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YIELD SPREAD AS A PREDICTOR OF RECESSION IN ASIA-PACIFIC: THE ROLE OF MONETARY POLICY OBJECTIVES

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ABSTRACT

Introduction/Main Objectives: This research examines the predictive power and stability of yield spread in relation to recession for five Asia-Pacific Countries, with monetary policy as the control variable. **Background Problems:** Yield spread has been extensively studied in industrial countries, but its impact on the real economy in developing regions remains underexplored. Moreover, the informational content underlying the yield spread is still unclear. **Novelty:** This research incorporates the role of monetary policy objectives in influencing the informational content and stability of the predictive power of yield spread. **Research Methods:** The research utilizes a *fixed effects* panel probit approach to conduct in-sample forecasting using monthly secondary data from October 2004 to May 2022. To test parameter stability, Likelihood Ratio Tests were also used. **Findings/Results:** The yield spread outperforms money supply and stock index for predicting recessions, with an optimal lag of three months. Monetary policy plays a crucial role as every inversion of the yield curve is associated with an interest rate hike, but the model performs better when central bank have prioritized output stabilization and the relationship between interest rate and output is not disturbed. **Conclusion:** Yield spread is a reliable predictor of recession in Asia-Pacific, but its predictive power depends on the interest rate–output relationship. Therefore, central banks shouldn't use the yield spread during zero lower bound or supply shock conditions.

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INTRODUCTION

Yield spread is a financial market indicator well known for its accuracy in predicting real activity. It represents the slope and shape of the yield curve. Changes in the shape of the yield curve to flat or inverted, or a negative yield spread, are often associated with a decline in real activity. For instance, since 1970, the yield curve in the United States has inverted eight times to consistently precede recession.

Formal research proving the predictive power of the yield spread began with Estrella and Hardouvelis (1991), who used a probit regression model to predict recessions based on the spread between 10-year U.S. government bonds and 3-month treasury bills. They found that yield spread outperformed other predictors over medium-to-long term horizons. This result was subsequently confirmed by numerous researchers in other industrialized countries, including Moneta (2005), Chinn and Kucko (2015), and Hasse and Lajaunie (2022).

The predictive power of the yield spread has been theorized by Estrella (2005), who combined the expectation hypothesis and the monetary policy reaction function. Estrella (2005) argued that the relationship between yield spread and the real economy is a consequence of contractionary monetary policy in the form of interest rate hikes. Specifically, when monetary policymakers react to an output gap and inflation gap by raising the interest rate, the short-term interest rate within the yield spread will increase, leading to a reduction in the yield spread. The smaller the spread value, the tighter the monetary stance.

On the other hand, the expectation hypothesis, developed by Lutz (1940), contends that long-term interest rates are the weighted average of current and future short-term interest rates. When contractionary monetary policy is implemented, investors will therefore also expect lower future inflation and output in the real sector (Estrella, 2005). This expectation will lead to lower interest rate expectations. Expectations of lower interest rates will, in turn, be reflected in a decrease in long-term interest rates. Through this expectation mechanism, the decline in long-term rates during contractionary monetary policy periods will also cause the spread to decrease.

Moreover, besides explaining the mechanism behind the relationship, Estrella (2005) also linked the predictive power of the yield spread to monetary policy objectives. He argued that the more reactive the monetary authority to inflation deviations relative to output deviations, the lower the predictive power of the yield spread. Thus, the monetary policy regime and relationship between interest rates and output are considered crucial in determining the predictive power of the yield spread.

The theoretical framework developed by Estrella (2005) is considered by some as the most accurate explanation of how yield spread predicts output and inflation via monetary policy, as evidenced by Chauvet and Potter (2002), Chinn and Kucko (2015), Hwang (2019), and Fendel, Mai, and Mohr (2021), who found ample evidence linking yield spread parameter changes to shifts in monetary policy regimes. After 1984 in the United States, when Paul A. Volcker's leadership regime actively fought inflation, the yield spread’s predictive accuracy was found to weaken (Chauvet & Potter, 2002).

However, other empirical results contradict Estrella (2005). Studies by Wright (2006), Ng (2012), Christiansen, Eriksen, and Møller (2014), and Bauer and Mertens (2018)have collectively rejected the notion of yield spread parameter instability. They contend instead that the predictive power of the yield spread remains stable over time, regardless of the prevailing monetary regime. Consequently, the instability

of the yield spread as influenced by monetary policy remains unclear.

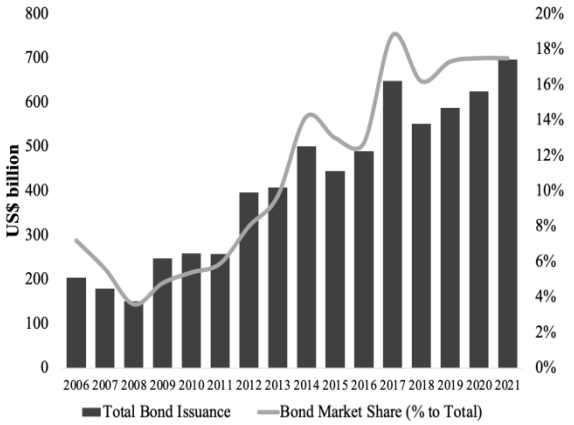
Resolving the issue of the informational content in the spread is therefore crucial as this will determine the value of yield spread as an informative indicator for monetary policy. If the yield spread is solely influenced by monetary policy, it will merely reflect the central bank's policy stance. Conversely, if the yield spread contains information beyond monetary policy, it holds valuable insights potentially useful for policymakers in forecasting real activity.

Besides the issue of model parameter stability, another gap in the literature is the lack of evidence for developing regions, with research limited to studies by Mehl (2009), Khomo and Aziakpono, (2007), and Ozturk and Pereira (2013). Mehl (2009) pioneered research on the predictive power of the yield spread in developing countries using a sample of 14 countries, including India, South Korea, and Malaysia. Subsequently, Ozturk and Pereira (2013) developed an unbalanced panel dataset from 32 OECD countries.

These few empirical studies in developing countries do not attempt to explain the theoretical mechanisms behind the relationship between yield spread and recession. This makes it difficult to explain the heterogeneity of results across countries. Furthermore, they do not account for parameter stability and so are unable to contribute to the issue of yield spread model instability.

Among developing regions, the Asia-Pacific region was chosen as the research setting for this study due to the rapid economic and financial market development in the region over the past few decades, making asset price potentially more liquid and efficient in representing future economic activity. As shown in Figure 1, in 2006, the Asia-Pacific region controlled only 7.2% of the global bond market, with a bond value of US$203.8 billion. By 2022, this share had increased to 17.5%, with the bond value rising by 241.8% to US$697.3 billion.

Figure 1. Total Bond Issuance in Asia-Pacific Region, 2006–2021 (in billion US$)



Source: International Capital Market Association (ICMA), 2023

In addition, the Asia-Pacific region has historically been highly vulnerable to financial crises. This highlights the importance of reliable economic indicators that can signal downturns. Kusumah et al. (2022) analyzed the impact of the Asian Financial Crisis and Subprime Mortgage Crisis in the region. Their findings suggest that Asia-Pacific countries experienced varying degrees of financial shock during the two crises, with the Asian Financial Crisis spreading in a unidirectional pattern, whereas the Subprime Mortgage Crisis caused bidirectional spillovers.

Similarly, Hubbansyah and Husodo (2018) examined financial-business sector interactions in ASEAN-4 countries. Their study found that the business sector initially played a leading role in transmitting shocks at the onset of crises, but as the crises deepened, the financial sector emerged as the dominant transmitter. This reinforces the importance of predictive financial indicators such as the yield spread for anticipating economic downturns and guiding monetary policy responses in the region.

Based on the research background outlined above, this study differs from previous research reported in the literature in several ways. First, while prior research in developing nations has typically focused on predicting industrial and GDP growth, this study exclusively aims to forecast the timing of business cycles using the binary variable for recessions, thereby minimizing forecasting errors. This approach aligns with methodologies used in advanced economies (Estrella and Hardouvelis, 1991; Moneta, 2005; Hasse & Lajaunie, 2022).

Additionally, most of the research in developing regions has tended to focus on empirical methodology with a limited theoretical framework. Therefore, this research is the first in the Asia-Pacific region to incorporate parameter stability testing within a comprehensive framework proposed by Estrella (2005), which is based on the monetary policy reaction function and the expectation hypothesis. As a result, conclusions can be drawn regarding the mechanisms underpinning the relationship and the informational content within yield spread. Furthermore, this research is only the second after Hasse and Lajaunie (2022) to incorporate balanced panel framework into the model.

Later in this paper, the panel probit model results reveal that yield spread significantly predicts the probability of recession occurring within 1 to 15 months, with the highest pseudo R^2 at 3 months (18.3%). The yield spread model outperformed other financial variables, such as money supply growth and stock indices. However, Japan's results are less robust compared to the other four countries due to the Zero Lower Bound condition in the country.

