. They highlight that there is a significant relationship between inflation and bond-stock realized correlation by means of the business cycle news regression model. They also suggest that bond market is more sensitive compar-

ed to stock market when the macroeconomic data is released according to their estimation.

3. METHODOLOGIES AND DATA

3.1 Panel Data Regression Analysis

The data used in the study is Panel data, also known as longitudinal or cross-sectional time-series data is a dataset in which the behavior of entities is observed across time. Hence, using panel data regression model is considerable and reasonable. As my best knowledge, there are three types of panel data: dated and undated panels, regular and irregular panels, balance, and unbalance panels. A balanced panel is one in which each panel member is observed once a year and consists of time series and cross-sectional aspects. As a result, if a balanced panel has N panel member and T periods, the number of observations(n)in the dataset must equal $n = NT$. Traditional panel data regression is described as follows:

$$Y_{it} = \beta_{1i} + \sum_{k=2}^{k} \beta_k X_{kit} + \varepsilon_t \tag{3}$$

Where $i = 1\cdots\cdots N$ means observation unit and $T = 1\cdots\cdots T$ is broadly defined as observation period. β_{1i} is intercept and refers to the individual effect, which does not change with period but different observation units have different individual effects. $\beta = (\beta_1,\beta_2\cdots\cdots,\beta_k)'$ can be thought of as $(k-1)\times 1$ row vectors, X_{kit} represents the natural number vectors that correspond to row vectors. Y_{it} is defined as the i-th dependent variable at time t. According to the different estimate methods, three type of panel data estimate model can be distinguished: Pooled Regression Model, Random Effect Model and Fixed Effect Model. More significantly, we need to test whether panel data exits a unit root first by means of related-models such as Levin-Lin-Chu (2002) test. In this study, we use above-mentioned model to do the empirical research and reach the conclusion. And then, to ensure the stability of the time series, we will use the post-differential data to study this issue.

3.2 Data and Variables Description and Model

3.2.1 Data Description

Our research utilizes monthly data from five developed and five developing countries,

spanning January 2002 to December 2022. And then, we take the panel data of the ten countries mentioned above as our observations. Moreover, independent variables are constituted by Growth of CPI, The Wage Growth, Oil Price, Real Board Effective Exchange Rate, Interest Rate, the dummy variables called Covid-2019 and negative interest rate. Because interest rates were negative at times during our research period, we added the dummy variables to investigate whether this affected the variables related to bonds. Meanwhile, the dependent variables are the changes of two-year bond yield, ten-year bond yield and bond spread. Our data originates from investing.com and Federal Reserve Economic Data (FRED) and Organization for Economic Cooperation and Development (OECD) data.[1]

3.2.2 Model

What follows here is a model for this research.

$$Y_{it} = \alpha_i + \beta_1 G - CPI_{it} + \beta_2 IR_{it} + \beta_3 OP_{it} + \beta_4 ER_{it} + \beta_5 WG_{it} + \beta_6 D_{1it} + \beta_7 D_{2it} + \varepsilon_{it} \qquad (4)$$

Where Y_{it} denotes dependent variable such as the change of two-year bond yield, ten-year bond yield and bond spread. In the formula, arguments are represented by acronyms. Take a case in point, IR means interest rate. Furthermore, Right subscript "it" means the ith country and the observed period $t = 1 \cdots\cdots T$.

3.2.3 Variables Description

In this study, we use three variables as our dependent variables such as two-year bond yield, ten-year bond yield and bond spreads[2]. The reasons are the above-mentioned prevalence of the bond types and the Yield Curve Inversion. And then, the Yield Curve Inversion refers to the fact that the short-term bond yields are higher than long-term bond yields. Most frequently, the difference of U.S. two-year bond yield and U.S. ten-year bond yield is utilized to determine whether the yield is inverted. What's more, a recession is precited by the appearance of this phenomena. Therefore, selecting these dependent variables have a great value in this research.

