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Article

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Accruals anomalies could be explained by the adverse selection risk induced by the information structure: the case of the Japanese securities market

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ABSTRACT

Accruals are regarded as investments in working capital and are an integral component in the growth process of firms. By assuming asymmetry of information among investors when predicting the returns on such investments, investors are exposed to adverse selection problems. Consequently, in market equilibrium, investors are believed to require compensation for the systematic risk associated with adverse selection exposure. By constructing the accruals factor as a variable to proxy for such risks, this study demonstrates that the accruals factor is priced and can enhance existing asset pricing models. Moreover, categorizing accruals into discretionary and non-discretionary components and constructing accruals factors from these components yields similar results. When the discretion of managers or market environment increases the degree of asymmetric information, adverse selection problems become more pronounced. Therefore, the accruals factor, serving as a proxy for the systematic risk associated with adverse selection, is an essential risk factor in asset pricing models.

IMPACT STATEMENT

The accruals anomaly is a phenomenon that contradicts the EMH (efficient market hypothesis). This anomaly has been a compelling topic for accounting and finance scholars over the past quarter-century, as it pertains to fundamental issues, including the function of capital markets in pricing risk assets, allocating resources efficiently, and the institutional framework of information disclosure that affects the information environment of capital markets.

While numerous studies have validated the robustness of this phenomenon, the reasons behind its occurrence remain unclear. Assuming the presence of information asymmetry among investors, as described by market microstructure theory, uninformed investors are exposed to the risk of adverse selection. To compensate for such risk exposure, it is believed that these investors require a risk premium. Empirical analyses using the GRS test, its Bayesian framework, and HJ-Distance (Hansen-Jagannathan-Distance) support this theoretical prediction.

Excluding the role of the information structure when discussing market efficiency is akin to disregarding a crucial puzzle piece. Considering a more intricate structure makes it possible to rationally explain phenomena previously deemed anomalous. Therefore, it is believed that conducting analyses based on aspects of market microstructure theory, which specifically describe information asymmetry, is highly important for future research in accounting and finance.

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1. Introduction

Accounting reports provide investors with useful information about asset values, the profitability of audited firms, and inherent risks related to management. According to the efficient market hypothesis (EMH), stock prices reflect this information instantly and perfectly after the disclosure of an accounting report.

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However, as a phenomenon contradicting the EMH, the accruals anomaly was initially discovered by Sloan (1996). Sloan (1996) conducted the Mishkin test (Mishkin, 1983) and presented evidence indicating that investors overvalue the persistence of accruals as if investors in the market appear to fixate on earnings. The error in this prediction is corrected in the subsequent financial statements, revealing an accruals anomaly indicating that firms with a high (low) level of accruals are likely to experience future negative (positive) stock returns.

While numerous studies have validated the robustness of this discovery, the underlying causes of the accruals anomaly remain unclear. Following the discovery of the accruals anomaly by Sloan (1996), Xie (2001) identified that market investors tend to overestimate the persistence of discretionary (abnormal) accruals. Xie (2001) argued that investors in the market overprice discretionary accruals derived from managerial discretion. Additionally, the accruals anomaly is notably observed in cases such as low accruals quality (Dechow & Dichev, 2002), low reliability of accruals (Richardson et al., 2005, 2006), significant differences in the persistence of cash flow and accruals (Shi & Zhang, 2012), and high levels of information asymmetry (Park et al., 2018). Furthermore, Mashruwala et al. (2006) argued that idiosyncratic volatility and transaction costs constrain the arbitrage trading of accruals, serving as reasons for the persistence of the accruals anomaly.

Zhang (2007) pointed out that, by definition, accruals capture investments in working capital and are an integral component in the growth process of firms. Zhang (2007) argued that the fundamental investment information contained in accruals represents a first-order effect on the accruals anomaly, and that subjective measurements induced by accounting systems and profit manipulation by managers are considered second-order effects on accruals.

Wu et al. (2010) analyzed a model that incorporated working capital as a proxy variable for accruals, motivated by the q-theory of Tobin. They demonstrated that if the discount rate decreases, accruals increase because the profitability of more investment projects improves. Conversely, if the discount rate increases, accruals decrease as the profitability of investment projects diminishes.

Their analysis of the production side of the economy is crucial because risk and expected returns are inherently connected to the operational, investment, and financial activities of firms within the context of general equilibrium. While the consumption-based approach simplifies firms by treating them as external cash flow processes, it does not offer much insight into the correlation between risk, expected returns, and accounting variables. Therefore, in a general equilibrium setting, their q-theory framework complements traditional asset pricing derived from investors' utility-maximization problems, which include mean-variance frameworks and consumption-based asset pricing where accruals are not explicitly modeled.

This implies the necessity to focus on the investors' utility-maximization problem, which can capture the correlation between risk, expected return, and accounting variables. Following Easley and O'Hara (2004), assuming an information structure stemming from accruals, it is possible to analyze the impact of accruals on systematic risk in market equilibrium.

The market is believed to consist of uninformed investors who are not particularly skilled at analyzing public information (e.g., earnings announcements) and sophisticated informed investors with specialized skills, allowing them to thoroughly analyze public information and discern private information sources.

Investors are assumed to trade based on signals about the future values of stocks and their precision. Signals are assumed to be composed of private and public information. Among these signals, private information can only be received by informed investors, while public information is accessible to all investors.

If accruals are considered as investments in working capital, it is believed that, compared with uninformed investors, informed investors can engage in trading based on a greater amount of more accurate information about the returns on investments included in accruals. In such a setup, by analytically examining the impact of the composition ratio of public and private information on the equilibrium expected return (details in Section 2.3), it is shown that in market equilibrium, investors require higher expected returns for stocks with a higher proportion of private information. This is because informed investors can adjust the weight of their portfolio based on private information, judging whether a firm's fundamentals are good or bad. Meanwhile, uninformed investors cannot determine whether the fundamentals of a firm with a high proportion of private information are good or bad, as they cannot fully speculate

on the information embedded in security prices. This uncertainty leads uninformed investors to perceive higher risk.

Wang (1993) demonstrated two effects of asymmetric information on asset prices in a multi-period model involving two assets. Uninformed investors, to address adverse selection issues when trading with informed investors, require a risk premium. Additionally, trading by informed investors enriches the information content of security prices, reducing the risk for uninformed investors and lowering the risk premium. While it is not clear which effect dominates in the equilibrium of the two-asset model, Easley and O'Hara (2004) presented a multi-asset rational expectation equilibrium model. In this model, when the amount of information is kept constant, the adverse selection effect predominates. Consequently, private information induces systematic risk, and investors in market equilibrium require compensation for being exposed to this risk.

Even though uninformed investors are rational and hold an optimally diversified portfolio to mitigate risk, they cannot replicate the optimal portfolio held by informed investors, who can adjust the weights of their investments in good and bad firms using private information. Uninformed investors, lacking knowledge of the value of private information, cannot eliminate this risk regardless of how they diversify. Furthermore, uninformed investors cannot profit or offset this effect by adopting an arbitrage strategy of holding stocks with high private information and selling those with low private information. This is because, while uninformed investors know the proportion of private information within firms, there are both good and bad ones, making such arbitrage strategies excessively risky.

If an economic variable influences such an information structure, it may initially appear as the idiosyncratic risk of individual assets. However, in market equilibrium, this economic variable serves as a proxy for the risk associated with adverse selection. If accruals are considered as investments in working capital, the signals representing the returns on those investments are believed to be constructed from both private and public information. In this context, accruals can be regarded as an economic variable that influences the information structure. Firms with relatively low levels of accruals report profits that are less than their cash flows. These firms aim to retain a portion of their earnings internally, which is then reinvested. The discretion over these reinvestment opportunities lies with the firm managers' decisions. Consequently, firms with lower accruals tend to possess a significant amount of private information. A low-accruals portfolio, composed of stocks from such firms, is considered to serve as a portfolio that proxies for the systematic risk associated with adverse selection induced by the information structure.

Previous studies suggest that (total) accruals can be categorized into discretionary and non-discretionary accruals (Dechow et al., 1995; Dechow et al., 2003; Jones, 1991; Kasznik, 1999). Non-discretionary accruals are components required by accounting standards to provide information about a firm's profitability. Discretionary accruals are calculated by subtracting estimated non-discretionary accruals from total accruals, which is the outcome of earnings management and representative of the degree of deliberately raised private information.

For example, to increase the probability of continuity and survival of a firm and prepare for future crisis, accounting standards require that firm managers be conservative. Therefore, managers should carefully account for the predicted profit and recognize predicted expenses immediately. Nevertheless, managers can discretionally interpret the conservatism of accounting standards. Thus, the discretion of a firm manager who chooses to disclose information strategically can increase the inherent risk associated with private information. It is believed that the more significant the discretion granted to managers, the more pronounced the adverse selection problem.

Although previous studies have mainly focused on discretionary accruals as a source of private information, non-discretionary accruals can also be a source of private information. An accounting standard is a bundle of functions that map economic events to numerical values and convey appropriate information to investors. However, this bundle of functions is not always appropriate. As the economy develops or fluctuates, the domain of the functions assumed by the accounting standard or the firm manager's disclosure policy becomes unstable. Therefore, economic development or fluctuation can impact the information structure.

Hence, the composition of public and private information may fluctuate depending on the economic condition or the firm manager's strategy. Despite the belief that accruals can influence the information structure surrounding firms, existing asset pricing models do not consider the adverse selection effect

caused by the information structure. In recent years, various risk factors have been proposed in asset pricing models. Fama and French (2015) extended the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) with the dividend discount model, introducing size factor SMB (small minus big), value factor HML (high minus low), profitability factor RMW (robust minus weak), and investment factor CMA (conservative minus aggressive). Furthermore, Fama and French (2018) proposed a model that incorporates the momentum factor UMD (up minus down) introduced by Carhart (1997). However, the risk associated with adverse selection caused by information structure is not explicitly described. Verification of market efficiency is a joint test of mispricing and the benchmark pricing model (the EMH-joint hypothesis problem; Fama, 1970). Thus, mispricing may simply be due to the misspecification of risk (Ball, 1978). In other words, if we assume market efficiency, the risk premium as compensation for bearing risk not described in the benchmark pricing model should explain the accruals anomaly. Particularly, previous studies explaining the accruals anomaly through the earning fixation hypothesis (based on the Mishkin test) assert market inefficiency. However, excluding the role of the information structure when discussing market efficiency is akin to disregarding a crucial puzzle piece. By considering a more intricate structure, it becomes possible to rationally explain phenomena previously deemed anomalous. Therefore, this study aims to address the research gap concerning the risk premium of adverse selection induced by the information structure based on total, discretionary, and non-discretionary accruals.

Section 2.2 clarifies how the presence of such omitted variables in the Mishkin test can influence the test results, aiming to identify the roots of a controversy. As highlighted by Wu et al. (2010), the novel contribution of Sloan (1996) has fascinated researchers for approximately a quarter of a century. This study does not intend to refute Sloan's earnings fixation hypothesis. Since the world is nuanced and intricate, while such cases may exist, the risk explanation of adverse selection induced by the information structure is also plausible. Moreover, extensive evidence of empirical analysis previously explained by the earning fixation hypothesis simultaneously serves as evidence suggesting the existence of the systematic risk factor associated with accruals.

By disclosing information about the actual state of corporate management, which includes internal and external finance, there is an effect of mitigating information asymmetry with investors, thereby reducing the cost of capital. There is a trade-off relationship between this effect and the effect where, in the process of firms expanding their business through investment activities, the discretion given to managers increases asymmetric information, leading to an increase in capital costs. Consequently, the issue of asymmetric information will persist and so will adverse selection problems. Investors seeking to address the adverse selection problem will continue to require a risk premium.

This study investigates whether market investors require a risk premium for the fluctuations in the composition ratio of private information to public information, assuming the market microstructure described by Easley and O'Hara (2004). Since the 5- and 6-factor models by Fama and French (2015, 2018; henceforth FF5 and FF6, respectively) do not include explanatory variables representing adverse selection risk induced by the information structure, the factors related to accruals that are orthogonal to the FF5 factors are constructed. Spanning regression test reveals that the accruals factors include risks not explained by the FF5 and FF6 risk factors. The results of panel data analysis indicate that in situations with a high degree of asymmetric information, investors seek compensation for exposure to adverse selection risk. Furthermore, a GRS model comparison test based on test asset irrelevance and its Bayesian framework (Barillas & Shanken, 2017, 2018; Chib et al., 2020) demonstrates that the accruals factors can improve upon FF5 and FF6. Additionally, using the HJ-Distance (Hansen & Jagannathan, 1997) to verify whether factors are priced, it is found that not only accruals factors based on total accruals but also, in several cases, those based on discretionary and non-discretionary accruals are priced in the market.

This paper makes several contributions to the academic literature:

1. The differences in coefficients in the Mishkin test, which served as evidence for the earning fixation hypothesis in the context of the accruals anomaly (coefficients from the pricing equation being significantly larger than those from the forecast equation), simultaneously suggest the presence of systematic risk factors related to accruals. This observation suggests that the extensive results

accumulated in existing research could potentially be explained by adverse selection risk induced by the information structure.

2. Accruals factors serve as proxies for the risk associated with adverse selection not explained by FF5 and FF6, and the addition of accruals factors improves asset pricing models.
3. Market investors require a risk premium as compensation for being exposed to the risk described by accruals factors.
4. In a general equilibrium context, the relationship between risk, expected returns, and financial activities is crucial. While Wu et al. (2010) demonstrate this relationship on the production side of the economy, the current study empirically evaluates this relationship that is predicted by solving the investors' utility-maximization problem based on market microstructure assumptions. These findings have the potential to complement each other in a general equilibrium.

The remainder of this paper is structured as follows. [Section 2](#) presents a review of previous studies, followed by descriptions on how in the context of the accruals anomaly, the presence of omitted variables in the Mishkin test influences the test results. Additionally, a brief description of Easley and O'Hara's (2004) market microstructure is provided. Based on this premise, testable hypotheses are formulated, and the methodology of model comparison tests is briefly outlined. [Section 3](#) describes the composition and properties of the factors. [Section 4](#) presents the results of the analysis, including spanning regression test, panel data analysis, model comparison using GRS and its Bayesian framework, and the analysis using HJ-Distance. In [Section 5](#), the conclusions of the empirical analysis, the relevance to existing research, and the directions for future studies is described.

2. Review, the roots of a controversy, underlying theory, hypothesis development, and analysis methods

2.1. Literature review

Sloan's discovery in 1996, indicating a negative correlation between accruals and future returns, continues to be a compelling topic of research. While numerous studies have validated the robustness of this discovery, the underlying causes of the accrual anomaly remain unclear. There are four main hypotheses to explain this phenomenon: the earnings fixation, limits of arbitrage, growth, and risk hypotheses.

Sloan (1996) conducted the Mishkin test (Mishkin, 1983) to examine market efficiency, revealing significant differences in the coefficients of accruals in the forecast equation and pricing equation. The evidence suggests that investors inadequately assess the differences in the persistence of accruals and cash flow, and the market appears to fixate on earnings because it overestimates the persistence of accruals. This phenomenon is known as the earnings fixation hypothesis. Additionally, Sloan (1996) demonstrated the accruals anomaly, indicating that firms with a high (low) level of accruals are likely to experience negative (positive) future stock returns. Subsequently, Xie (2001) used the Mishkin test to provide evidence that the market overprices discretionary accruals derived from managerial discretion. The accruals anomaly has been notably observed in cases where accruals quality is low (Dechow & Dichev, 2002), accruals reliability is low (Richardson et al., 2005, 2006), the difference in the persistence of cash flow and accruals is significant (Shi & Zhang, 2012), and there is a high degree of asymmetric information (Park et al., 2018).

Hirshleifer et al. (2012) argued that the accruals anomaly is not explained by the risk premium of factors composed of accruals but rather by behavioral mispricing resulting from investors' limited attention to the characteristics of accruals.

Mashruwala et al. (2006) argued that owing to constraints imposed by idiosyncratic volatility and transaction costs on arbitrage trading, the accruals anomaly remains unresolved, asserting the concept of the limit of arbitrage. Similar evidence supporting this claim has been demonstrated by Collins et al. (2003), Lev and Nissim (2006), and Ali et al. (2008). Hirshleifer et al. (2011) found that short arbitrageurs target high accruals firms, particularly the firm held by institutions. While short selling helps eliminate the downside of the accruals anomaly, they argue that the anomaly still remains.

The growth hypothesis explains the accruals anomaly as a specific case of the growth anomaly, where firms indicating high growth exhibit low returns. Fairfield et al. (2003) categorized growth in net operating assets into accruals and growth in long-term net operating assets, demonstrating that both components have a negative correlation with one-year-ahead return on assets. They also showed that the market tends to overvalue them similarly.

Zhang (2007) pointed out that accruals, by definition, capture investment in working capital and serve as an integral component in the growth process of firms. Zhang (2007) demonstrated a significant correlation between accruals and the number of employees, investment in fixed assets, external financing, and other growth attributes. Therefore, Zhang (2007) argued that fundamental investment information included in accruals constitutes the first-order effect on the accruals anomaly, and argued that the subjective measurement of accruals induced by accounting systems and profit manipulation by managers are considered second-order effects on accruals.

Khan (2008) demonstrated that the accruals anomaly can be explained using a four-factor model, where N_d (news or revision in expectation at time t of future dividend growth) and N_r (news or revision in expectation at time t of future discount rates) are added in place of the Mkt factor in Fama and French's (1993) 3-factor model (FF3). Khan (2008) argued that accruals are correlated with financial distress characteristics. Nevertheless, the underlying economic mechanism making the low (high) accrual portfolio more (less) risky remains unclear in these tests.

Wu et al. (2010) pointed out that accruals represent investments in working capital, and the accruals anomaly can be explained by the negative correlation between investment and the discount rate. In their model motivated by the q -theory of Tobin, they showed that as the discount rate decreases, accruals increase because the profitability of more investment projects improves. Conversely, when the discount rate rises, accruals decrease as the profitability of more projects diminishes.

The accruals anomaly is a worldwide phenomenon (Fan & Yu, 2013; Gordon et al., 2014; LaFond, 2005; Leippold & Lohre, 2012; Papanastasopoulos & Tsiritakis, 2015; Pincus et al., 2007), and it has been observed in Japan (Kubota et al., 2010; Muramiya et al., 2008; Takehara, 2018). Muramiya et al. (2008) utilized the Probability of Informed Trading (PIN) metric developed by Easley et al. (1996, 2002). They discovered that in firms where the proportion of informed traders is high, the relationship between abnormal accruals and returns cannot be identified. The empirical results of their analysis are considered consistent with analytical predictions. Furthermore, they concluded that the observation of abnormal return in firms with low PIN is attributed to the earnings fixation of naive investors. However, it is important to note that in the model assumed by Muramiya et al. (2008), uninformed investors are treated as exogenously given. Therefore, in that model, there is no assumption that uninformed investors seek a risk premium as compensation for exposure to adverse selection risk.

Takehara (2018) conducted Mishkin tests using the FF5 model as a benchmark and subdividing the estimation period. There are periods when the difference in coefficients between the forecast equation and pricing equation is not observed significantly, periods when it is observed significantly, and periods when the sign supporting earnings fixation hypothesis is opposite. Takehara (2018) argued that the clear observation of such structural changes serves as evidence against the earnings fixation hypothesis. Furthermore, when regressing accruals return spreads on 2×3 portfolios constructed in the calculation process of RMW (profitability) and CMA (investment) factors, the intercept was found to be statistically significant. This implies the existence of risks not explained by RMW and CMA factors. These results suggest the presence of missing factors not described in the FF5 model.

The next section demonstrates that the difference in coefficients between the forecast equation and pricing equation, which constitutes the basis for the earnings fixation hypothesis, can be explained by the omitted variable bias.

2.2. What the Mishkin test suggests in the presence of omitted variables

The Mishkin test is designed to verify hypotheses such as market efficiency and rational pricing. If market efficiency holds, the conditional expected value based on prior information for abnormal returns is expected to be zero, and it can be expressed as follows:

$$E(r_{t+1} - r_{t+1}^* | \phi_t) = 0 \quad (1)$$

where

ϕ_t : the set of information available to the market at the end of period t .

r_{t+1} : the return of security during period $t + 1$.

r_{t+1}^* : the market's subjective expectation of the normal return for period $t + 1$.

If we consider X_t to represent the relevant variables in assessing security returns, the model in accordance with condition (1), as demonstrated by Mishkin (1983), is as follows:

$$r_{t+1} - r_{t+1}^* = \beta(X_{t+1} - X_{t+1}^*) + \varepsilon_{t+1} \quad (2)$$

where

ε_{t+1} : the error term with the property that $E(\varepsilon_{t+1} | \phi_t) = 0$.