Furthermore, the structural breaks test also revealed a decline in model accuracy after 2013. This decline is attributed to a weakened relationship between interest rates and output due to the presence of supply shocks and unconventional monetary policies, especially during the 2018 –2021 recession. Consequently, while the yield spread remains a reliable predictor of recessions in the region, its strength depends on the interest rate–output relationship.

This paper is organized as follows. Section 1 outlines the background research into yield spread's predictive power regarding the real economy in the Asia-Pacific context. Section 2 presents the background to the theoretical framework developed by Estrella (2005). Section 3 specifies the variables, the data, and the econometrics methodology conducted in the research. Section 4 describes the nature of the data followed by the results and discussion, while Section 5 presents the conclusion.

LITERATURE REVIEW

1. Expectation Hypothesis and Term Premium

According to Lutz (1940), the pure expectation hypothesis posits that the yield from holding a long-term bond will be equal to the yield from continuously holding a short-term bond until the total maturity of the short-term bond matches that of the long-term bond (Lutz, 1940). In other words, long-term interest rates are a weighted average of expected short-term interest rates. Using *m* to represent the maturity of the bond purchased at *t*, Hall, Anderson, and Granger (1992) described the pure expectation hypothesis alternatively as follows:

$$R_t^m = \frac{1}{m}\sum_{i=0}^{m-1} E_t\, r_{t+i}^1 \quad (1a)$$

$$R_t^m = \frac{1}{m}(r_t + \sum_{i=1}^{m-1} E_t\, r_{t+i}^1 \quad (1b)$$

The equation suggests that market expectations play a crucial role in the movement of the yield spread. If the market anticipates an increase in short-term interest rates, both long-term interest rates and the yield spread will rise. Therefore, the yield curve tends to slope upward

when short-term rates are low and slope downward when short-term rates are high. This is because when short-term interest rates are low, market participants generally expect short-term rates to rise. This expectation is reflected in higher long-term interest rates, resulting in an upward-sloping yield curve.

However, although the pure expectation hypothesis is able to explain the interaction between long-term and short-term rates, it does not explain why the majority of yield curves exhibit $R_t > r_t$ or have a positive slope. One primary reason for this limitation is that the pure expectation hypothesis overlooks various market risks and uncertainties investors face in reality when investing in bonds (Orphanides & Kim, 2007).

Orphanides and Kim (2007) stated that the longer the bond's maturity, the greater the exposure to these risks, necessitating compensation for long-term bond investors to balance their increased risk exposure. This compensation is referred to as the term premium. Therefore, the long-term interest rate is determined as follows:

$$R_t^m = \frac{1}{m}\sum_{i=0}^{m-1} E_t\, r_{t+i}^1 + TP_t^m \qquad (2)$$

where TP represents the term premium for a bond with maturity *m* at time *t*. The increasing risk with longer maturities makes TP larger as *m* increases. Thus, the presence of a term premium implies that R_t includes a larger term premium than r_t,, thus explaining the $R_t > r_t$ condition in most circumstances. However, in the analysis reported in this paper, it was assumed that the term premium (*TP*) is constant across time (*t*). This approach is in line with Bauer and Mertens (2018) who found that TP tended to be constant in the preceding decade due to improvements in market efficiency.

2. Yield Spread Relationship with Real Activity

To address the theoretical foundation between yield spread and real economy, Estrella (2005) proposed a nominal yield spread model in his article "*Why Does the Yield Curve Predict Output and Inflation?*". Estrella's yield spread model is considered the most accurate and comprehensive because it is built on various macroeconomic components. In essence, Estrella (2005) aimed to establish the relationship through the expectation hypothesis as influenced by the monetary reaction function.

Estrella (2005) employed substitution and elimination methods expressed in matrix form to derive an equation based on the expectation hypothesis, interest rate rule or the monetary policy reaction function, IS curve, Phillips Curve, and Fisher Equation that describes the relationship between the yield spread and future economic activity at time *t + 1*. The resulting theoretical equation is as follows:

$$E_t y_{t+1} = \frac{2}{g_y}(R_t - r_t) + \frac{1 - g_r}{g_y}(r_t - \pi^*) + \frac{g_\pi}{g_y}(\pi^* - \pi_t - \alpha\gamma_t) \qquad (3)$$

While $E_t y_{t+1}$ is the future activity at time *t* + 1, $R_t - r_t$ is the yield spread and g_y, g_r, g_πarethe parameters of monetary policy based on the interest rate reaction function formulated by Taylor (1993):

$$r_t = g_r r_{t-1} + g_\pi \pi_t + g_y y_t + (1 - g_r - g_\pi)\pi^* \qquad (4)$$

The parameters g_π, g_y, and g_r respectively represent the weight of the prioritized policy target set by the monetary authority in terms of either its inflation deviation (π_t), output deviation (y_t), or past interest rate value with the constraints $g_\pi > 0, g_y > 0$, and $1 \leq g_r \leq 1$.

Therefore, Equation 3 states that the relative strength of the yield spread depends on the policy parameters prioritized by the monetary authority.

From the equation, we can easily conclude that the more reactive the monetary authority is to the output gap (g_y)relative to the inflation gap (π_t), the stronger the predictive power of the yield spread for the real economy (Estrella, 2005). Therefore, the predictive strength and stability of the yield spread parameter depend on the relationship between interest rates and real economic output. Nevertheless, in general, the yield spread still contains valuable information about future real economic activity.

Chauvet and Potter (2002) and Estrella, Rodrigues, and Schich (2003) had previously discovered statistical evidence of a structural break in the United States in 1984, believed to be associated with shifts in monetary policy regimes under Paul A. Volcker's leadership. Following a period marked by high inflation volatility and a lack of monetary credibility, the Volcker regime aggressively tackled inflation by targeting the money supply, M1. Parameter instability resulting from alterations in monetary objectives was also identified by Chinn and Kucko (2015) for the European region in 1999, and for Japan after the Zero Lower Bound (ZLB) in the early 1990s.

In contrast, Estrella et al. (2003) reported instability in the yield spread parameter while predicting output growth using the LM Test. However, no evidence of instability was found in the probit model employing binary variables. Starting with Wright (2006), followed by Christiansen et al. (2014), Ng (2012), and Bauer and Mertens (2018), other researchers have also rejected the hypothesis of instability. Their findings show the yield spread variable remained robust over time, even after conducting LM Tests. One primary reason is that most of these empirical results focused on the United States after the year 2000, a period characterized by a relatively stable monetary regime.

3. Source of Movement in the Yield Spread

If we state that $SPREAD_t$ is the yield spread at time *t*, then the yield spread can be portrayed by the following equation:

$$\text{SPREAD}_t = \left(\frac{1}{m}\left(r_t + \sum_{i=1}^{m-1} E_t\, r_{t+i}^{1}\right)\right) - r_t \qquad (5)$$

By deconstructing the yield spread, it can be inferred that the movement of the spread comes from two different sources: the short-term rate and the long-term rate. First, the variable influenced directly by the central bank, r_t, can influence the shape of the yield curve through the short-term rate. By reacting to deviation in inflation and output as represented in Equation 4, in other words, if the monetary authority adopts a contractionary monetary policy, all else being equal, a hike in r_t will decrease the yield spread.

Besides, an increase in $r_t$will also be seen as a commitment by the central bank to control inflation, thus it is assumed that inflation expectation (π_{t+n}) will decrease according to the Fisher Effect, leading to a slowdown in output expectation $E_t\, y_{t+n}$as the Phillip Curve shows. Furthermore, expectations regarding output and inflation can be stated as the expectation version of the monetary policy reaction function:

$$E_t r_{t+n} = g_r r_t + g_\pi \pi_{t+n} + g_y y_{t+n} + (1 - g_r - g_\pi)\pi^* \qquad (6)$$

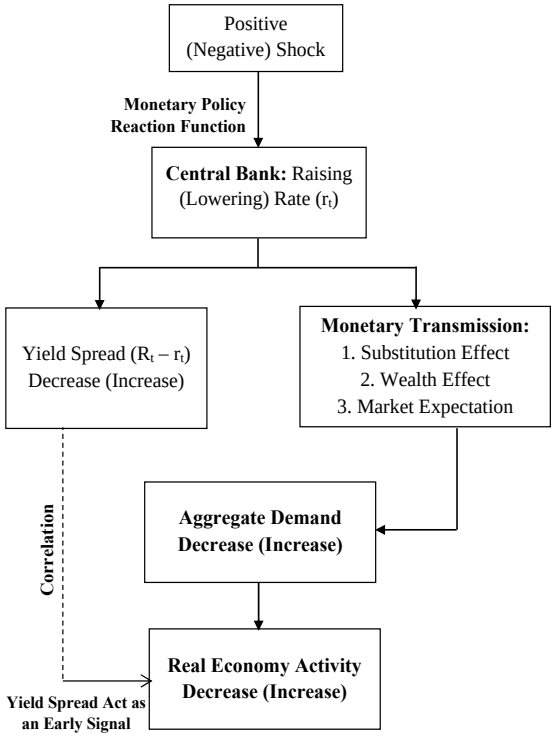
From Equation 6, decline in inflation and output expectations will eventually reduce expectations for the short-term interest rate, $E_t\, r_{t+n}$, leading to a long-term rate decrease and a further decline in the yield spread. In other words, when the central bank implements an interest rate hike, market participants anticipate

that the monetary authority will bring down the interest rate in the future to counteract future output and inflation declines by the current contractionary policy (Estrella & Mishkin, 1998). Figure 2 illustrates how the short term-rate and long-term rate interact through monetary policy that leads to changes in the yield spread.