Moreover, we provide examples of dentifications of independent variables in the table 1 which are listed as follows:

Table 1 Dentifications of Independent Variables

Variable Name	Variable Dentification
CPI	The Growth of CPI
Exchange Rate	A Measure of the Value of a Currency Against a Weighted Average of Several Foreign Currencies
Interest Rate	The Interbank Rate: 3-Months or 90 days Rates
Oil Price	The Global Brent Oil Price
Wage Growth	The Growth of Wage
D1(Covid-19)	A Dummy Variable: Set the Covid-19 to 1 if one exists. Set it to 0 if not.
D2(Negative Interest Rate)	A Dummy Variable: Set the Negative Interest Rate to 1 if this country employs the negative interest rate policy. Set it to 0 if not.
Two-Year Bond Yield	The change of two-year Bond Yield
Ten- Year Bond Yield	The change of two-year Bond Yield
Bond Spreads	The change of two-year Bond Yield Minus The change of two-year Bond Yield

4. EMPRICAL RESULTS

4.1 Descriptive Statistics

Descriptive Statistics of fall variables in this study are shown in table 1 and table 2, which are divided into two parts: developed markets and emerging markets. In table 1, the extreme minimum value of the change of 10-year bond yield and the extreme maximum of the change of 2-year bond yield are -103 and 38, which is shown in the France data and Germany data. This fact reflects that certain variables cause the bond yields to fluctuate sharply throughout a given month. On the other hand, there can possibly be a mistake in the data that investing.com has gathered. The minimum of interest rate is -0.5820 respectively in the developed market countries, which is follow from the “Negative Interest on Excess Reserves”. During 2014, European central bank announced a negative interest rate policy to solve the

problem of the slow growth of economic and severe deflation. At the same time, Japan used the same approach. However, this policy will likely result in recession in the stock and bond markets, for exa mple, the bond yields and the stock payouts become lower. Besides, negative bond spread is another symptom of an inverted yield, which denote a slump in the developed market economy. To take it a step further, due to the Covid-2019, inflation, the war and rate hike, this phenomenon is tending to intensify possibly. In what follows, we will discuss other inflation-related variables. Their mean, minimum and maximum are organized in table 1.

In particular, the minimum value of CPI growth rate is negative, which are attributable to the global financial crisis brought on by subprime mortgages during 2007 to 2008 in USA. After the financial crisis, the Federal Reserve is forced to turn to a quantitative easing monetary policy because of the credit bust in the U.S. market, which cause a sharp decrease in market interest rate. Finally, according to the Skewness-kurtosis test, most variable distributions cannot fit the normal distributions. Their probabilities of SK test are 0.000, which are strongly significant under the 1%. More detailed, kurtosis coefficient of GCPI, ER, 2-YBY, 10-YBY, BS, WG, IR are higher than 3, which are leptokurtic and other variables are platykurtic. Focus on the skewness, distributions of 2-YBY, GCPI, IR, WG, OP, are right skewness. Oppositely, distributions of other variables are left skewness. Because the SK statistic is not displayed when the variables are 2-YBY, 10-YBY, BS, the corresponding position in table 1 is blank. The value in the probability column is based on the Shapiro-Wilk normality test.

In table 2, for the emerging market, there is negative bond yield and positive interest rate ($Min_{2\text{-}year}$ = -0.8764, $Min_{10\text{-}year}$ = -0.3222, Min_{IR} = 0.0000). However, the bond spread is negative, which means that "Inverted yield curve" is also exited in the emerging market. The phenomenon implies that developed and emerging market engage in interaction because of globalization. And then, the maximum of monthly CPI growth rate is 9.6%, which is often caused by covid-2019, the Russian-Ukrainian War. On the other hand, the minimum is -2.0972%, resulting from the Quantitative Easing Monetary Policy after the 2008 financial crisis. In addition, all variable distributions are right skewness expect the bond spread. Turning to the kurtosis, kurtosis coefficient of OP is less than 3, so these two variable distribu-

tions are platykurtic. Other variable distributions are leptokurtic.

