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Does the Choice of Firm-Performance Metric Matter? Bayesian Evidence on Macro Risks from the US Market

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Abstract

Purpose: Organizational decision-making depends critically on selecting performance metrics that accurately reflect firms' economic conditions. Choosing a suitable firm-performance metric and understanding its determinants are significant for managers, investors, and scholars. In the literature, researchers often employ a single firm-performance measure, the accounting-based one, and then implicitly assume that empirical findings are invariant to performance measurement. This study challenges that assumption and examines whether the choice of firm-performance metrics, including the accounting-based ROA, a hybrid Q-based ratio, and the market-based excess stock return, affects conclusions about the relationship between macro risks and firm performance via a Bayesian framework and the macro risk asset pricing model. Additionally, the relationship between macro risks and metrics is scrutinized.

Methodology: Using a sample of 432 S&P 500 firms from 2007 to 2022, this study investigates the effects of key macroeconomic risk factors, including market risk premium, prime rate risk premium, long-term government bond yield risk premium, and exchange rate movements. A Bayesian estimation framework with Gibbs sampling is employed to account for parameter uncertainty and improve robustness. Model performance is assessed using Bayesian goodness-of-fit measures and posterior statistical inference.

Findings: The findings indicate substantial differences across performance metrics. The Q-based and excess stock return metrics outperformed ROA in terms of model fit or explanatory power. The excess stock return displays the highest Bayesian R-squared, followed by the Q-based ratio. Importantly, the macro risks exert statistically and economically significant effects on firm performance, although the magnitude and direction of these effects vary across performance measures. The findings suggest that performance metric selection materially influences empirical inferences about firm performance and highlight the importance of incorporating macro risks into performance evaluation.

Originality: This study contributes to the macro-finance and firm performance literature by showing that conclusions regarding macro risks are sensitive to the choice of performance metric. By integrating accounting-based, hybrid, and market-based measures within a unified Bayesian framework and a macro risk asset pricing model, the study provides additional evidence that market-oriented and hybrid performance metrics more effectively capture firms' exposure to macroeconomic shocks.

Practical implications: This study has important practical implications. An effective choice of performance metric can provide a better approach to managers, investors, and scholars in evaluating firm performance, the cost of equity, resource allocation, dividend policy, and investment decisions. It also highlights the effectiveness of the macro risk asset pricing model in the literature. The use of the Bayesian framework, a robust Bayes estimator, and MCMC sampling offers a robust methodology for addressing parameter uncertainty in this field of study.

Keywords: Firm performance, ROA, Tobin's Q, excess stock return, Bayes

JEL Classifications: E43, E44, G12

1 Introduction

Stakeholder theory indicates that the firm's liquidity, solvency, financial flexibility, and performance are fundamental for survival, success, and stakeholders. Organizational decision-making depends critically on selecting performance metrics that accurately reflect firms' economic conditions. Managers rely on these metrics to evaluate strategic investments, capital structure, dividend policy, and risk management. The investors and scholars use these metrics in stock valuation and portfolio allocation since they make their earnings from capital gains and dividends (Desai et al., 2022; Estra, 2022) and studies, respectively. As a result, choosing a suitable firm-performance metric and knowledge of its determinants are significant to managers, investors, and scholars in evaluating firm performance, cost of equity, resource allocation, dividend policy, and investment planning in an increasingly uncertain economic environment, and reinforce the usefulness of the macro risk asset pricing model in the literature.

Prior studies indicate that macro, micro conditions, and even biodiversity risk may affect firm performance (Ahmad & Karpuz, 2024; Bach et al., 2024; Bassen et al., 2024; Cevik & Miryugin, 2023; Garel et al., 2024; Vu et al., 2024). Microeconomics are firm attributes (micro risks) or internal factors (e.g., size, assets, liability, equity, investment, production policies, culture, and governance) and generally within management's control. In contrast, the macro risks (e.g., GDP, inflation, economic policy uncertainty, unemployment rate, geopolitical risk, interest, tax, exchange rates, etc.) are external sources, non-diversified risks, and beyond the control of management (Egbunike & Okerekeoti, 2018; Iqbal et al., 2020).

Macroeconomic risks can wield either positive or negative effects on firm performance, depending on the nature and severity of macroeconomic conditions. Evidence from major episodes of financial instability, including the Latin American and East Asian crises and the 2007–2009 global financial crisis, illustrates how macroeconomic shocks can substantially affect firms' financial outcomes and operating environments (Cheong & Hoang, 2021). More recently, the economic recession in Nigeria has further highlighted the consequences of macroeconomic instability for corporate survival, with prolonged adverse conditions reportedly contributing to the delisting of several firms (Zeitun et al., 2007). Beyond recessionary pressures, fluctuations in nominal interest and inflation rates can influence firms' financing conditions, operating costs, cash flows, and ultimately their probability of financial distress or default. Monetary policy is particularly consequential because changes in policy conditions can affect firms' after-tax cash flows, cost of capital, and aggregate product demand, thereby shaping investment decisions, financial performance, and even firms' long-term survival prospects (Zeitun et al., 2007). As a result, these arguments suggest that macroeconomic conditions constitute an important external source of risk that can materially shape firm-level performance and financial resilience.

Prior studies often use firm attributes (micro risks) as determinants of firm performance (Ayalew, 2021; Dao & Ta, 2020; Dang et al., 2018; Raja & Kumar, 2005). Among commonly used measures of firm performance, accounting-based indicators such as return on assets (ROA) and return on equity (ROE) remain widely employed because they capture firms' realized profitability relative to their asset and equity bases (Arioglu, 2021; Chan & Chu, 2022; Dao & Ta, 2020; Lee et al., 2019). Nevertheless, the

informational content of these measures is inherently influenced by the underlying accounting framework and the recognition, measurement, and valuation choices embedded in financial reporting. In particular, accounting performance measures depend on the timing of revenue and expense recognition, asset and liability valuation, depreciation and impairment policies, and other accounting estimates that may involve substantial managerial judgment. Therefore, differences in accounting policies and estimation practices can affect the comparability and reliability of accounting-based measures across firms and over time (Govindarajan, Rajgopal et al., 2018; Kieso et al., 2024).

These limitations are further compounded by the possibility of managerial discretion and earnings management. Although financial reporting standards are designed to enhance the reliability and comparability of reported information, empirical evidence and audit-related investigations indicate that firms may, in some circumstances, use accounting choices or reporting practices to influence the presentation of revenues, expenses, assets, and liabilities, potentially obscuring their underlying economic conditions (Chapman, 2022; Roychowdhury, 2006; U.S. News & World Report, 2022; Vo et al., 2022). Moreover, certain economically relevant resources and obligations—particularly internally generated intangible assets, intellectual capital, and other forms of non-financial information—may not be fully recognized or separately reported under applicable GAAP or IFRS requirements. As a result, accounting statements may not capture the full spectrum of information available to investors when evaluating a firm's economic value and future prospects (Govindarajan, Srivastava et al., 2021).

By contrast, market-based measures can incorporate investors' expectations regarding a firm's future profitability, growth opportunities, risk, and other information that may not be fully reflected in historical accounting numbers. This distinction is particularly relevant in relatively efficient capital markets, such as the US market, where security prices are expected to incorporate publicly available information rapidly. Accordingly, while accounting-based measures such as ROA and ROE provide important information about realized operating and financial performance, market-based measures may offer a more forward-looking assessment of firm value and performance. This suggests that relying exclusively on accounting-based indicators may provide an incomplete representation of firm performance, thereby supporting the use of market-based measures as complementary indicators in empirical corporate finance research.

