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Time-varying Risk Premia in Korea: Inference from Large Panel*

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Abstract

We provide novel empirical evidence on the time-varying risk premia in Korean stock market using the econometric methodology developed by Gagliardini et al. (2016) that exploit individual stock returns. To do this, we first implement model diagnostics tests to search for a possibility of omitted factors in the specifications considered. Our selected workhorse model is the Fama-French three-factor model equipped with conditioning variables such as default and term spreads. The estimated risk premia from the conditional Fama-French three-factor model exhibit a unique time-variation pattern, especially during the 2008 financial crisis. Lastly, the asset pricing restrictions derived by the no-arbitrage assumption hold for individual stocks implying that the estimated betas well explain the cross-sectional alphas.

KRF Classification : B030600
Keywords : Large Panel, Factor Model, Risk Premium, Asset Pricing, Model Selection

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Ⅰ. Introduction

The risk principle in asset pricing literature states that investors require financial compensation for bearing systematic risk. As the degree of such risk varies over time, the compensation required by investors should also be varying. Despite the abundance of empirical evidence of time-varying risk premia in U.S. stock market, it has not drawn much attention to researchers who study Korean stock market given its importance.

In this paper, we investigate the time-varying risk premia in Korean stock market estimated using a large panel of individual stock returns under the conditional linear factor model framework developed by Gagliardini et al. (2016) (GOS hereafter). GOS estimate the behavior of risk premia in U.S. stock market in a linear multi-factor setting builds on the two-pass cross-sectional regression method of Black et al. (1972) and Fama and MacBeth (1973). A novel contribution of GOS is that they extend the inferential theory to the large panel setting, which delivers better small-sample performance when the cross-sectional dimension (n) is large relative to the time dimension (T).[1] They also provide testable asset pricing implications based on the no-arbitrage assumption in the Arbitrage Pricing Theory (APT) framework. Using ten-thousand U.S. stocks from 1964 to 2009, they empirically show that estimated risk premia are indeed time-varying, which becomes more volatile, especially during crisis

1) As discussed in GOS, the use of large panel instead of test portfolios such as size and book-to-market sorted portfolios has advantages in terms of information losses and unbiasedness. Avramov and Chordia (2006) show that asset pricing tests with a finite sample of portfolios can cause a loss of information (Litzenberger and Ramaswamy, 1979) and data-snooping bias (Lo and MacKinlay, 1990), but these issues can be prevented by testing with single securities. Similarly, Lewellen, Nagel, and Shanken (2010) point out that the typical sample of 25 portfolios formed on size and value used in many asset pricing studies may have an inherent factor structure suggesting instead to use individual stocks.

periods (e.g. the oil crisis in the early 1970s and the recent financial crisis around 2008). However, the asset pricing restrictions implied by no-arbitrage are rejected for the conditional four-factor model of Carhart (1997), the workhorse asset pricing model of GOS.

Whenever working with observables factors to estimate risk premia, there is always a concern of omitted factors in the model. Since omitted factors lead to biased estimates for factor loadings, the estimated risk premia will also be biased even if the omitted factors are not priced, which leads to the false rejection of asset pricing restrictions. For this reason, we first need to validate our selected workhorse model in terms of model misspecification before risk premia estimation. To address this concern, we utilize the model diagnostic criterion for the factor structure of Gagliardini et al. (2019). The simple criterion checks whether the errors are weakly cross-sectionally correlated or share at least one unobservable common factor given observable factor models. If the set of observable factors is correctly specified, the errors should show a weak cross-sectional correlation, or the covariance matrix of the error terms in the factor model has a fast-vanishing largest eigenvalue.

We exploit a total of 2,483 stocks listed on the entire Korea Composite Stock Price Index (KOSPI) and Korea Securities Dealers Automated Quotation (KOSDAQ) market over the period from January 2001 to June 2019 (222 months) to investigate time-varying risk premia alongside with model validation. We consider (i) the Capital Asset Pricing Model (CAPM), (ii) the Fama and French (1993) three-factor model, (iii) the Carhart (1997) four factor model, and (iv) the Fama and French (2015) five-factor model as potential candidates. The diagnostic test shows that the conditional CAPM is not a correctly specified model in accordance with the APT because the residuals from the factor structure are not weakly cross-sectionally correlated. In this regard, we conclude that the conditional Fama-

French three-factor model is the most parsimonious specification that best describes stock returns in Korean stock market. The addition of momentum, profitability, and investment factors has only a marginal effect.

The estimated premia from a large panel of individual assets show a significant time-variation rejecting the hypothesis of time-invariance. Besides, we find a unique divergent pattern of size and value premia around the 2008 financial crisis. Consistent with the notion of counter-cyclical risk premia (Gomes et al., 2003; Zhang, 2005), size premia show an increasing pattern during the period. However, the value premia show the opposite, suggesting that growth firms become relatively riskier during the period. Furthermore, the asset pricing restrictions derived from the no-arbitrage assumption holds, implying that the estimated betas well explain the cross-sectional alphas.