Therefore, by implementing contractionary monetary policy through lowering rates alone, the combination of an increase in the short-term rate and a decrease in the long-term ratewill simultaneously reduce the yield spread, thus directly affirming the role of monetary policy and public expectations in shaping the movement of the yield curve. At the same time, in the presence of contractionary monetary policy, an increase in the benchmark interest rate will also serve as a signal for rising interest rates across various financial markets, leading to a reduction in money supply, circulation, consumption, and investment, and in turn resulting in decreased aggregate demand and economic output. In this way, the yield spread serves as a signal for monetary policy stance. The position of yield spread as a leading indicator is illustrated in Figure 3.

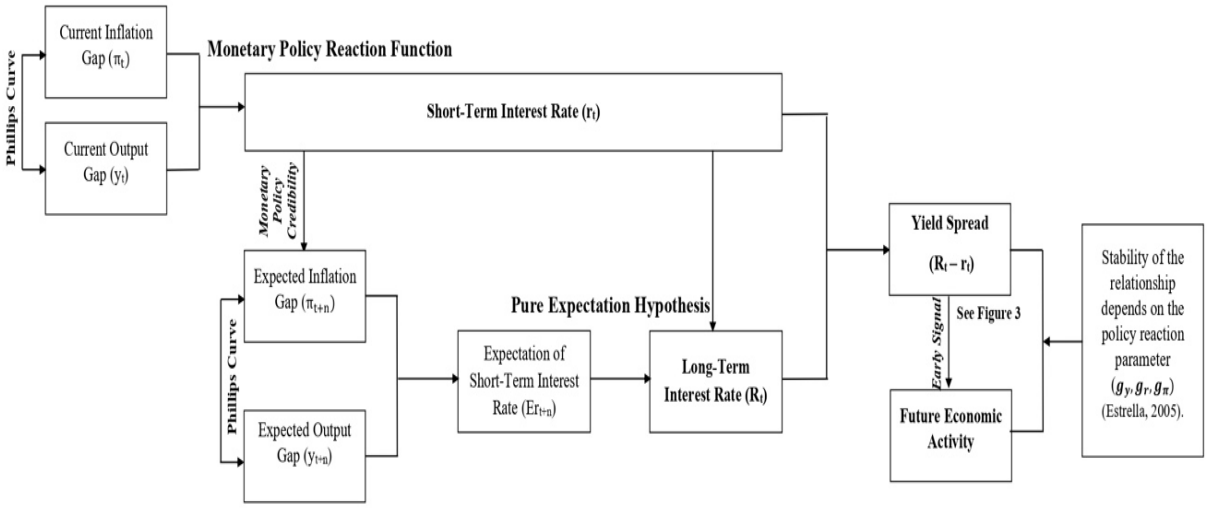
As Figure 3 implies, the lower the value of the yield spread, the more the central bank increases interest rates, the tighter the monetary policy stance of a country becomes, and the higher the probability that real economic activity will decline in the future.

Figure 3. The Transmission of Yield Spread as a Leading Indicator for the Real Economy



Source: Author Illustration Based on Estrella (2005).

Figure 2. Sources of Change in the Yield Spread



Source: Illustrated by Author based on Estrella (2005)

METHOD, DATA, AND ANALYSIS

1. Data

Quantitative data from five Asia-Pacific countries (Indonesia, China, India, Japan, and South Korea) are utilized in this research. This sample represents the Asia-Pacific nations with the largest bond market capitalization, thereby allowing for the construction of a more efficient yield spread model. All the data used in this study are monthly data spanning October 2004 to May 2022.

The primary independent variable used in this study is the yield spread, defined as the difference between long-term government bond yields and short-term government bond yields:

$$SPREAD_t = R_t - r_t \quad (7)$$

Where $SPREAD_t$ is the yield spread in month t, R_t is the long-term government bond yield in month t and r_t is the short-term government bond yield in month t. Historically, the majority of the highest maturity interest rate data available in the sample countries is for 10 years, while the lowest maturities in the data are 3 months and 1 year.

The primary explanatory variable used in this study is the binary recession variable. The business cycle indicator known as the Composite Leading Index (CLI), published by OECD (2022), is utilized to measure and identify recessions. The OECD data has been converted into a binary variable by the Federal Reserve Economic Data (FRED)using the following empirical rule:

$$\begin{aligned} &R_t = 1 \text{ if recession happens on month t} \\ &R_t = 0 \text{ if expansion happens on month t} \end{aligned} \quad (8)$$

The binary variable is empirically superior compared to other approaches as it isolates business cycle turning points and strength, enhancing model accuracy and also aligning with the theoretical framework of yield spread as a signal of monetary policy stance (Dueker, 1997). Empirical studies have also shown that binary recession models have more stable parameters over time (Stock & Watson, 2003; Estrella et al., 2003).

Additionally, to dissect the informational content of the yield spread concerning monetary policy, the policy rate will serve as a control variable. This choice also aligns with Estrella's theoretical framework, utilizing the interest rate rule in determining the relationship between the yield spread and the real economy, given the close connection between the yield spread and changes in policy rate. For comparison purposes, a leading indicator model based on money supply and stock index growth is also carried out.

All data were obtained through the Bloomberg Terminal except for the binary recession variable, which was sourced from OECD and FRED. For the *SPREAD* data, short-term and long-term yield were first obtained from the Bloomberg Terminal, and their differences calculated to obtain the *SPREAD* value. Detailed data, data units, and data sources are presented in Table 1.

EMPIRICAL MODEL AND DATA ANALYSIS METHOD

1. Baseline Model

The panel probit model by Hasse and Lajaunie (2022), which extends the probit model by Kauppi and Saikkonen (2008)is utilized to estimate the model with a binary dependent variable. The panel method is used to enhance the model's forecasting power by combining data from the five Asia-Pacific countries. By applying the fixed effect method, various potential static biases for each country can also be controlled to reduce endogeneity issues.

Table 1. List of Variables

No.	Variable	Empirical Definition	Source
1	Recession (REC_t)	Dummy variable of recession	OECD
2	Short-term Yield (r_t)	Average yield of short-term government bonds	Bloomberg
3	Long-term Yield (R_t)	Average yield of long-term government bonds	Bloomberg
4	Yield Spread ($SPREAD_t$)	Difference between long-term and short-term yield	Bloomberg
5	Money Supply Growth (MS_t)	Growth of broad money supply (M2) year-on-year	Bloomberg
6	Stock Index Return (SI_t)	Growth of the domestic stock index year-on-year	Bloomberg
7	Policy Rate (PR_t)	Policy rate used by the central bank	Bloomberg

Source: Author Model

The baseline model specification is as follows:

$$\Pr(\mathrm{REC}_{i,t} = 1) = \Phi\,(\beta_1 \mathrm{SPREAD}_{i,t-k} + \eta_i) \quad (9)$$

for $t = 1, 2, ..., T$ and $i = 1, 2, ..., I$

where *Pr* denotes the probability of a recession occurring, conditional on the explanatory variable *SPREAD* lagged by *k* months for each country (*i*). Meanwhile, $\Phi(.)$ represents the cumulative distribution function, which is the probability distribution of the probit regression model. The presence of the CDF ensures that the model's probability results will be between 0 and 1. Finally, η_i represents the average of each country's fixed effects to control for potential bias. Subsequently, all the parameters are estimated using the maximum likelihood method (Gujarati, 2021).

As denoted by Estrella (2005) and previous empirical research, we should expect a positive relationship between yield spread and an increase in real economy activity, and therefore a negative relationship with recession. Therefore, the one-tailed hypotheses are as follows:

$\boldsymbol{H_0 : \beta_1 \geq 0}$: Yield spread is not significant.

$\boldsymbol{H_1 : \beta_1 < 0}$: *Yield spread* has a negative and significant impact on the probability of recession.

Additionally, to account for heteroskedasticity and/or serial correlation, adjustments will be made to the standard errors based on Driscoll and Kraay (1998) to ensure the resulting statistical inferences remain valid, following the methodology applied by previous researchers such as Hasse and Lajaunie (2022). This will address the issue of cross-sectional dependence effectively.