X_{t+1} : a variable relevant to the pricing of the security $t + 1$.

X_{t+1}^* : the rational forecast of the relevant variable conditional on prior information,

$$X_{t+1}^* = E(X_{t+1} | \phi_t).$$

β : a valuation multiplier.

Equation (2) implies that only unanticipated changes in X_{t+1} affect abnormal returns. In this context, X_t represents earning performance, and β is the earnings response coefficient and is considered a positive value.

Here, if earnings are represented by a first-order auto-regressive model, we can obtain the following forecasting and pricing equations:

$$Earnings_{t+1} = \alpha_0 + \alpha_1 Earnings_t + v_{t+1} \quad (3)$$

$$r_{t+1} - r_{t+1}^* = \beta(Earnings_{t+1} - \alpha_0 - \alpha_1^* Earnings_t) + \varepsilon_{t+1} \quad (4)$$

The forecasting equation presented in (3) utilizes past information ($Earnings_t$) to predict future earnings, $Earnings_{t+1}$. The coefficient assigned to past earnings (α_1) serves as an objective measure of the relationship between $Earnings_t$ and future earnings. By the joint estimation of (3) and (4), one can use return information to infer how the market utilized information in $Earnings_t$ to forecast $Earnings_{t+1}$. The rational expectation hypothesis embedded in the Mishkin test asserts that the market's subjective expectation of earnings, given past information, should be equal to the objective expectation of earnings. Therefore, a test for rationality is verifying whether α_1 equals α_1^* .

To obtain the estimated values of β and α_1^* , the α_0 in the forecasting equation and the α_0 in the pricing equation need to be equal. Since $Earnings_t = Accruals_t + CashFlow_t$ holds, we can derive the following system of equations:

$$Earnings_{t+1} = \gamma_0 + \gamma_1 Accruals_t + \gamma_2 CashFlow_t + v_{t+1} \quad (5)$$

$$r_{t+1} - r_{t+1}^* = \beta(Earnings_{t+1} - \gamma_0 - \gamma_1^* Accruals_t - \gamma_2^* CashFlow_t) + \varepsilon_{t+1} \quad (6)$$

Market efficiency implies $\gamma_1 = \gamma_1^*$ and $\gamma_2 = \gamma_2^*$. If $\gamma_1 = \gamma_1^*$ and $\gamma_2 = \gamma_2^*$, then the sum of squared residuals from the estimation with the constraints $\gamma_1 = \gamma_1^*$ and $\gamma_2 = \gamma_2^*$ (SSR^C) should be the same as those without constraining $\gamma_1 = \gamma_1^*$ and $\gamma_2 = \gamma_2^*$ (SSR^U). Mishkin (1983) demonstrates that this restriction can be examined through the following likelihood ratio test which is asymptotically distributed as chi-square statistic with degree of freedom q under the null hypothesis:

$$\chi^2(q) = 2n \log \left(\frac{SSR^C}{SSR^U} \right) \quad (7)$$

where

q : the number of constraints imposed by market efficiency

n : the number of observations.

In prior studies such as that by Sloan (1996), the estimated values of $\hat{\alpha}_1$ and $\hat{\alpha}_1^*$ obtained from the system of equations in (3) and (4) are close, suggesting that the market adequately predicts the persistence of earnings. Therefore, market efficiency is not rejected in this case. However, in the system of equations in (5) and (6), $\hat{\gamma}_1$ is estimated to be less than $\hat{\gamma}_1^*$. This implies that despite a low degree of γ_1 , which is the 'persistence of earnings' for the next period, the impact of accruals on abnormal return (γ_1^*)

is significantly large. Consequently, it can be recognized that the market overestimates the persistence of accruals. This result serves as evidence for the earnings fixation hypothesis.

However, as highlighted by Kraft et al. (2007), the forecasting equation in (5) and the pricing equation in (6) face the problem of omitted variables. When predicting $Earnings_{t+1}$, it is evident that other variables, which have explanatory power along with $Earnings_t$, exist. Whether there is bias in the estimated coefficients depends on whether the omitted variables are rationally priced and whether they are correlated with the variables in the forecasting and pricing equation. In other words, if a variable is correlated with both accruals and future returns, and that variable is excluded from the system of equations, it introduces bias to the estimated coefficients of $Accruals_t$. Therefore, excluding such variables from the estimation may lead to erroneous conclusions.

Kraft et al. (2007) noted that unconsidered risk factors in the benchmark model may serve as potential candidates for such variables. Takehara (2018) also points out that the benchmark asset pricing model chosen when estimating abnormal returns in valuation equation (6) has not been appropriately selected. Using Size-adjusted return as a benchmark in the Mishkin test, as seen in studies, including those by Sloan (1996), Xie (2001), Shi and Zhang (2012), and Park et al. (2018), may lead to inconsistencies with the recent context of asset pricing models.

We consider the bias introduced to the coefficients estimated in the equations of the Mishkin test (5) and (6) when representing such omitted variables as Z_t , as given below:

$$Earnings_{t+1} = \gamma_0 + \gamma_1 Accruals_t + \gamma_2 CashFlow_t + \gamma_3 Z_t + v_{t+1} \quad (5)$$

$$r_{t+1} - r_{t+1}^* = \beta(Earnings_{t+1} - \gamma_0 - \gamma_1^* Accruals_t - \gamma_2^* CashFlow_t - \gamma_3^* Z_t) + \varepsilon_{t+1} \quad (6)$$

Substituting $Earnings_{t+1}$ expressed as the forecasting equation (5') into equation (6'), we have:

$$\begin{aligned} r_{t+1} - r_{t+1}^* &= \beta(\gamma_0 + \gamma_1 Accruals_t + \gamma_2 CashFlow_t + \gamma_3 Z_t + v_{t+1} - \gamma_0 - \gamma_1^* Accruals_t - \gamma_2^* CashFlow_t - \gamma_3^* Z_t) \\ &\quad + \varepsilon_{t+1} \\ &= \beta(\gamma_1 - \gamma_1^*) Accruals_t + \beta(\gamma_2 - \gamma_2^*) CashFlow_t + \beta(\gamma_3 - \gamma_3^*) Z_t + \beta v_{t+1} + \varepsilon_{t+1} \end{aligned} \quad (7)$$

which can be written as:

$$r_{t+1} - r_{t+1}^* = \varphi_1 Accruals_t + \varphi_2 CashFlow_t + \varphi_3 Z_t + \beta v_{t+1} + \varepsilon_{t+1} \quad (8)$$

Here, $\varphi_i = \beta(\gamma_i - \gamma_i^*)$, $i = 1, 2, 3$, holds. Suppose the regression of Z_t on $Accruals_t$ is represented as follows:

$$Z_t = a + b Accruals_t + e_t \quad (9)$$

When substituting Equation (9) into Equation (8), we have:

$$r_{t+1} - r_{t+1}^* = (\varphi_1 + b\varphi_3) Accruals_t + \varphi_2 CashFlow_t + \varphi_3(a + e_t) + \beta v_t + \varepsilon_t \quad (10)$$

This implies that excluding Z_t from the system of equations and estimating the system of equations will introduce a bias to the estimated coefficient of $Accruals_t$ as follows:

$$\hat{\varphi}_1 = \varphi_1 + b\varphi_3 \quad (11)$$

Specifically, if Z_t and $Accruals_t$ demonstrate a negative correlation (with a coefficient $b < 0$ in the regression of Z_t on $Accruals_t$), and there is an unconsidered risk factor Z_t not included in the benchmark ($\varphi_3 > 0$), then the estimated value of $\hat{\varphi}_1$ will be negatively biased.

The coefficient $\varphi_3 > 0$ representing a scenario where, in contrast to the assumption in equation (5'), in equation (6'), the coefficients are estimated to describe the component of return variability explained by Z_t , which is a violation of the assumption that only unanticipated changes in $Earnings_{t+1}$ affect abnormal returns. Therefore, γ_3^* is estimated to be a smaller value than γ_3 .

Scholars advocating the earnings fixation hypothesis argue that when expressed in the form of Equation (10), the coefficient for $\hat{\varphi}_1 = \hat{\beta}(\hat{\gamma}_1 - \hat{\gamma}_1^*)$ is negative, that is, $\hat{\beta} > 0$ and $\hat{\gamma}_1 < \hat{\gamma}_1^*$, suggesting that investors overestimate the persistence of accruals. However, such estimation results naturally arise due to the exclusion of variable Z_t related to $Accruals_t$ from the system of equations, leading to a negative bias in the estimated coefficient of $Accruals_t$.

In the context of accruals anomaly, where there is a difference in the coefficients of accruals ($\hat{\gamma}_1 < \hat{\gamma}_1^*$) between the forecasting equation ($\hat{\gamma}_1$) and pricing equation ($\hat{\gamma}_1^*$) as determined by the Mishkin test,

Table 1. Results of the Mishkin test in the presence of omitted variables.

Under the assumption of market efficiency			Under the assumption of earning fixation		
$\varphi_1 = 0$			$\varphi_1 < 0$		
(1)	$\varphi_3 = 0$ $b = 0$	Variables omitted and unrelated to accruals are rationally priced. Market efficiency is supported	(5)	$\varphi_3 = 0$ $b = 0$	Accruals are not rationally priced, but omitted variables unrelated to accruals are priced rationally. Accruals are mispriced and the earning fixation hypothesis is supported.
(2)	$\varphi_3 \neq 0$ $b = 0$	There are other omitted variables unrelated to accruals that are not included in the benchmark. There is room for improvement in the benchmark concerning the risk associated with omitted variables.	(6)	$\varphi_3 \neq 0$ $b = 0$	There is no risk factor associated with accruals. The coefficients are biased with respect to the risk associated with omitted variables. Nevertheless, the earnings fixation hypothesis might still be supported.
(3)	$\varphi_3 = 0$ $b < 0$	A risk factor related to accruals is already included in the benchmark and is rationally priced. Market efficiency is supported	(7)	$\varphi_3 = 0$ $b < 0$	Accruals are not rationally priced, but omitted variables related to accruals are priced rationally. Contradiction between φ_1 and φ_3 arises in the assumption.
(4)	$\varphi_3 > 0$ $b < 0$	There exists a risk factor related to accruals that is not included in the benchmark. There is room for improvement in the benchmark concerning the risk associated with accruals.	(8)	$\varphi_3 > 0$ $b < 0$	The earning fixation hypothesis and the existence of a factor related to accruals that is not included in the benchmark are intermingled; the earning fixation hypothesis should be tested after controlling the risk factor related to accruals.

The variable γ_i represents the estimated coefficient in the forecast equation (5'), and γ_i^* represents the estimated coefficient in the pricing equation (6'). φ_i is defined as $\beta(\gamma_i - \gamma_i^*)$, $i = 1, 2, 3$, where β is the earnings response coefficient. If the omitted variable Z_t , which is not included in the benchmark asset pricing model, is expressed as $Z_t = a + b\text{Accruals}_t + e_t$, the coefficient b is believed to be less than 0. Equation (11), $\hat{\varphi}_1 = \varphi_1 + b\varphi_3$, represents the estimated coefficient for Accruals_t when systematic risk related to accruals is not described in the benchmark asset pricing model, expressed as Equation (10). Table 1 illustrates eight plausible scenarios for values of (φ_1 , φ_3 , and b). Scenarios (1)–(4) correspond to cases where market efficiency is supported, while scenarios (5)–(8) correspond to cases where the earning fixation hypothesis is supported.

and when the benchmark asset pricing model does not include a factor associated with accruals, this disparity serves as evidence suggesting the existence of a factor (Z_t) associated with accruals.

This argument is considered the fundamental source of controversy surrounding the accruals anomaly. Equation (11) is described by three variables (φ_1 , φ_3 , and b), and various scenarios can be considered based on the possible values these variables can take. The implications of the Mishkin test in the presence of omitted variables are outlined for eight plausible cases in Table 1.

Researchers supporting the earnings fixation hypothesis are believed to consider scenarios such as those outlined in Table 1, specifically case (5) or (6). In case (5), accruals are considered to be not rationally priced, while omitted variables are priced rationally. In case (6), there is no risk factor associated with accruals, and the estimated coefficients are biased with respect to the risk factor associated with omitted variables. While such cases may exist, scenarios such as (4) or (8), where the systematic risk associated with accruals is omitted, are also sufficiently plausible. Therefore, this study explores the possibility of incorporating factors related to accruals into the benchmark asset pricing model. Kraft et al. (2007) highlighted that, as with any test for market efficiency, the Mishkin test serves as a combined assessment of both market efficiency and the assumed equilibrium pricing model. Identifying the appropriate model for equilibrium market returns is a non-trivial issue.

The next subsection focuses on the impact of the composition ratio of private information and public information on risk premium in the market equilibrium, assuming the market microstructure described by Easley and O'Hara (2004).

2.3. Market microstructure

Let us consider a two-period model. In this model, there exists a single risk-free asset, which is money and has a constant price of 1. Additionally, there are K stocks with risks, indexed as $k = 1, \dots, K$. The future values of these stocks, denoted as v_k , are independently normally distributed with a mean of \bar{v}_k and a precision of ρ_k . The stock k per capita supply, represented as x_k , is also independently normally distributed with an average of \bar{x}_k and a precision of η_k . The prices of the stocks, p_k , are determined by

the market. Investors participate in trading at present at prices $(1, p_1, \dots, p_K)$ per share and receive pay-offs the day after in the form of $(1, v_1, \dots, v_K)$ per share.

Investors receive signals at present concerning the future values of these stocks. Stock k is associated with l_k signals, where l_k is an integer. These signals, denoted as s_{k1}, \dots, s_{kl_k} , are independently sampled from a normal distribution with a mean of v_k and a precision of γ_k .

Some of these signals are disclosed as public, while others remain private. The proportion of signals related to the value of stock k that are kept private is indicated by α_k , while the proportion of signals that are made public is $1 - \alpha_k$. All investors receive public signals before trading commences, whereas private signals are exclusively received by informed investors. Let μ_k represent the fraction of investors who receive the private signals regarding stock k . All the random variables are independent, and the investors are aware of their respective distributions.

There are J investors, with indices $j = 1, \dots, J$. These investors all possess CARA utility, characterized by a risk aversion coefficient $\delta > 0$. In equilibrium, these investors need to hold the available supply of money and stocks. The budget constraint for investor j at present is represented as:

$$m^j + \sum_k p_k z_k^j = \bar{m}^j \quad (12)$$

Where, z_k^j is the quantity of shares of stock k that investor j purchases, m^j is the amount of money they hold, and \bar{m}^j is their initial wealth. Their wealth the day after is a random variable, denoted as \tilde{w}^j , and can be expressed as:

$$\tilde{w}^j = \sum_k v_k z_k^j + m^j \quad (13)$$

By substituting the budget constraint for \bar{m}^j , investor j 's wealth can be written as the sum of capital gains and initial wealth:

$$\tilde{w}^j = \sum_k (v_k - p_k) z_k^j + \bar{m}^j \quad (14)$$

Because investor j has CARA utility and all the distributions are normal, the objective function for investor j can be expressed in a standard mean-variance form.

$$\max_{z_k^j} E[\tilde{w}^j] - \frac{\delta}{2} \text{var}[\tilde{w}^j] \quad (15)$$

There exists a rational expectations equilibrium.

$$p_k = a\bar{v}_k + b \sum_{i=1}^{\alpha_k l_k} s_{ki} + c \sum_{i=\alpha_k l_k + 1}^{l_k} s_{ki} - dx_k + e\bar{x}_k \quad (16)$$

where $a = \rho_k / C_k$, $b = \frac{\mu_k \gamma_k + \frac{(1-\mu_k)\rho_{0k}}{\alpha_k l_k}}{C_k}$, $c = \gamma_k / C_k$, $d = \frac{\delta + \frac{(1-\mu_k)\rho_{0k}\delta}{\alpha_k l_k \mu_k \gamma_k}}{C_k}$, $e = \frac{(1-\mu_k)\rho_{0k}\delta}{C_k}$,

$C_k = \rho_k + (1 - \alpha_k)l_k \gamma_k + \mu_k \alpha_k l_k \gamma_k + (1 - \mu_k)\rho_{0k}$, and

$$\rho_{0k} = \left[(\mu_k \gamma_k \alpha_k l_k)^{-2} \eta_k^{-1} \delta^2 + (\alpha_k l_k \gamma_k)^{-1} \right]^{-1}$$

In equilibrium, the risk premium on asset k is described as follows:

$$E[v_k - p_k] = \frac{\delta \bar{x}_k}{\rho_k + (1 - \alpha_k)l_k \gamma_k + \mu_k \alpha_k l_k \gamma_k + (1 - \mu_k)\rho_{0k}} \quad (17)$$

The risk premium is influenced by the information structure of the stock. The denominator in this context reflects the impact of traders' initial beliefs and the influence of both public and private information. When there is higher uncertainty about the asset's value, leading to a smaller precision value ρ_k , the stock's risk premium tends to be greater. It is of utmost importance that how the required return is affected by the fraction of the signals that are private, which is denoted as α_k .

$$\frac{\partial E[v_k - p_k]}{\partial \alpha_k} = \frac{\delta \bar{x}_k (1 - \mu_k) l_k \gamma_k}{(C_k)^2 (1 + \alpha_k l_k \eta_k \mu_k^2 \gamma_k \delta^{-2})^{-2}} > 0 \quad (18)$$

This demonstrates that a stock with a higher proportion of private information and a lower proportion of public information will tend to have a greater expected excess return. This phenomenon arises because when information is private, uninformed investors are unable to completely deduce the information from prices. Consequently, they perceive the stock as being riskier, thus requiring the risk premium.

Even though uninformed investors are rational and optimally diversify their portfolios to mitigate risk, uninformed investors, lacking knowledge of the value of private information, cannot eliminate this risk, regardless of how much they diversify. Moreover, they cannot arbitrage this effect away, nor can they make arbitrage profits by solely holding all high α stocks and shorting all low α stocks. Adopting such strategy is extremely risky for uninformed investors as these stocks encompass both positive and negative news. Informed investors have the advantage of buying more of the stocks with positive news and holding fewer of the stocks with negative news, allowing them to exploit their information. This option is not available to uninformed investors.

In market equilibrium, informed and uninformed investors hold different mean-variance efficient portfolios. Assuming a representative agent and constructing a mean-variance efficient average market portfolio, the utility level of this representative agent is lower than that of the uninformed investor. In a world with symmetric information, such as in the CAPM, market prices are not informative, with nothing to learn from prices. However, in a world with asymmetric information, uninformed investors can learn, albeit not completely, from public information and equilibrium prices. By ignoring this effect and holding the average market portfolio, the representative agent would achieve only a lower level of utility.

As the fraction of the private signals and uncertainty about the asset's value increase, the required return increases. Furthermore, as the proportion of informed investors, precision of both public and private information, and overall quantity of information increase, the required return decreases. Cross-sectional returns on stocks will, therefore, be contingent on the information structure specific to each stock. As highlighted by Easley and O'Hara (2004), if information structures are associated with other readily observable variables, these variables may serve as proxies for the effect of information structures in elucidating the cross-section of returns. In contrast to the conventional CAPM pricing framework, investors require compensation for what can be initially perceived as idiosyncratic risk related to each individual asset. In market equilibrium, investors require a risk premium as compensation for being exposed to the risk associated with adverse selection, where the effect of adverse selection resulting from the information structure predominates the impact of trading by informed investors enriching the information content of security prices.

2.4. Hypothesis development

The dividend discount model with clean surplus accounting by which FF5 is motivated does not consider the adverse selection problem arising from the information structure, as described by Easley and O'Hara (2004). Accruals are considered investments in working capital and play a crucial role in the growth process of firms. Given the asymmetric information among investors when forecasting returns on such investments, investors face adverse selection problems. Consequently, in a market equilibrium, investors are believed to require a premium as compensation for their exposure to adverse selection risk. Therefore, this study examines whether fluctuations in the composition ratio of private and public information are recognized as systematic risks.

By modeling portfolio payoffs as elements of the Hilbert space, the asset pricing model is a proxy for the stochastic discount factor (SDF) (Chamberlain & Rothschild, 1983; Harrison & Kreps, 1979). The existence of strictly positive SDFs provides no-arbitrage conditions. Assuming a complete market, a unique strictly positive SDF exists. Simply assuming the existence of SDFs, the portfolio payoff obeys the Law of One Price. Following previous studies, this study assumes the existence of SDFs. The asset-pricing model represented as SDF is the pricing operator on payoff. Because the analysis of the asset pricing model is the analysis of the dual space of the payoff space, which is also the Hilbert space, the asset-pricing model has an orthogonal basis.