In recent years, US firms have had to deal with increasingly complex macroeconomic conditions characterized by the COVID-19 pandemic, geopolitical conflicts in Ukraine and the Middle East, elevated inflation, and substantial increases in interest rates (Carlsson-Szlezak et al., 2022, 2023; Cheong & Hoang, 2021; Isayas, 2022). These developments have heightened macroeconomic uncertainty and created significant challenges for firms through their effects on financing costs, aggregate demand, investment conditions, supply chains, and business expectations. Consistent with these developments, worldwide evidence points out significant associations between macroeconomic risks and firm performance across different countries and economic settings (Fung et al., 2011; Hussain et al., 2021; Pervan et al., 2019; Reyad et al., 2022).

Despite this growing body of international evidence, relatively limited recent research has systematically examined the relationship between macroeconomic risks and firm performance in developed economies, particularly the US (Browne et al., 2001; Doruk, 2019; Issah & Antwi, 2017). Existing studies have also tended to concentrate on specific sectors, with financial institutions receiving substantially greater attention because of their direct exposure to interest rates, inflation, credit conditions, and monetary policy (Athanasoglou et al., 2008; Hasan et al., 2018; Isayas, 2022). Therefore, the effects of macro risks on the broader population of non-financial firms remain comparatively underexplored. Addressing this gap is important because macro shocks can affect firms through multiple transmission channels, while the magnitude and direction of these effects may vary according to firms' operating and financial characteristics. More comprehensive studies of the relationship between the macro risk–firm performance are urgent. These studies can contribute to the macro-finance literature while providing managers, investors, and scholars insights of how macro risks and firm performance are related, firm's risk exposure and investment decisions. As a result, the managers and investors can manage these risks and their investment more effectively.

The accounting-based measures as proxies for firm performance are easily tampered with and may not fully capture the financial health of a firm. As a result, they may not be more effective than the hybrid and market-based ratios in representing firm performance. Importantly, managers rely on performance metrics to evaluate strategic investments, capital structure, dividend policy, and risk management, while investors use them in stock valuation and portfolio allocation. Consequently, choosing a suitable firm-performance metric and understanding its determinants are significant to managers, investors, and scholars.

This study focuses on contributing to the ongoing literature and narrows the gaps between the earlier and the more recent empirical research by scrutinizing whether the choice of firm-performance metric influences conclusions regarding the relationship between macro risks and firm performance. Although each performance measure has distinct advantages and limitations, prior studies often rely on a single firm-performance metric, the accounting-based ones, and then implicitly assume that empirical findings are invariant and independent of the chosen performance measurement. This assumption is particularly problematic when investigating the effects of macroeconomic factors because accounting-based, hybrid, and market-based measures may respond differently to changes in systematic economic conditions.

Accordingly, this study challenges the above assumption by contrasting the hybrid Q-based ratio and market-based excess stock return with accounting-based ROA as proxies for firm performance within a unified Bayesian framework and macro risk asset pricing model based on the macro-finance theory, as in Equations 1 to 3. Besides, this study employs a robust Bayes estimator and MCMC sampling. Few studies use a Bayesian framework and MCMC sampling capable of incorporating parameter uncertainty through posterior distributions and long-term effects. Bayesian inference provides richer probabilistic interpretation while offering additional robustness when analyzing data. The impact of macro risks (instead of firm attributes) on the firm performance is also analyzed and validated within this setting using the confidence interval approach, the test hurdle t-statistic of 3.0 from the frequentist statistics, and economic effect (Cheng et al., 2022; Wong & Pham, 2023; Wong et al., 2024). As a result, the findings

offer valuable insights and practical implications for managers, investors, and scholars evaluating firm performance, cost of equity, resource allocation, dividend policy, and investment planning in an increasingly uncertain economic environment. This study also strengthens the importance of the macro risk asset pricing model in the literature.

2 Literature Review and Hypothesis Development

2.1 Theoretical Foundation

Macro Finance Theory

This theory examines the relationship between asset prices, firm performance, and economic shocks (Cochrane, 2017). These main shocks include interest rates, inflation, money supply, exchange rate, GDP, etc. Therefore, macroeconomic conditions represent an important external environment within which firms operate.

The interest-rate risk is one of the most important macro risks of firm performance. Changes in lending rates directly affect firms' borrowing costs and investment opportunities. Low real and nominal interest rates will reduce the cost of financing, often leading to an increase in investment and firm performance. Previous studies have reported significant relationships between interest rates and firm performance, although the direction and magnitude of these effects vary across markets and periods.

Long-term government bond yields also contain valuable information regarding future economic conditions. Government bond yields influence the term structure of interest rates and affect firms through capital market channels. Higher bond yields increase the attractiveness of fixed-income securities relative to equities, potentially reducing stock valuations. At the same time, bond yields often reflect market expectations regarding inflation, economic growth, and monetary policy. Hence, fluctuations in bond yields can significantly affect corporate financial performance.

Exchange rate risk represents another important macroeconomic factor, particularly in increasingly globalized financial markets. Exchange rate movements influence export competitiveness, import costs, foreign revenues, and international investment activities. Firms with significant international exposure may experience substantial changes in profitability and market valuation following exchange rate fluctuations. Therefore, exchange rate risk is expected to influence both accounting-based and market-based measures of firm performance.

Asset Pricing Theory

From an asset pricing perspective, macroeconomic risks influence both expected cash flows and discount rates. One of the most extensively examined macroeconomic variables in the literature is the market risk premium. The market risk premium represents the additional return investors require for holding risky assets instead of risk-free securities. A firm with greater systematic risk requires higher expected returns.

In the traditional capital asset pricing model (CAPM, Sharpe, 1964) and asset pricing literature, various studies (Malkiel, 2023; Pham & Phuoc, 2020b) argue that to enhance performance, a firm should not spend time and resources to manage its idiosyncratic or specific risks, but the systematic (market) and other macro risks. The reason is that the idiosyncratic risks can be minimized in a well-diversified portfolio. Multi-factor models (French, 2018, 2020; Feng et al., 2020; Hou et al., 2019, 2021) point out that systematic risk is also significant to firm performance. Hence, the expected returns of stock and firm performance are positively related to systematic market risk. This argument indicates that the changes in market risk conditions can influence firm performance, valuation, and financing costs.

Since market-based measures directly incorporate these expectations, they should provide a more comprehensive representation of firms' exposure to systematic risk. Therefore, empirical relationships between macroeconomic variables and firm performance may differ substantially depending on whether accounting-based, hybrid, or market-based measures are employed.

2.2 Firm-Performance Measurement

Firm performance is a multidimensional concept that reflects a firm's ability to create value for shareholders and other stakeholders. Consequently, researchers have employed various measures to capture different aspects of organizational performance. Accounting-based indicators ROA and ROE are among the most widely used measures (Arioglu, 2021; Chan & Chu, 2022; Dao & Ta, 2020; Miah et al., 2026) in corporate finance and strategic management research. The accounting-based measures evaluate managerial effectiveness in utilizing corporate resources and generating profits from invested capital. Their popularity stems from their availability, simplicity, and direct connection to financial reporting systems.