2. In-Sample Forecasting

Following the approach used by Estrella and Mishkin (1997), Moneta (2005), and Kauppi and Saikkonen (2008), the model is estimated with different lag months (*k*) ranging from $k = 1$ to $k = 18$, with 3-month intervals. To evaluate model accuracy and strength over the varying time horizons, the calculation proposed by Estrella (1998) using Pseudo $R^2$is employed. Pseudo R^2 is defined as follows:

$$\text{Pseudo } R^2 = 1 - \left(\frac{L_u}{L_c}\right)^{-(2/N)L_c} \quad (10)$$

where L_u is the value of the log-likelihood in the estimated model (unrestricted), while L_c is the log-likelihood value in the restricted model containing only the constant value. A larger value indicates greater predictive strength of the yield spread model for recessions (Estrella, 1998). In addition to Pseudo R^2, the statistical values of the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) will also be calculated. Finally, as a form of comparative analysis with other financial variables, panel probit model estimations for the money supply (*MS*) and stock index (*SI*) variables will be conducted as well.

3. Model with Policy Rate

Following Estrella and Hardouvelis (1991), Wright (2006), Chen, Valadkhani, and Grant (2016), and Hasse and Lajaunie (2022), analysis of the informational content of yield spread is carried out by adding the policy rate (PR), which controls for the influence of monetary policy:

$$\Pr(REC_{i,t} = 1) = \Phi\,(\beta_1 SPREAD_{i,t-k} + \eta_i + \beta_2 PR_{i,t-k}) \quad (11)$$

for $t = 1, 2, ..., T$ and $i = 1, 2, ..., I$

where *PR* is the policy rate at time $t - k$ for each observational unit *i*. By controlling for the monetary policy stance, the source of information in the yield spread can be identified.

There are two stages to analyzing the source of information in the yield spread. The first stage is to determine the presence of monetary policy information in the model. This stage is performed through the LRT by comparing the parameters of the unrestricted model (Equation 11) and the restricted model (Equation 9). The formula for the Likelihood Ratio Statistic (LRS) is as follows (Gujarati, 2021):

$$LRS = -2 \times ln\frac{L(\theta_0)}{L(\theta_1)} \quad (12)$$

where L(.) is the likelihood of a specific model, θ_0 is the parameter of the restricted model, and θ_1 is the parameter of the unrestricted model. Thus, the empirical hypotheses are as follows:

$\boldsymbol{H_0}$**:** $\boldsymbol{\theta_0 = \theta_1}$: There is no significant difference between the two parameters.

$\boldsymbol{H_1}$**:** $\boldsymbol{\theta_0 \neq \theta_1}$: There is a significant difference between the two parameters.

The null hypothesis implies that adding the *PR* variable does not provide significant information regarding the model's accuracy. In other words, the dynamics of monetary policy are already well-reflected by the SPREAD.

Beyond determining the presence of monetary policy information in the model, the next stage is to analyze whether monetary policy is the sole determinant of yield spread movements. According to Chen et al. (2016), if the predictive power of *SPREAD* remains significant after adding the policy rate, monetary policy is not the only factor shaping yield spread information, with yield spread movements also influenced by the high-end source. Thus, market expectation also plays a significant role in influencing the yield spread.

4. Test for Parameter Stability

To demonstrate parameter stability in the yield spread model, two methods are employed: sub-sample analysis and the Likelihood Ratio Test for structural breaks as proposed by Andrews and Fair (1988). Following Moneta (2005), the sub-sample analysis is performed by dividing the time sample in the main research model into two parts, which are then estimated independently.

In this paper, the sub-sample analysis is conducted with the midpoint (assumed structural break) in July 2013. This choice of midpoint as the assumed structural break is due to the adjustment of the monetary policy regime framework in many countries in the sample following the 2008 Financial Crisis, which potentially altered the predictive power of the yield spread.

To formally test the parameter stability of the model, statistical testing will also be carried out using the Likelihood Ratio Test (LRT) for structural breaks developed by Andrews and Fair (1988) under the assumption that the break point is known. The LRS equation for the structural breaks is specified as follows:

$$LRS = 2(T_1 + T_2) \times ln\frac{L(\theta_0)}{L(\theta_{S1} + \theta_{S2})} \quad (13)$$

where T_1 is the number of time observations in sub-sample 1, T_2 is the number of time observations in sub-sample 2, and $\theta_{S1} + \theta_{S2}$ is the sum of the likelihood of each sub-sample. The

LRT for structural breaks will also follow a chi-squared distribution according to the following hypothesis specifications:

H_0:$\theta_{S1}=\theta_{S2}$: No difference between both parameters (no structural break).

H_1:$\theta_{S1}\neq\theta_{S2}$: Significant difference between both parameters (structural break).

The null hypothesis implies that, statistically, the parameters in the first and second sub-sample models do not change. Conversely, if the null hypothesis is rejected, the parameters in the two sub-sample models change at the assumed break point, thereby confirming the presence of a structural break.

RESULTS AND DISCUSSION

1. Yield Spread Movement in Asia-Pacific

Table 2 presents the descriptive statistics for the yield spread variable. It can be observed that, on average, the yield curve in all of the countries was upward sloping. Indonesia had the highest average spreads (1.58), while Japan had the lowest (0.67). Note that during the study period, China never experienced an inverted yield curve. This can be explained by China's massive real growth in the 2000s, which led to the appreciation in risk premium (Kim, 2021).

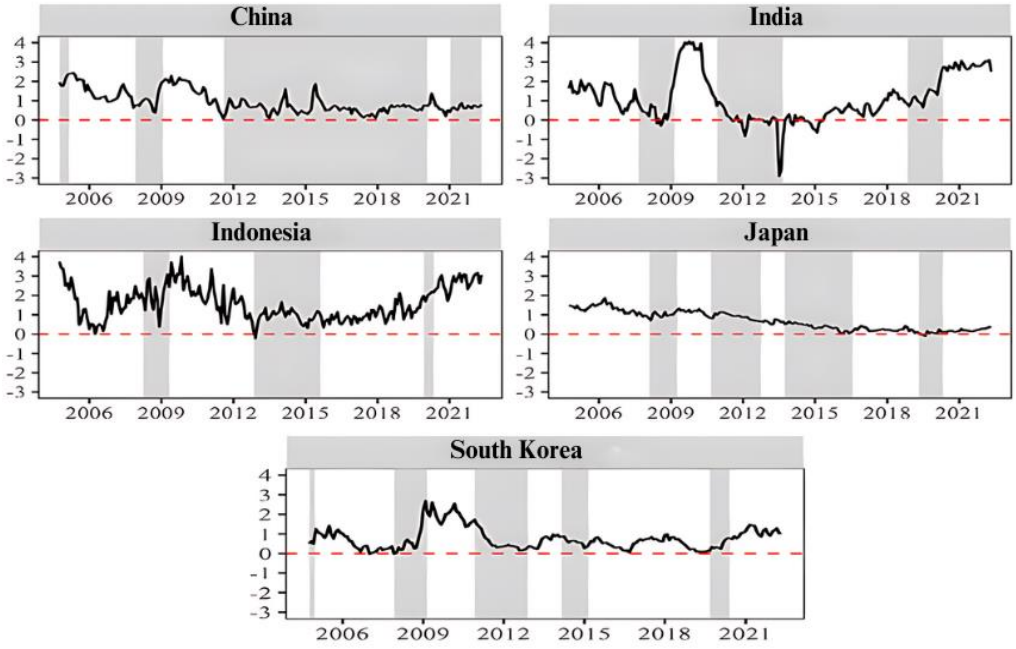
Table 2. Descriptive Statistics of Yield Spread

	n	Mean	SD	Min	Max
Indonesia	212	1.58	0.88	-0.22	3.99
India	212	1.10	1.21	-2.90	4.07
China	212	0.95	0.57	0.05	2.43
Japan	212	0.67	0.48	-0,12	1.86
South Korea	212	0.76	0.56	-0.02	2.71