Table 1 Descriptive Statistics (developed market)

Variables	Obs	Mean	Std.Dev	Skewness	Kurtosis	SK	Prob
2-YBY	1255	0.0559	1.4376	16.5751	421.3521		0.0000***
10-YBY	1255	-0.0372	3.1357	-27.4886	930.1021		0.0000***
BS	1255	-0.0932	3.4527	-21.8085	646.1368		0.0000***
GCPI	1255	1.6149	1.6759	1.5409	7.3665	317.47	0.0000***
WG	1255	0.8495	1.6038	0.9935	3.9401	137.10	0.0000***
IR	1255	1.2322	1.6583	1.2714	3.5518	176.07	0.0000***
OP	1255	69.4099	28.0238	0.2873	2.0996	144.08	0.0000***
ER	1255	104.2385	12.4851	0.7404	3.6504	86.76	0.0000***
Variables	Min	Max					
2-YBY	-10.5000	38.0000					
10-YBY	-103.0000	29.0000					
BS	-103.0476	28.9865					
GCPI	-2.0972	9.6000					
WG	-5.5000	6.8000					
IR	-0.5820	6.6469					
OP	20.0330	133.5852					
ER	73.7000	140.9600					

Notes: 2-YBY: the change of 2-Year Bond Yield, 10-YBY: the change of 10-Year Bond Yield, BS: 2-YBY Minus 10-YBY, GCPI: Growth of CPI, IR: Interest Rate, OP: Oil Price, ER: Real Effective Exchange Rate, WG: The Growth of Wage, SK: The Skewness-Kurtosis Test; The significant level is 5% in this test.

Table 2　Descriptive Statistics (emerging market)

Variables	Obs	Mean	Std.Dev	Skewness	Kurtosis	SK	Prob.
2-YBY	1255	0.0200	0.0273	11.6022	236.5831		0.0000***
10-YBY	1255	0.0050	0.0255	0.7510	6.4899	159.77	0.0000***
BS	1255	0.0385	0.0150	12.6756	279.8406		0.0000***
GCPI	1255	3.7928	0.0353	1.5774	5.4648	278.74	0.0000***
IR	1255	5.3375	0.0286	1.7796	7.8515	362.17	0.0000***
OP	1255	69.4299	26.4458	0.2847	2.0910	148.62	0.0000***
ER	1255	106.0727	17.9396	0.4199	3.3361	33.36	0.0000***
Variables	Min	Max					
2-YBY	-0.8764	3.7273					
10-YBY	-0.3222	0.3842					
BS	-0.7804	3.6860					
GCPI	-1.6000	20.3700					
IR	0.0000	25.0000					
OP	20.0330	133.5852					
ER	65.6000	171.8200					

Notes: 2-YBY: 2-Year Bond Yield, 10-YBY: 10-Year Bond Yield, BS: Bond Spread, GCPI: Growth of CPI, IR: Interest Rate, OP: Oil Price, ER: Real Effective Exchange Rate, SK: The Skewness-Kurtosis Test; The significant level is 5% in this test.

4.2 Panel Data Unit Root Test

Before running the panel data regression models, we need to use Levin-Lin Chu (2002) test to check the unit root. Their null hypothesis and alternative hypothesis are as follows, respectively.

H_0: *Panels contain unit roots*
H_1: *panels are stationary*

Table 3 and table 4 report the results of the panel data unit root for all variables in developed market and emerging market. In table 3, under the 5% significant level, variables called GCPI, IR WG exit unit root (p-value >0.05). The analysis yielded no statistically significant evidence to reject the null hypothesis for these and other previously mentioned vari-

ables.. Equally, for emerging market, the GCPI and IR variables exit unit root based on the p-value. On the contrary, the reason why other variables have unit roots, their p-value is higher than 5% and accept the null hypothesis. Because unit roots can strongly influence the empirical findings, we apply the difference to eliminate unit roots. After the difference, the findings of the unit root test are displayed in the difference column of table 3 and table 4. Our panel data unit root test, after applying first-order differencing to the data, confirms stationarity for these variables based on the obtained p-values. This suggests that the panels exhibit stationarity.