Our results provide a new piece of empirical evidence on the time-varying risk premia of Korean stock market, which has not been studied extensively. Ryu and Lee (2009) test the conditional CAPM using the adjusted Kalman Filter approach with the biased beta correction to decrease the pricing errors. Chang and Hong (2012) investigate the market price of risk using both the Fama-French three-factor model and the multivariate GARCH-M Model. Using four industry indices, they provide supportive empirical evidence of time-varying betas as well as the price of risk in Korean stock market. Our first contribution is that we directly quantify time-varying risk premia and its time-series path implied by asset pricing theory. The path of risk premia explicitly described by macroeconomic instruments such as term spreads and default spreads exhibit a significant time-variation during the sample period.

There are a wide variety of studies analyzed the relationship between stock returns and risk factors in Korea. Many papers demonstrate the validity of the Fama-French three-factor models (Kim and Yoon, 1999; Kim and Kim, 2000; Kim and Kim, 2001; Yun et al., 2009; Hahn and Yoon, 2016) and the momentum (Kim, 2012; Jang, 2017).[2)] The alternative three-factor model by Chen et al. (2010) and the q-factor model by Hou et al. (2015), using the investment and the profitability as an additional factor are tested by Kim and Ahn (2011), Kam and Shin (2014), Ahn and Kim (2014), and Kang et al. (2019).[3)] A more recent Fama-French five-factor model is tested by Kang and Jang (2016) and Kang et al. (2019).[4)] However, most empirical studies have focused on the cross-sectional estimation of risk premia without considering its time-series behavior. Moreover, the abovementioned studies are limited to testing the sorted portfolio, such as the size and the value portfolios. Since we rely on a large panel of single security returns, the estimations are unbiased and more robust to cross-sectional and time-series dimensions.

Lastly, our paper is also the first that identify the number of

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2) In the Fama-French 3 factor model, market, size, and book-to-market factors significantly explain the cross-section of stock returns in Korean stock market (Kim and Yoon, 1999; Kim and Kim, 2000; Kim and Kim, 2001). Yun et al. (2009) argue that liquidity risk measured by stock turnover, instead of value factor, better explains the Korean stock market. Hahn and Yoon (2016) confirm that the value effect is not observed before 2000 but observed after 2000, showing that the significance of value factors may vary depending on the study period. Similarly, Kim (2012) and Jang (2017) report that momentum does not appear in the Korean market before 2000.

3) Kim and Ahn (2011) find evidence that the investment factor exists, but the alternative three-factor model's explanatory power is not higher than that of FF3. Kam and Shin (2014) show that capital investment does not significantly affect the determination of stock returns. However, Ahn and Kim (2014) note that the profitability premium measured by gross profit-to-assets exists in the Korean stock market. Furthermore, Kang et al. (2019) report that the q-factor model is comparable to FF5 in Korean stock market.

4) In a study that tests the Fama-French five-factor model in Korea, Kang and Jang (2016) point out that only the SMB factor is statistically significant, and the Fama-French 3 factor model as well as the Fama-French 5 factor model are not suitable to explain the Korean stock market. However, Kang et al. (2019) find that the five-factor model with quarterly based profitability factor performs well in Korean stock market.

omitted common factors in asset pricing models used to study Korean stock market. Domestic researches also acknowledge the latent factor problem. Ryu and Lee (2009) argue that the CAPM is correlated with the return dynamics due to omitted risk factors and the errors-in-variables problems from the imperfect proxy for the unobservable market portfolio. This argument is consistent with our results that the CAPM shows at least a missing factor. Besides, our analysis suggests using at least three-factors, including size and value.

The outline of the paper is as follows. In Section 2, we describe a general framework of conditional linear factor model and estimation procedure. Section 3 presents data and factor construction details. Section 4 provides empirical results. Section 5 concludes.

Ⅱ. Theoretical Framework and Empirical Methodology

GOS develops an econometric technique to estimate the conditional linear factor model under an approximate factor structure in a multi-period economy with a continuum of assets. In this section, we briefly review the estimation procedure of GOS.

Let $\mathbb{F}_t$ be the information available to investors at time t. The excess returns $R_t(\gamma)$ of an asset (indexed by $\gamma \in [0,1]$ that represent the continuum of assets) at each date satisfy the following conditional linear factor model:

$$R_t(\gamma) = a_t(\gamma) + b_t(\gamma)' f_t + \epsilon_t(\gamma), \qquad (1)$$

where a_t is the intercept, b_t is the sensitivity of excess returns to risk factors, and f_t denotes the values of K factors at date t. The error terms, ϵ_t, have mean zero and are uncorrelated with the factors conditional on information $\mathbb{F}_{t-1}$ which also satisfy weak cross-sectional dependence condition.