Source: Bloomberg, processed with R 3.4.1

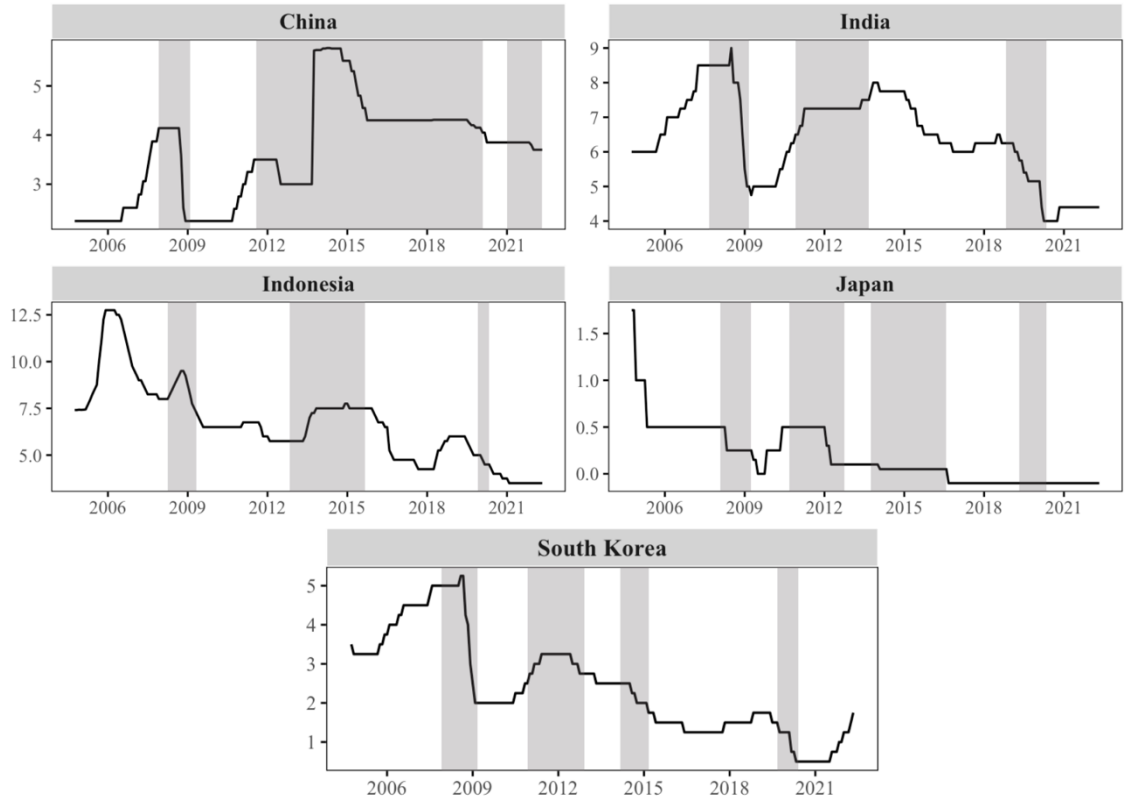
Next, Figure 4 illustrates the yield spread trend from 2004 to 2022 for each country compared to periods of recession (marked in grey). In general, we can categorize three major recessions that occurred across all sample countries: 1) the 2008 Subprime Mortgage Recession; 2) the 2013 Taper Tantrum Recession; and 3) the Trade War, COVID-19 Pandemic, and Energy Crisis Recession from 2018–2021.

Figure 4. Yield Spread and Recession Periods in Five Asia-Pacific Countries, 2004–2022



Source: Bloomberg, Illustrated with R 3.4.1

Figure 5. Policy Rate and Recession Periods in Five Asia-Pacific Countries, 2004–2022



Source: Bloomberg, Illustrated with R 3.4.1

First, all sampled countries experienced a recession during 2008 as a direct consequence of the spillover effects of the U.S. Subprime Mortgage Crisis. The yield spread declined simultaneously across the five countries 12 months before the recession. During this time, heightened investor concerns led to a flight to long-term bonds as safe-haven assets, resulting in declining long-term interest rates.

A decline in the yield spread was also observed across all countries between 2010 and 2013, even turning negative in India and Indonesia. The most pronounced yield spread declines were observed in India and South Korea 12 months before the recession, whereas China and Indonesia respectively experienced declines 8 and 6 months prior. Similar to the previous period, this phase was also marked by financial market instability, first triggered by the European Debt Crisis in 2010 and culminating in the U.S. Taper Tantrum in late 2013. This event led to rising inflationary pressures and interest rate hikes across the globe, including in the Asia-Pacific region.

Finally, a decline in yield spread was observed from late 2017 to 2021. This can be attributed to the global economic slowdown that occurred as a result of multiple factors, including the U.S.–China Trade War, the COVID-19 Pandemic, and the Energy Crisis of 2021–2022, all of which heightened financial market uncertainty. In this period, the yield spread declined more than 12 months prior in India, China, and South Korea, whereas Indonesia experienced a decline approximately 6 to 4 months before the recession.

Figure 4 demonstrates that the yield spread has always declined prior to recession in the Asia-Pacific region, although the movement is less clear for Japan. Notably, compared to the

other four countries, Japan's yield spread exhibits slower movements and remains at relatively low levels. Moreover, the timing of these declines varied among the countries. These variations in timing can be attributed to the differing characteristics of financial markets across countries. However, overall, Figure 4 demonstrates that the descriptive observation successfully proves the predictive strength of the yield spread in the Asia-Pacific region.

An interesting fact can be observed from Figure 5, which shows the movements of each country's policy rate over a similar period. It is noteworthy that among the five sample countries in the sample, Indonesia, South Korea, and India (since 2013) have adopted an explicit Inflation Targeting Framework (ITF), while China has implicitly adopted ITF. Therefore, Japan is the only country that has not adopted ITF.

As can be seen in Figure 5, Japan's policy rate is relatively low. This can be linked to the deflation condition following the asset bubble crisis that has affected the country since the 1990s. Recognizing that policy rate control had become ineffective due to the Zero Lower Bound condition, the Bank of Japan (BOJ) continued to explore alternative approaches through unconventional monetary policies. These policies included Quantitative Monetary Easing (QQE) in 2013, the introduction of a negative interest rate policy in 2016, and the adoption of Yield Curve Control (YCC) in 2017.

Most of these unconventional policies targeted the long-term interest rate, potentially disturbing the Estrella (2005) model, which portrays the long-term interest rate as a function of the expectation hypothesis. If the long-term interest rate is being artificially increased as a form of contractionary policy, the downward inflation and output expectation will not be captured effectively. Hence, the relationship between yield spread and recession will be disturbed.

It can be inferred that during the three periods of recession, all countries apart from Japan simultaneously adopted contractive monetary policies by raising their policy rate. The movement of policy rate in alignment with periods of recession and decline in yield spread indicates that monetary policy that prescribes the relationship between the short-term interest rate and output might play a crucial role in explaining the predictive power of the yield spread.

2. In-Sample Results of the Baseline Model

Table 3 presents the baseline results of the panel probit model for yield spread, money supply, and stock index in each country. It is evident that *SPREAD* is a significant variable in predicting recessions from 1 to 12 months ahead at the α = 1% level. Consistent with the theoretical framework, the relationship between the yield spread and recession is also found to be negative (except for k = 18).

Specifically, a decline in the yield spread can be associated with an increased likelihood of a recession several months later. Meanwhile, the predictive power of *MS* and *SI* only becomes apparent after 1 to 6 months. Furthermore, it is also evident that the Pseudo R^2 value of *SPREAD* is significantly higher than that of *MS* and *SI* for forecast horizons below 12 months.

The predictive power of *SPREAD* peaks at k = 3 before declining from k = 6 to k = 18.On the other hand, the predictive power of *SI* continues to decrease until k = 9, before increasing again. Lastly, the predictive power of *MS* tends to remain stagnant at around 8%. The *MS* and *SI* models have their highest Pseudo R2 values at k = 1, at 8.7% and 17.8%, respectively, whereas the lag optimum for *SPREAD* is 3 months (18.3%).

Table 3. Baseline In-Sample Model Results

	***k* = lag in months**						
$X_{i,\,t-k}$	**1**	**3**	**6**	**9**	**12**	**15**	**18**
			Yield Spread				
SPREAD	-0.622***	-0.642***	-0.525***	-0.354***	-0.218***	-0.076*	0,028
	(0.065)	(0.066)	(0.062)	(0.058)	(0.056)	(0.054)	(0,054)
Country Effects	0.325	0.335	0.238	0.101	-0.010	-0.129	-0,215
Pseudo R^2	0.178	0.183	0.150	0.114	0.093	0.082	0,083
AIC	1228.016	1210.826	1231.282	1255.277	1262.621	1259.052	1242,979
BIC	1237.939	1220.730	1241.156	1265.123	1272.437	1268.837	1252,734
			Money Supply				
MS	-0.033***	-0.030***	-0.020**	-0.014*	-0.009	-0.005	0.001
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Country Effects	0.086	0.051	-0.039	-0.088	-0.12	-0.152	-0.203
Pseudo R^2	0.087	0.084	0.077	0.077	0.078	0.080	0.083
AIC	1328.263	1318.712	1308.490	1293.742	1277.681	1260.858	1242.236
BIC	1338.185	1328.712	1308.490	1293.742	1277.681	1260.858	1243.236
			Stock Index				
SI	-0.015***	-0.009***	-0.003**	0.002	0.006	0.009	0.007
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Country Effects	-0.089	-0.154	-0.218	-0.262	-0.298	-0.306	-0.279
Pseudo R^2	0.178	0.118	0.079	0.076	0.096	0.112	0.111
AIC	1228.916	1282.011	1307.026	1293.615	1260.165	1228.875	1214.124
BIC	1238.839	1291.914	1316.900	1303.460	1303.460	1269.980	1238.660
No. of Observations	1055	1045	1030	1015	1000	985	970

Notes: Processed using R 3.4.1. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. The values in parentheses represent the standard errors of the parameters. To ensure valid statistical conclusions, all standard errors have been adjusted according to Driscoll and Kraay (1998) to correct for heteroskedasticity and serial correlation.