If we consider asset pricing models as analyses on Hilbert space, factors are expected to be orthogonal. Therefore, the stocks listed on the first and second sections of the Tokyo Stock Exchange were categorized into low and high groups based on five criteria: firm size, book-to-market ratio, operational (or cash) profitability, the growth of total assets, and accruals value. This process resulted in the formation of 32 portfolios, with all the criteria being orthogonal to each other. The factors related to accruals

are denoted as the portfolio value-weighted average return of firms with low-accruals minus those with high-accruals, labeled as PMP (private minus public). By constructing a portfolio using such a method, this portfolio is considered to proxy for the difference between the expected returns of portfolios for firm groups with high α_k , described as Equation (17), and those with low α_k . This basic spread portfolio factor is commonly considered as proxy for the corresponding mimicking portfolio (Barillas & Shanken, 2018). By constructing factors related to accruals to be orthogonal to each of the FF5 factors, these accruals factors are presumed to represent variables expressing the adverse selection risk not described in FF5. This study aims to investigate whether the following asset pricing model can enhance FF5 and FF6.

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_iSMB_t + h_iHML_t + r_iRMW_t + c_iCMA_t + p_iPMP_t + e_{it} \quad (19)$$

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_iSMB_t + h_iHML_t + r_iRMW_t + c_iCMA_t + u_iUMD_t + p_iPMP_t + e_{it} \quad (20)$$

Additionally, the study aims to test the following hypotheses:

H1: Factors related to accruals represent risks not explained by FF5.

H2: The addition of accruals factors can enhance FF5 or FF6.

H3: Both discretionary accruals factors based on discretionary accruals and non-discretionary accruals factors based on non-discretionary accruals can improve FF5 or FF6.

H4: Accruals factors are priced in the market.

H1 is tested by conducting a spanning regression test with accruals factors as the dependent variable and factors from FF5 or FF6 as independent variables, examining whether the intercept is statistically significant. H2 and H3 are tested through the GRS model comparison test based on test asset irrelevance, and these are further verified in a Bayesian framework. H4 testing involves estimating the HJ-Distance while estimating the risk premiums of the factors.

2.5. Model comparison test and test asset irrelevance

The traditional HJ-Distance suggested by Hansen and Jagannathan (1997) is a quadratic form of specification error using the second moment matrix of the payoff as the weighting matrix. Kan and Robotti (2008) showed that the modified HJ-Distance of which the weighting matrix is replaced by the variance covariance matrix of test asset is analogous to the GRS test. Kan and Robotti (2008) showed that under the condition where factors are priced without errors, the GRS test statistic is a special version of the modified HJ-Distance. This constraint means that the factor premia equal the expected factor values, which is a standard assumption in the alpha-based framework.

Barillas and Shanken (2017) showed the neutrality of the test asset under a model comparison using the GRS test. They demonstrated that for a model to be considered appropriate, it is necessary for it to be able to price factors from other models, akin to how it prices the test asset. This indicates a potential for improving the squared Sharpe ratio if the ‘alphas’ from regressing the factors of other models onto that particular model are jointly different from zero. In this context, it has been shown that the test asset is dropped out and becomes irrelevant when conducting model comparisons.

Let f_1 represent the factors in Model 1, and let Model 1 be nested within Model 2, where its factors are represented as (f_1, f_2) . Additionally, consider the test asset as R . When pricing factors f_2 and R with respect to factor f_1 , the resulting ‘alphas’, which quantify the extent to which f_1 fails to price f_2 and test asset R , leads to a squared Sharpe ratio increase, as expressed by the following formula:

$$sh^2(f_1, f_2, R) - sh^2(f_1) = \alpha'_{R2} \Sigma_{R2}^{-1} \alpha_{R2} = \delta_1^2 \quad (21)$$

The first equality in Equation (21), as observed in studies by Gibbons et al. (1989) and Barillas and Shanken (2017, 2018), demonstrates that the difference between the squared Sharpe ratio of the efficient frontier formed by combining the test asset R and the factors (f_1, f_2) and the squared Sharpe ratio of the efficient frontier formed by factor f_1 is expressed as a quadratic form of ‘alphas.’ The second

equality in Equation (21), as shown by Kan and Robotti (2008), indicates that, under the condition where factor f_1 is priced without errors, the GRS test statistic is a special version of the modified HJ-Distance. Similarly, the GRS test statistic when regressing the test asset R on the factors (f_1, f_2) of Model 2 can be expressed as follows, as in Equation (21).

$$sh^2(f_1, f_2, R) - sh^2(f_1, f_2) = \alpha'_R \Sigma_R^{-1} \alpha_R = \delta_2^2 \quad (22)$$

Subtracting Equation (22) from Equation (21), we have:

$$\delta_1^2 - \delta_2^2 = \{sh^2(f_1, f_2, R) - sh^2(f_1)\} - \{sh^2(f_1, f_2, R) - sh^2(f_1, f_2)\} = sh^2(f_1, f_2) - sh^2(f_1) \quad (23)$$

The difference in the modified HJ-Distance defined for the two models as mentioned above implies that it is equal to the difference in the squared Sharpe ratio between Model 2 and Model 1, indicating that selecting the model with a lower modified HJ-Distance is equivalent to choosing the model with a higher squared Sharpe ratio. Additionally, it signifies that the test asset has been dropped out, and, similar to GRS tests, using the modified HJ-Distance for model comparisons also demonstrates the concept of test asset irrelevance.

2.6. Bayesian model comparison

Barillas and Shanken (2018) provide a Bayesian F-test, implementing the GRS test with test asset irrelevance. The Bayesian F-test is based on the results of Barillas and Shanken (2017), who highlight that, when comparing models using traded factors, it is sufficient to assess each model's capability to price the factors in the other models.

Chib et al. (2020) argued that the Bayesian setting proposed by Barillas and Shanken (2018) is unsound. Since the improper priors of nuisance parameters described by Barillas and Shanken (2018) are the same as those multiplied by any arbitrary positive constant, the marginal likelihood is indeterminate. To mitigate this arbitrariness, Barillas and Shanken (2018) refer to nuisance parameters that are common across models. However, the assumption that the nuisance parameters are common across models is violated in model comparison. Chib et al. (2020) provide the solution to this problem by using the invertible map of nuisance parameters that connects all models under consideration, as well as the Jacobian of the transformation. In this study, the Bayesian framework of model comparison follows that of Chib et al. (2020). A brief notation of the Bayesian framework is given below.

Suppose a collection of K traded risk factors. The market factor Mkt is one of these K factors and is contained in all models. The asset pricing model is composed of remaining $K - 1$ risk factors and the model space is $J = 2^{K-1}$. Let $M_j, j = 1, 2, \dots, J$ stand for any one of the possible models. The vector of risk factors is defined as $\{Mkt, \mathbf{f}_j\}$ and size of risk factors is denoted as L_j . The excluded factor is denoted as \mathbf{f}_j^* and its size is $K - L_j$. Let $t = 1, 2, \dots, T$ denote a particular point in the sample observation. The model M_j is defined as follows.

$$\mathbf{f}_{j,t} = \alpha_j + \beta_j Mkt_t + \varepsilon_{j,t} \quad \varepsilon_{j,t} \sim \mathcal{N}_{L_j-1}(\mathbf{0}, \Sigma_j) \quad (24)$$

$$\mathbf{f}_{j,t}^* = (\beta_{j,m}^* \quad \mathbf{B}_{j,f}^*) \begin{pmatrix} Mkt_t \\ \mathbf{f}_{j,t} \end{pmatrix} + \varepsilon_{j,t}^* \quad \varepsilon_{j,t}^* \sim \mathcal{N}_{K-L_j}(\mathbf{0}, \Sigma_j^*) \quad (25)$$

In Equation (25), an intercept vector is absent because of the pricing restriction, which means that the excluded factor $\mathbf{f}_{j,t}^*$ does not span the space. It is assumed that the error terms $\varepsilon_{j,t}$ and $\varepsilon_{j,t}^*$ are mutually independent and independently distributed. Let M_1 denote the model in which all K factors are risk factors, $M_j, j = 2, \dots, J - 1$ denote the models in which $\{Mkt, \mathbf{f}_j\}$ are the risk factors, and M_J denotes the model in which $\{Mkt\}$ is the only risk factor.

Let $\text{vec}(\cdot)$ denote the vec operator which transforms a matrix into a column vector by vertically stacking the columns of the matrix. Let $\text{vech}(\cdot)$ denote the operator which stacks the elements of a matrix below and including the diagonal elements. By using those operators, $\beta_{j,f}^* = \text{vec}(\mathbf{B}_{j,f}^*)$, $\sigma_j = \text{vech}(\Sigma_j)$, and $\sigma_j^* = \text{vech}(\Sigma_j^*)$ are denoted as the vectorized forms of $\mathbf{B}_{j,f}^*$, Σ_j , and Σ_j^* , respectively. Then, the parameters of M_j are

$$\theta_j = (\alpha_j, \beta_j, \beta_{j,m}^*, \beta_{j,f}^*, \sigma_j, \sigma_j^*) \in \Theta_{\theta_j} \quad (26)$$

Further, the nuisance parameters of M_j are

$$\eta_j = (\beta_j, \beta_{j,m}^*, \beta_{j,f}^*, \sigma_j, \sigma_j^*) \quad (27)$$

Suppose that Θ_{θ_j} and Θ_{η_j} are the parameter space of θ_j and η_j . Since the improper priors of nuisance parameters are the same as those multiplied by any arbitrary positive constant, let $c\psi(\eta_1|M_1)$ denote an improper prior on η_1 with an arbitrary constant c . Suppose the invertible map which connects the nuisance parameter η_1 of M_1 and the nuisance parameters η_j of generic model M_j .

$$\eta_1 = g_j^{-1}(\eta_j) \quad (28)$$

The improper priors of η_j can be described as follows with the absolute value of the Jacobian of the transformation.

$$\tilde{\psi}(\eta_j|M_j) = c\psi(g_j^{-1}(\eta_j)|M_1) \left| \det \left(\frac{\partial g_j^{-1}(\eta_j)}{\partial \eta_j'} \right) \right|, j = 2, \dots, J \quad (29)$$

Let $\mathbf{y}_{1:T} = (\mathbf{f}_1, \mathbf{f}_1^*, \dots, \mathbf{f}_T, \mathbf{f}_T^*)$, denoted as the sample observation of the factors. The marginal likelihood of M_1 and M_j are the integral of the sampling density with respect to the prior.

$$m(\mathbf{y}_{1:T}|M_1) = \int_{\Theta_{\eta_1}} \int_{\Theta_{\alpha_1}} p(\mathbf{y}_{1:T}|M_1, \theta_1) \pi(\alpha_1|M_1, \eta_1) c\psi(\eta_1|M_1) d\theta_1 \quad (30)$$

$$\begin{aligned} \tilde{m}(\mathbf{y}_{1:T}|M_j) &= \int_{\Theta_{\eta_j}} \int_{\Theta_{\alpha_j}} p(\mathbf{y}_{1:T}|M_j, \theta_j) \pi(\alpha_j|M_j, \eta_j) \tilde{\psi}(\eta_j|M_j) d\theta_j \\ &= \int_{\Theta_{\eta_j}} \int_{\Theta_{\alpha_j}} p(\mathbf{y}_{1:T}|M_j, \theta_j) \pi(\alpha_j|M_j, \eta_j) c\psi(g_j^{-1}(\eta_j)|M_1) \left| \det \left(\frac{\partial g_j^{-1}(\eta_j)}{\partial \eta_j'} \right) \right| d(\alpha_j, \eta_j) \end{aligned} \quad (31)$$

where

$$\pi(\alpha_j|M_j, \eta_j) = \mathcal{N}_{L_j-1}(\alpha_j|\mathbf{0}, k\Sigma_j) \quad (32)$$

and $k > 0$ represent our belief about the possible extent of deviations from the expected return relation. Since the same arbitrary constant c arises from the right-hand side of marginal likelihood in the collection of $M_j, j = 1, 2, \dots, J$, the constant c cancels out when comparing any two models. In this study, the computation of the marginal likelihood follows Chib et al. (2020).

3. Composition and properties of the factors

3.1. 5 × 5 Sorted portfolios properties

Table 2 presents the descriptive statistics and correlation coefficients for firm size (Size), book-to-market ratio (BE/ME), operating profitability (OP), cash profitability (CP), investment (Inv), total accruals (TA), discretionary accruals (DA), and non-discretionary accruals (NDA). Discretionary accruals are defined as the difference between total accruals and the estimated non-discretionary accruals. The detailed methodology for estimating NDA using the Jones model, modified Jones model (MJones), CFO-modified Jones model (CFO-MJones), and Forward Looking model (FL) is provided in Appendix A.

Following Fama and French (2015), the first step is to examine the Size, BE/ME, profitability, investment, and accruals patterns in average return. Panel A (left side) of Table 3 shows the average monthly excess return for 25 value-weighted portfolios, obtained through independent sorts of stocks into five Size groups and five BE/ME groups (5 × 5 Size-BE/ME sorts). The right side of panel A shows t -statistics of the average return for 25 value-weighted portfolios. The samples investigated include the stocks of firms listed on the Tokyo Stock Exchange. The financial data were provided by Nikkei Financial Quest. Data were collected for the period September 1978–June 2012 (407 monthly observations). The Size and BE/ME quintile break points are based on the first section of the Tokyo Stock Exchange, and the sample includes stocks from both the first and second sections of the Tokyo Stock Exchange. Following

Table 2. Descriptive statistics and correlation.

Panel A: Descriptive statistics.								
Variables	N	Mean	s.d	min	max			
Size	38,787	146.227	526.817	0.139	23,321			
BE/ME	38,787	1.064	0.848	0.000	24.720			
OP	38,787	0.088	0.660	−66.000	8.742			
CP	38,787	0.094	0.939	−39.450	75.440			
Inv	38,787	0.047	0.840	−0.779	154.000			
TA	38,787	−0.008	0.088	−2.075	5.799			
DA_Jones	15,174	−0.005	0.108	−1.621	4.291			
DA_MJones	15,174	−0.006	0.107	−1.613	4.107			
DA_CFOMJones	15,174	−0.001	0.055	−0.861	1.573			
DA_FL	15,174	−0.002	0.048	−0.554	1.494			
NDA_Jones	15,174	−0.014	0.072	−4.369	1.529			
NDA_MJones	15,174	−0.014	0.070	−4.185	1.592			
NDA_CFOMJones	15,174	−0.018	0.066	−0.814	2.608			
NDA_FL	15,174	−0.018	0.072	−1.190	2.678			
Panel B: Correlation coefficient.								
	Accruals	Size	BE/ME	OP	CP	Inv		
Accruals	1							
Size	0.012	1						
BE/ME	−0.058	−0.201	1					
OP	0.070	0.044	−0.057	1				
CP	−0.041	0.008	−0.045	0.407	1			
Inv	0.152	0.098	−0.076	0.069	−0.062	1		
DA_Jones	0.745	0.011	−0.045	0.045	−0.035	0.078		
DA_MJones	0.756	0.013	−0.053	0.052	−0.039	0.136		
DA_CFOMJones	0.646	0.004	−0.018	0.071	0.002	0.108		
DA_FL	0.561	0.003	−0.004	0.039	−0.006	0.079		
NDA_Jones	0.094	−0.001	−0.003	0.016	0.002	0.067		
NDA_MJones	0.087	−0.004	0.009	0.007	0.008	−0.018		
NDA_CFOMJones	0.772	0.013	−0.061	0.032	−0.055	0.109		
NDA_FL	0.831	0.013	−0.068	0.058	−0.046	0.131		
	DA_Jones	DA_MJones	DA_CFO MJones	DA_FL	NDA_Jones	NDA_MJones	NDA_CFO MJones	NDA_FL
DA_Jones	1							
DA_MJones	0.951	1						
DA_CFOMJones	0.417	0.422	1					
DA_FL	0.325	0.327	0.859	1				
NDA_Jones	−0.595	−0.508	0.155	0.190	1			
NDA_MJones	−0.526	−0.587	0.156	0.197	0.889	1		
NDA_CFOMJones	0.628	0.638	0.014	0.020	−0.006	−0.016	1	
NDA_FL	0.681	0.694	0.204	0.006	−0.015	−0.027	0.919	1

Panel A in Table 2 presents the descriptive statistics, and Panel B presents the correlation coefficients. Firm size (Size), book-to-market equity ratio (BE/ME), operating profitability (OP), cash profitability (CP), investment (Inv), and total accruals (TA) represent samples of firms available from September 1978 to July 2012. Additionally, discretionary accruals (DA) and non-discretionary accruals (NDA) represent samples of firms available from September 1994 to July 2012, as there is a period during which coefficients are estimated in a time series context. Size represents the market capitalization as of the end of August, and BE/ME is the book-to-market equity ratio. OP is calculated as annual revenues minus the cost of goods sold; interest expense; and selling, general, and administrative expenses, all divided by book equity at the end of the fiscal year before year t . CP is calculated as OP minus the changes in accounts receivable from $t-2$ to $t-1$, inventory, and prepaid expenses, plus the change in deferred revenue, accounts payable, and accrued expenses, all divided by book equity at the end of the fiscal year before year t . Inv is defined as the growth of total assets for the fiscal year ending in $t-1$ divided by total assets at the end of $t-2$. TA is profit before income taxes minus cash flows from operating activities, divided by the average total assets of fiscal year $t-1$. Discretionary accruals (DA) are the difference between TA and the estimated non-discretionary accruals (NDA). The detailed methodology for estimating non-discretionary accruals using the Jones model, Modified Jones model (MJones), CFO-modified Jones model (CFO-MJones), and a Forward-Looking model (FL) is provided in Appendix A.

Kubota and Takehara (2018), given that over 90% of Japanese firms have their fiscal year-end at the end of March, the portfolio updating period has been set at the end of August each year.

As pointed out by Fama and French (1993, 2015), within each BE/ME category in panel A of Table 3, the average return decreases from small stocks to big stocks, which is commonly referred to as the size effect. There are some exceptions, but overall, it follows the same trend as the average return pattern that has been revealed in prior research. The relationship between average return and BE/ME, commonly referred to as the value effect, appears to be more consistently observed. Across all Size categories, there is a consistent trend of average return increasing with BE/ME.

Panel B of Table 3 displays the average excess return for 25 value-weighted portfolios resulting from the independent sorting of stocks into quintiles based on firm size and operating profitability. Operating

Table 3. 5×5 Sorted portfolio property.