Razak and Palahuddin (2014) examined the relationship between firm performance using the ROA metric and earnings management using Malaysian listed firms from 2007 to 2011. This study showed that ROA was negatively associated with earnings management. Similarly, Okougbo and Okike (2015) documented a positive association between ROA and earnings management among non-financial Nigerian firms. Another recent study, Chan and Chu (2022), provides an important examination of the relationship between corporate governance, (represented by independent directors, board size, and CEO duality), ownership structure (represented by foreign ownership, state ownership, domestic private ownership, state-control status) and firm performance as measured by ROA and ROE with firm attributes as control variables in the context of Chinese firms. This study is particularly relevant because Chinese dual-listed companies operate within a distinctive institutional environment characterized by concentrated ownership, substantial state participation, evolving investor protection, and differences between domestic and international capital-market institutions. Using a sample of 100 dual-listed Chinese firms on the Shanghai or Shenzhen Stock Exchanges and the Hong Kong Stock Exchange during the period from 2003 to 2019, the main findings of this study indicate that state ownership is negative but insignificant in affecting firm performance. However, the state-control status is positive and significant for both ROA and ROE. Similar results are found in another study. Miah et al. (2026) tested the relationship between family ownership

and female participation in board governance, influencing firm performance via ROA and Tobin's Q, using 50 manufacturing firms listed on the Dhaka Stock Exchange from 2017 to 2023. The findings showed that family ownership is negatively associated with firm performance. Besides, the independent female directors significantly increased Tobin's Q by 2.06 units, and foreign female directors improved ROA by 1.72 percentage points.

The accounting-based measures are widely used in the literature. However, they are inherently backward-looking and may be influenced by accounting conventions and methods, earnings management practices, depreciation policies, and managerial discretion (Govindarajan, Rajgopal et al., 2018; Kieso et al., 2024). Moreover, financial statements may not fully capture intangible assets, innovation capability, growth opportunities, and other value-relevant information that increasingly characterize modern firms (Govindarajan, Srivastava et al., 2021; Kieso et al., 2024).

To address the limitations of accounting-based metrics, the hybrid and market-based measures are also considered. Hybrid measures attempt to combine the strengths of accounting and market perspectives. Tobin's Q is among the most widely used hybrid indicators because it incorporates both accounting information and market valuation (Miah et al., 2026). Unlike accounting-based measures, Tobin's Q reflects investors' expectations regarding future profitability and growth opportunities. At the same time, it maintains a connection with firms' underlying asset base. Consequently, Tobin's Q is often regarded as a more comprehensive measure of firm performance than purely accounting-based indicators.

Market-based indicators, including stock returns, incorporate investors' expectations regarding future cash flows, growth opportunities, and risk exposures. According to efficient market theory, stock prices aggregate publicly available information and therefore provide a forward-looking assessment of firm performance. As a result, market-based measures may react better to changes in economic conditions than accounting-based measures.

2.3 Evidence on Macro Risk and Firm Performance

Macro risks constitute an important source of systematic risk affecting corporate performance. Unlike firm-specific factors or micro-risks, these macro risks cannot be diversified away and influence virtually all firms operating within an economy. Asset pricing theory suggests that investors require compensation for bearing systematic risk because such risks affect expected future cash flows and discount rates.

There is some evidence that macro risks affect firm performance worldwide. Some studies examined the relationship between macro risks and firm performance in the EU. Clare and Thomas (1994) employed the beta sorted portfolios, monthly data of the UK stock market from 1983 to 1990, and 18 macro risks. This study showed that the oil price, market risk, inflation rate, bank lending rate, and bond yield affected stock prices in the UK. Pasiouras and Kosmidou (2007) evaluated the impact of inflation and GDP growth rates on the domestic and foreign commercial banks' financial performance (ROA) in the 15 EU countries during 1995-2001. They found that the macro risks affected the banks' ROA with different signs for domestic and foreign banks. Similarly, Athanasoglou et al. (2008) examined the impact of inflation

expectations and cyclical output on Greek banks' ROA and ROE from 1985 to 2001. They found that expected inflation positively and significantly affects banks' financial performance, and the impact of the cyclical output is asymmetric.

Other studies examined the relationship between macro risks and firm performance in the EU's non-financial industry. Issah and Antwi (2017) evaluated the impact of the 59 macro risks and the lagged ROA in the UK. They found that the adjusted unemployment rate, benchmarked unit labor costs, real GDP, and the exchange rate were significant variables. Doruk (2019) examined the impact of trade openness, financial depth, real exchange rate, and GDP growth rate on the firm performance (a ratio of net operating profit to capital stock) in the Turkish manufacturing sector from 2006 to 2017. This study found that all four macro risks significantly impact the firm's performance. Similarly, Pervan et al. (2019) looked at the impact of GDP growth and inflation rates on the ROA in Croatia from 2006 to 2015 and found that these two determinants greatly impacted the ROA.

Some other studies examined the relationship between macro risks and firm performance in developing countries and Asia. Egbunike and Okerekeoti (2018) investigated the impact of interest, inflation, exchange, and GDP growth rates on the ROA of firms listed on the Nigerian Stock Exchange from 2011 to 2017. They found that inflation and GDP growth rates significantly affected ROA. Ho and Mohd-Raff (2019) analyzed the effect of the inflation rate, trade openness, interest rate, exchange rate, money supply, and GDP growth rate on the ROA and ROE of Shariah-compliant and non-Shariah-compliant firms in Malaysia from 1999 to 2015. They found that the interest rate, trade openness, and exchange rate marginally affected the ROA and ROE. Lee et al. (2019) examined the association between the Taiwan misery index and the unemployment rate, the annual inflation rate, and the ROA and ROE of Taiwanese food firms from 2010 to 2016. They found a negative relationship between the misery index and the firms' ROA and ROE. Isma et al. (2023) examined the impact of inflation on firm performance (Tobin's Q is used as a proxy) in Indonesia from 2016 to 2021. Using a sample of 696 publicly traded firms from the Indonesia Stock Exchange, this study showed that inflation harmed firm performance.

There are studies examining the nexus between US macro risks and the performance of US firms. Graham and Harvey (2001) surveyed 392 chief financial officers (CFOs) from large Fortune 500 companies in 1999 about the models and determinants of firm performance. One of the results from this study showed that exchange rate risk was often considered one of the most important risks and included in the model, especially for large companies and company leaders with MBA degrees. Faria and Mollick (2010) examined Tobin's Q of US firms, which was below 1 for most of the time during the last 50 years, even though the US economy grew robustly in this postwar period. Using data from 1953 to 2000, this study found that the US inflation strongly hurt firm performance via Tobin's Q. Iqbal et al. (2020) examined the relationship between the macro risk, economic policy uncertainty, and firm performance via ROA, ROE, profit, and Tobin's Q of the US publicly traded firms. This study found that this macro risk harmed firm performance through all four proxies.

Another study examined the relationship between four macro risks and the firm performance (stock returns) in the US. Using a macroeconomic asset pricing model, Pham and Phuoc (2020b) investigated the relationship between the excess market return, US prime rate, long-term US government bond yield, and USD/EUR and excess stock returns of S&P 500 firms from 2007-2019. They found that the US prime rate had a negative impact, but the other three determinants significantly positively impacted stock returns. Dai and Zhou (2020) and Dai and Zhu (2020) examined the relationship between 14 macro risks and firm performance (stock returns) from 1927 to 2017. They found significant stock return predictability both in statistical and economic terms.