Table 4. Probability of Recession Based on *SPREAD* at 3 Months Prior

SPREAD	Recession Probability (%)
4	1.3
3,5	2.8
3	5.6
2,5	10.2
2	17.1
1,5	26.5
1	37.9
0,5	50.5
0	63.1
-0,5	74.4
-1	83.6
-1,5	90.3
-2	94.7

Notes: Processed with R 3.4.1. Each SPREAD value represents average, maximum, and minimum values to obtain representative results.

The finding that *SPREAD* is a negative and significant predictor of recession in the Asia-Pacific region confirms previous researchers' findings, including Mehl (2009) for Korea and India, and Hasse and Lajaunie (2022) for Japan. However, the optimal forecast horizon for *SPREAD* in the Asia-Pacific region is found to be shorter than in Europe. Most researchers, including Bernard and Gerlach (1998) and Estrella and Mishkin (1998), have identified the optimal lag for the SPREAD model as 9 to 12 months.

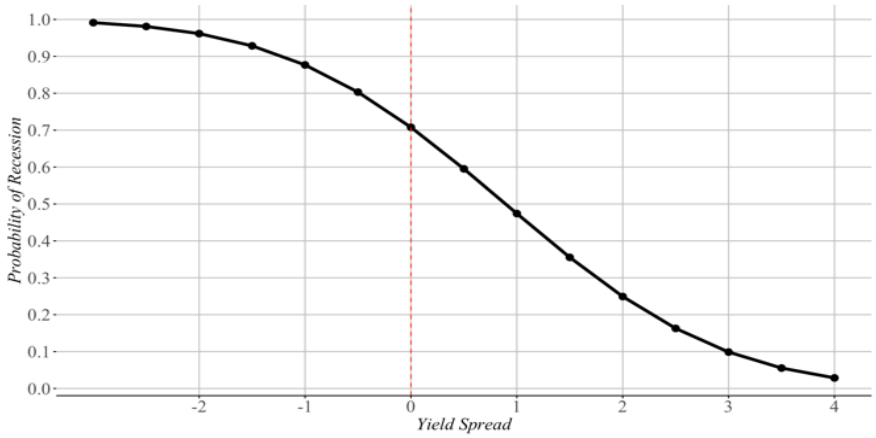
According to Mehl (2009), the difference in optimal lag can be attributed to the varying efficiency of financial markets. Indeed, the market share of bonds in Asia has not yet reached 10%, far behind North America (50%) and Europe (41%). Consequently, yield movements in developed regions more efficiently reflect expectations of real economic movements compared to developing regions.

Next, Table 4 and Figure 6 depict recession probabilities based on the *SPREAD*. It is evident that recession probabilities gradually increase in a non-linear manner as the *SPREAD* value decreases. One unique finding is that the *SPREAD* value does not need to enter negative territory to predict a significant recession probability in the future. At a *SPREAD* level of only 0.5, the recession probability is already 50.5% and continues to rise as the yield spread decreases.

These results differ from the recession probabilities found by Bernard and Gerlach (1998), where probabilities only reached 50% after the *SPREAD* fell below -1. This difference can be explained through the descriptive statistics of the yield spread in Table 2. Over the past 20 years, it is evident that the *SPREAD* value in the five countries has rarely fallen below -1, except for India. This may be due to the fact that many Asia-Pacific countries in the sample are emerging economies with higher term premiums on the long-term bonds, thus preventing the *SPREAD* from falling too far into negative territory.

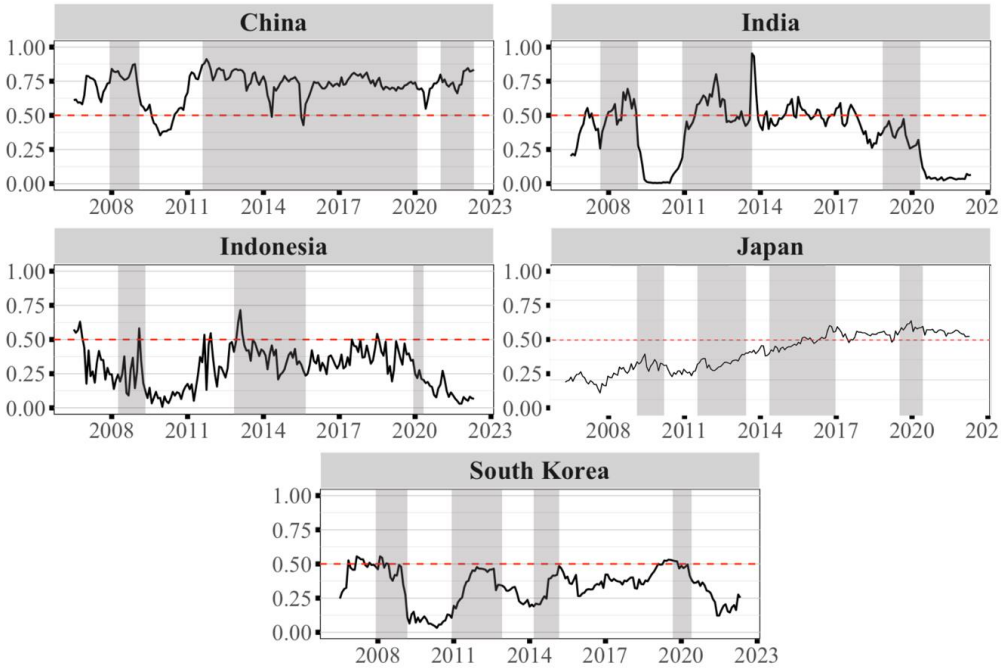
To understand how *SPREAD* has predicted recessions over the past 20years, Figure 7 shows the recession probability movement based on the *SPREAD* model at $k = 3$. First, the model proves to be a reliable predictor of recessions in China, as evidenced by consistently high probability values exceeding the 50% threshold during recessionary periods in 2008, 2011–2020, and 2021. Notably, during the prolonged recession from 2011 to 2020, the probability of recession briefly falls below 50% only once before subsequently rising again.

Figure 6. Cumulative Distribution Function of the *SPREAD* Model ($k = 3$)



Notes: Visualized using R 3.4.1.

Figure 7. Probability of Recession in Five Countries of Asia-Pacific Based on *SPREAD* 3 Months Prior, 2004–2022



Notes: Visualized using R 3.4.1. The vertical axis shows the probability of a recession occurring in the next 3 months based on the SPREAD value, while the grey shading indicates recession periods. Additionally, the red dashed line indicates the threshold at a probability value of 0.5.

In India, the *SPREAD* model effectively predicts the recessions of 2008 and 2013, with probability values exceeding the 50% threshold. However, during the 2019–2020 recession, while the probability of recession in India exhibits an upward trend, it remains below the threshold at approximately 40%. A similar pattern is observed in Indonesia, where the model successfully predicts the recessions of 2008 and 2013–2016. However, it fails to capture the 2020 recession, as the probability of recession declines rather than increases during this period.

In South Korea, no probability values exceed the 50% threshold. However, if the threshold is adjusted downward to 40%, the model demonstrates predictive capability, successfully identifying recessions in 2008, 2010–2013, and 2020. Meanwhile, the performance of the model is weakest in Japan. Unlike the other four countries, recession probabilities exhibit a persistent upward trend over time, failing to reflect the cyclical transition between expansionary and recessionary phases. The poor forecasting performance in Japan confirms findings reported in previous studies, including Bernard and Gerlach (1998) and Chinn and Kucko (2015).

Japan's economy has experienced the Zero Lower Bound, leading its monetary policy to focus on unconventional instruments. As Japan cannot rely on the policy rate, the yield spread becomes rigid and unable to represent future economic outcomes. This in contrast to other Asia-Pacific countries that generally have a stable relationship between interest rate and output. Therefore, the heterogeneous results between Japan and other countries can be explained by interest rate and output relationship differences.

Additionally, it can also be observed that the yield spread model predicts the 2008 and 2013 recessions better than the 2020 recession. This is because the recessionary conditions in the Asia-

Pacific region around 2020 were also marked by the adoption of unconventional monetary policies due to the presence of supply-based shocks from the trade war and a rise in commodity prices. For example, the Bank of Indonesia implemented a burden-sharing policy with the Ministry of Finance, while the Bank of Korea established emergency liquidity facilities. The change in the model's effectiveness thus occurred due to the disrupted transmission of monetary policy, resulting in an ineffective relationship between output and interest rates.