Average return						t-Statistics					
	Low	2	3	4	High		Low	2	3	4	High
Panel A: Size-BE/ME portfolios											
Small	0.666	0.813	0.838	0.937	1.070	Small	1.766	2.340	2.501	2.917	3.421
2	0.322	0.406	0.530	0.676	0.943	2	0.887	1.203	1.653	2.161	2.922
3	0.092	0.314	0.443	0.710	0.911	3	0.280	1.054	1.533	2.318	2.941
4	0.037	0.325	0.606	0.734	0.827	4	0.118	1.165	2.065	2.523	2.708
Big	−0.149	0.305	0.674	0.665	0.985	Big	−0.494	1.131	2.377	2.196	2.689
Panel B: Size-OP portfolios											
Small	1.240	0.882	0.799	0.739	0.661	Small	3.296	2.807	2.660	2.464	1.996
2	0.937	0.661	0.578	0.513	0.363	2	2.439	2.061	1.875	1.742	1.162
3	0.683	0.567	0.534	0.424	0.278	3	1.857	1.910	1.848	1.477	0.909
4	0.723	0.587	0.417	0.334	0.302	4	2.046	2.049	1.484	1.223	1.033
Big	0.025	0.266	0.339	0.161	0.176	Big	0.065	0.887	1.187	0.603	0.637
Panel C: Size-CP portfolios											
Small	1.120	0.788	0.911	0.780	0.858	Small	3.041	2.581	2.974	2.506	2.534
2	0.715	0.666	0.546	0.661	0.580	2	1.971	2.036	1.794	2.201	1.749
3	0.644	0.349	0.470	0.547	0.454	3	1.869	1.156	1.615	1.906	1.506
4	0.569	0.444	0.450	0.415	0.428	4	1.703	1.544	1.613	1.519	1.451
Big	0.100	0.248	0.126	0.314	0.282	Big	0.290	0.861	0.463	1.123	1.011
Panel D: Size-Inv portfolios											
Small	1.190	0.971	0.818	0.770	0.678	Small	3.307	2.860	2.675	2.534	2.072
2	0.914	0.669	0.664	0.536	0.355	2	2.522	2.039	2.110	1.736	1.148
3	0.642	0.699	0.532	0.368	0.254	3	1.930	2.160	1.819	1.287	0.846
4	0.647	0.686	0.445	0.357	0.209	4	1.960	2.386	1.592	1.253	0.736
Big	0.403	0.327	0.262	0.271	0.091	Big	1.217	1.087	0.956	1.012	0.320
Panel E: Size-TA portfolios											
Small	1.060	0.994	0.934	0.736	0.818	Small	3.025	3.002	2.981	2.306	2.478
2	0.873	0.796	0.607	0.477	0.431	2	2.467	2.338	2.048	1.530	1.350
3	0.676	0.695	0.492	0.322	0.332	3	2.029	2.212	1.657	1.144	1.103
4	0.660	0.547	0.452	0.276	0.333	4	2.158	1.883	1.553	0.994	1.143
Big	0.330	0.323	0.183	0.218	0.098	Big	1.170	1.114	0.616	0.744	0.350

Panel A in Table 3 shows the average monthly excess return for 25 value-weighted portfolios, obtained through independent sorts of stocks into five firm size (Size) groups and five book-to-market equity ratio (BE/ME) groups (5×5 Size-BE/ME sorts). On the right side of the panel A, *t*-statistics are presented. Using a similar portfolio composition method, Panel B displays the average returns and *t*-statistics for Size-OP (operating profitability), Panel C for Size-CP (cash profitability), Panel D for Size-Inv (investment), and Panel E for Size-TA (total accruals) in a 5×5 sorted portfolio. During September 1997–August 1998 and September 1999–August 2002, when conducting 5×5 Size-BE/ME sorts, no firms belonged to the largest Size and BE/ME groups. Therefore, the analysis was conducted by replacing this period with the excess return being zero. Of the 10,175 portfolio years, 48 had missing data, accounting for 0.472% of the total sample period. The Nikkei Financial Quest provided the financial data. Data were collected from September 1978 to June 2012 (407 monthly observations). The 5×5 sorted portfolio break points are based on the first section of the Tokyo Stock Exchange. The sample includes stocks from both the first and second sections of the Tokyo Stock Exchange. Given that over 90% of Japanese firms have their fiscal year-end at the end of March, the portfolio updating period has been set at the end of August each year.

profitability (OP) is calculated as annual revenues minus the cost of goods sold; interest expense; and selling, general, and administrative expenses, all divided by book equity at the end of the fiscal year prior to year *t*. The details of 5×5 Size-OP sorts are identical to those in Panel A, with the only difference being that the second sort is based on operating profitability rather than BE/ME. The size effect is apparent in the 25 Size-OP portfolios, and the profitability effect is shown to be opposite between panel B of Table 3 and the results reported by Novy-Marx (2013) and Fama and French (2015). The profitability effect is characterized by a low average return for the lowest OP quintile and a high average return for the highest OP quintile; however, panel B of Table 3 shows the average return decrease from low operating profitability to high operating profitability. This property of operating profitability observed using Japanese market data was already revealed by Kubota and Takehara (2018); they showed that the differences of average return, which were the portfolios return of high profitability minus those of low profitability, were negative across all size categories, although they were not statistically significant. The discounted dividend model is a supported model when using United States (Fama and French, 2015, 2018) and international data (Novy-Marx, 2013), and from the perspective of validating the discounted dividend model, it is considered necessary to incorporate RMW (profitability) factor into the model for validation, even if RMW exhibits characteristics opposite to United States and international data.

Panel C of Table 3 shows the average excess return for 25 Size-CP portfolios, which are formed in the same manner as the 25 Size-BE/ME portfolios, but with the second sort based on cash profitability. Following Ball et al. (2016), cash profitability (CP) is calculated as operating profitability, minus the

changes in accounts receivable from $t-2$ to $t-1$, inventory, and prepaid expenses, plus the change in deferred revenue, accounts payable, and accrued expenses, all divided by book equity at the end of the fiscal year prior to year t . Panel C shows a decline in average return as cash profitability increases, going from low cash profitability to high cash profitability except for large market capitalization. Fama and French (2018) demonstrated through bootstrapping simulations that their six-factor models incorporating cash profitability factors yield higher Sharpe ratios compared to those incorporating operating profitability factors. Since the operating and cash profitability effects exhibit different trends from the data in the United States, this study aims to examine both cases.

Panel D of Table 3 displays the average excess return for 25 Size-Inv portfolios, which are formed in the same manner as the 25 Size-BE/ME portfolios, but with the second sort based on investment. Investment (Inv) is defined as the growth of total assets for the fiscal year ending in $t-1$ divided by total assets at the end of $t-2$. In each size quintile, the average return on the portfolio in the lowest investment quintile is higher than the return on the portfolio in the highest investment quintile. The investment effect is apparent as the average return declines from the low investment portfolio to high investment portfolio. Although Fama and French (2015) show that a size effect is not observed in the highest investment quintiles, in the Japanese market data, the size effects were evident across all investment categories.

Panel E of Table 3 displays the average excess return for 25 Size-TA (total accruals) portfolios, which are formed in the same manner as the 25 Size-BE/ME portfolios, but with the second sort based on total accruals. TA is defined as profit before income taxes minus cash flows from operating activities, divided by the average total asset of fiscal year $t-1$. Because Japanese GAAP do not mandate the disclosure of the cash flow statement before the year 2000, operating cash flow is computed using the indirect method. The calculation method for TA follows the same approach as that by Muramiya et al. (2008). The net income of Japanese firms shares similarities with income before extraordinary items in the U.S. Consequently, TA is defined as the difference between net income and CFO, divided by the average total asset of fiscal year $t-1$. The impact of the accruals effect is evident as the average return decreases when moving from the low TA portfolio to high TA portfolio. The smaller the portfolio size and the lower the total accruals, the higher the average return and the likelihood of statistically significant t -statistics. There are a few exceptions, but the overall trend is evident.

The correlation coefficients between the values of accruals and the criteria used to compose the factors in the FF5, namely firm size (Size), book-to-market equity ratio (BE/ME), operating profitability (OP), cash profitability (CP), and investment (Inv), are indicated to be low in Panel B of Table 2. Hence, the returns from accruals are believed to differ from those based on FF5 criteria variables.

3.2. Factor definitions

The method used to generate value factor HML (high minus low book-to-market equity) follows that of Fama and French (1993, 2015). HML involves categorizing stocks annually into two size categories and three book-to-market equity groups. The operating profitability RMWo (robust minus weak), cash profitability RMWc, investment CMA (conservative minus aggressive), and accruals factors PMP (private minus public) for the 2×3 sorting method are built in a similar manner to HML, with the exception of the second sorting criterion. The momentum factor UMD (up minus down) involves categorizing stocks monthly into two size categories and three average monthly returns from $t-12$ to $t-2$. Let us denote those factors as 2×3 factors. Using the 2×3 sorting approach, four additional Size factors are generated. Following the methodology outlined by Fama and French (2015), the two types of SMB size factors SMBo and SMBc are calculated as the average of $SMB_{BE/ME}$, SMB_{OP} , and SMB_{Inv} , or alternatively, as the average of $SMB_{BE/ME}$, SMB_{CP} , and SMB_{Inv} .

In addition to these factor composition methods, factors were composed using orthogonal decomposition. To expand the asset pricing model and enhance the ability to isolate the premium in average returns linked to Size, BE/ME, OP (or CP), Inv, and TA, the method utilizes five sorting criteria to simultaneously manage these five variables, ensuring they are orthogonalized with respect to each other. The stocks are independently categorized into two Size, BE/ME, OP (or CP), Inv, and TA groups using the first section of the Tokyo Stock Exchange. These intersections of the groups result in 32 value-weighted

portfolios. Let us denote those factors as $2 \times 2 \times 2 \times 2 \times 2$ factors. The size factor, SMB, is determined by calculating the average return of the 16 small stock portfolios minus the average return of the 16 big stock portfolios. Similarly, HML, RMWo (or RMWc), CMA, and PMP are derived using the same approach. Following Kubota and Takehara (2018), the portfolio updating period has been set at the end of August each year. The updating frequency of categories when constructing the UMD factor is monthly, while the updating frequency of categories for other factors is annual, which is why the UMD factor was not included in the orthogonal decomposition. Moreover, the classification of up to 6 categories result in 64 value-weighted portfolios, which are too many classifications to effectively diversify. The void portfolio may occur in 64 classifications.

3.3. Summary statistics of factor returns

Table 4 shows the summary statistics for factor returns and correlation of factors. Panel A of Table 4 shows the market factor Mkt and two types of Size factors SMBo and SMBc. The average return of market factor is 0.260% per month, which is not statistically significant (t -statistics is 0.988). The inclusion of Japan's bubble period and the subsequent long-term economic stagnation following the burst of the bubble period is considered to have influenced the statistical insignificance of a market factor; the result is consistent with that of Kubota and Takehara (2018). Even if market factor Mkt is not statistically significant, Mkt is considered essential in asset pricing models and is included in all of the following models. The difference in average returns between SMBo and SMBc is a mere 0.004%. The only difference between SMBo and SMBc lies in their operating profitability and cash profitability, and thus, their correlation coefficient is very high at 0.999.

Panel B of Table 4 shows the average return, t -statistics, and standard deviation of HML, RMWo, RMWc, CMA, PMP, and UMD. The average return of the HML factor is 0.701% per month, which is significantly higher compared to the other FF5 factors. Fama and French (2018) report that the value and investment effects are roughly of the same magnitude. However, when using Japanese data, it was demonstrated that the value effect is approximately 1.826 times greater than the investment effect. Regarding profitability, as seen in the average return of the 5×5 sorted portfolio, the trend has reversed compared to the data in the United States, with RMWo and RMWc showing negative values. The CMA factor representing the investment effect has an average return of 0.384% per month, with a t -statistic of 3.003. The average return of the PMP factor representing the accruals effect is 0.269% per month, and with a t -statistic of 2.673, it is statistically significant at the 1% level. The average return of the UMD factor takes a value that is an order of magnitude higher when compared to that of the other factors.

For example, when considering the HML factor, a 2×3 factor constructs six portfolios based on size and BE/ME criteria. Afterward, for both small size and big size categories, the HML factor is calculated by taking the average of the portfolios return with higher BE/ME values minus the portfolios return with lower BE/ME values. To verify whether these values differ by size, the values of the portfolios before averaging by size are presented in the rows below. The 'Small' row represents the calculation for the small size, and the 'Big' row represents the calculation for the large size. The 'Average' row is the average of these values.

The impact of the value effect is more noticeable in larger portfolios compared to smaller ones, with a discernible variation of 0.375%. The profitability effect shows a significant reversal with United States data in small-size portfolios, while in large-size portfolios, the profitability effect is not statistically significant. The investment effect is observed to a similar extent in both small- and large-size portfolios, with a difference of approximately 0.028%. The accruals effect is notably observed in small-size portfolios, being 0.129% greater than in large-size portfolios. The accruals effect in small-size portfolios is statistically significant at the 1% level. The momentum effect is not statistically significant in small-size portfolios but is notably accentuated in large-size portfolios, exhibiting a significant difference of 6.487%. Fama and French (2018) observe that all of these effects (except for accruals) are more prominent in portfolios with smaller sizes. However, when using Japanese data, it was found that in the case of the value, profitability, and momentum effects, larger-sized portfolios exhibited higher average returns.

Table 4. Average return of factors and correlation of factors.Panel A: Summary statistics for market and size factors (2×3)

Factors	Average return			t-Statistics		
	Mkt	SMB _o	SMB _c	Mkt	SMB _o	SMB _c
	0.260	0.340	0.344	0.988	1.895	1.896
	Standard deviation			Mkt	SMB _o	SMB _c
	0.053	0.036	0.037			

Panel B: Summary statistics of value, operating profitability, cash profitability, investment, accruals, and momentum factors (2×3)

Factors	Average return						t-Statistics					
	HML	RMW _o	RMW _c	CMA	PMP	UMD	HML	RMW _o	RMW _c	CMA	PMP	UMD
	0.701	-0.237	-0.011	0.384	0.269	3.730	5.612	-1.654	-0.110	3.003	2.673	6.377
	0.514	-0.475	-0.130	0.398	0.334	0.490	4.262	-3.641	-1.459	3.699	3.636	0.672
_Big	0.889	0.000	0.107	0.370	0.205	6.977	4.553	-0.001	0.664	1.954	1.296	4.498
	Standard deviation						HML	RMW _o	RMW _c	CMA	PMP	UMD
	0.025	0.029	0.021	0.026	0.020	0.118						

Panel C: The correlation of factors (2×3)

	Mkt	SMB _o	SMB _c	HML	RMW _o	RMW _c	CMA	PMP	UMD
Mkt	1								
SMB _o	-0.055	1							
SMB _c	-0.056	0.999	1						
HML	-0.213	0.199	0.200	1					
RMW _o	-0.229	-0.383	-0.412	0.025	1				
RMW _c	-0.221	-0.371	-0.376	0.098	0.738	1			
CMA	0.158	0.217	0.240	0.139	-0.620	-0.236	1		
PMP	0.084	-0.020	-0.001	0.006	-0.392	-0.004	0.593	1	
UMD	0.000	0.036	0.034	0.062	0.039	0.033	-0.028	-0.029	1

Panel D: Summary statistics of size, value, operating profitability, cash profitability, investment, and accruals

(2 × 2 × 2 × 2 × 2)		Average return					t-Statistics				
Factors		SMB	HML	RMW	CMA	PMP	SMB	HML	RMW	CMA	PMP
Total Accruals	_OP	0.197	0.429	-0.106	0.198	0.110	1.208	4.808	-1.236	2.699	1.804
	_CP	0.208	0.458	-0.034	0.229	0.157	1.272	5.341	-0.464	2.943	2.381
	_OP	0.165	0.385	-0.054	0.131	-0.088	0.705	3.019	-0.415	1.137	-1.182
	_CP	0.198	0.354	-0.025	0.159	-0.054	0.825	2.776	-0.252	1.295	-0.708
DA Jones	_OP	0.169	0.364	-0.068	0.121	-0.051	0.718	2.854	-0.520	1.075	-0.617
	_CP	0.197	0.343	-0.017	0.151	-0.032	0.828	2.733	-0.176	1.265	-0.386
	_OP	0.147	0.360	-0.057	0.127	0.079	0.632	2.808	-0.450	1.149	0.889
	_CP	0.192	0.366	-0.025	0.152	0.091	0.807	2.901	-0.263	1.288	1.031
CFOMJones	_OP	0.180	0.370	-0.015	0.108	0.150	0.772	2.871	-0.115	0.937	1.774
	_CP	0.202	0.353	-0.015	0.131	0.167	0.844	2.783	-0.159	1.098	2.075
	_OP	0.178	0.409	-0.024	0.114	0.098	0.768	3.242	-0.191	0.989	1.115
	_CP	0.170	0.405	0.030	0.150	0.123	0.725	3.210	0.313	1.236	1.491
NDA Jones	_OP	0.175	0.401	-0.041	0.116	0.109	0.766	3.231	-0.330	1.043	1.332
	_CP	0.183	0.400	0.004	0.157	0.136	0.782	3.223	0.037	1.323	1.780
	_OP	0.202	0.357	-0.058	0.090	-0.003	0.866	2.924	-0.453	0.777	-0.031
	_CP	0.201	0.365	-0.032	0.121	-0.002	0.840	3.024	-0.329	1.008	-0.026
FL	_OP	0.151	0.394	-0.024	0.117	-0.132	0.649	3.210	-0.193	1.027	-1.524
	_CP	0.171	0.371	-0.025	0.148	-0.110	0.725	2.973	-0.259	1.240	-1.367

Panel E: The correlation of factors ($2 \times 2 \times 2 \times 2 \times 2$, OP)

	Mkt	SMB _o	HML	RMW _o	CMA	PMP	UMD
Mkt	1						
SMB _o	-0.053	1					
HML	-0.204	0.021	1				
RMW _o	-0.236	-0.394	0.285	1			
CMA	0.152	0.201	0.049	-0.353	1		
PMP	0.002	-0.150	-0.085	-0.027	0.188	1	
UMD	0.000	0.016	0.090	0.052	-0.002	-0.034	1

Panel F: The correlation of factors ($2 \times 2 \times 2 \times 2 \times 2$, CP)

	Mkt	SMB _c	HML	RMW _c	CMA	PMP	UMD
Mkt	1						
SMB _c	-0.045	1					

(continued)

Table 4. Continued.Panel F: The correlation of factors ($2 \times 2 \times 2 \times 2 \times 2$, CP)

	Mkt	SMBc	HML	RMWc	CMA	PMP	UMD
HML	-0.154	0.065	1				
RMWc	-0.206	-0.343	0.220	1			
CMA	0.155	0.248	0.148	-0.258	1		
PMP	0.096	0.039	-0.133	-0.357	0.322	1	
UMD	0.000	0.017	0.100	0.023	-0.016	-0.047	1

Generating value factor HML (high minus low book-to-market equity) follows Fama and French (1993, 2015). HML categorizes stocks annually into two firm size (Size) categories and three book-to-market equity ratio (BE/ME) groups. The operating profitability (OP) RMWo (robust minus weak), cash profitability (CP) RMWc, investment (Inv) CMA (conservative minus aggressive), and accruals factors PMP (private minus public) for the 2×3 sorting method are built similarly to HML, except for the second sorting criterion. The momentum factor UMD (up minus down) involves categorizing stocks monthly into two firm size categories and three average monthly returns from $t-12$ to $t-2$. Let us denote those factors as 2×3 factors. Using the 2×3 sorting approach, four additional size factors are generated. Following Fama and French (2018), the two types of SMB size factors, SMB_o and SMB_c, are calculated as the average of $SMB_{BE/ME}$, SMB_{OP} , and SMB_{Inv} or as the average of $SMB_{BE/ME}$, SMB_{CP} , and SMB_{Inv} . Factors were also composed using orthogonal decomposition, which utilizes five sorting criteria (Size, BE/ME, OP (or CP), Inv, and TA (total accruals)) to simultaneously manage these five variables, ensuring they are orthogonalized with respect to each other. The stocks are independently categorized into two Size, BE/ME, OP (or CP), Inv, and TA groups using the first section of the Tokyo Stock Exchange. These factors are denoted as $2 \times 2 \times 2 \times 2 \times 2$ factors. The size factor, SMB, is determined by calculating the average return of the 16 small stock portfolios minus the average return of the 16 large stock portfolios. Similarly, HML, RMWo (or RMWc), CMA, and PMP are derived using the same approach. Panel A in Table 4 shows the average return, t -statistics, and standard deviation of the market factor Mkt and two types of size factors, SMB_o and SMB_c. Panel B shows the average return, t -statistics, and standard deviation of HML, RMWo, RMWc, CMA, PMP, and UMD. The correlation coefficient matrix of 2×3 factors is shown in Panel C. In Panel D, the 'OP' row represents the scenario when operating profitability is used for orthogonal decomposition, while the 'CP' row indicates the situation when cash profitability is used for orthogonal decomposition. The correlation coefficient matrix of $2 \times 2 \times 2 \times 2 \times 2$ factors is shown in Panels E and F.

The correlation coefficient matrix of these factors is shown in Panel C of Table 4. SMB_o exhibits a relatively high negative correlation of -0.383 with RMWo. Similarly, SMB_c shows a negative correlation of -0.376 with RMWc. The correlation coefficients between HML and the other factors range from -0.213 to 0.200, suggesting relatively modest levels of correlation. As expected, RMWo and RMWc exhibit a high correlation coefficient of 0.738. Additionally, RMWo displays a high negative correlation of -0.620 with CMA. Furthermore, RMWo has a relatively high correlation coefficient of -0.392 with PMP, but the correlation between RMWc and PMP is -0.004, suggesting almost no correlation. CMA shows a high correlation coefficient of 0.593 with PMP. Although the PMP factor exhibits high correlations with RMWo and CMA in the 2×3 factor model, orthogonal decomposition is performed in the $2 \times 2 \times 2 \times 2 \times 2$ factor model to extract independent components of variation, with a specific emphasis on isolating the accruals effect. The UMD factor representing momentum effect is shown to have minimal correlation with the other factors.

The average returns for the composition of a $2 \times 2 \times 2 \times 2 \times 2$ factor model where each of the SMB, HML, RMW, CMA, and PMP factors is orthogonally decomposed are presented in Table 4, Panel D. The 'OP' row represents the scenario when operating profitability is used for orthogonal decomposition, while the 'CP' row indicates the situation when cash profitability is used for orthogonal decomposition. When comparing the $2 \times 2 \times 2 \times 2 \times 2$ factor model to the 2×3 factor model, it is evident that the average returns for SMB, HML, CMA, and PMP have decreased. This suggests that in the $2 \times 2 \times 2 \times 2 \times 2$ factor model, effects that were overlapping in the 2×3 factor model have been removed or isolated.