Table 3 Results of Panel Data Unit Root Test (developed market)

Variables	Statistics	Prob.	Unit root	Number of Differences	Differenced p-value
2-YBY	1.7113	0.0000***	No	0	
10-YBY	6.3395	0.0000***	No	0	
BS	-0.8772	0.0000***	No	0	
GCPI	6.6466	1.0000	Yes	1	0.0000***
IR	3.6035	0.9998	Yes	1	0.0000***
OP	-2.6890	0.0036***	No	0	
ER	-2.4990	0.0062***	No	0	
WG	-0.5898	0.2777	Yes	1	0.0000***

Notes: the significant level is 5% in this test.

Table 4 Results of Panel Data Unit Root Test (emerging market)

Variables	Statistics	Prob.	Unit root	Number of Differences	Differenced p-value
2-YBY	-2.9979	0.0014***	No	0	
10-YBY	-21.9721	0.0000***	No	0	
BS	-24.4796	0.0000***	No	0	
GCPI	1.6913	0.9546	Yes	1	0.0000***
IR	1.7939	0.9636	Yes	1	0.0000***
OP	-2.6890	0.0036***	No	0	
ER	-2.6548	0.0040***	No	0	

Notes: the significant level is 5% in this test

4.3 Testing the Fixed Effect and Random Effect for Developed Market

In this section, we discuss the fixed effect regression model for the developed market and emerging market. As described above, we need to test which model is better: Pooled regression model (OLS model) and Fixed effect regression model though the F test (LR test). Meanwhile, we also test the random effect based on the Breusch and Pagan (1980) test. And then, their findings are listed in the table 5 table 6 and table 7. When the dependent variable is two-year bond yield, the null hypothesis of LR test is OLS model is efficient and the alternative hypothesis is fixed effect regression model is efficient. Because the F statistic is 0.33 and P-value is 0.8568 under the significant level 5%, we accept the null hypothesis and select the pooled regression model. According to the Breusch and Pagan (1980) test, the LM statistic is 0.00 and p-value is 1.0000, not existing the random effect, so the OLS model (pooling regression model) is efficient. Simply stated, for testing the fixed effect, we give a conclusio n that the fixed effect regression model is efficient. For testing the random effect, the pooled model is efficient. Therefore, choosing pooled regression model is optimal for two-year bond yield.

Secondly, table 6 reports the process of choosing model for ten-year bond yield. Similarly, the F statistic is 0.60 and p-value is 0.6643, then the null hypothesis is accepted. selecting the pooled regression model. Moreover, the LM statistic is 0.00 and the LM test of p-value is 1.0000 (>0.05), which means that we accept the alternative hypothesis and choose the pooling regression model. In summary, the optimal model is pooled regression model which is equivalent to the result of two-year bond yield. Finally, table 7 also report the result of choosing model for bond spread. More detailed, the F statistic is 0.84 and p-value is 0.5015 (>0.05), which represents that the null hypothesis is accepted, and choose the pooled regression model. Furthermore, for testing the random effect, the LM statistic is 0.00 and p-value is 1.0000, not existing the random effect. Therefore, the pooled regression model is optimal model for bond spread. To sum up, the optimal model for developed market is the pooled r egression model.

Table 5 Choosing model for two-year bond yield.

	Hypothesis	Statistic	P-value	Best model
Fixed effect	H_0 : *OLS model is efficient* H_1 : *FE model is efficient*	F (5%) = 0.33	0.8568	OLS model
Random effect	H_0 : *OLS model is efficient* H_1 : *RE model is efficient*	LM (5%) = 0.00	1.0000	OLS model
Hausman test: Not need				

Notes: FE model and RE model represent fixed effect regression model and random effect regression model. And the significant level is 1%.