3. In-Sample Results of Model with Policy Rate

Table 5 presents the estimation results with the addition of the policy rate control variable. It shows that collectively, across all forecast horizons, the Likelihood Ratio Test fails to reject the null hypothesis that there is no difference between the regular model and the model using the control variable. The lack of significant difference in strength between the two models indicates that information regarding monetary policy is already embedded in the yield spread.

The results directly validate Estrella's (2005) model explaining the predictive power of the yield spread through the monetary policy reaction function and the expectation hypothesis. As seen in the recessions of 2008, 2013, and 2020, which were marked by policy increases in interest rates, there is an important implication that the yield spread will be a good predictor of recessions when central banks implement restrictive monetary policy.

Furthermore, the *SPREAD* parameter in Table 5 is still found to be negative and significant from lag $k = 1$ to lag $k = 15$. Thus, controlling for monetary policy does not make the yield spread variable immediately insignificant. This further confirms that both short-term yield and long-term yield jointly play a role in explaining the relationship between yield spread and recessions. Consequently, the yield spread remains a robust predictor of recessions regardless of whether its movements originate from the low or high-end of the curve.

Table 5. In-Sample Model Results with Policy Rate

	***k* = lag in months**						
$X_{t-k,i}$	**1**	**3**	**6**	**9**	**12**	**15**	**18**
SPREAD	-0.630***	-0.642***	-0.531***	-0.361***	-0.220***	-0.077*	0.029
	(0.065)	(0.066)	(0.063)	(0.058)	(0.056)	(0.055)	(0.055)
PR	-0.623	-0.154	0.843	1.143	1.131	1.090	0.986
	(0.232)	(0.220)	(0.265)	(0.278)	(0.275)	(0.271)	(0.265)
Country Effects	0.325	0.333	0.246	0.109	-0.004	-0.125	-0.211
Pseudo R^2	0.185	0.183	0.160	0.133	0.112	0.100	0.098
AIC	1221.672	1212.351	1221.958	1237.638	1245.276	1242.765	1229.365
BIC	1236.556	1227.207	1236.770	1252.406	1260.000	1257.442	1242.997
Likelihood Ratio Test							
LRS	8.344	0.474	11.324	19.639	19.344	18.287	15.613
H_0	Not Rejected	Not Rejected	Not Rejected	Not Rejected	Not Rejected	Not Rejected	Not Rejected
No. of Observations	1055	1045	1030	1015	1000	985	970

Notes: Processed using R 3.4.1. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. A statistical test based on the Likelihood Ratio was conducted to compare the unrestricted model (with PR) and the restricted model (without PR). The null hypothesis for the Likelihood Ratio is that there is no statistical difference between the two models

This result confirms the findings of Estrella and Hardouvelis (1991), Wright (2006), and Hasse and Lajaunie (2022). Estrella and Hardouvelis (1991),this indicates that apart from monetary policy, public expectations regarding economic activity also play a crucial role in influencing the yield spread, especially from the long-term yield.

Estrella (2005) assumed that the high-end is also influenced by the low-end, as monetary authorities also influence public expectations. However, the expectation element contained within the yield spread makes it more than just a monetary policy indicator; potentially it can be used as a robust leading indicator in the region. However, as the previous sub-section suggests, policymakers may not consider yield spread as an indicator in a country where the relationship between interest rate and output is disturbed.

4. Parameter Stability Test Results

Table 6 presents the result for the spread model divided into two different subsamples. In sub-sample I, the yield spread is significant from k = 1 to k = 15. In subsample II, the yield spread is only significant between lag k = 1 and k = 3 at α = 1% and at k = 6 at α = 10%. Beyond the forecast horizon of 6 months, yield spread is no longer a good predictor of recessions. This suggests that after July 2013, the accuracy of yield spread in the Asia-Pacific region slightly diminished.

To further verify the statistical stability of the parameter, Table 7 presents the results of the structural break test based on the Likelihood Ratio. It is evident that the obtained LR Statistic results are highly negative, strongly rejecting the null hypothesis of no structural break across all forecast horizons. This confirms the presence of a structural break in the yield spread in July 2013.

Table 6. In-Sample Model Results (Sub-sample)

	***k* = lag in months**						
$X_{t-k,i}$	**1**	**3**	**6**	**9**	**12**	**15**	**18**
Sub-sample I (2004M10 - 2013M7)							
SPREAD	-0.870***	-1.048***	-0.82***	-0.55***	-0.396***	-0.203***	-0.039
	(0.099)	(0.110)	(0.098)	(0.085)	(0.080)	(0.076)	(0.076)
Country Effects	0.689	0.879	0.672	0.427	0.286	0.079	-0.098
Pseudo R^2	0.218	0.266	0.200	0.125	0.085	0.048	0.035
AIC	582.377	544.880	565.587	591.943	597.255	599.477	588.637
BIC	590.904	553.369	574.016	600.312	605.560	607.719	596.811
Sub-sample II (2013M8 - 2022M5)							
SPREAD	-0.234***	-0.194**	-0.147*	-0.050	0.105	0.208	0.202
	(0.095)	(0.095)	(0.098)	(0.099)	(0.104)	(0.112)	(0.117)
Country Effects	-0.011	-0.044	-0.083	-0.155	-0.264	-0.332	-0.324
Pseudo R^2	0.284	0.258	0.221	0.177	0.131	0.084	0.025
AIC	556.467	558.657	560.414	562.267	561.570	559.261	559.657
BIC	564.994	567.146	568.843	570.636	569.876	567.502	567.831
No. of Observations	530	515	500	485	470	455	440

Notes: Processed using R 3.4.1. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. To ensure valid statistical conclusions, all standard errors have been adjusted according to Driscoll and Kraay (1998) to correct for heteroskedasticity and serial correlation.

Table 7. Structural Break Test with Likelihood Ratio between Subsample I and Subsample II

Model lag	*LR Statistic*	**H0: No Structural Break.**
	***Break Assumption*: July 2013**	**Critical Value 5%**
1	(16,004.65)	Rejected
3	(20,208.82)	Rejected
6	(21,896.78)	Rejected
9	(24,285.40)	Rejected
12	(24,372.53)	Rejected
15	(22,380.26)	Rejected
18	(21,119.25)	Rejected

Notes: Processed using R 3.4.1. A structural break test based on the Log-Likelihood Ratio follows the method proposed by Andrews and Fair (1988) for nonlinear models using maximum likelihood. The null hypothesis is that there is no structural break between subsample model I and subsample model II.

The results of the structural break are consistent with research by Chauvet and Potter (2002) and Chinn and Kucko (2015), making this the first study to confirm the instability of the yield spread parameter in the Asia-Pacific region.

However, these findings are not consistent with those of Wright (2006), Ng (2012), Christiansen et al. (2014), and Bauer and Mertens (2018).

Differences in stability test results can be attributed to differences in time samples and countries, where the majority of countries tested by researchers who reject the instability hypothesis are countries with relatively stable monetary policy dynamics, such as the United States.

Inalow-interest rate environment combined with numerous crises affecting the supply side of the economy, the relationship between interest rates and output has tended to be more disrupted after 2013. Consequently, many countries in the Asia-Pacific region have begun to implement unconventional monetary policies as traditional interest rate channels have become less effective. Many of these policies have targeted long-term interest rates, leading to a decrease in yield spread amidst easy monetary policy (Hasse & Lajaunie, 2022).

Furthermore, another explanation for the declining predictive power of yield spread after July 2013 can be associated with an equation developed by Estrella (2005). Estrella (2005) showed that the predictive power of yield spread depends on the sensitivity of monetary authorities to inflation (g_π) compared to output (g_y). Indeed, the period after 2013 is characterized by the increased tendency to maintain inflation levels stable at the target range among the sample countries.

This contrasts with the period before 2013, when high and volatile inflation levels in the Asia-Pacific region were still prevalent. Moreover, it implies that monetary authorities can forecast change in the accuracy of the yield spread through altering the objective of monetary policy.

However, it should be noted that the decrease in the accuracy of yield spread is only relative when compared through the sub-sample analysis. In absolute terms, yield spread remains a good predictor for recessions, as evidenced by significant results from k = 1 to k = 6 for the period after 2013.

CONCLUSION AND SUGGESTIONS

This research has examined the predictive power and stability of the yield spread in forecasting recessions in five Asia-Pacific countries from

2004 to 2022, using the panel probit model with the monetary policy approach developed by Estrella (2005). The results indicate that the yield spread is a significant predictor of recessions from a forecast horizon of 1 to 15 months, outperforming money supply and the stock index and also proving that the yield spread's forecasting power is not limited to United States and Europe.

The model is found to effectively predict recession in 2008 and 2013, but is not as effective for Japan and the recession in 2020. The disrupted relationship between interest rates and output due to the Zero Lower Bound is considered the reason why the yield spread model fails to predict recessions in Japan. In the other countries in the sample, the interest rate–output relationship has not been disturbed. The yield spread is also found to be more accurate in predicting demand-driven recessions than supply-driven ones, as the 2020 Recession was associated with supply chain disruption.