In the case of 'OP', compared to the 2×3 factor model, the average return for PMP has decreased from 0.269% to 0.110%, with a t -statistic of 1.804. Furthermore, in the case of 'CP', the average return has decreased from 0.269% to 0.157%, with a t -statistic of 2.381.

Total Accruals is categorized into discretionary accruals (DA) and non-discretionary accruals (NDA) using the Jones, modified Jones (MJones), CFO-modified Jones (CFO-MJones), and Forward Looking (FL) models, and based on these components, $2 \times 2 \times 2 \times 2 \times 2$ factors are constructed. Regarding the PMP factor, the DA decomposed using the FL model are statistically significant in both the 'OP' and 'CP' cases. Additionally, NDA decomposed using the MJones model are statistically significant in the 'CP' case.

Not only total Accruals but also several $2 \times 2 \times 2 \times 2 \times 2$ factors composed of DA and NDA were found to be statistically significant. This suggests that these factors have the potential to improve asset

pricing models. Therefore, conducting a spanning test was considered necessary to determine whether these factors possess intercepts that cannot be explained by other factors.

Panel E of Table 4 displays the correlation coefficients for a $2 \times 2 \times 2 \times 2 \times 2$ factor. In the 2×3 factor, RMWo and CMA exhibited relatively high correlation coefficient (-0.620), and CMA and PMP showed a correlation of 0.593 . However, in the $2 \times 2 \times 2 \times 2 \times 2$ factor, RMWo and CMA had a correlation of -0.353 , while CMA and PMP had correlations of 0.188 and 0.322 . These values are considered relatively low correlation coefficients. Therefore, it is inferred that the operation of orthogonal decomposition of factors is functioning.

4. Results

4.1. Spanning regression test

A spanning regression test is conducted to determine whether a certain factor represents risks not captured by other factors. Consider α_i as the intercept in the spanning regression test that factor i is regressed on the other factors in the model, and $rmse_i$ as root mean square error of the regression. The increase in the maximum squared Sharpe ratio for a model's factors when factor i is added to the model is as follows (Barillas & Shanken, 2017, 2018; Fama & French, 2018).

$$\alpha_i / rmse_i = sh^2(f, i) - sh^2(f) \quad (33)$$

Fama and French (2018) defined this value as the marginal contribution to $shmax^2$, which represents the maximum squared Sharpe ratio. Table 5 presents the results of the spanning regression test, the values of $shmax^2$, and the marginal contribution to $shmax^2$ for each factor.

Table 5 in Panel A presents the results of a spanning regression test incorporating the 2×3 factor PMP into the 2×3 factor FF5. When performing spanning regression test on Mkt, the intercept of Mkt is 0.479% , and it is statistically significant (t -statistics 1.835). In Panel A of Table 4, the average return of Mkt is 0.260% , which is not statistically significant (t -statistics 0.988). Since the coefficients for the SMBo, HML, and RMWo factors are negative, controlling for the effects of these factors results in the intercept showing a value 1.842 times the average return. As pointed out by Fama and French (2018), this suggests that discussing the importance of factors based solely on average return may lead to incorrect conclusions.

As discussed later, in some cases, CMA may become statistically significant, but the coefficient of PMP on Mkt is not statistically significant, suggesting that PMP is describing different variations compared to Mkt. With an adjusted R-squared of only 0.103 , it can be said that there is relatively little variation in Mkt that can be explained by other factors. This suggests that the diversification of portfolios based on the 2×3 factor composition method is functioning to some extent. $shmax^2$, with a value of 0.1070 , represents the squared Sharpe ratio of the efficient frontier generated from all independent and dependent variables, and $\alpha^2 / rmse^2$, with a value of 0.0091 , represents the marginal contribution of Mkt to $shmax^2$. Thus, Mkt has the second largest marginal contribution after HML.

The intercept of SMBo is not statistically significant, and its marginal contribution to $shmax^2$ is only 0.0014 . Meanwhile, the intercept of HML is statistically significant at the 1% level with a value of 0.631 , and its marginal contribution to $shmax^2$ is 0.0711 . The fact that the value effect is particularly pronounced in Japanese stock market data, while the small-cap effect is not very strong, has also been demonstrated in other empirical studies (Honda, 2008; Kubota & Takehara, 2007). Fama and French (2018) found that when spanning regression test was applied to the HML factor, the intercept was small and not statistically significant, indicating that it contributed little to $shmax^2$. However, the results derived in this study differ from those obtained using United States data.

Fama and French (2018) argue that small firms tend to have lower profitability, so the negative coefficient of RMW when SMB is regressed against other factors is consistent with this trend. They also state that value stocks tend to have lower investments, so the positive coefficient of CMA when HML is regressed against other factors is consistent with this trend. The dividend discount model with clean surplus accounting suggests that the expected net income has a positive ceteris paribus effect on the expected return. Additionally, the growth rate of book-equity has a negative ceteris paribus effect on

Table 5. Spanning regression test.

Panel A	α	Mkt	SMB _o	HML	RMW _o	CMA	PMP	<i>Adj_R2</i>	<i>rmse</i>	<i>shmax</i> ²	$\alpha^2/rmse^2$	
Mkt	0.479* (1.835)		−0.194** (−2.475)	−0.415*** (−3.985)	−0.430*** (−3.587)	0.235 (1.628)	−0.200 (−1.278)	0.103	5.024	0.1070	0.0091	
SMB _o	0.120 (0.723)	−0.078** (−2.475)		0.259*** (3.923)	−0.590*** (−8.284)	0.075 (0.821)	−0.406*** (−4.183)	0.229	3.182	0.1070	0.0014	
HML	0.631*** (5.295)	−0.092*** (−3.985)	0.143*** (3.923)		0.192*** (3.400)	0.293*** (4.411)	−0.082 (−1.109)	0.118	2.366	0.1070	0.0711	
RMW _o	0.011 (0.106)	−0.072*** (−3.587)	−0.248*** (−8.284)	0.146*** (3.400)		−0.551*** (−10.460)	−0.136** (−2.131)	0.489	2.062	0.1070	0.0000	
CMA	0.023 (0.255)	0.028 (1.628)	0.022 (0.821)	0.158*** (4.411)	−0.389*** (−10.460)		0.530*** (11.247)	0.549	1.734	0.1070	0.0002	
PMP	0.143* (1.716)	−0.020 (−1.278)	−0.103*** (−4.183)	−0.037 (−1.109)	−0.082** (−2.131)	0.452*** (11.247)		0.378	1.602	0.1070	0.0080	
Panel B	α	Mkt	SMB _c	HML	RMW _c	CMA	PMP	<i>Adj_R2</i>	<i>rmse</i>	<i>shmax</i> ²	$\alpha^2/rmse^2$	
Mkt	0.478* (1.839)		−0.205*** (−2.669)	−0.399*** (−3.845)	−0.539*** (−4.037)	0.373*** (2.882)	−0.061 (−0.388)	0.111	5.002	0.1068	0.0091	
SMB _c	0.116 (0.688)	−0.085*** (−2.669)		0.261*** (3.895)	−0.644*** (−7.881)	0.314*** (3.797)	−0.225** (−2.250)	0.225	3.225	0.1068	0.0013	
HML	0.630*** (5.290)	−0.089*** (−3.845)	0.140*** (3.895)		0.224*** (3.540)	0.227*** (3.737)	−0.143* (−1.946)	0.120	2.363	0.1068	0.0711	
RMW _c	0.015 (0.159)	−0.072*** (−4.037)	−0.208*** (−7.881)	0.135*** (3.540)		−0.186*** (−3.950)	0.150*** (2.640)	0.237	1.834	0.1068	0.0001	
CMA	0.026 (0.263)	0.054*** (2.882)	0.110*** (3.797)	0.148*** (3.737)	−0.202*** (−3.950)		0.740*** (15.781)	0.452	1.911	0.1068	0.0002	
PMP	0.138* (1.666)	−0.006 (−0.388)	−0.055** (−2.250)	−0.065* (−1.946)	0.114*** (2.640)	0.518*** (15.781)		0.380	1.599	0.1068	0.0074	
Panel C	α	Mkt	SMB _o	HML	RMW _o	CMA	UMD	PMP	<i>Adj_R2</i>	<i>rmse</i>	<i>shmax</i> ²	$\alpha^2/rmse^2$
Mkt	0.334 (1.229)		−0.276*** (−3.240)	−0.451*** (−3.010)	−0.663*** (−3.764)	0.469** (2.487)	0.011 (0.539)	−0.287 (−1.350)	0.098	5.040	0.1871	0.0044
SMB _o	0.046 (0.288)	−0.093*** (−3.240)		0.165* (1.879)	−0.807*** (−8.419)	0.228** (2.077)	0.007 (0.545)	−0.461*** (−3.795)	0.212	2.925	0.1871	0.0002
HML	0.400*** (4.574)	−0.049*** (−3.010)	0.053* (1.879)		0.365*** (6.486)	0.236*** (3.830)	0.010 (1.460)	−0.138** (−1.980)	0.143	1.662	0.1871	0.0579
RMW _o	−0.122 (−1.607)	−0.052*** (−3.764)	−0.187*** (−8.419)	0.261*** (6.486)		−0.317*** (−6.259)	0.005 (0.794)	−0.007 (−0.126)	0.341	1.407	0.1871	0.0075
CMA	0.057 (0.795)	0.032** (2.487)	0.047** (2.077)	0.150*** (3.830)	−0.282*** (−6.259)		0.000 (0.086)	0.252*** (4.613)	0.192	1.326	0.1871	0.0018
UMD	3.524*** (5.748)	0.063 (0.539)	0.110 (0.545)	0.517 (1.460)	0.333 (0.794)	0.038 (0.086)		−0.211 (−0.423)	−0.004	11.811	0.1871	0.0890
PMP	0.127** (1.994)	−0.016 (−1.350)	−0.075*** (−3.795)	−0.070** (−1.980)	−0.005 (−0.126)	0.200*** (4.613)	−0.002 (−0.423)		0.071	1.183	0.1871	0.0115
Panel D	α	Mkt	SMB _c	HML	RMW _c	CMA	UMD	PMP	<i>Adj_R2</i>	<i>rmse</i>	<i>shmax</i> ²	$\alpha^2/rmse^2$
Mkt	0.330 (1.198)		−0.235*** (−2.788)	−0.412*** (−2.627)	−0.717*** (−3.502)	0.586*** (3.246)	0.010 (0.442)	−0.166 (−0.777)	0.077	5.097	0.1920	0.0042
SMB _c	0.072 (0.441)	−0.081*** (−2.788)		0.154* (1.658)	−0.871*** (−7.626)	0.426*** (4.042)	0.004 (0.325)	−0.348*** (−2.794)	0.177	2.997	0.1920	0.0006
HML	0.380*** (4.463)	−0.041*** (−2.627)	0.044* (1.658)		0.288*** (4.495)	0.271*** (4.822)	0.013** (1.967)	−0.145** (−2.155)	0.127	1.612	0.1920	0.0556
RMW _c	0.001 (0.012)	−0.041*** (−3.502)	−0.146*** (−7.626)	0.167*** (4.495)		−0.087** (−1.991)	−0.001 (−0.123)	−0.301*** (−6.110)	0.298	1.226	0.1920	0.0000
CMA	0.061 (0.804)	0.044*** (3.246)	0.092*** (4.042)	0.202*** (4.822)	−0.113** (−1.991)		−0.003 (−0.575)	0.344*** (6.150)	0.214	1.393	0.1920	0.0019
UMD	3.472*** (5.648)	0.051 (0.442)	0.064 (0.325)	0.716** (1.967)	−0.059 (−0.123)	−0.243 (−0.575)		−0.251 (−0.507)	−0.002	11.80	0.1920	0.0866
PMP	0.150** (2.338)	−0.009 (−0.777)	−0.055*** (−2.794)	−0.079** (−2.155)	−0.284*** (−6.110)	0.251*** (6.150)	−0.003 (−0.507)		0.201	1.191	0.1920	0.0159

Table 5 presents the results of the spanning regression test, values of $shmax^2$, and marginal contribution to $shmax^2$ for each factor. The presence of a statistically significant intercept α_i indicates that the factor includes a risk component that cannot be explained by other factors. $shmax^2$ represents the squared maximum Sharpe ratio of the efficient frontier generated from all independent and dependent variables, and $\alpha^2/rmse^2$ represents the marginal contribution of the factor i to $shmax^2$. The marginal contribution of factor i to $shmax^2$ is defined as $\alpha_i/rmse_i = sh^2(f, i) - sh^2(f)$, where $rmse_i$ is root mean square error. Panel A displays the results of a spanning regression test for the FF5, where the profitability factor is determined by operating profitability and extended by adding the accruals factor, all defined by a 2×3 factor. Panel B illustrates the results of a spanning regression test for a model that incorporates the accruals factor into FF5 using cash profitability factor RMW_c, all defined by 2×3 factor. Panel C displays the results of a spanning regression test for a model that incorporates the accruals factor into the FF6 using operating profitability factor RMW_o (FF6 includes the momentum factor UMD in addition to FF5), which is based on a $2 \times 2 \times 2 \times 2 \times 2$ orthogonalized factors structure (excluding the UMD factor). Panel D presents the results of a spanning regression test for a model that includes the accruals factor in the FF6 using cash profitability factor RMW_c, which is based on a $2 \times 2 \times 2 \times 2 \times 2$ orthogonalized factors structure (excluding the UMD factor). T-statistics are presented in parentheses. *, **, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

the expected return. The negative *ceteris paribus* effect indicates that the firm has low capital efficiency. 'Conservative' refers to firms with high capital efficiency and do not engage in capital reinforcement that does not affect the expected net income. Meanwhile, 'Aggressive' refers to firms that have low capital efficiency and actively engage in capital reinforcement that does not affect the expected net income. Therefore, CMA (conservative minus aggressive) is considered a variable that explains the impact of the difference in capital efficiency on returns. However, it is unclear whether the effect of an increase in book-equity leading to an increase in expected net income is captured by RMW or CMA. If, hypothetically, this effect is captured more strongly by CMA, an increase in net income would be explained by both CMA and RMW, making the explanatory power of RMW potentially unstable.

In Table 5, as suggested by the dividend discount model with clean surplus accounting, when the rate of increase in profitability falls below the rate of increase in capital, a decrease in expected returns is predicted. The negative coefficient of CMA relative to RMW is believed to indicate the extent to which capital efficiency decreases in relation to profitability. The fact that these coefficients are negative is consistent with the results of Fama and French (2018), suggesting that this spanning regression test appropriately captures the structure between factors.

The economic significance of PMP is considered to be the compensation that investors require for the exposure to risk associated with adverse selection, particularly in cases where information asymmetry is prominent. The statistical significance and sign of PMP coefficients when spanning each factor suggest the conditions under which the compensation required by investors becomes more pronounced. Given that the coefficient of PMP for SMB is negative, it implies that when firms are larger, information asymmetry is recognized as a more prominent risk. While the PMP coefficient for HML is not statistically significant in Panel A, it becomes statistically significant and negative in subsequent analyses. The negative coefficient for HML indicates that when there is information asymmetry in firms with growth stocks rather than value stocks, investors perceive a higher level of risk. The signs of PMP coefficients for RMW and CMA are negative and positive, respectively. This suggests that, despite having high capital efficiency, the fact that disclosed net income is small suggests a situation where retained profits within the firm have increased. In this scenario, investors perceive it as a higher risk. In summary, for large-cap growth firms that disclose net income modestly, leading to an increase in book-equity, this situation implies a significant information asymmetry. Investors require compensation for the risk associated with adverse selection in such cases.

The sign of PMP concerning other factors naturally corresponds to the sign of the coefficients when performing spanning regression test with PMP on those factors. Moreover, the statistical significance of PMP's intercept implies that PMP is describing risks that cannot be explained by other factors. In other words, even after controlling for the attributes described by other factors, investors still perceive the variation in information asymmetry across the entire market as a risk. In Panel A of Table 5, the intercept of PMP has a value of 0.143%, and it is statistically significant at the 10% level. Additionally, the marginal contribution of PMP to $shmax^2$ is 0.0080, making it the third-largest value after HML and Mkt. This indicates that PMP contributes to the efficient frontier generated using all dependent and explanatory variables.

The intercepts of RMW and CMA are not statistically significant, and the marginal contributions to $shmax^2$ for RMW and CMA are 0.0000 and 0.0002, respectively, indicating that they contribute very little to the improvement of $shmax^2$. Therefore, it is anticipated that testing whether the addition of these factors will enhance FF3 would be challenging. The underperformance of FF5 when applied to Japanese data has also been reported in previous studies (Kubota & Takehara, 2018), which is consistent with the current results. Fama and French (2018) have reported that using cash profitability rather than operating profitability to construct factors results in higher $shmax^2$. Thus, a 2×3 RMWc factor is constructed using cash profitability and the results of the spanning regression test are presented in Panel B of Table 5.

The insights from the results presented in Panel B of Table 5 are quite similar to those indicated by Panel A. RMWc, similar to RMW, has a minimal marginal contribution to $shmax^2$, resulting in $shmax^2$ values that are almost unchanged from those in Panel A. A notable difference between Panel A and Panel B is that, in the spanning regression test of Mkt and SMBc, the coefficient for CMA is statistically significant and positively observed. The positive and statistically significant coefficient of CMA for SMBc suggests that smaller firms have higher capital efficiency.

The 2×3 factors used in these analyses do not perform orthogonal decomposition, so there is a possibility that the effects of each factor are mixed in their descriptions. Therefore, orthogonal decomposition should be performed to construct a $2 \times 2 \times 2 \times 2 \times 2$ factor, describing the independent variation of each factor, and spanning regression test should be conducted using these factors.

Panel C of Table 5 presents the results of a spanning regression test with a $2 \times 2 \times 2 \times 2 \times 2$ factor model that includes Mkt, SMB_o, HML, RMW_o, CMA, PMP, and the UMD factor related to momentum. Panel E of Table 4 shows that the correlation coefficients between the factors confirm the effectiveness of orthogonal decomposition, with RMW_o and CMA at -0.353 and CMA and PMP at 0.188. The correlation coefficients between the UMD factor and other factors are relatively low and the coefficients of the UMD factor in the spanning regression test are not statistically significant, suggesting that it captures independent variation. Furthermore, the intercept for UMD is remarkably high at 3.524%, which is 8.810 times the intercept value of HML, at 0.400%. However, the *rmse* of UMD is relatively high at 11.811, resulting in a UMD marginal contribution to $shmax^2$ of 0.0890, roughly 1.537 times that of HML. Fama and French (2018) have also reported that despite having a high intercept, UMD can have a lower marginal contribution to $shmax^2$ when its adjusted R-square is lower and *rmse* is higher compared to other factors. The $shmax^2$ in Panel A is 0.1070, while in Panel C, it has increased to 0.1871, indicating a 1.749-fold improvement in the squared Sharpe ratio of the efficient frontier due to the inclusion of UMD.

When conducting spanning regression test for Mkt, RMW_o, and UMD, the coefficients for PMP are not statistically significant. Likewise, when performing spanning regression test for PMP, the coefficients for Mkt, RMW_o, and UMD do not achieve statistical significance. The intercept for PMP stands at 0.127%, with a *t*-statistic of 1.994, indicating statistical significance at the 5% level. The adjusted R-squared drops from 0.378 in Panel A to 0.071, implying that the PMP factor describes the variability component that is not captured by other factors. The marginal contribution of PMP to $shmax^2$ is 0.0115, ranking as the third-largest after UMD and HML. Once again, the addition of PMP suggests the potential for improving the asset pricing model.

Panel D of Table 5 displays the results of spanning regression test with a $2 \times 2 \times 2 \times 2 \times 2$ factor model, which includes Mkt, SMB_c, HML, RMW_c, CMA, PMP, and the UMD factor. The sign of the coefficients for the PMP factor during spanning regression test is negative for SMB_c, HML, and RMW_c and positive for CMA, which are consistent with those in Panel A. In Panel B, the coefficient for PMP with respect to RMW_c is positive and statistically significant. However, after orthogonal decomposition, the coefficient for PMP with respect to RMW_c becomes negative and statistically significant. This result suggests the potential for drawing incorrect conclusions when orthogonal decomposition is not employed. The intercept for PMP stands at 0.150%, with a *t*-statistic of 2.338, indicating statistical significance at the 5% level. The marginal contribution to $shmax^2$ is 0.0159, ranking as the third-largest, following UMD and HML.

The intercepts of PMP in the results presented in Panel A through Panel D of Table 5 are all statistically significant. These results suggest the existence of unique risk components within PMP, even after controlling for attributes related to other risk factors.