Table 6 Choosing model for ten-year bond yield.

	Hypothesis	Statistic	P-value	Best model
Fixed effect	H_0 : *OLS model is efficient* H_1 : *FE model is efficient*	F (5%) = 0.60	0.6643	OLS model
Random effect	H_0 : *OLS model is efficient* H_1 : *RE model is efficient*	LM (5%) = 0.00	1.0000	OLS model
Hausman test: Not need				

Notes: same as Table 5

Table 7 Choosing model for bond spread.

	Hypothesis	Statistic	P-value	Best model
Fixed effect	H_0 : *OLS model is efficient* H_1 : *FE model is efficient*	F (5%) = 0.84	0.5015	OLS model
Random effect	H_0 : *OLS model is efficient* H_1 : *RE model is efficient*	LM (5%) = 0.00	1.0000	OLS model
Hausman test: Not need				

Hausman test: Not needNotes: same as Table 5

4.4 Testing the Fixed Effect and Random Effect for Emerging Market

Similarly, we use the same method to test the fixed effect and random effect for emerging market. The results are shown in table 8, table 9 and table 10. First, for two-year bond yield (see table 8), we find that F statistic is 0.75 and p-value is 0.5623 (>0.05) and reflect the null hypothesis, that is, Fixed effect regression model is efficient. This fact is contradic-

tory with developed market result. Second, when the dependent variable is ten-year bond yield (see table 9), the F statistic is 0.74 and p-value is 0.5670 (>0.05), then we accept the null hypothesis and choose the pooled regression model. In addition, the finding of testing the random test is equal to the developed market result. Therefore, for ten-year bond yield, we select the pooled regression model. Third, regarding the dependent variable bond spread (see table 10), the F statistic is 5.10 and p-value is 0.0004 (<0.05), we reject the null hypothesis and choose the fixed effect regression model. In the same way, according to the p-value of F test (0.0004), there is no random effect when the dependent variable is bond spread. So, the fixed effect regression model is the optimal model.

In the case of emerging markets, only the pooled regression model is used for analyzing the ten-year bond yield. Both two-year bond yield and bond spread use fixed effect regression model. It's worth noting that no random effect model is chosen for both developed market and emerging market, which indicates selected countries of monetary policies are consistent. And possible cause includes the strong U.S. dollar and interest rate cycle by Fed.

Table 8　Choosing model for two-year bond yield.

	Hypothesis	Statistic	P-value	Best model
Fixed effect	H_0 : *OLS model is efficient* H_1 : *FE model is efficient*	F (5%) = 4.55	0.0012***	FE model
Random effect	H_0 : *OLS model is efficient* H_1 : *RE model is efficient*	LM (5%) = 0.00	1.0000	OLS model
Hausman test: Not need				

Notes: FE model and RE model represent fixed effect regression model and random effect regression model. And the significant level is 1%.

Table 9　Choosing model for ten-year bond yield.

	Hypothesis	Statistic	P-value	Best model
Fixed effect	H_0 : *OLS model is efficient* H_1 : *FE model is efficient*	F (5%) = 0.74	0.5670	OLS model
Random effect	H_0 : *OLS model is efficient* H_1 : *RE model is efficient*	LM (5%) = 0.00	1.0000	OLS model
Hausman test: Not need				

Notes: same as Table 8

Table 10 Choosing model for bond spread.

	Hypothesis	Statistic	P-value	Best model
Fixed effect	H_0 : *OLS model is efficient* H_1 : *FE model is efficient*	F (5%) = 5.10	0.0004***	FE model
Random effect	H_0 : *OLS model is efficient* H_1 : *RE model is efficient*	LM (5%) = 0.00	1.0000	OLS model
Hausman test: Not need				

Notes: same as Table 8

4.5 The Developed Market

Though testing the random effect and fixed effect, we choose the fixed effect model for the developed market. Besides, the fixed effect model is the most stable of three models in the panel data regression model. Therefore, we select the fixed effect model for developing market and developed market. In this section, we will illustrate the findings of fixed effect model and the explore the financial and economic meaning. What follows here is a selection process for the results of developed market.