Another study (Ding, 2021) examined the relationship between exchange rates and firm stock prices in the US stock market from 1991 to 2020. The results showed that stock prices in the US stock market are closely correlated with the exchange rate, especially for stocks with high sensitivity to exchange rates. Similarly, Deng et al. (2022) studied the impact of lockdown and other social-distancing policies and interest rates on firm stock prices across 11 countries (Argentina, Australia, Canada, China, India, Italy, the United Kingdom, the United States, Singapore, Spain, Sweden) and Hong Kong during the Covid-19 pandemic using the difference-in-difference method. One of the findings of this study showed that the interest rate had a negative and substantial impact on firm stock prices. Reyad et al. (2022) examined the nexus between macro risks, economic policy uncertainty, and exchange rate risk, and firm performance via cash conversion cycle and ROA from 2006 to 2020. One of the results showed that these macro risks strongly affected the firm's performance.

The sensitivity of firm performance to macro risks may depend on how performance is measured. The accounting data is reported periodically and reflects transactions in past periods. As a result, the accounting-based measures primarily capture realized outcomes. Since the market is not always in the form of strong form efficiency, macroeconomic shocks may take time to be fully reflected in accounting performance indicators. In contrast, market-based measures incorporate investors' expectations regarding future economic conditions and firm prospects. Stock prices and firm performance respond continuously to new information and therefore may reflect macroeconomic shocks more rapidly than accounting-based indicators. Similarly, hybrid measures such as Tobin's Q capture both current firm fundamentals and expected future growth opportunities, potentially making them more sensitive to systematic economic risks.

Although prior studies generally confirm the importance of macro risks in explaining firm performance, empirical findings still remain mixed. One possible explanation is that alternative performance measures capture different dimensions of firm operating outcomes and therefore exhibit different sensitivities to macroeconomic shocks. Hence, this argument suggests that performance measurement is not merely a methodological choice but may fundamentally affect conclusions regarding the determinants of firm performance.

2.4 Hypothesis Development

As proxies for firm performance, the accounting-based, hybrid, and market-based indicators capture different dimensions of firm performance; their ability to reflect macroeconomic influences may vary. The accounting-based measures rely on the past accounting data; therefore, they are easily managed by accounting methods and controlled by managers (Govindarajan, Rajgopal et al., 2018; Kieso et al., 2024). In contrast, the hybrid and market-based measures rely on the market data that limit the influence of managers. Hence, they may be more efficient in representing firm performance. Given the evidence suggesting that the hybrid and market-based measures respond quickly to the macro risks, the hypothesis is constructed as follows:

H1: The hybrid and market-based performance measures provide greater explanatory power than accounting-based measures in capturing firms' exposure to macroeconomic risks.

Asset pricing theory suggests that systematic market risk influences firm performance and expected returns through its effect on required rates of return. Consequently, firms' performance should be significantly associated with changes in the market risk premium.

H2: Market risk premium is significantly associated with firm performance.

Interest rates influence firms through financing costs, investment opportunities, and discount rates. Changes in lending rates, therefore, alter corporate profitability and market valuation.

H3: Prime rate risk premium is significantly associated with firm performance.

Government bond yields contain information regarding macroeconomic expectations and influence capital allocation decisions between equity and debt markets. As a result, fluctuations in long-term government bond yields are expected to affect firm performance.

H4: Long-term government bond yield risk premium is significantly associated with firm performance.

Exchange rate movements influence firms' revenues, costs, competitiveness, and international investment activities. Therefore, exchange rate risk should exert a significant effect on firm performance.

H5: Exchange rate risk is significantly associated with firm performance.

3 Data and Methodology

3.1 Data

None of the capital markets in the world is known to be perfectly efficient or in a state of strong form efficiency at all times. However, compared with other markets, the US market provides an appropriate setting for this investigation because it hosts one of the world's largest and most liquid capital markets, characterized by a high degree of informational efficiency and extensive investor participation. In addition, the stocks of the S&P 500 firms are known to be more efficient since they are the largest US firms. As a result, this study purposely selects only these firms (432 firms) to make sure the results can hold up in other, less efficient markets or stocks (Pham & Phuoc, 2020b). The S&P 500 data are also employed numerous times in finance literature. Similarly, the S&P 500 index, the finest gauge of large-cap US stocks, is also used as the market data (Fama & French, 2018, 2020). The risk-free rate (the three-month US

Treasury secondary market rate) and data of the other three macro risks (secondary market rate) are collected from the Federal Reserve Economic Data (FRED), Federal Reserve Bank of St. Louis (<https://fred.stlouisfed.org>).

This study uses three data sets. The two hand-collected quarterly data sets are for the Q-based ratio and ROA, since these ratios are calculated using accounting information from financial statements. The daily data is for the excess stock returns, about 3,600 observations for each firm, using adjusted prices from a credible source, Yahoo Finance (<https://finance.yahoo.com/>). The quarterly and daily data used in this study are more efficient than annual data (Cenesizoglu et al., 2019; Hollstein, 2020; Hollstein et al., 2020; Pham & Phuoc, 2020a). In addition, this study employs a non-parametric Bayes estimator to calibrate the possible effects from outliers in stock returns (Bian et al., 2013; Phuoc et al., 2018; Phuoc & Pham, 2020).

The data is collected from 2007 to 2022, a short horizon that aligns with other studies (Berry-Stölzle & Xu, 2016; Pham & Phuoc, 2020b). This sample period is particularly suitable for examining macroeconomic risk exposure since it encompasses several major economic events, including the global financial crisis, the COVID-19 pandemic, and the subsequent monetary tightening cycle. Therefore, this sample provides a comprehensive environment for assessing the responsiveness of alternative firm-performance measures to systematic economic conditions.

3.2 Methodology

3.2.1 Variables and Models

This study employs three dependent variables: the ROA (Equation 1), the Q-based ratio (Equation 2), and excess stock returns (Equation 3), the accounting, hybrid, and market-based ratios, respectively, and they are proxies for the firm performance.

The ROA, Q-based ratio, and excess stock returns on the stock of firm i , $i = 1, 2, 3, \dots, N$ at time t , $t = 1, 2, \dots, n$ are calculated as follows:

$$ROA_{it} = \frac{Net\ income_{it}}{Total\ Assets_{it}}, \quad (1)$$

$$Q_{it} = \frac{Capitalization_{it}}{Assets_{it}}, \quad (2)$$

$$Excess\ stock\ return_{it} = R_{it} - R_{ft} = \frac{(P_{it} - P_{it-1})}{P_{it-1}} - R_{ft}, \quad (3)$$

where,

- ROA_{it} : Return on assets of firm i at time t ,
- Q_{it} : Q-based ratio of firm i at time t ,

- R_{it} : Return on the stock of firm i at time t ,
- R_{ft} : Risk-free rate at time t ,
- P_{it} : Stock price of the firm i at time t ,
- P_{it-1} : Stock price of the firm i at time $t-1$.