4.2. Panel data analysis

Table 6 presents the results of the panel data analysis, with the return of accruals' decile portfolios as the dependent variable and a $2 \times 2 \times 2 \times 2 \times 2$ orthogonalized factor as the independent variables. The Hausman test supports the random effect model over the fixed effect model, and the Breusch and Pagan test indicates that the random effect model is favored over pooled OLS. This suggests that the covariance between time-invariant, portfolio-specific unobserved fixed effects, and factors is close to zero. It could be hypothesized, for instance, that the presence of extreme-rank portfolios with distorted accounting information might lead to a time-invariant tendency in portfolios. The suggestion implies that the covariance between such unobserved fixed effects and factors is close to zero.

To investigate whether returns unexplained by factors vary across accruals' ranks, dummy variables and the interaction terms of dummy variables with factors are included in the regression equation for random effect panel data analysis. The coefficients presented in Table 6 represent the differences

Table 6. Panel data analysis.

Panel A.								
	α	Mkt	SMBc	HML	RMWc	CMA	UMD	
dummy_1	0.194** (1.986)	−0.005 (−0.260)	−0.032 (−1.074)	−0.041 (−0.737)	−0.227*** (−3.210)	0.659*** (10.572)	0.008 (1.000)	
dummy_2	0.167* (1.713)	−0.024 (−1.363)	−0.138*** (−4.601)	−0.060 (−1.066)	−0.276*** (−3.895)	0.681*** (10.920)	0.007 (0.960)	
dummy_3	0.151 (1.548)	−0.033* (−1.879)	−0.130*** (−4.324)	−0.007 (−0.118)	−0.328*** (−4.623)	0.581*** (9.321)	0.003 (0.417)	
dummy_4	0.097 (0.997)	−0.046*** (−2.586)	−0.105*** (−3.509)	−0.083 (−1.487)	−0.221*** (−3.116)	0.534*** (8.565)	0.006 (0.745)	
dummy_5	0.021 (0.219)	−0.099*** (−5.547)	−0.137*** (−4.553)	−0.005 (−0.088)	−0.301*** (−4.253)	0.402*** (6.443)	0.006 (0.808)	
dummy_6	0.034 (0.349)	−0.083*** (−4.645)	−0.128*** (−4.260)	−0.074 (−1.328)	−0.165** (−2.325)	0.369*** (5.916)	0.002 (0.258)	
dummy_7	−0.096 (−0.985)	−0.063*** (−3.525)	−0.091*** (−3.027)	0.009 (0.164)	−0.128* (−1.802)	0.272*** (4.361)	0.008 (1.003)	
dummy_8	−0.081 (−0.829)	−0.062*** (−3.465)	−0.123*** (−4.097)	−0.033 (−0.590)	−0.099 (−1.393)	0.280*** (4.499)	0.007 (0.894)	
dummy_9	−0.105 (−1.080)	−0.029 (−1.638)	−0.098*** (−3.266)	0.019 (0.345)	−0.062 (−0.878)	0.156** (2.500)	0.011 (1.436)	
rank 10	−0.033 (−0.476)	1.031*** (81.871)	0.832*** (39.202)	0.476*** (12.023)	0.073 (1.466)	−0.245*** (−5.555)	−0.002 (−0.447)	
Panel B.								
	α	Mkt	SMBc	HML	RMWc	CMA	UMD	PMP
dummy_1	0.053 (0.566)	0.004 (0.232)	0.020 (0.682)	0.033 (0.623)	0.040 (0.571)	0.422*** (6.815)	0.010 (1.383)	0.943*** (13.022)
dummy_2	0.008 (0.086)	−0.015 (−0.864)	−0.080*** (−2.766)	0.025 (0.458)	0.026 (0.369)	0.413*** (6.674)	0.010 (1.383)	1.063*** (14.691)
dummy_3	0.027 (0.292)	−0.026 (−1.534)	−0.084*** (−2.929)	0.059 (1.100)	−0.093 (−1.318)	0.373*** (6.025)	0.005 (0.729)	0.827*** (11.424)
dummy_4	−0.022 (−0.241)	−0.039** (−2.292)	−0.061** (−2.131)	−0.020 (−0.373)	0.006 (0.090)	0.333*** (5.373)	0.008 (1.065)	0.800*** (11.051)
dummy_5	−0.099 (−1.059)	−0.091*** (−5.407)	−0.092*** (−3.214)	0.059 (1.096)	−0.073 (−1.043)	0.200*** (3.226)	0.008 (1.132)	0.803*** (11.089)
dummy_6	−0.027 (−0.287)	−0.079*** (−4.670)	−0.105*** (−3.665)	−0.042 (−0.788)	−0.049 (−0.700)	0.266*** (4.303)	0.003 (0.414)	0.407*** (5.622)
dummy_7	−0.157* (−1.684)	−0.059*** (−3.491)	−0.068** (−2.378)	0.041 (0.775)	−0.012 (−0.170)	0.169*** (2.736)	0.009 (1.198)	0.407*** (5.627)
dummy_8	−0.117 (−1.249)	−0.060*** (−3.519)	−0.110*** (−3.818)	−0.014 (−0.265)	−0.031 (−0.443)	0.221*** (3.562)	0.007 (1.024)	0.238*** (3.288)
dummy_9	−0.138 (−1.476)	−0.027 (−1.608)	−0.086*** (−2.993)	0.036 (0.681)	−0.001 (−0.013)	0.102 (1.639)	0.012 (1.587)	0.216*** (2.984)
rank 10	0.054 (0.811)	1.026*** (85.718)	0.800*** (39.328)	0.430*** (11.381)	−0.090* (−1.817)	−0.100** (−2.279)	−0.004 (−0.757)	−0.577*** (−11.273)

Table 6 presents the results of panel data analysis with the return of accruals' decile portfolios as the dependent variable and factors as the independent variables. Panel A presents the outcomes of the examination utilizing the FF6 model with a $2 \times 2 \times 2 \times 2$ orthogonalized factor structure (excluding the UMD factor), whereas Panel B illustrates the findings of the analysis conducted with the ACCcm model. The ACCcm model incorporates the FF6 model with the addition of PMP, featuring a $2 \times 2 \times 2 \times 2$ orthogonalized factor structure (excluding the UMD factor). The Hausman test favors the random effect model over the fixed effect model, and the Breusch and Pagan test supports the random effect model over the pooled OLS. To investigate whether returns unexplained by factors vary across accruals' ranks, dummy variables and the interaction terms of dummy variables with factors are included in the regression equation for random effect model panel data analysis. The coefficients presented in Table 6 represent the differences between the coefficients of each rank, with rank 10 serving as the reference for accruals' decile portfolios. T-statistics are presented in parentheses. *, **, and *** present significance at the 10%, 5%, and 1% levels, respectively.

between the coefficients of each rank, with rank 10 serving as the reference for accruals' decile portfolios.

Panel A presents the results of the verification using the FF6 model. The intercept α shows the most significant difference between the ranks 1 and 10 of accruals, with a gap of 0.194%, and this difference is statistically significant. Additionally, a statistically significant difference is observed for rank 2.

The Mkt coefficients for rank 1 and rank 2 are not statistically significantly different from the Mkt coefficient of rank 10. This suggests that the extent to which these portfolios are exposed to the fluctuations in Mkt risk is similar for rank 10 as well.

Moreover, regarding the coefficients for SMBc, the difference between the coefficients of rank 1 and rank 10 is not statistically significant, while the differences between the coefficients of rank 10 and the other ranks are statistically significant with negative values. Therefore, it is suggested that the differences

in the returns of accruals' decile portfolios cannot be explained by the small-cap effect. Furthermore, as there is no observed difference between rank 10 and other ranks for HML, variations in the returns of accruals' decile portfolios cannot be explained by differences in the value effect.

RMWc exhibits statistically significant negative differences in coefficients from ranks 1–7 compared to rank 10, while CMA shows statistically significant positive differences in coefficients from ranks 1–9 compared to rank 10. This suggests that in situations with high capital efficiency but modestly disclosed profit amounts, the returns of accruals' portfolios increase. Instances where capital efficiency is high but profits are disclosed modestly may indicate a high degree of asymmetric information. In such circumstances, the elevated level of asymmetric information may lead investors to require compensation for the exposure to the risk associated with adverse selection.

Furthermore, even after controlling for the risks represented by RMWc (cash profitability) and CMA (capital efficiency), the statistically significant intercept α for ranks 1 and 2 indicates the presence of remaining unexplained risks. UMD shows no statistically significant differences in coefficients at any rank, suggesting that it fails to capture the variability in returns attributable to accruals.

Panel B displays the results of the validation using the ACCcm model, which incorporates the PMP factor into the FF6 model. The coefficients for the PMP factor are statistically significant at all ranks. With a coefficient of -0.577 for rank 10, the actual values of the coefficients for the PMP factor are 0.366 for rank 1 and 0.486 for rank 2. The lack of a significant difference in the intercept α between ranks 1 or 2 and rank 10 suggests that PMP has effectively accounted for the return variations across different ranks.

Additionally, for the coefficient of RMWc, the difference with rank 10 is not statistically significant, and for the coefficient of CMA, the difference with rank 10 is relatively small in actual value compared to the estimates in Panel A. In Panel A, the noticeable differences in RMWc and CMA coefficients with rank 10 were likely due to RMWc and CMA inadvertently explaining the variability in returns that should have been attributed to PMP. However, in Panel B, where PMP is explicitly included and accounts for return variability, the differences in coefficients with rank 10 for RMWc and CMA are reduced.

4.3. GRS and its Bayesian model comparison

Barillas and Shanken (2018) pointed out that all models are a simplification of complex reality, and when conducting empirical analysis, asset pricing models are validated using proxies for the relevant theoretical factors. Thus, it is believed that verifying the models through posterior provability given the data, rather than testing with a sharp null hypothesis, can sometimes provide insight into the models. Therefore, considering the evaluation of model fitness in a Bayesian setting is warranted.

Barillas and Shanken (2017) emphasize that in model comparisons, what matters most is the explanatory power of the model regarding the factors included in other models. This also implies that the test asset irrelevance should hold when conducting model comparison. If the model under consideration is correct, the intercepts or 'alphas' resulting from regressing the factors included in other models on the model under consideration should be jointly zero. Therefore, a GRS test is conducted to verify whether the intercepts are jointly zero. By defining a Bayes Factor (BF) based on the ratio of the marginal likelihoods between the model with a zero constraint on the intercepts and the model without such a constraint, the posterior probability of the model, given the data, can be evaluated.

Panel A of Table 7 presents the results of the GRS test, which tested the comparison between CAPM and (FF3, FF5, FF6, ACCc, and ACCcm), and the Bayes Factor using the Bayesian marginal likelihood model comparison method, as modified by Chib et al. (2020) following Barillas and Shanken (2018). ACCc is a model that adds the accruals factor to the FF5 model, which calculates the profitability factor as cash profitability. Meanwhile, ACCcm is a model that adds the accruals factor to the FF6 model, which calculates the profitability factor as cash profitability. Additionally, factors are orthogonalized, excluding UMD.

In the GRS test, when testing whether FF3 improves upon CAPM, the left-hand side (LHS) comprises SMBc and HML, while the right-hand side (RHS) consists of Mkt. If CAPM is correct, the intercepts of the regression should be jointly zero. This test aims to determine whether adding SMBc and HML to Mkt enhances the squared Sharpe ratio of the efficient frontier. The GRS test statistic is 15.918, and the p -

value is 0.000, indicating the statistical significance of the joint non-zero intercepts resulting from the regressions of SMBc and HML on Mkt.

The Bayes Factor, computed through equations (30) and (31) for Bayesian marginal likelihood, is 0.000. Since the probability of the alternative being true is complementary to the probability of the null being true, we can deduce that the posterior probability of the null hypothesis being correct is $BF/(1 \pm BF)$ when both models have prior probabilities of 0.5. This gives a posterior probability of 0.0% for the CAPM with the Bayes Factor of 0.000. According to the well-known Jeffreys (1961) criteria for the Bayes Factor, there is 'decisive' evidence against the CAPM.

The rows below Panel A illustrate the comparisons of FF5, FF6, ACCc, and ACCcm with the CAPM, respectively. The Bayesian model comparison test results indicate that all these models enhance the CAPM, with a posterior probability of 0.0% for the CAPM in each instance.

Panel B of Table 7 presents the GRS test for FF3 vs. (FF5, FF6, ACCc, and ACCcm), as well as the Bayes Factor and posterior probability for FF3. The GRS test statistic for FF3 vs. FF5 is 1.548 with a p -value of 0.214. Furthermore, the Bayes Factor is 0.993, and the posterior probability for FF3 is 0.498, suggesting that the hypothesis of a jointly zero intercept when regressing RMWc and CMA on FF3 is not rejected. This result is in line with the prediction, given that the spanning regression test found no statistical significance in the intercept of RMWc and CMA.

When comparing FF3 to ACCc, the GRS test statistic is 2.789, which is statistically significant at the 5% level. The posterior probability for FF3 is 25.5%. The Bayes Factor is 0.341, indicating that the evidence against FF3 is 'not worth more than a bare mention', according to Jeffreys' (1961) criteria. However, the data favor the conclusion that the three additional alphas of RMWc, CMA, and PMP are not jointly zero, with odds of approximately 3 to 1. As mentioned earlier, since RMWc and CMA are considered to contribute little to model improvement, PMP enhances the model.

FF6 and ACCcm, which include the UMD factor, also show improvements over FF3, as demonstrated by both the GRS test and Bayesian model comparison. This finding aligns with the observation of a significant intercept for the UMD factor in the spanning regression test.

Panel C of Table 7 displays the results of the model comparison between FF5 and (FF6, ACCc, and ACCcm). The GRS test statistic to assess whether ACCc can improve upon FF5 is 5.237, which is statistically significant at the 5% level. Additionally, the posterior probability for FF5 is 21.5%, and the Bayes Factor is 0.274, indicating 'substantial' evidence against FF5.

Furthermore, Panel D of Table 7 presents the results of the test between FF6 and ACCcm. The GRS test statistic is 5.468, which is statistically significant at the 5% level. The posterior probability for FF6 is 19.9%, and the Bayes Factor is 0.248, suggesting 'substantial' evidence against FF6. In other words, the data support the hypothesis that adding the PMP factor to FF6 can enhance the model. These results are consistent with the statistical significance observed when regressing PMP on other factors in the spanning regression test. These results show that the PMP factor can improve CAPM, FF3, FF5, and FF6.

The total accruals were decomposed into discretionary accruals and non-discretionary accruals using the Jones, MJones, CFO-MJones, and the FL models. Subsequently, $2 \times 2 \times 2 \times 2 \times 2$ portfolios were constructed based on the orthogonal decomposition criteria of firm size, book-to-market, cash profitability, investment, and (discretionary accruals or non-discretionary accruals). Then, ACCc and ACCcm models with PMPd (discretionary PMP) and PMPnd (non-discretionary PMP) as PMP factors are evaluated. To save space, only the results of models using PMPd from the CFO-MJones and FL models and those using PMPnd from the Jones and MJones models are shown. Model comparisons are presented only for the cases of FF5 vs. (FF6, ACCc, and ACCcm) and FF6 vs. ACCcm.

In Panels E and F of Table 7, it is indicated that the PMPd composed by the CFO-MJones model cannot improve FF5 or FF6. However, in Panel G, it is shown that the PMPd composed by the FL model can enhance FF5. The GRS test statistic is 3.908, which is statistically significant at the 5% level. Additionally, the Bayes Factor is approximately 0.459, and according to Jeffreys' (1961) criteria, the evidence against FF5 is 'not worth more than a bare mention'. However, the data favor the conclusion that the additional alpha of PMPd is not zero, with odds of approximately 2–1. Furthermore, the GRS test statistic to assess whether PMPd can improve FF6 was 2.490, with a p -value of 0.116. The Bayes Factor is approximately 0.757, indicating that incorporating the PMPd factor does not improve FF6.

Table 7. GRS model comparison test and its Bayesian framework.

Panel A		Mkt(CAPM)				Panel B		Mkt,SMBc,HML(FF3)			
RHS		GRS				RHS		GRS			
LHS	GRS	p-value	BF	BF/(1 + BF)		LHS	GRS	p-value	BF	BF/(1 + BF)	
SMBc,HML(FF3)	15.918	0.000	0.000	0.000							
SMBc,HML,RMWc,CMA(FF5)	8.755	0.000	0.000	0.000		RMWc,CMA(FF5)	1.548	0.214	0.993	0.498	
SMBc,HML,RMWc,CMA,UMD(FF6)	13.884	0.000	0.000	0.000		RMWc,CMA,UMD(FF6)	11.686	0.000	0.000	0.000	
SMBc,HML,RMWc,CMA,PMP(ACCc)	8.125	0.000	0.000	0.000		RMWc,CMA,PMP(ACCc)	2.789	0.040	0.341	0.255	
SMBc,HML,RMWc,CMA,UMD,PMP(ACCcm)	12.610	0.000	0.000	0.000		RMWc,CMA,UMD,PMP(ACCcm)	10.229	0.000	0.000	0.000	
Panel C		Mkt,SMBc,HML, RMWc,CMA(FF5)				Panel D		Mkt,SMBc,HML, RMWc,CMA,UMD(FF6)			
RHS		GRS				RHS		GRS			
LHS	GRS	p-value	BF	BF/(1 + BF)		LHS	GRS	p-value	BF	BF/(1 + BF)	
UMD(FF6)	31.724	0.000	0.000	0.000							
PMP(ACCc)	5.237	0.023	0.274	0.215							
UMD,PMP(ACCcm)	18.773	0.000	0.000	0.000		PMP(ACCcm)	5.468	0.020	0.248	0.199	
Panel E		Mkt,SMBc,HML, RMWc,CMA(FF5)				Panel F		Mkt,SMBc,HML, RMWc,CMA,UMD(FF6)			
RHS		GRS				RHS		GRS			
LHS	GRS	p-Value	BF	BF/(1 + BF)		LHS	GRS	p-Value	BF	BF/(1 + BF)	
UMD(FF6)	90.489	0.000	0.000	0.000							
PMPd(ACCc)	0.668	0.415	1.130	0.531							
UMD,PMPd(ACCcm)	45.714	0.000	0.000	0.000		PMPd(ACCcm)	0.957	0.329	1.105	0.525	
Panel G		Mkt,SMBc,HML, RMWc,CMA(FF5)				Panel H		Mkt,SMBc,HML, RMWc,CMA,UMD(FF6)			
RHS		GRS				RHS		GRS			
LHS	GRS	p-Value	BF	BF/(1 + BF)		LHS	GRS	p-Value	BF	BF/(1 + BF)	
UMD(FF6)	90.643	0.000	0.000	0.000							
PMPd(ACCc)	3.908	0.049	0.459	0.315							
UMD,PMPd(ACCcm)	46.889	0.000	0.000	0.000		PMPd(ACCcm)	2.490	0.116	0.757	0.431	
Panel I		Mkt,SMBc,HML, RMWc,CMA(FF5)				Panel J		Mkt,SMBc,HML, RMWc,CMA,UMD(FF6)			
RHS		GRS				RHS		GRS			
LHS	GRS	p-Value	BF	BF/(1 + BF)		LHS	GRS	p-Value	BF	BF/(1 + BF)	
UMD(FF6)	88.058	0.000	0.000	0.000							
PMPnd(ACCc)	1.171	0.280	1.072	0.517							
UMD,PMPnd(ACCcm)	44.237	0.000	0.000	0.000		PMPnd(ACCcm)	0.590	0.443	1.131	0.531	
Panel K		Mkt,SMBc,HML, RMWc,CMA(FF5)				Panel L		Mkt,SMBc,HML, RMWc,CMA,UMD(FF6)			
RHS		GRS				RHS		GRS			
LHS	GRS	p-Value	BF	BF/(1 + BF)		LHS	GRS	p-Value	BF	BF/(1 + BF)	
UMD(FF6)	87.837	0.000	0.000	0.000							
PMPnd(ACCc)	4.309	0.039	0.394	0.283							
UMD,PMPnd(ACCcm)	44.994	0.000	0.000	0.000		PMPnd(ACCcm)	1.811	0.180	0.927	0.481	

Panel A of Table 7 presents the results of the GRS model comparison under the assumption of test asset irrelevance, which tested the comparison between CAPM and (FF3, FF5, FF6, ACCc, and ACCcm), and the Bayes Factor using the Bayesian marginal likelihood model comparison method. ACCc is a model incorporating the accruals factor into the FF5 model, where the profitability factor is computed as cash profitability. Meanwhile, ACCcm is a model that incorporate the accruals factor into FF6 model, where the profitability factor is determined by cash profitability. Furthermore, the factors are orthogonalized, with the exception of UMD. Bayesian marginal likelihood is computed as Equations (30) and (31). BF/(1 ± BF) presents posterior probabilities for the RHS model, when both compared models have prior probabilities of 0.5. Panel B presents the GRS test for FF3 vs. (FF5, FF6, ACCc, and ACCcm), as well as the Bayes Factor and posterior probability for FF3. Panel C displays the results of the model comparison between FF5 and (FF6, ACCc, and ACCcm). Furthermore, Panel D lists the results of the test between FF6 and ACCcm. The total accruals were decomposed into discretionary accruals (DA) and non-discretionary accruals (NDA) using the Jones model, modified Jones model (MJones), CFO-modified Jones model (CFO-MJones), and the Forward Looking (FL) model. Subsequently, $2 \times 2 \times 2 \times 2$ portfolios were constructed based on the orthogonal decomposition criteria of firm size, book-to-market, cash profitability, investment, and (discretionary accruals or non-discretionary accruals). Then, ACCc and ACCcm models with PMPd (discretionary PMP) and PMPnd (non-discretionary PMP) as PMP factors are evaluated, by conducting GRS model comparison for FF5 vs. (FF6, ACCc and ACCcm) and FF6 vs. ACCcm. Panels E and F present verification results on whether PMPd, composed by the CFO-MJones, can improve FF5 or FF6. Similarly, Panels G and H show results for the potential improvement of FF5 or FF6 using PMPd composed by the FL model. Panels I and J display verification results on whether PMPnd, composed by the Jones model, can enhance FF5 or FF6. Panels K and L provide verification results for the potential improvement of FF5 or FF6 using PMPnd composed by the MJones model.