First, we run the ordinary database to get the significance of all variables and list the probability of the F test to check the fixed effect. Secondly, we will delve into the significance and correlation of each variable, as well as the economic implications behind them. Table 11 reports that CPI growth rate was not statistically significant under the significant level 1% when the dependent variables are the change of two-year bond yield and ten-year bond yield and bond spread. Their coefficients are 0.0432, 0.3369 and 0.2937. This fact highlights that both short-term bond yield and long-term bond yield have fluctuated in respond to fluctuations in inflation. However, For the following reasons, therefore, we cannot assume that a high rate of inflation has no influence on the bond market: First off, there are a lot of variables that impact the bond market and cause inflation; it's possible that some crucial ones were overlooked or are not statistically significant. Secondly, we execute the model using first-order differenced data to ensure time series stability in the panel data. The differencing may indicate that the variables are not significant.

Regarding as the exchange rate, as we pointed out in the previous chapter, we select

the real board effective exchange rate as independent variable. From the table 11, exchange rate has negative correlation with short-term bond yield (2-year bond yield), but for the long-term bond yield (10-year bond yield), it has no effect. Their coefficients are -0.0452 and -0.0079. Bond investors benefit when the exchange rate rises because it lowers the return on short-term bonds and increases their value. On the other hand, long-term bond investments are unaffected. Unfortunately, when the dependent variable is bond spread, exchange rate has not statically significantly related to bond spread.

In bank, the loan rate is based on the 10-year bond yield, 2-year bond is foundation for the deposit rate and bank's profit source is the difference of interest rate. In an environment of high inflation, Fed raise federal funds rate (interbank rate) to curb inflation, increasing cost of funds for inter-bank operations. In our model, we choose the interbank rate: 3-month or 90 days rate to research the relationship between bond yields and interest rate. There is no significant correlation between interest rate and bond yields, which is different from the basic theory. Besides, we add a dummy variable called negative interest rate, which aim to investigate potential effects on bond yields and bond spreads should a negative interest rate policy be implemented. Based on the research result, negative interest rate of p-value is 0.039, which means that implementing the negative interest rate policy can negatively influence the change of 2-year bond yield. Their coefficient is -1.4942. Table 11 also shows th at in the developed market, both short and long-term bond yields remained unaffected by the Covid-19 pandemic, which is regrettable. This could be attributed to low explanatory power and limitations in the data period as contributing factors. On the other hand, our research data may have yielded non-significant estimates because the period (2002-2022) included a greater number of months without Covid-19 compared to those with Covid-19. This imbalance may have limited our ability to detect a clear relationship between the variables.

Oil price is significantly negatively and positively correlated with 2-year bond yield and bond spread, coefficients of this variable are -0.0129 and 0.0330. Organization of the Petroleum Exporting Countries, OPEC, points out that under the low seasonal demand, oversupply will occur in the next quarter. Although the positive correlation of oil price and inflation can result in increasing in the bond yield, the supply-demand imbalance of oil production and the war are larger than inflation. From table 11, the lack of statistical signifi-

cance in wage growth when bond yields and bond spreads are the dependent variables might be attributed to the steadier compensation growth and developed pay systems found in mature market nations. Finally, the p-value of the F test for all three models is greater than 10%. so, fail to reject the null hypothesis, which means that three models have not fixed effect.