Based on the macro-finance theory and the findings of other recent empirical studies (Ding, 2021; Fromentin et al., 2022; Graham & Harvey, 2001; H. Vo & D. Vo, 2023), this study proposes the excess market return and three other risks including US prime rate, long-term US government bond yield, and the exchange rate of USD/EUR as proxies for macro risks as independent variables in the model to examine the effects of macro risks on firm performance. Hence, these models are as follows:

For the stock of firm i , $i = 1, 2, 3, \dots, N$ at the time t , $t = 1, 2, \dots, n$, the relationship between the excess market return, US prime rate, long-term US government bond yield, and USD/EUR and the ROA (Model 1 - Equation 4), Q-based ratio (Model 2 - Equation 5) and excess stock return (Model 3 - Equation 6) are as follows:

$$ROA_{it} = \alpha_i + \beta_i(RM_t - RF_t) + \gamma_i(US_t - RF_t) + k_i(LTB_t - RF_t) + \lambda_i EX_t + \epsilon_{it}, \quad (4)$$

$$Q_{it} = \alpha_i + \beta_i(RM_t - RF_t) + \gamma_i(US_t - RF_t) + k_i(LTB_t - RF_t) + \lambda_i EX_t + \epsilon_{it}, \quad (5)$$

$$R_{it} - RF_t = \alpha_i + \beta_i(RM_t - RF_t) + \gamma_i(US_t - RF_t) + k_i(LTB_t - RF_t) + \lambda_i EX_t + \epsilon_{it}, \quad (6)$$

where,

- ROA_{it} : Return on assets of firm i at time t ,
- Q_{it} : Q-based ratio of firm i at time t ,
- R_{it} : Return on the stock of firm i at time t ,
- RM_t : Return of the market portfolio at time t ,
- RF_t : Risk-free rate at time t ,
- US_t : US prime rate at time t ,
- LTB_t : US government's long-term bond yield at time t ,
- EX_t : Exchange rate of USD/EUR at time t ,
- α_i : Jensen's alpha coefficient (alpha) of the stock of firm i ,
- β_i : Market risk coefficient (beta) of the stock of firm i ,
- γ_i : Interest risk coefficient (gamma) that the stock of firm i is bearing,
- k_i : US government's long-term bond yield risk coefficient (kappa) that the stock of firm i is bearing,
- λ_i : Exchange rate risk coefficient (lambda) that the stock of firm i is bearing,
- ϵ_{it} : Random error term with a mean of zero and variance σ^2 (Sigma2).

3.2.2 Bayesian Framework, MCMC Sampling, and Non-Parametric Estimator

This study applies the frequentist approach but the Bayesian framework and MCMC (Gibbs) sampling with 100,000 iterations per chain and three chains per stock to minimize errors in data mining and avoid data bias (Advani et al., 2019; Barillas & Shanken, 2018; Dyckman, 2016; Kothari & Warner, 2001). Another unique characteristic of the Bayesian statistical method is that it uses prior knowledge about the theta parameter (Θ , prior distribution) (Dyckman, 2016) to determine/estimate the posterior distribution. Another reason for using the Bayesian method is that it works exceptionally well with time-series data of stock returns because the parameters may not be fixed, not meeting the assumption of the frequentist approach (Ang & Liu, 2004; Ferson & Harvey, 1999; Jostova & Philipov, 2005). Using the WINBUGS software, this study estimated the posterior distribution of the parameters of interest (e.g., model fit, beta, gamma, kappa, lambda, and Bayesian posterior confidence intervals of the parameters) much more easily than the frequentist approach. Other studies in the field of economics and finance discussed and successfully applied Bayesian statistical methods (Pham & Phuoc, 2020a, 2020b; Wong & Bian, 2000). To make sure the MCMC sampling convergence and results of the sampling are reliable, we ran three chains, then inspected Gelman-Rubin potential scale reduction factor (Brooks & Gelman, 1998; Gelman & Rubin, 1992) of the interested parameters against the threshold of one or close to one. The trace plot and posterior density of the parameters of interest in each sampling were also examined in the process. We also examined the ratio of the sample parameter MC error to its standard deviation (MC error/sd) against the threshold of 5% (Spiegelhalter et al., 2003). Using the Bayesian framework, this study used a different technique to address possible non-stationarity in data and autoregressive variables (Wong & Pham, 2023). First, the autocorrelation plot of each interested parameter of each sampling is screened, and then a burn-in rate of 5,000 and a thin of 10 per sampling was applied. In addition, the data were from 2007 to 2022, a short time span to yield a meaningful unit root test (URT) (Dickey & Fuller, 1981; Greene, 2003). Besides, a unit-root test conducted with a p -value of less than 5% for stationarity does not necessarily provide reliable results from the subsequent regression (Wong et al., 2024). Furthermore, if the first or second difference techniques are applied, then the new parameter is not the original parameter as in the model, and therefore, the interpretation of this new parameter may not be directly related to the objectives of this study. Hence, in this Bayesian framework, the URT was not really necessary to be done. This practice is common and consistent with many recent studies (Fama & French, 2018, 2020; Fromentin et al., 2022).

The actual stock returns always contain outliers and are not necessarily normally distributed (Jostova & Philipov, 2005; Phuoc, 2018; Wong & Bian, 2000). Therefore, a parametric estimator may not be more efficient than a robust estimator (Bian et al., 2013; Phuoc et al., 2018; Phuoc & Pham, 2020). Therefore, to ensure the robustness of the results, this study uses the non-parametric Bayes estimator since it does not need to rely on the assumption of normality of stock returns. More precisely, this study uses the Student's t -distribution with 3 degrees of freedom (the variance of this distribution is also: $3/(3-2) = 3$) because of its flat tails, making it more suitable for outliers than the normally distributed, and when the variance of the data is unknown. Some studies discussed and successfully applied this non-parametric estimator in economics and finance (Pham & Phuoc, 2020a, 2020b; Phuoc & Pham, 2020; Wong & Bian, 2000). In addition, with a large number of observations per firm, especially the daily stock returns from Model 3, the normally distributed data is supported by the law of large numbers, and the data has the

property of stationarity (Cheng et al., 2021, 2022). The weak-informative priors, a Gaussian distribution with a mean of 0 and a variance of 1, are applied to reflect the oscillations of stock prices and macro risks.

Most studies in this field analyzed collected data directly without simulations. This practice could produce bias in results (Advani et al., 2019; Barillas & Shanken, 2018). Also, the test t -statistics of 2.0 or lower are often employed to make decisions in hypothesis testing. This threshold is inadequate, so the newfound factor could be just pure luck (Harvey & Liu, 2021; Harvey et al., 2016). Besides, if the p -value is used in hypothesis testing, the results of this approach could be affected by the sample size, and it is a trade-off between type 1 and type 2 errors (Dyckman, 2016; Ranstam, 2012; Wasserstein & Lazar, 2016). Furthermore, this approach cannot distinguish between statistical and economic significance. These weaknesses can mislead the interpretation of findings (Dyckman & Zeff, 2019; Greenland et al., 2016; Halsey, 2019). As a result, this study employs the Bayesian framework and MCMC sampling on the real data. The confidence interval approach, t -statistic of 3.0 from the frequentist approach, and economic effect are used for hypothesis testing and interpretation of findings (Cheng et al., 2022; Wong et al., 2024).