Panels I and J of Table 7 show that PMPnd from the Jones model cannot improve FF5 or FF6. However, in Panel K, it is indicated that PMPnd composed by the MJones model can enhance FF5. The GRS test statistic is 4.309, which is significant at the 5% level. Furthermore, the Bayes Factor is 0.394,

suggesting that the data support the inference that the additional alpha of PMPnd is not zero, with odds of approximately 2.5–1. Additionally, the GRS test statistic for testing whether PMPnd can improve FF6 is 1.811, with a p -value of 0.180. Given a Bayes Factor of 0.927, including the PMPnd factor does not enhance the performance of FF6.

It can be argued that PMP composed by total accruals can substantially improve both FF5 and FF6. Furthermore, the results indicate that PMPd and PMPnd composed of DA and NDA may have the potential to improve FF5 in certain cases.

4.4. Model comparison using modified HJ-Distance

The HJ-distance was devised to measure the specification errors of the SDF models and is the least-squares distance between the proposed SDF model and the set of theoretical SDFs that price all assets correctly.

As the proposed SDF y is viewed as an approximation, and its empirical counterpart to the proposed SDF is error-ridden, the proposed SDF y cannot belong to the family of theoretical SDFs \mathcal{M} . Therefore, the distance between the proposed SDF and the set of theoretical SDFs is minimized with respect to L^2 -norm. The distance $|m^*-y|$ between $m^* \in \mathcal{M}$ and the proposed SDF y is the minimum adjustment that makes the proposed SDF y belong to the family of theoretical SDFs. Since there exists nuisance parameter θ to describe the proposed SDF y , HJ-distance is to minimize $|m^*-y|$ for the SDF parameters θ . The minimum distance is the deviation width between the proposed SDF and the set of theoretical SDFs; this distance is the projection of the deviation width $m - y$ onto the payoff space. In other words, the minimum adjustment that makes the proposed SDF y belong to the family of theoretical SDFs is measuring the deviation width, affecting the asset prices.

The estimated values of the modified HJ-Distance and the estimated values of the SDF parameter that minimizes the modified HJ-Distance are presented in Table 8. The value multiplied by the variance of the factor corresponding to the SDF parameter is equivalent to the risk premium, so the statistical significance of the SDF parameter implies that the corresponding factor is a priced systematic risk. As shown in Section 2.5, both the modified HJ-Distance and the model comparison using the GRS test can be achieved to satisfy the concept of test asset irrelevance. The results of model comparison tests using the modified HJ-Distance to satisfy test asset irrelevance are presented. The HJ-Distance and SDF parameter are calculated under both the assumption of a correctly specified model and the assumption of a potentially misspecified model. However, in this context, the results primarily focus on the assumption of a potentially misspecified model. The asymptotic distribution of HJ-Distance and SDF parameters, as well as the asymptotic distribution for model comparison using HJ-Distance and SDF parameters, are presented in Appendix B. The factors used in the analysis are orthogonal decomposed $2 \times 2 \times 2 \times 2 \times 2$ factors, and the profitability factor RMW is based on RMWc in the case of cash profitability.

Panel A of Table 8 displays the modified HJ-Distance for CAPM, FF3, FF5, FF6, ACCc, and ACCcm. The test assets used are the 5×5 Size-BE/ME sorts portfolios, which are portfolios commonly employed in empirical analysis. The t -statistics are computed under the assumption of a potentially misspecified model, while the p -values are computed under the assumption of a correctly specified model.

The values of the modified HJ-Distance indicate that CAPM has the highest value at 0.441, with FF3 at 0.309 and FF5 at 0.307. There is little difference between FF3 and FF5, which is consistent with the findings of spanning regression tests and GRS analysis. FF6 and ACCc show smaller modified HJ-Distance values compared with FF5, suggesting potential improvements over FF5 through UMD and PMP. Additionally, ACCcm exhibits the smallest value. However, it is important to note that under the assumption of a potentially misspecified model, the t -statistics are 5.494, whereas under the assumption of a correctly specified model, the p -value is 0.143. This implies that without considering model misspecification, one might draw incorrect conclusions. Considering the high value of the t -statistics, it is advisable to base the analysis on the assumption of a potentially misspecified model.

Panel B of Table 8 presents the SDF parameters that minimize the modified HJ-Distance along with their t -statistics. Furthermore, Panel C of Table 8 shows the risk premiums for the factors. Since it is believed that the SDF parameter and risk premium should take positive values, a one-sided test is conducted.

Table 8. HJ-distance and SDF parameter.

Panel A		HJDm						t_statistics						p_value	
CAPM		0.441						7.634						0.000	
FF3		0.309						6.109						0.043	
FF5		0.307						6.225						0.031	
FF6		0.288						5.864						0.072	
ACCc		0.293						5.968						0.053	
ACCcm		0.271						5.494						0.143	
Panel B		SDF_parameter							t_statistics						
	Mkt	SMBc	HML	RMWc	CMA	UMD	PMP		Mkt	SMBc	HML	RMWc	CMA	UMD	PMP
CAPM	0.008							CAPM	2.991						
FF3	0.018	0.008	0.196					FF3	2.535	0.807	3.139				
FF5	0.015	0.002	0.177	0.027	0.076			FF5	1.769	0.122	2.525	0.218	0.619		
FF6	0.015	0.016	0.130	0.100	0.094	0.038		FF6	1.441	0.658	1.725	0.699	0.694	1.399	
ACCc	0.020	0.023	0.197	0.082	−0.024		0.160	ACCc	2.082	1.024	2.565	0.711	−0.171		2.012
ACCcm	0.021	0.038	0.148	0.165	−0.013	0.041	0.174	ACCcm	1.659	1.292	1.858	1.163	−0.083	1.692	1.743
Panel C		Risk premium													
	Mkt	SMB			HML		RMWc		CMA		UMD		PMP		
CAPM	0.238														
FF3	0.515	0.085			0.584										
FF5	0.425	0.026			0.527		0.057		0.187						
FF6	0.430	0.171			0.386		0.215		0.232		5.328				
ACCc	0.575	0.247			0.587		0.176		−0.058				0.285		
ACCcm	0.593	0.419			0.442		0.353		−0.031		5.656		0.308		
Panel D		$T(\hat{\delta}_1^2 - \hat{\delta}_2^2)$					p-Value								
	CAPM	FF3	FF5	FF6	ACCc		CAPM	FF3	FF5	FF6	ACCc				
FF3	42.183					FF3	0.001								
FF5	47.127	4.846				FF5	0.001	0.107							
FF6	80.857	39.869	34.137			FF6	0.000	0.000	0.000						
ACCc	52.484	11.554	5.573	2.844		ACCc	0.001	0.012	0.009	0.358					
ACCcm	87.667	47.885	43.054	7.960	34.620	ACCcm	0.000	0.000	0.000	0.013	0.000				
		$T(\theta_2^+ \text{Avar}(\theta_2^+)^{-1} \theta_2^+)$					p-Value								
	CAPM	FF3	FF5	FF6	ACCc		CAPM	FF3	FF5	FF6	ACCc				
FF3	9.888					FF3	0.007								
FF5	9.895	0.484				FF5	0.042	0.785							
FF6	9.537	2.082	1.958			FF6	0.089	0.556	0.162						
ACCc	9.621	5.030	4.047			ACCc	0.087	0.170	0.044						
ACCcm	9.066	4.381	4.107	3.037	2.862	ACCcm	0.170	0.357	0.128	0.081	0.091				
Panel E		$T(\hat{\delta}_1^2 - \hat{\delta}_2^2)$						p-Value							
DA_CFOModifiedJones															
PMPd(ACCc)	t-Statistics	Risk premium			CAPM	FF3	FF5	CAPM	FF3	FF5					
0.022	0.280	0.038		ACCc	28.419	15.188	1.716	ACCc	0.004	0.032	0.193				
DA_ForwardLooking		$T(\hat{\delta}_1^2 - \hat{\delta}_2^2)$						p-Value							
PMPd(ACCc)	t-Statistics	Risk premium			CAPM	FF3	FF5	CAPM	FF3	FF5					
0.154	1.519	0.216		ACCc	28.963	19.120	4.495	ACCc	0.012	0.021	0.052				
NDA_Jones		$T(\hat{\delta}_1^2 - \hat{\delta}_2^2)$						p-Value							
PMPnd(ACCc)	t-Statistics	Risk premium			CAPM	FF3	FF5	CAPM	FF3	FF5					
0.156	1.749	0.219		ACCc	33.206	13.406	3.399	ACCc	0.001	0.023	0.077				
NDA_ModifiedJones		$T(\hat{\delta}_1^2 - \hat{\delta}_2^2)$						p-Value							
PMPnd(ACCc)	t-Statistics	Risk premium			CAPM	FF3	FF5	CAPM	FF3	FF5					
0.110	1.839	0.161		ACCc	26.472	6.956	3.842	ACCc	0.000	0.047	0.013				

Table 8 displays the following information: the estimated values of the modified HJ-Distance in Panel A, the estimated values of the SDF parameter that minimizes the modified HJ-Distance in Panel B, risk premium in Panel C, model comparison using modified HJ-Distance and SDF parameters with total accruals of PMP in Panel D, and model comparison using modified HJ-Distance with PMPd of PMPnd in Panel E. The asymptotic distribution of HJ-distance and SDF parameters were both calculated under the assumption that SDF is a correctly specified (CS) model and a potentially misspecified (MS) model as one of 2π times frequency zero spectral density estimators, which are heteroskedasticity autocorrelation consistent. The optimal lags were those chosen by Newey and West (1994). However, in this context, the results primarily focus on the assumption of a potentially misspecified model. The factors used in the analysis are $2 \times 2 \times 2 \times 2$ orthogonalized factors, and profitability factor RMW is based on RMWc in the case of cash profitability.

For the Mkt, the SDF parameter is 0.008, with a t -statistic of 2.991, making it statistically significant at the 1% significance level. The statistical significance of the SDF parameter for the Mkt factor implies that the Mkt factor represents priced systematic risk. Since the risk premium is the product of the SDF parameter and the factor's variance, the risk premium for Mkt is 0.238.

In the case of ACCcm, the SDF parameter for SMBc is statistically significant at the 10% significance level. While adding the UMD factor in FF6 does not make SMBc's SDF parameter statistically significant, including UMD and PMP in the ACCcm model demonstrates that SMBc functions as a risk factor. As indicated by the spanning regression test, when regressing SMB on other factors, the coefficient of the PMP factor is negative. Therefore, SMB and PMP describe opposite characteristics concerning firm size. Therefore, the lack of apparent functionality of SMBc in FF3, FF5, and FF6 is likely due to not controlling for the PMP factor.

The SDF parameters for the HML factor are statistically significant at the 1% level in FF3, FF5, and ACCc, and at the 5% level in FF6 and ACCcm. In FF3, the risk premium for the Mkt factor is 0.515 and that for HML is 0.584. Controlling for other factors has led to a significantly higher risk premium for Mkt compared to the CAPM case, and the risk premium for Mkt is shown to be approximately equal to that of HML.

The SDF parameters for RMWc and CMA are not statistically significant in any of the models, which is consistent with the results of spanning regression and GRS tests. Therefore, when analyzing Japanese market data, it is believed that RMWc and CMA are not priced factors, and their status as systematic risks is not statistically supported.

In FF6, the SDF parameter for UMD is statistically significant at the 10% level, while in ACCcm, the SDF parameter for UMD is statistically significant at the 5% level. Furthermore, the risk premiums for UMD are notably higher in FF6 (5.328) and ACCcm (5.656) than the other factors, which is also suggested by the magnitude of the intercept in spanning regression test. In FF6, owing to the significant contribution of the UMD factor, the value of the modified HJ-Distance decreases from 0.307 to 0.288. Therefore, based on these results, it is expected that FF6 will outperform FF5 in model comparisons.

The SDF parameter for the PMP factor is 0.160 in ACCc and 0.174 in ACCcm, both statistically significant at the 5% level. This indicates that PMP is a priced factor and that it represents systematic risk. The risk premiums for PMP are 0.285 in ACCc and 0.308 in ACCcm. Although they are approximately half the size of the risk premiums for Mkt and HML, they are statistically significant. Therefore, the inclusion of PMP suggests the potential for improving FF5 and FF6.

The results of model comparisons to satisfy test asset irrelevance using the modified HJ-Distance are presented in Panel D of [Table 8](#). Model comparisons based on the HJ-Distance are demonstrated in studies by Hansen et al. (1995) and Hansen and Jagannathan (1997), and model comparisons based on the SDF parameter are shown in Kan and Robotti's (2009) study. When using the squared HJ-Distance, the test statistic for CAPM versus FF3 is 42.183 with a p -value of 0.001. When using the SDF parameter, the test statistic is 9.888 with a p -value of 0.007. As noted in Hansen and Jagannathan (1997), the HJ-Distance represents the maximum pricing error per unit of payoff 1 norm. The modified HJ-Distance for CAPM is 0.441, while the modified HJ-Distance for FF3 is 0.309. This indicates that FF3 has smaller pricing errors and is considered to dominate CAPM in asset pricing.

In both cases using the squared HJ-Distance and the SDF parameter, no statistical significance is noted regarding FF5 improving upon FF3. This was predicted, as the statistical significance of the SDF parameters for RMWc and CMA is not demonstrated.

When comparing FF3 and FF6, using the squared HJ-Distance results in statistical significance at the 1% level, but when using the SDF parameter, it is not statistically significant. When conducting model comparison tests with SDF parameters, the test statistic is a quadratic form of the estimated parameter with a weighting matrix of asymptotic variance. The influence of the larger variance of the UMD factor compared to other factors likely contributes to such results. A similar observation can be made for FF3 vs. ACCcm.

When conducting a model comparison between FF3 and ACCc using the squared HJ-Distance, it is statistically significant at the 5% level. However, when using the SDF parameter, it is not statistically significant. This is likely because RMWc, CMA, and PMP, which are additionally included in ACCc, are evaluated together. In other words, the estimated SDF parameter of RMWc and CMA have larger variances

compared to their estimated values, rendering them statistically insignificant, and this lack of significance affects the test statistic when considering the combined set of RMWc, CMA, and PMP.

When comparing FF5 and FF6, the squared HJ-Distance is statistically significant at the 1% level, but when using the SDF parameter, it is not statistically significant. This value is believed to be influenced by the high variance of the UMD factor, similar to the cases of FF3 versus FF6 and FF3 versus ACCcm.

Since FF6 and ACCc are not nested models, model comparison was performed only using the squared HJ-Distance, and the estimation was based on Proposition 6 by Kan and Robotti (2009). In this case, test asset irrelevance is not satisfied. The modified HJ-Distance value for FF6 is 0.288, and for ACCc, it is 0.293. This suggests that UMD is a factor that reduces pricing error more than PMP. Therefore, the test statistic for FF6 vs. ACCc is 2.844 with a p -value of 0.358, indicating that ACCc does not outperform FF6.

The comparison of FF6 vs. ACCcm aims to test whether adding PMP to FF6 improves the model. ACCcm has a modified HJ-Distance value of 0.271, smaller than all other models, and when performing model comparison between FF6 and ACCcm using the squared HJ-Distance, the test statistic is 7.960 with a p -value of 0.013. Furthermore, when conducting model comparison using the SDF parameter, the test statistic is 3.037 with a p -value of 0.081. Therefore, it is statistically significant that PMP can enhance FF6, and ACCcm can be said to dominate FF6.

ACCc is compared to ACCcm to test whether adding UMD improves ACCc. When using the squared HJ-Distance, the test statistic is 34.620 with a p -value of 0.000, whereas when using the SDF parameter, the test statistic is 2.862 with a p -value of 0.091, which is significant at the 10% level.

Fama and French (2018) seemed hesitant to add UMD to their model; in the current analysis, the uniqueness of the UMD factor is also evident. Specifically, in model comparisons that include the UMD factor, it is often observed that significant improvements are achieved when using the squared HJ-Distance but statistically significant improvements are not observed in most cases when using the SDF parameter. UMD exhibits a significant intercept, as shown in the spanning regression test. The lack of statistical significance in model comparisons using the SDF parameter may be due to the high variance in the UMD factor.

According to Fama and French (2018), empirical analysis should be grounded in theoretical models, and adding factors to the model that lack economic meaning, even if strongly suggested by empirical results, can raise concerns about the nature of data mining. The factors composing FF5, namely SMBc, HML, RMWc, and CMA, have a theoretical basis in the discount dividend model with clean surplus accounting. Additionally, the PMP factor is theoretically grounded as discussed in Section 2.3. In model comparisons using PMPd constructed from discretionary accruals and PMPnd constructed from non-discretionary accruals, UMD is excluded from further analysis because there is a possibility that the functionality of PMPd and PMPnd is disrupted and cannot be observed due to the uniqueness of UMD.

Panel E of Table 8 presents the analysis for the cases where the intercept was significant in the spanning regression test, specifically for DA_CFO-MJones, DA_FL, NDA_Jones, and NDA_MJones. Furthermore, in the analysis, similar to the case of total accruals, orthogonal decomposed $2 \times 2 \times 2 \times 2$ factors were used, and RMW employs RMWc for cash profitability. To conserve space, Panel E of Table 8 displays the estimated values of SDF parameters and risk premiums corresponding to PMPd and PMPnd in the ACCc model, along with the results of model comparison tests ACCc versus (CAPM, FF3, and FF5) using modified HJ-Distance.

The corresponding SDF parameter for PMPd in the DA_CFO MJones model is 0.022, which is not statistically significant. However, in the DA_FL model, the corresponding SDF parameter for PMPd is 0.154, statistically significant at the 10% level. The risk premium is 0.216, which is slightly smaller than the premium calculated for total accruals. Additionally, ACCc significantly improves upon CAPM, FF3, and FF5 at the 5%, 5%, and 10% levels, respectively.

For the NDA_Jones model, the corresponding SDF parameter for PMPnd is 0.156, which is statistically significant at the 5% level. The risk premium is 0.219. In this case, ACCc significantly improves upon CAPM, FF3, and FF5 at the 1%, 5%, and 10% levels, respectively.

The corresponding SDF parameter for PMPnd in the NDA_MJones model is 0.110, which is statistically significant at the 5% level. The estimated values of SDF parameters are smaller compared to the DA_FL

model and NDA Jones model, but owing to the smaller variance of SDF parameter, the t -statistics are the highest among the case of DA_FL, NDA_Jones and NDA_MJones. Additionally, the value of the risk premium is slightly modest at 0.161. ACCc significantly improves upon CAPM, FF3, and FF5 at the 1%, 5%, and 5% levels, respectively.

The statistical significance of SDF parameters indicates that the corresponding risk factors are priced risk factors, which represent a systematic risk. Therefore, the ACCc model that includes the PMPd and PMPnd factors is believed to be able to dominate over CAPM, FF3, and FF5 in several cases.

5. Discussion

Accruals are regarded as investments in working capital and are an integral component in the growth process of firms. Assuming asymmetry of information among investors when predicting the returns on such investments, investors are exposed to adverse selection problems. Consequently, in market equilibrium, investors are believed to require compensation for the systematic risk associated with adverse selection exposure.