Table 11　Summary of Fixed Effect Model (developed market)

Variables	(1)	(2)	(3)
CPI	0.0432	0.3369	0.2937
ER	-0.0452*	-0.0079	0.0377
IR	0.2881	-0.5953	-0.8834
OP	-0.0129*	0.0201	0.0330
WG	0.0963	0.3369	-0.0640
D1(Covid-19)	-0.0984	-0.9629	-0.8645
D2(NIR)	0.039**	-0.4957	0.9985
Observation	1245	1245	1245
Prob	0.8751	0.7596	0.5811

Notes: When two-year bond yield is dependent variable, we denote as equation (1). Equation (2) represent that ten-year bond yield is dependent variable and equation (3) represent that bond spread is dependent variable. Coef.1, Coef.2, Coef.3 separately represent the coefficient of equation (1), (2), (3) Meanwhile, " *** " indicates that the p-value less than 1% and " ** " represents that p-value ranging from 1% to 5% and " * " indicates that p-value between 5% and 10%.

4.6 The Emerging Market

In contrast to developed markets, the proportion of variable significances in the findings of emerging markets has significantly increased. However, when we run the fixed effect model, we delete two variables called negative interest rate and wage growth because of the form of data. We have tried to gather data on pay increases, but most of the data is in yearly or quarterly format, which is inconsistent with the monthly data format that has been developed. As a result, this variable has been eliminated. For the negative interest rate variable, in the emerging market countries, no countries have implemented the negative interest rate policy. If we add this dummy variable, the multicollinearity problem can occur. Equally, we delete this dummy variable.

Table 12 reports that the increase in CPI has shown no significant correlation with

either 2-year bond yield or bond spread. On the contrary, the positively significant correlation is shown between the growth of inflation and 10-year bond yield, coefficients of them are 0.0012 and 0.0058. This fact implies that there is positive effect of higher inflation on long-term bond yield, which is constant with the normal finding. The inflation component is more significant in developing markets than in mature markets because the bond trading mechanism in advanced markets is more sophisticated than in emerging economies.

It is customary to combine interest rates and exchange rates when analyzing empirical data to examine how they impact bond yields and spreads because interest rates and exchange rates are interdependent. From table 12, bond spreads have no statistically meaningful relationship with interest rates, however there is a positive correlation between 2-year and 10-year bond yields. On the other hand, there is a noteworthy inverse correlation between the exchange rate and the yield on a 10-year bond, but a large positive correlation with the bond spread. This phenomenon reflects how changes in the overall economic climate, which raise interest rates and currency rates, directly affect 10-year bond yields. Regression coefficients indicate that the 10-year bond yield is more sensitive to interest rates since the exchange rate variable's coefficient is lower. When examining the individual variables, there is a considerable positive link between interest rates and 2-year bond yields and between exchange rates and bond spreads.

Moreover, oil price has positively significant correlation with 2- and 10-year bond yields. But no significance is shown between oil price and bond spread. OPEC highlights that oil production cuts are only implemented by its member countries. This policy only influences the bond market in the Gulf oil-producing countries. Therefore, Oil Price are not related to the bond yields and spreads in the selected countries. But the world's bond market is impacted by fluctuations in inflation and oil prices because of globalization, which makes crude oil supplies vital energy sources. And then, from table 3, a dummy variable called Covid-19 has statistically significance with 2- and 10- year bond yields and bond spread. This fact highlights that the occurrence of the Covid-19 affects the movement of bond yields and bond spread in the emerging market, which is inconstant with the finding in the developed market. Meanwhile, table 3 reports the p-value of F-test. When dependent variables are 2-year bond yield and bond spread, model exit fixed effect. Oppositely, when dependent vari-

able is 10-year bond yield, the fixed effect is not shown in the model.

Finally, in this paragraph, we discuss the other factor that is important to this issue: forms of government and State System. First, in the selected emerging countries, China is the second largest economy in the world, which has a significant impact on other countries. And then, facing the shock of high inflation, the Fed carries out a policy of raising interest rates. At the same time, the Chinese central bank takes a cut in the reserve requirement ratio conversely. This significant difference suggests that Chinese central bank is independent. And they can set monetary policy in accordance with their national conditions and create the spillover effect.