4 Results and Discussion

4.1 *The model fit (R2B)*

The first objective of this study is to evaluate whether alternative firm-performance measures differ in their ability to capture firms' exposure to macro risks. The Bayesian R-squared (R2B), an adjusted R-squared, is a statistical measure that represents the proportion of the variance in the dependent variable explained by the independent variables. Hence, the higher R2B implies a better fit and a more predictive model. The Bayesian estimation results of R2B reveal substantial variation across performance measures, suggesting that the choice of performance proxy materially influences empirical conclusions regarding firm performance determinants.

Specifically, Table 1 showed the mean and 95% confidence interval of R2B of 0.538 and (0.143, 0.934), respectively, for the ROA model. Table 1 also showed the mean and 95% confidence interval of R2B of 0.675 and (0.624, 0.726), respectively, for the Q-based ratio model. Similarly, Table 1 showed the mean and confidence interval of R2B of 0.799 and (0.794, 0.803), respectively, for excess stock return. These results indicate that three models fit 53.8%, 67.5%, and 79.9% of the observed data, respectively. As a result, the firm performance (ROA, Q-based ratio, and excess stock returns) can be well explained by the selected variables (excess market return and three macro risks) in the model. More importantly, the ROA yields the lowest, and the market-based ratio (excess stock returns) yields the highest model fit compared with the other two models. In addition, the ROA yields the longest, and the market-based ratio (excess stock returns) model yields the shortest confidence interval of model fit compared with the other two models. These findings imply that the ROA is less effective than the Q-based ratio and excess stock returns. As a result, the conclusion supports the hypothesis H1 that the hybrid and market-based performance measures provide greater explanatory power than accounting-based measures in capturing firms' exposure

to macroeconomic risks. This conclusion is in contradiction to the use of other studies (Athanasoglou et al., 2008; Doruk, 2019; Issah & Antwi, 2017; Lee et al., 2019; Pervan et al., 2019).

The efficient market hypothesis indicates that stock prices continuously incorporate new information and investor expectations. Therefore, the hybrid and market-based performance measures are likely to reflect macroeconomic shocks more rapidly than accounting-based measures, which rely on past financial accounting data and are subject to accounting conventions and methods. As a result, the hybrid and market-based metrics are recommended as measures of firm performance rather than the traditional accounting-based ratio ROA, which is aligned with the efficient market hypothesis.

The findings also contribute to the growing literature by questioning the adequacy of traditional accounting ratios, such as ROA and ROE, as indicators of firm performance despite their common use in empirical studies. Therefore, the findings of this study suggest that managers, investors, and scholars should exercise caution when interpreting empirical results based solely on accounting performance measures, as conclusions about firm performance determinants may depend critically on the performance metric employed.

Table 1. The means and 95% confidence intervals of R2B of ROA, Q-based ratio, and excess stock return.

Model	Mean	95% confidence interval
ROA	0.538 (53.8%)	(0.143, 0.934)
Q-based ratio	0.675 (67.6%)	(0.624, 0.726)
Excess stock returns	0.799 (79.9%)	(0.794, 0.803)

Note: Results are from statistical inference.

4.2 The variance inflation factor (VIF)

VIF is frequently used to assess a regression model's degree of multicollinearity or intercorrelation between independent variables. Many practitioners view a VIF of greater than ten as an indicator of severe multicollinearity (J. Kim, 2019; O'Brien, 2007). Table 2 shows the VIF of four independent variables of 1.085, 1.292, 1.433, and 1.938, respectively. The average VIF of 1.437 is much smaller than 10. These findings mean there is no severe multicollinear relationship between the four independent variables. Therefore, the inferential statistics of the parameters of these four independent variables of these two models are reliable.

Table 2. The multicollinearity check using the VIF.

Variables	R^2	VIF
The market risk premium (RM – RF)	0.078	1.085
The US prime rate risk premium (US - RF)	0.226	1.292
The US government's long-term bond yield risk premium (LTB - RF)	0.302	1.433
The exchange rate (EX)	0.484	1.938
The average of VIFs		1.437

Note: The VIF is calculated as the ratio of $1/(1-R^2)$.

4.3 The Ratio of the Sample Parameter MC Error to Standard Deviation and Gelman-Rubin Statistics

As a general guideline, the simulation should be run until the results converge or stabilize, with the ratio of sample parameter MC error to its standard deviation (MC error/sd) less than 5% (Spiegelhalter et al., 2003). Using Winbugs, this study simulated the observed data with 100,000 iterations per chain and three chains in each sampling. The results showed that the ratio of MC error/SD of beta, gamma, kappa, and lambda was less than 5% for all 432 stocks for the Q-based ratio and excess stock return (not shown here). These findings indicate that the 100,000 iterations for the Q-based ratio and excess stock return are appropriate, and that the statistics for the four parameters in this research are reliable.

Furthermore, the results showed that the Gelman-Rubin statistic for parameters beta2, beta2, beta3, and beta4 approaches 1, suggesting satisfactory convergence of the three independent Markov chains and that they cover the entire posterior distribution. These results indicate that the statistics of beta1, beta2, beta3, beta3 are reliable. In addition, visual inspection of trace plots, posterior density plots, and autocorrelation plots (not shown here) confirms stable posterior sampling with no evidence of non-convergence. Overall, the diagnostics above imply that the posterior distributions are well identified and provide reliable statistical inference regarding the relationships between macroeconomic conditions and firm financial performance.

4.4 The Effect of Market Risk Premium and Three Macro Risks on Q-based Ratio and Excess Stock Returns

The Market Risk Premium and Firm Performance

First, this study examines the relationship between the market risk premium, the Q-based ratio, and excess stock returns via the beta coefficient. Table 3 showed that Q-based and excess stock return yielded betas of -0.21 and 1.02 with standard errors of 0.03 and 0.01, respectively. In addition, these two models yielded 95% confidence interval of the beta of (-0.27, -0.13) and (0.99, 1.04), respectively. These confidence intervals exclude 0, representing statistically significant results. These findings support hypothesis H2 that market risk premium is significantly associated with firm performance, negatively associated with the Q-based ratio, and positively associated with excess stock return. Importantly, two models yielded absolute t-statistics of 5.65 and 77.70 for hypothesis H2, exceeding the test hurdle of 3.0. This result is another very robust piece of evidence to support hypothesis H1 that the market risk premium is strongly associated with firm performance. These conclusions align with other studies (Barillas & Shanken, 2018; Dai & Zhou, 2020; Fama & French, 2018; Fung et al., 2011). It is worth noting that the market risk premium has an opposite association with the Q-based ratio and excess stock return. Importantly, it has a low but negative and a moderate positive economic effect of -6.28% and 30.52% on the Q-based ratio and excess stock return, respectively. This result suggests that the market risk premium has an economically meaningful effect on excess stock return.

The findings of this study suggest that the market risk premium may be an important determinant of excess stock returns, which reflect shareholder wealth. During periods of heightened risk, such as the global financial crisis and the COVID-19 pandemic, investors often require higher returns on risky assets. Therefore, firms with greater exposure to market risk experience more pronounced variations in stock-market performance. The findings are also consistent with the broader asset pricing literature emphasizing the role of systematic risk in determining expected returns. Importantly, the findings demonstrate that market-based performance measures can capture macro risk transmission mechanisms that may not be fully reflected in accounting-based indicators.