By constructing the accruals factor as a variable to proxy for such risks, it is demonstrated that the accruals factor is priced and can enhance existing asset pricing models. Moreover, categorizing accruals into discretionary and non-discretionary components and constructing accruals factors from these components yields similar results.

These findings were derived by applying the GRS model comparison, its Bayesian framework, and HJ-distance. Having conducted an analysis using GRS model comparison based on test asset irrelevance (Barillas & Shanken, 2017, 2018; Chib et al., 2020) and model comparison using HJ-Distance to satisfy test asset irrelevance, it is believed that the issue of 'Home Game' has been overcome.

Fama and French (2018) proposed the FF6, which adds momentum factor UMD introduced by Carhart (1997) to FF5 somewhat reluctantly to satisfy popular demand. Because they believe that theory can limit the range of competing models and the robustness of results is another limiting consideration, they emphasize that a certain umbrella theory such as the dividend discount model or the production-based model of Cochrane (1991) should exist as a precondition to choose factors. Consequently, they were concerned that an undisciplined search that lacks theoretical motivation would bring us to a dark age of data mining.

Accordingly, the accruals anomaly ought to be elucidated through theory proposed by Easley and O'Hara (2004). They showed that the systematic risk associated with adverse selection induced by composition of public and private information affects capital cost. The dividend discount model with clean surplus accounting, by which FF5 is motivated, does not consider this perspective.

Disclosing information about the actual state of corporate management, which includes internal and external finance, is believed to have a dual effect on the cost of capital. On one hand, it alleviates information asymmetry with investors, thereby lowering capital costs. On the other hand, during the process of firms expanding their business through investment activities, the discretion given to managers, which increases asymmetric information, is thought to increase capital costs. Hence, there is a trade-off relationship between these effects. Consequently, the issue of asymmetric information will persist, and so will adverse selection problems. Investors seeking to address the adverse selection problem will continue to require a risk premium.

The results derived from the empirical verification are consistent with Jensen's (1986) free cash flow hypothesis. Managers increase their discretionary power by increasing the resources under control with accruals. The increase in the free cash flow and discretion of the firm's manager also increases the agency costs that investors bear, and they require a risk premium for the excessive discretion entrusted to the firm's manager. Hence, the more significant the discretion granted to managers, the more pronounced the adverse selection problem.

As accounting standards act as filters that convert economic events into information, they cover the entire capital market and affect the informational environment. As the economy develops or fluctuates, the domain of functions assumed by the accounting standard or the firm manager's disclosure policy becomes unstable. An economic event that investors could not predict in the previous informational

environment would become an uncertainty embedded in the system design. Therefore, economic growth or fluctuations in the economy can influence the information structure.

As pointed out by Khan (2008), the risk factors in equilibrium pricing models such as the ICAPM (Campbell, 1993; Merton, 1973) originate from the examination of how investors' preferences impact their decisions regarding consumption and savings. These risk factors are inherently general since the model is developed without specifying the risk or cross-section of returns.

In the context of the ICAPM, the factors in the FF5 model, motivated by the dividend discount model with clean surplus accounting, are considered factors related to N_d (news or revision in expectation at time t of future dividend growth). Meanwhile, the systematic risk associated with adverse selection induced by the information structure, as examined in this study, is believed to be a factor related to N_r (news or revision in expectation at time t of future discount rates). Therefore, it is suggested that the proxy for the systematic risk associated with adverse selection can complement the FF5.

The concept of parsimony, aiming to describe an asset pricing model with a high Sharpe ratio using as few factors as possible, is considered valid, as seen in previous studies (Ali & Ülkü, 2021). However, there may be periods when the problem of adverse selection is prominently evident and those when it is not, depending on the economic conditions. Additionally, the sensitivity to adverse selection risk will fluctuate. While it is crucial to eliminate redundant bases of the asset pricing model, caution should be exercised to avoid excluding risk factors necessary for understanding real-world phenomena during the excessive process of contraction in analysis.

The impact of omitting systematic risk from the benchmark asset pricing model in the Mishkin test was explained in Section 2.2. The extensive body of research supporting earnings fixation hypothesis simultaneously suggests the presence of omitted risk factors related to accruals. In particular, this is believed to be associated with issues related to adverse selection. Therefore, analyses based on this premise are expected to become future research topics.

Hirshleifer et al. (2012) conducted an analysis using the approach proposed by Daniel and Titman (1997) and Fama and MacBeth (1973) regressions, and argued that the accruals anomaly is not explained by the risk premium of factors composed of accruals but rather by behavioral mispricing resulting from investors' limited attention to the characteristics of accruals.

However, applying the assumptions from Daniel and Titman (1997) that firm characteristics are 'slowly varying firm attributes' in the analysis of accruals is inappropriate, since accruals are variables that may reverse in the subsequent period. Even if factor loadings for individual assets are estimated using data from the past five years (at least two years), assuming that this enables the estimation of expected returns for the next period, accurate estimates cannot be obtained for accruals based on the assumption of reversal. There is also a possibility that the estimated values of factor loadings may oscillate in some cases. Therefore, it is challenging to expect returns to vary based on the magnitude of factor loadings when forming portfolios through a three-stage sort of accruals, size, and factor loading.

Furthermore, even if their assumptions were correct (excluding the fact that accruals undergo radical changes), the simultaneous inclusion of accruals and factor loadings as explanatory variables in the Fama and MacBeth (1973) regression is expected to lead to a severe issue of multicollinearity. The coefficients obtained by regressing return on factor loadings are expected to represent the factor's expected return. They compose the factor by taking the difference between the average return of portfolios with low accruals and that with high accruals. Therefore, after normalizing accruals to take values between -0.5 and 0.5 , it is expected that the coefficients obtained by regressing return on accruals will be the values obtained by multiplying the factor's expected return by -1 . Since two variables with the expected same coefficients but opposite signs are simultaneously included in the regression analysis, the issue of multicollinearity cannot be ignored.

This argument illustrates the difficulty of capturing the risk represented by accruals at the individual firm level. While it may initially appear as the idiosyncratic risk of individual assets, in market equilibrium, it is believed that accruals serve as a proxy for the risk associated with adverse selection. Adverse selection depends on the degree of asymmetric information in the cross-section. Therefore, even if a significant turnover occurs between firms incorporated into portfolios representing the asymmetry of information in period t and those in period $t+1$, the overall degree of information asymmetry in the economy between periods t and $t+1$ may not change significantly. Consequently, when examining

individual firms over time, the degree of risk exposed to adverse selection is expected to fluctuate dramatically. A method of estimation based on such assumptions is deemed necessary and is considered a suitable avenue for future research.

According to Zhang (2007), accruals are an integral component in the growth process of firms. Given the asymmetric information among investors when forecasting returns on such investments, investors face adverse selection problems. Consequently, in a market equilibrium, investors are believed to require a premium as compensation for being exposed to the risk associated with adverse selection. Therefore, the risk premium associated with adverse selection induced by the information structure is considered a first-order effect of accruals. The subjective measurement of accruals and profit manipulation by managers are viewed as second-order effects of accruals, as analyzed by Kothari et al. (2006), who were motivated by the agency theory of overvalued equity (Jensen, 2005).

Wu et al. (2010), motivated by the q-theory of Tobin, demonstrated the relationship between risk, return, and financial activities on the production side. Assuming asymmetric information, this study empirically illustrated the relationship between risk, return, and financial activities on the investor side. Within the framework of general equilibrium, as these aspects may complement each other, constructing a model that can simultaneously address these issues is believed to contribute to further research.

The results presented in this study provide valuable insights for regulators and policy planners working in the capital market space. Given the presence of adverse selection problems, whether in internal or external finance, frameworks must be established to encourage more proactive information disclosure, particularly regarding accruals related to investment in firm growth and aspects of information asymmetry such as transparency and corporate governance structure. This could lead to a reduction in the overall cost of capital in the economy, with the potential to enhance economic welfare.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, H.I., upon reasonable request.

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Appendix A: The definition of discretionary accruals and non-discretionary accruals

The method to estimate non-discretionary accruals (NDA) is as follows. Discretionary accruals (DA) are calculated by subtracting estimated non-discretionary accruals from total accruals.

i) Jones model:

According to Jones (1991), the change in revenues (ΔRev) and gross property, plant, and equipment (PPE) affect NDA. ΔRev was included in the expectation model because NDA are affected by changes in the working capital, and PPE was regarded as non-discretionary depreciation expenses. The expected NDA from the Jones model are as follows:

$$\frac{NDA_{j,t}}{TA_{j,t-1}} = \beta_{0,j} \frac{1}{TA_{j,t-1}} + \beta_{1,j} \frac{\Delta \text{Rev}_{j,t}}{TA_{j,t-1}} + \beta_{2,j} \frac{PPE_{j,t}}{TA_{j,t-1}} + \varepsilon_{j,t} \quad (34)$$

where $NDA_{j,t}$ is firm j 's NDA in year t , $TA_{j,t-1}$ is the total asset at the beginning of year t , $\Delta \text{Rev}_{j,t}$ is the change in revenues, and $PPE_{j,t}$ denotes PPE. $\beta_{0,j}$, $\beta_{1,j}$, and $\beta_{2,j}$ were estimated based on pre-event 15 years data for each firm, and the NDA was calculated for the event year using a pre-estimated coefficient.

ii) Modified Jones model:

Dechow et al. (1995) modified the Jones model by subtracting the change in receivables (ΔRec) from ΔRev as changes in receivables may include managers' intended manipulation. The NDA expected from the modified Jones model are as follows:

$$\frac{NDA_{j,t}}{ATA_{j,t-1}} = \beta_{0,j} \frac{1}{ATA_{j,t-1}} + \beta_{1,j} \frac{(\Delta \text{Rev}_{j,t} - \Delta \text{Rec}_{j,t})}{ATA_{j,t-1}} + \beta_{2,j} \frac{PPE_{j,t}}{ATA_{j,t-1}} + \varepsilon_{j,t} \quad (35)$$

where $\Delta \text{Rec}_{j,t}$ is change in accounts receivable. $ATA_{j,t-1}$ represents average total assets of fiscal year $t - 1$. NDA were estimated using Equation (35) based on the pre-event 15 years data for each firm.

iii) CFO-modified Jones model:

Kasznik (1999) suggested that ΔCFO should be included in the modified Jones model to control for the component of NDA caused by a change in the CFO. As the proposed model is based on cross-sectional regression, firms are assigned to the estimation portfolio p according to the TOPIX17 industry code (the 17 classifications of the stocks listed on the Tokyo Stock Exchange). Using the estimated coefficients of assigned portfolio p , the NDA for each firm-year observation are as follows:

$$\frac{NDA_{j,t}}{ATA_{j,t}} = \beta_{0,p,t} \frac{1}{ATA_{j,t}} + \beta_{1,p,t} \frac{(\Delta \text{Rev}_{j,t} - \Delta \text{Rec}_{j,t})}{ATA_{j,t}} + \beta_{2,p,t} \frac{PPE_{j,t}}{ATA_{j,t}} + \beta_{3,p,t} \frac{\Delta \text{CFO}_{j,t}}{ATA_{j,t}} + \varepsilon_{j,t} \quad (36)$$

where $\Delta \text{CFO}_{j,t}$ is the change in cash flow from operation.

iv) Forward-looking model:

A growing firm tends to increase inventory due to future sales. This increase in inventory is not the result of earnings manipulation. Dechow et al. (2003) suggested that including future sales growth (GRSale) in the NDA estimate would smooth financial reports. As accruals could be predicted by the previous year's accruals, the lagged value of total accruals (LagTA) should also be included in the NDA estimate. The cross-sectional NDA of the forward-looking model are as follows:

$$\frac{NDA_{j,t}}{ATA_{j,t}} = \beta_{0,p,t} \frac{1}{ATA_{j,t}} + \beta_{1,p,t} \frac{((1+k)\Delta Rev_{j,t} - \Delta Rec_{j,p,t})}{ATA_{j,t}} + \beta_{2,p,t} \frac{PPE_{j,t}}{ATA_{j,t}} + \beta_{3,p,t} \frac{LagTA_{j,t}}{ATA_{j,t}} + \beta_{4,p,t} \frac{GRSale_{j,t}}{ATA_{j,t}} + \varepsilon_{j,t} \quad (37)$$

where $LagTA_{j,t}$ is the lagged value of total accruals, $GRSale_{j,t}$ is the change in sales from the current year to the next year, scaled by current sales, and k is estimated for each TOPIX17 industry grouping as $\Delta Rec = \beta_0 + k\Delta Sales + \epsilon$, restricted to between 0 and 1.

Appendix B: Model comparison using HJ-distance

The results of the model comparison test using the HJ-distance are as follows. Let y_t be a proposed SDF described as $y_t = 1 - \theta' f_t$ —a linear function of k systematic risk factors f_t and SDF parameter θ . Let the excess return and the mean excess return be denoted by R_t^e and $\bar{r} = E[R_t^e]$, respectively. The deviation from the mean is $r_t = R_t^e - \bar{r}$. The systematic risk factor f_t is denoted as the deviation from its mean. Let \mathcal{M} denote the set of theoretical SDFs that correctly price all the payoffs. Solving the problem of $\min_{m \in \mathcal{M}} |m - y|^2$ s.t. $E[mr] = 0$, the SDF parameter θ is estimated to minimize the HJ-distance. The estimated SDF parameter $\hat{\theta}$ and estimated HJ-distance $\hat{\delta}$ are as follows:

$$\hat{\delta} = \bar{r}' \text{var}(r_t)^{-1} \bar{r} - \bar{r}' \text{var}(r_t)^{-1} E[r_t f_t'] \left(E[f_t r_t'] \text{var}(r_t)^{-1} E[r_t f_t'] \right)^{-1} E[f_t r_t'] \text{var}(r_t)^{-1} \bar{r} \quad (38)$$

$$\hat{\theta} = \left(E[f_t r_t'] \text{var}(r_t)^{-1} E[r_t f_t'] \right)^{-1} E[f_t r_t'] \text{var}(r_t)^{-1} \bar{r} \quad (39)$$

The estimated HJ-distance provides the maximum pricing error per unit norm (Hansen & Jagannathan, 1997). The multiplication of the estimated SDF parameter and variance of systematic risk factor implies the risk premium required by market investors as compensation for bearing the exposure to systematic risks per unit. Consequently, statistically significant estimators of the SDF parameters imply the evidence of systematic risk.

Some SDFs are assumed to be misspecified; thus, statistical tests should be performed for both SDF as correctly specified and potentially misspecified model. As the asymptotic variances of the SDF parameters are larger under the assumption of potentially misspecified models than under correctly specified models (Kan & Robotti, 2009), the test statistics are larger when assuming a correctly specified model. Ignoring the model misspecifications may lead to incorrect conclusions.

Under the assumption that the SDF is correctly specified (i.e., $\delta = 0$), the asymptotic distribution of the estimated HJ-distance ($\hat{\delta}^2$) is shown as follows (Jagannathan & Wang, 1996):

$$T\hat{\delta}^2 \sim \sum_{i=1}^{N-k-1} \varphi_i x_i \quad (40)$$

where x_i is an independent χ_1^2 random variable, and the weight φ_i is equal to the nonzero eigenvalue of

$$S^{\frac{1}{2}} \text{var}(r_t) S^{\frac{1}{2}} - S^{\frac{1}{2}} \text{var}(r_t)^{-1} E[r_t f_t'] \left(E[f_t r_t'] \text{var}(r_t)^{-1} E[r_t f_t'] \right)^{-1} E[f_t r_t'] \text{var}(r_t)^{-1} S^{\frac{1}{2}} \quad (41)$$

where S is the asymptotic covariance of $\frac{1}{\sqrt{T}} \sum_{t=1}^T (r_t f_t' / \theta)$.

Meanwhile, under the assumption of potentially misspecified (i.e., $\delta \neq 0$), the asymptotic distribution of the HJ-distance is shown as follows (Hansen et al., 1995; Hansen & Jagannathan, 1997):

$$\sqrt{T}(\hat{\delta}^2 - \delta^2) \sim \mathcal{N}(0, \text{Avar}(\hat{\delta}^2)) \quad (42)$$

$$\sqrt{T}(\hat{\delta} - \delta) \sim \mathcal{N}(0, \text{Avar}(\hat{\delta}^2)/4\delta^2) \quad (43)$$

where $\text{Avar}(\hat{\delta}^2) = \sum_{j=-\infty}^{\infty} E[q_t q_{t+j}']$, $q_t = y_t^2 - (y_t - \eta' r_t) - 2\eta' \bar{r} - \delta^2$ and $\eta = \text{var}(r_t)^{-1} (\bar{r} - E[r_t f_t'] \theta)$.

In conducting statistical tests, asymptotic distribution is denoted as 2π times frequency zero spectral density estimators—the heteroscedasticity autocorrelation consistent (HAC) estimators (Newey & West, 1987). Thus, $\text{Avar}(\hat{\delta}^2)$ is estimated by using 2π times the spectral density of q_t at frequency zero estimator. Optimal lags were chosen following Newey and West (1994).

The asymptotic distribution of the SDF parameter under the assumption of potentially misspecified ($\delta \neq 0$) is shown as follows (Kan & Robotti, 2008):

$$\sqrt{T}(\hat{\theta} - \theta) \sim \mathcal{N}(0, \text{Avar}(\hat{\theta})) \quad (44)$$

where $\text{Avar}(\hat{\theta}) = \sum_{j=-\infty}^{\infty} E[h_t h_{t+j}']$, $h_t = H E[f_t r_t'] \text{var}(r_t)^{-1} r_t (1 - y_t) + H [f_t - E[f_t r_t'] \text{var}(r_t)^{-1} r_t] u_t + \theta$, $H = (E[f_t r_t'] \text{var}(r_t)^{-1} E[r_t f_t'])^{-1}$, $u_t = e' \text{var}(r_t)^{-1} r_t$, and $e = \bar{r} - E[r_t f_t'] \theta$. Assuming that the SDF is correctly specified ($\delta = 0$), h_t can be simplified to $h_t = H E[f_t r_t'] \text{var}(r_t)^{-1} r_t (1 - y_t) + \theta$, as we have $e = 0$ and $u_t = 0$.

Kan and Robotti (2009) formally tested whether the candidates for the two linear asset-pricing models have the same HJ-distance. Let the risk factor of Model 1 be $f_{t,1} \in \mathbb{R}^{k_1}$. Subsequently, the SDF of Model 1 is $y_{t,1} = 1 - \theta_1' f_{t,1}$ with SDF parameter $\theta_1 \in \mathbb{R}^{k_1}$. Let the risk factor of Model 2, which nests Model 1, be $f_{t,2} = (f_1', f_2^+)' \in \mathbb{R}^{k_1+k_2}$, and the SDF of Model 2 is $y_{t,2} = 1 - (\theta_1', \theta_2^{+})'(f_{t,1}, f_{t,2}^+)$ with SDF parameter $\theta_2^+ \in \mathbb{R}^{k_2}$ corresponding to additional risk factor $f_2^+ \in \mathbb{R}^{k_2}$. To test the hypothesis that Model 2 can improve Model 1, the null hypothesis $H_0 : \delta_1^2 = \delta_2^2$ was tested, and the asymptotic distribution of $\hat{\delta}_1^2 - \hat{\delta}_2^2$ is as follows:

$$T(\hat{\delta}_1^2 - \hat{\delta}_2^2) \sim \sum_{i=1}^{k_2} \psi_i x_i \quad (45)$$

where x_i are independent random variables distributed on the χ_1^2 random variable, and the weight ψ_i is equal to the eigenvalues of $H_{2,22}^{-1} \text{Avar}(\hat{\theta}_2^+)$. $H_{2,22}$ is a component of $H_2 = (E[f_2^+ r_t'] \text{var}(r_t)^{-1} E[r_t f_2^{+'}])^{-1} \in \mathbb{R}^{k_2} \times \mathbb{R}^{k_2}$. $\text{Avar}(\hat{\theta}_2^+)$ is the asymptotic variance of the SDF parameter θ_2^+ , assuming that the SDF is potentially misspecified ($\delta \neq 0$). This is because, without considering the potential model misspecification, one might mistakenly reject $H_0 : \delta_1^2 = \delta_2^2$. As $\delta_1^2 = \delta_2^2$ if and only if $\theta_2^+ = 0_{k_2}$, to test the equality of the HJ-distances of the two models, one can simply test $H_0 : \theta_2^+ = 0_{k_2}$. Under the null hypothesis, the test statistics are as follows:

$$T\hat{\theta}_2^{+'} \text{Avar}(\hat{\theta}_2^+)^{-1} \hat{\theta}_2^+ \sim \chi_{k_2}^2 \quad (46)$$