The optimal lag of the yield spread is 3 months, with the highest Pseudo R^2 at 18.3%, lower than the average model in Europe, which ranges from 9 to 12 months. The main factor behind this is lower financial market efficiency in the Asia-Pacific compared to Europe.

Furthermore, using the Likelihood Ratio Test, there was no significant difference in the model after adding the policy rate variable. This confirms Estrella's (2005) theory that information related to monetary policy is already embedded in the yield spread. Thus, the yield spread will be a good predictor of recessions when central banks implement restrictive monetary policy through interest rate hikes.

Lastly, to prove the stability of the yield spread parameter, structural breaks were tested with a break assumption in July 2013. The subsample analysis results show a decrease in model strength after July 2013, the period where the utilization of unconventional policies due to the presence of supply shocks was more common. This also confirms Estrella's (2005) theory that the predictive power of the yield spread will decrease if the strength of the relationship between interest rates and output is less amplified.

The findings of this study offer valuable insights for central banks in the Asia-Pacific region on how to refine their frameworks in forecasting recessions. First, central banks that have prioritized output over inflation stabilization may benefit from stronger predictive signals. Hence, in inflation-targeting economies, yield spread models should be preferred during periods when output stabilization takes precedence.

For example, the weighting of yield spread in recession forecasting models should be lowered during supply-driven crises, such as the 2022 Global Energy Crisis. Under these conditions, central bank shave prioritized stabilizing inflation over output by using unconventional monetary measures, such as quantitative tightening. This can disrupt the interest rate–output relationship and thus predictive power of the yield spread.

In contrast, yield spread should be preferred during times such as the 2008 Global Financial Crisis, as many central banks adopted aggressive interest rate cuts to support economic recovery. In such conditions, interest rate policies were directly tied to output fluctuations, leading to enhanced accuracy of the yield spread model. Furthermore, regular structural break analysis is crucial to assess the stability of the yield spread's predictive power over time.

Second, in economies like Japan, where the Zero Lower Bound (ZLB) weakens the yield spread's effectiveness, alternative indicators such as shadow rates or credit spreads should be considered. Fendel et al. (2021) have already

proposed replacing short-term rates with shadow rates to restore forecasting power in Europe. Thus, future research should explore a similar approach for the Asia-Pacific region. This may also benefit economies with implicit-targeting regimes, such as China.

A limitation of this research is that the forecasting method used is in-sample. In other words, the forecast only utilizes the information and data in the research sample to predict each recession. Therefore, future research methodologies could be enhanced by using the out-of-sample method to predict real-time data outside the sample in the model for upcoming recessions.

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APPENDIX 1. The Components of the Composite Leading Indicator (CLI) from OECD

No.	Country	Components	Source
1.	**Indonesia**	Share prices: IDX Composite index (2015 = 100)	Indonesia Stock Exchange
		Central Bank Discount Rate (%) inverted	Bank Indonesia
		IDR/USD exchange rate end period (%) inverted	International Monetary Fund
		Wholesale Price Index (2015 = 100) inverted	Bank Indonesia
		Consumer - Confidence indicator (normal = 100)	Bank Indonesia
		Production index of paper and paper products (2015 = 100)	Central Statistic Authority
		Tourist arrival (number)	Central Statistic Authority
2.	**India**	IP Production of manufactured durable consumer goods (2015 = 100)	India's Ministry of Statistics
		IP Production of manufactured non-metallic mineral products (2015 = 100)	India's Ministry of Statistics
		Passenger car sales (number)	Society of Indian Automobile Manufacturers
		Monetary aggregate M1 (INR)	Reserve Bank of India
		Share prices: BSE (100) national index (2015 = 100)	Reserve Bank of India
		Call money rate (%) inverted	Reserve Bank of India
3.	**China**	IP Production of chemical fertilizer (ton)	China's National Bureau of Statistics
		IP Production of manufactured crude steel (ton)	World Steel Association
		5000 Industrial Enterprises: Diffusion Index: Overseas order level (%)	People's Bank of China
		Production of total construction (m^2)	China's National Bureau of Statistics
		Production of motor vehicles (number)	China's National Bureau of Statistics
		Share prices: Shanghai Stock Exchange turnover (CNY)	Shanghai Stock Exchange
4.	**Japan**	Ratio of inventories to shipments (2015 = 100) inverted	Statistics Japan
		ITS imports/exports (volume) (2015 = 100)	Japan Customs
		Ratio loans to deposits (%) inverted	Bank of Japan
		Monthly hours worked: manufacturing (2015 = 100)	Statistics Japan
		Work started for dwellings (2015 = 100)	Japan's Ministry of Construction
		Share prices = TOPIX index (2015 = 100)	Bank of Japan
		Spread of interest rates (%)	Bank of Japan
		Small Business Survey: sales tendency (% balance)	Japan Finance Corporation
5.	**South Korea**	Manufacturing survey - business situation (% balance)	Bank of Korea
		Share prices: KOSPI index (2010 = 100)	Bank of Korea
		Stocks of manufactured investment goods (volume) inverted	Korea's National Statistics Office
		Inventory circulation indicator (manufacturing)	Korea's National Statistics Office
		Spread of interest rates (%)	Korea's National Statistics Office
		Net Barter Terms of trade (%)	Korea's National Statistics Office
		Net Barter Terms of trade (2015 = 100)	Korea's National Statistics Office

APPENDIX 2. Details of Policy Rate in Five Sample Countries

No.	Country	Policy Rate	Definition
1.	Indonesia* (2005 –2016)	BI Rate	The benchmark interest rate set by Bank Indonesia when providing short-term liquidity funds to commercial banks and other financial institutions.
2.	Indonesia (2016 –Now)	BI 7-Day Reverse Repo Rate (BI Rate)	The interest rate earned when commercial banks place their funds in Bank Indonesia for a seven-day period.
3.	India	Repo Rate	The interest rate set by the Reserve Bank of India when providing short-term loans to commercial banks.
4.	China (2005 –2013)	Benchmark Deposit Rate	The interest rate set by the People's Bank of China as a benchmark for commercial banks' deposit interest rates.
5.	China (2013 –2022)	Loan Prime Rate (LPR)	The lending rate set by the People's Bank of China and offered by selected commercial banks to their best clients.
6.	Japan	Policy Interest Rate (Overnight Call Rate)	The benchmark interest rate from the Bank of Japan for commercial banks to lend funds to each other overnight.
7.	South Korea	Base Rate (Overnight Call Rate)	The benchmark interest rate from the Bank of Korea for commercial banks to lend funds to each other overnight.

Note: The research model covers the period starting from October 2004, whereas the explicit ITF framework and the policy rate (BI Rate) in Indonesia were only introduced in July 2005 through the amendment of BI Regulation No. 3/2004. Therefore, as a reflection of short-term interest rates and the monetary policy stance closely correlated with the BI Rate, the 1-month SBI rate is used for the period between October 2004 and July 2005.

APPENDIX 3. Details of Expansion and Contraction Period on the CLI Indicator

Country	Phase	Period	Length (Months)
Indonesia	Expansion	2004M10 –2008M3	42
	Recession	2008M4 –2009M5	14
	Expansion	2009M6 –2012M10	41
	Recession	2012M11 –2015M9	35
	Expansion	2015M10 –2019M11	50
	Recession	2019M12 –2020M5	6
	Expansion	2020M6 –2022M5	24
India	Expansion	2004M10 –2007M8	35
	Recession	2007M9 –2009M3	19
	Expansion	2009M4 –2010M11	20
	Recession	2010M12 –2013M9	34
	Expansion	2013M10 –2018M10	61
	Recession	2018M11 –2020M5	19
	Expansion	2020M6 –2022M5	24
China	Recession	2004M10 –2005M3	6
	Expansion	2005M4 –2007M11	32
	Recession	2007M12 –2009M2	15
	Expansion	2009M3 –2011M7	29
	Recession	2011M8 –2020M2	103
	Expansion	2020M3 –2020M12	10
	Recession	2021M1 –2022M5	17
Japan	Expansion	2004M10 –2008M1	40
	Recession	2008M2 –2009M4	15
	Expansion	2009M5 –2010M8	16
	Recession	2010M9 –2012M10	26
	Expansion	2012M11 –2013M9	11
	Recession	2013M10 –2016M8	35
	Expansion	2016M9 –2019M4	32
	Recession	2019M5 –2020M5	13
	Expansion	2020M6 –2022M5	24
South Korea	Recession	2004M10 –2005M1	4
	Expansion	2005M2 –2007M11	34
	Recession	2007M12 –2009M3	16
	Expansion	2009M4 –2010M11	20
	Recession	2010M12 –2012M12	25
	Expansion	2013M1 –2014M2	14
	Recession	2014M3 –2015M3	13
	Expansion	2015M4 –2019M8	53
	Recession	2019M9 –2020M6	10
	Expansion	2020M7 –2022M5	23