The negative relationship observed between market risk premium and Q-based ratio is interesting but expected. The asset pricing theory indicates that in periods of heightened risk, higher required returns are expected. This increases the firm's required cost of equity, cost of capital, and its discount rate. This reduces the present value of expected future cash flows. As a result, the capitalization or market value component of Tobin's Q decreases. Hence, the negative coefficient suggests that greater market-wide risk is associated with lower market-based firm valuation. Another possible reason is the asset component in Equation 2. An increase in the cost of capital lessens profits and growth expectations, thus reducing assets in the Q-based ratio.

The Prime Rate Risk Premium and Firm Performance

Second, this study inspects the relationship between the US prime rate risk premium, the Q-based ratio, and excess stock returns via the gamma coefficient. Table 3 showed that Q-based and excess stock return yielded gammas of 0.91 and -7.42 with standard errors of 0.059 and 1.59, respectively. These two models yielded 95% confidence interval for gamma (0.78, 1.02) and (-10.55, -4.28), respectively. These two confidence intervals exclude 0, representing statistically significant results. These findings support hypothesis H3 that prime rate risk premium is significantly associated with firm performance, positively associated with the Q-based ratio, and negatively associated with excess stock return. In addition, these two models yielded absolute t-statistics of 15.25 and 4.65 for hypothesis H3, exceeding the test hurdle of 3.0. This result is further evidence to support hypothesis H3 that the prime rate risk premium is strongly associated with firm performance. These results are inconsistent with other studies (K. Kim, 2003; Lin et al., 2018) but align with others (Dai & Zhou, 2020; Dai & Zhu, 2020; Pham & Phuoc, 2020b). In addition, the prime rate risk premium has the opposite association with the Q-based ratio and excess stock return. Significantly, the prime rate risk premium has a low and a moderate negative economic effect of 3.34% and -27.26% on the Q-based ratio and excess stock return, respectively. This finding indicates that the prime rate risk premium has an economically meaningful effect on excess stock return.

The strong negative relationship between prime rate risk premium and excess stock returns is consistent with conventional corporate finance theory. Higher lending rates increase firms' financing costs, reduce investment incentives, and raise discount rates applied to future cash flows. These effects collectively reduce equity valuations and expected stock returns. The finding is particularly relevant in the context of

the post-pandemic monetary tightening cycle, during which rising interest rates substantially altered firms' financing environments.

Interestingly, the positive relationship observed between the prime rate risk premium and Q-based ratio suggests a more complex mechanism. One possible explanation is the complex relation between interest rate and the firm's investment policy; increases in interest rates disproportionately affect firms with weaker investment opportunities, while firms possessing stronger growth prospects maintain relatively higher market valuations. Another possible reason is the asset component in Equation 2. Hence, investors may continue to give higher valuations to firms expected to generate good future growth despite a tighter monetary environment.

These findings highlight the importance of monetary policy as a channel through which macroeconomic conditions affect firm performance. These findings also suggest that different performance measures capture distinct dimensions of firms' responses to changes in borrowing costs and capital-market conditions.

The Government's Long-Term Bond Yield Risk Premium and Firm Performance

Next, this study checks the relationship between the US government's long-term bond yield risk premium, the Q-based ratio, and excess stock return via the kappa coefficient. Table 3 showed that Q-based and excess stock return yielded kappas of 0.004 and 1.64 with standard errors of 0.08 and 0.53, respectively. The 95% confidence interval for kappa (-0.15, 0.16) from the Q-based model includes 0, representing a non-statistically significant result. In contrast, the 95% confidence interval for kappa (0.58, 2.70) from the excess stock return model excludes 0, representing a statistically significant result. These findings support hypothesis H4 that the US government's long-term bond yield risk premium is significantly and positively associated with firm performance, the excess stock return. Further, the excess stock return model yielded an absolute t-statistic of 3.05 for hypothesis H4, exceeding the test hurdle of 3.0, providing another strong piece of evidence in support of hypothesis H4. These results contradict some studies (Jareno & Negrut, 2016) but agree with others (Dai & Zhou, 2020; Dai & Zhu, 2020; Pham & Phuoc, 2020b). Notably, the US government's long-term bond yield risk premium has no economic effect on the Q-based ratio but a moderate positive economic effect of 35.99% on excess stock return, evidence of an economically meaningful effect.

While the prime rate is an indicator for short-term interest rates, the government long-term bond yield is an important meter for long-term interest rates. In contrast with the strong negative relationship between prime rate risk premium and excess stock return, the positive relationship between bond yield risk premium and excess stock return may indicate that investors require additional compensation for increased uncertainty regarding future economic conditions. As bond yields rise, firms face changes in capital costs and valuation benchmarks, leading to adjustments in expected stock returns. This interpretation is consistent with intertemporal asset pricing theory, which emphasizes the role of macroeconomic state variables in determining expected returns. Furthermore, the finding suggests that investors incorporate

information embedded in bond markets when evaluating the future of a firm. Therefore, government long-term bond yields are an important macroeconomic signal that influences equity market performance.

The Exchange Rate Risk Premium and Firm Performance

Lastly, this study tests the relationship between exchange rate risk, the Q-based ratio, and excess stock return using the lambda coefficient. Table 3 showed that Q-based and excess stock return yielded lambdas of -0.09 and 0.04 with standard errors of 0.03 and 0.01, respectively. These two models yielded 95% confidence intervals of lambda of (-0.15, -0.04) and (0.01, 0.06), respectively. These two confidence intervals exclude 0, representing statistically significant results. These findings support hypothesis H5 that exchange rate risk is significantly associated with firm performance, negatively associated with the Q-based ratio, and positively associated with excess stock return. In addition, these two models yielded absolute t-statistics of -2.95 and 2.86 for hypothesis H5, which are close to the test hurdle of 3.0. These findings are additional evidence supporting hypothesis H5. These results are consistent with some studies (K. Kim, 2003; Nieh & Lee, 2001; Pham & Phuoc, 2020b). Also, exchange rate risk has little to no economic effect on the Q-based ratio and excess stock return.

The negative relationship between exchange rate risk and Q-based ratio indicates that currency volatility increases uncertainty regarding future cash flows. In general, investors are risk-averse; increases in risk will reduce equity valuation, a component of Tobin's Q. Also, macroeconomic theory points out that the exchange rate fluctuations may affect export competitiveness, import costs, foreign revenues, and foreign investment opportunities, thereby affecting profits and growth opportunities, another component of Tobin's Q. In contrast, the positive relationship between exchange rate risk and excess stock returns may reflect a risk premium that investors demand for bearing currency-related uncertainty. Firms with greater exposure to international markets may experience higher expected returns as compensation for increased exchange rate risk. The findings of this study reinforce the importance of exchange rate dynamics as a source of macro risk. They also demonstrate that market valuation and stock returns may respond differently to identical macroeconomic shocks, highlighting the multidimensional nature of firm performance.

Implications

The findings of this study provide strong evidence that macro risks are significantly and economically associated with firm performance, particularly the excess stock return. Importantly, the observed relationships depend critically on how performance is measured. The dominance of the Q-based ratio and excess stock return over ROA implies that these measures more effectively capture firms' exposure to systematic economic conditions.