Table 12 Results of Fixed Effect Model (Emerging Market)

Variables	(1)	(2)	(3)
CPI	0.0012	0.0058*	-0.0046
ER	-0.0008	-0.0043***	0.0035**
IR	0.0265***	0.0191***	0.0074
OP	0.0028***	0.0017***	0.0011
D1(Covid-19)	0.0565***	0.0130**	0.0436***
Observation	1245	1245	1245
Prob	0.0000	0.0000	0.0000

Notes: Equation (1) is a finding of Pooled regression when the dependent variable is 10-year bond yield. Equation (2) and (3) are findings of fixed effect model when the dependent variable are 2-year bond yield and bond spread. Meanwhile, " *** " indicate that the p-value less than 1%.

5. CONCLUSION AND SUGGESTIONS

This study uses panel data from developed and emerging markets spanning the period from Jan 2002 to Dec 2022 to investigate the correlation between inflation-related variables and bond yields, as well as bond spreads. Meanwhile, we also investigate the impact of rate hike in developed market and emerging market. To summarize the conclusions drawn from the findings as follows. Firstly, upon conducting model testing, it has been observed that the random effect model was not selected as the most appropriate model for both developed markets and emerging markets, which represent monetary policy is consistent

across countries. Based on the data and analysis conducted in this study, the findings also imply that U.S. monetary policy is indicative of individual's countries. And the strong dollar has a big impact on the exchange rate of them. In addition, it is aligned with the current state of the world.

Secondly, we make a conclusion that inflation and bond yields have been shown to be positively correlated with one another in the emerging market, but this correlation does not exist in the developed market, which is agree with expected results. Moreover, we prove that interest rate is the most important factor for bond yields and spreads. However, for the emerging market countries, we must consider how various national regimes affect the bond market. Inflation is an extremely popular subject and much more has yet to be done. Thirdly, by mean of adding the dummy variable called negative interest rate in the developed market, we suggest that implementing negative interest rate policy can negatively affect short-term bond yield (2-year bond yield). However, our analysis did not reveal a statistically significant relationship between the 10-year bond yield and this factor.

This study should provide a descriptive basis for additional research. In future research, it is recommended that advanced correlation methods, such as copula functions, be employed to potentially obtain more accurate relationships. Utilizing copula functions, which are statistical tools that model the dependence structure between variables separately from their marginal distributions, may provide a more refined and robust approach for examining the relationships among variables in the context of the research at hand. By leveraging advanced correlation methods, future researchers may be able to gain deeper insights and enhance the accuracy of their findings. The findings from this research can also serve as a significant reference for bond investors in the development of their investment strategies.

Footnotes

1 Their detailed URL: https://www.investing.com, https://fred.stlouisfed.org and https://data.oecd.org.

2 Bond spreads mean the gap between the yields on 10-year and 2-year bonds.

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東吳經濟商學學報 第一〇九期
（民國一一三年十二月）：35-62.

通膨和升息循環對債券市場之影響

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摘 要

本研究主要探討通貨膨脹變數與債券殖利率（特別是2年和10年期債券）以及債券利差之間的關係。研究還納入了銀行間利率，以考慮在升息循環影響。在實證研究中，資料包括了成熟市場和新興市場在2002年至2022年期間的每月縱橫資料(Panel data)。透過縱橫資料迴歸模型，本文實證結果顯示，在升息循環期間，經過固定效果模型估計，2年和10年期債券殖利率都有增加的趨勢。相反，利率上升則與債券利差的收縮有關。與此同時，在高通貨膨脹環境下，一些優質債券可能會被低估。最後，本研究建議投資者應密切關注貨幣政策的變化，特別在是升息循環週期，並考慮投資於長天期的債券。

關鍵詞：縱橫資料迴歸模型、通貨膨脹、債券市場、貨幣政策，新冠肺炎

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