The findings have several important implications. According to cost management theory, managers often look for ways to cut costs, especially during periods of weak economic growth or recession (Carlsson-Szlezak et al., 2022, 2023; Ogonnaya et al., 2022). However, the cost of equity (stock return) cannot be eliminated and tends to increase during periods of rising lending rates to cope with inflation, such as from

early 2021 to the present (U.S. Bureau of Labor Statistics, 2023). One strategy often applied in cost reduction is restructuring capital and costs (Tan & Luo, 2021). To restructure sources of capital, managers must know their firm's cost of equity (Dempsey & Sheng, 2023; Mazouz et al., 2023). The Model 3 employed in this study, which is more flexible than the traditional CAPM, could be used to derive a firm's systematic risk and cost of equity. Therefore, the findings can assist managers in constructing an effective capital restructuring policy.

Further, dividend policy is always one of the strategic policies managers care about (Akindayomi & Amin, 2022; Bond et al., 2019). Therefore, they need to develop a policy that is consistent with the interests of the firm, investors, and stakeholders (DeAngelo et al., 2000; Fama & French, 2001). To develop an effective dividend policy, the managers must clearly understand the firm's cost of equity (Dempsey & Sheng, 2023; Mazouz et al., 2023). Since the model (Model 3 - Equation 6) employed in this study could be used to derive a firm's systematic risk and cost of equity, the findings of this study can assist managers in constructing an effective dividend policy.

For both investors and managers, investment theory suggests that they always look for promising assets and stocks for their investments. As a result, rational investors and managers always evaluate potential investments (Suhadak et al., 2019; Zaigham et al., 2019). They often employ criteria such as net present value (NPV), internal rate of return (IRR), and return on invested capital (ROCE) to ensure that these investments generate value for the firm and its stakeholders. To derive these criteria, managers and investors need to know the discount rate - the cost of capital. Again, Model 3 can help derive a firm's cost of equity and capital. As a result, the findings of this study can assist managers and investors in their investment planning.

For other scholars, the findings of this study suggest that empirical conclusions about determinants of firm performance may not be robust across alternative performance measures. An effective choice of performance metric can lead to more robust models. The findings also show the effectiveness of the macro risk asset pricing model in the literature. The methodology used in this study may offer a robust approach to addressing parameter uncertainty in this field.

Table 3. The mean, 95% confidence interval, and *t*-statistic of the coefficients of Models 2 and 3.

Coefficient t	Estimate		Standard Error		95% Confidence Interval		<i>t</i> -statistic (from frequentist approach)		Economic Effect	
	Q-based ratio	Excess stock return	Q-based ratio	Excess stock return	Q-based ratio	Excess stock return	Q-based ratio	Excess stock return	Q-based ratio	Excess stock return
Beta	-0.21	1.02	0.03	0.01	(-0.27, -0.13)	(0.99, 1.04)	-5.65	77.7	-6.28%	30.52%
Gamma	0.91	-7.42	0.059	1.59	(0.78, 1.02)	(-10.55, -4.28)	15.25	-4.65	3.34%	-27.26%
Kappa	0.004	1.64	0.08	0.53	(-0.15, 0.16)	(0.58, 2.70)	0.05	3.05	0.09%	35.99%

Lambda	-0.09	0.04	0.03	0.01	(-0.15, -0.04)	(0.01, 0.06)	-2.95	2.86	-0.29%	0.13%
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Note: Results are from statistical inference.

5 Conclusions

The accounting-based measures are often used in practice and research, but are easily manipulated and do not fully capture a firm's financial health. This study inspects whether the choice of firm performance metric influences conclusions about the relationship between macro risks and firm performance. Prior studies often implicitly assume that empirical findings are invariant to performance measurement. This study contests that assumption and examines the effectiveness of the accounting-based ROA, a hybrid Q-based ratio, and the market-based excess stock return within a unified Bayesian framework and a macro risk asset pricing model.

Using data of the S&P 500 firms from 2007 to 2022, a Bayesian framework, MCMC sampling, a non-parametric estimator, the confidence interval, t-statistic of 3.0, and economic effect, this study examines the relationship between market risk premium, prime rate risk premium, long-term government bond yield risk premium, exchange rate risk, ROA, a Q-based ratio, and excess stock returns. The findings reveal substantial differences across performance measures. In particular, the excess stock return yields the highest Bayesian R-squared, then the Q-based ratio, demonstrating superior explanatory power and model performance compared with the ROA. These findings suggest that market-oriented and hybrid performance indicators capture firms' exposure to macroeconomic conditions more effectively than accounting-based measures.

Further, the findings indicate that macro risks are significantly and economically associated with firm performance, particularly the excess stock return. The magnitude and direction of the relationship vary across performance metrics. Overall, the market risk premium, prime rate risk premium, long-term government bond yield risk premium, and exchange rate risk emerge as important determinants of firm performance. Importantly, the prime rate risk and long-term government bond yield risk premiums are economically meaningful influences on excess stock returns. In addition, market risk and prime rate risk premiums, and exchange rate risk display a conflicting relationship across performance measures. These results strengthen the argument that performance measurement is not merely a methodological consideration but a substantive factor influencing empirical inferences regarding firm behavior and operating outcomes.

This study contributes to the literature in several ways. It extends the firm-performance literature by demonstrating that conclusions regarding performance determinants are sensitive to the performance measurement choices. It also contributes to the macro-finance literature by integrating alternative performance measures within a common macroeconomic risk framework. In addition, this study provides additional evidence supporting the use of market-based and hybrid metrics as more comprehensive measures of firm performance, particularly in environments characterized by heightened uncertainty and rapid changes in economic conditions. Finally, the application of a robust Bayesian estimator and MCMC

sampling may offer a robust methodology to address parameter uncertainty and firm-performance evaluation in related field research.

The findings also have important practical implications. For managers, understanding the effects of macroeconomic risks on firm value can improve financing, investment, dividend, and risk-management decisions. The results suggest that market-based indicators may provide more timely and informative assessments of firms' exposure to changing economic conditions than traditional accounting ratios. For investors, the findings highlight the importance of incorporating macroeconomic risk factors into portfolio allocation, valuation, and performance evaluation decisions. For other scholars, the evidence underscores the need to carefully consider performance measurement choices when examining the determinants of firm performance.

Overall, new findings suggest a strong relationship between macro risks and firm performance in the US market. This relationship is reflected in the current US economy, especially since the hike in interest rates that started on March 17, 2022. This study also suggests that the choice of performance metric plays a critical role in understanding firms' responses to macro risks. Market-based and hybrid metrics provide a more comprehensive representation of firm performance than traditional accounting-based measures. Accordingly, this study offers valuable insights for managers and investors seeking to evaluate firm performance, cost of equity, resource allocation, dividend policy, and investment planning in an increasingly uncertain economic environment; it also highlights the effectiveness of the macro risk asset pricing model in the literature.

Despite the new findings, the Bayesian framework and MCMC sampling, this study is subject to limitations. This study focuses exclusively on the S&P 500 firms and the US market due to their efficiency and transparency, which may limit the applicability of the findings to other firms or markets. In addition, other macro factors, such as GDP, inflation, economic policy uncertainty, and geopolitical risks, may also be associated with firm performance. Therefore, future research can examine whether the superiority of market-based and hybrid performance measures persists in emerging markets or alternative institutional settings. The other direction is to use cross-country data and incorporate other macro risks to gain deeper insights into the relationship between macro risks and firm performance. These suggested extensions would further advance our understanding of how macroeconomic conditions influence corporate performance and how alternative performance measures shape empirical conclusions.

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