Under the no-arbitrage assumption as guided by APT, GOS show that the following asset pricing restriction holds for almost all γ:

$$a_t(\gamma) = b_t(\gamma)^{'}\nu_t, \tag{2}$$

where vector ν_t is unique and is $\mathbb{F}_{t-1}$ measurable. The restriction is actually equivalent to $E[R_t(\gamma)|\mathbb{F}_{t-1}] = b_t(\gamma)^{'}\lambda_t$, where $\lambda_t = \nu_t + E[f_t|\mathbb{F}_{t-1}]$ is the vector of conditional risk premia.

The conditioning information $\mathbb{F}_{t-1}$ is the vector of lagged instruments $Z_{t-1} \in \mathbb{R}^p$, which includes the constant and past observations of macroeconomic variables that affect entire assets in the economy.[5] GOS assume that the vector of factor loadings $(b_t(\gamma))$, the vector of risk premia (λ_t), and the conditional expectation of factors (f_t) are all linear function of the lagged instrument Z_{t-1}:

$$b_t(\gamma) = B(\gamma)Z_{t-1}, \tag{3}$$

$$\lambda_t = \Lambda Z_{t-1}, \tag{4}$$

$$E(f_t|\mathbb{F}_{t-1}) = FZ_{t-1}, \tag{5}$$

for some parameter matrices $B(\gamma), \Lambda$ and F.

The estimation of risk premia is from a sample of observations in the available datasets, while the theoretical framework assumes the continuum of assets. To reconcile this, GOS rewrite the model in Equation (1) as a random coefficient panel model with n assets

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5) Z_{t-1} may include asset-specific instruments in addition to common instruments as generalized in GOS.

drawn by random sampling. With drawings, asset pricing restriction in Equation (2) would not be affected by the so-called Shanken (1982) critique. For any asset i and date t, the excess returns are $R_{i,t} = R_t(\gamma_t)$ where γ_i is randomly drawn from the population [0,1]. Similarly, let $a_{i,t} = a_t(\gamma_i)$ and $b_{i,t} = b_t(\gamma_i)$ be the coefficients, and $\epsilon_{i,t} = \epsilon_t(\gamma_i)$ be the error terms. Therefore,

$$R_{i,t} = x_{i,t}^{'}\beta_i + \epsilon_{i,t}, \tag{6}$$

where $x_{i,t} = (vech[X_t]^{'}, f_t^{'} \otimes Z_{t-1}^{'})^{'}$ be a vector that have dimension $p(p+1)/2 + K_p$. The symmetric matrix $X_t = [X_{t,k,l}] \in \mathbb{R}^{p \times p}$ is such that $X_{t,k,l} = Z_{t-1,k}^2$ if $k = l$, and $X_{t,k,l} = 2Z_{t-1,k}Z_{t-1,l}$ otherwise. The operator $vech[\bullet]$ stacks the elements of the lower triangular part of a $p \times p$ matrix as a $p(p+1)/2$ vector.

The vector of coefficients β_i is a function of instruments representing the dynamics of $a_{i,t}$ and $b_{i,t}$:

$$\beta_i = (\beta_{1,i}^{'}, \beta_{2,i}^{'})^{'}, \tag{7}$$

$$\beta_{1,i} = N_p[(\Lambda - F)^{'} \otimes I_p] vec[B_i^{'}], \tag{8}$$

$$\beta_{2,i} = vec[B_i^{'}], \tag{9}$$

where $B_i = B(\gamma_i)$, Λ, and F are defined in Equation (3), (4), and (5). The vector operator $vec[\bullet]$ stacks the elements of a $m \times n$ matrix as a $mn \times 1$ vector. The N_p is defined as $\frac{1}{2}D_p^{+}(W_p + I_{p^2})$, where D_p^{+} is the $p(p+1)/2 \times p^2$ Moore-Penrose inverse of the duplication matrix D_p such that $vech[A] = D_p^{+} vec[A]$ for any matrix $A \in \mathbb{R}^{p \times p}$. The commutation matrix W_p is such that $vec[A^{'}] = W_p vec[A]$ for any matrix $A \in \mathbb{R}^{p \times p}$.

From Equation (8) and (9), the $\beta_{1,i}$ is a linear transformation of the $\beta_{2,i}$. This implies that the asset pricing restriction in Equation (2) is a constraint on the distribution of the random vector β_i via its support. The coefficients of the linear transformation depend on matrix $\Lambda - F$. For the purpose of estimating the loading coefficients of the risk premia in matrix Λ, we can rewrite the parameter restrictions as,

$$\beta_{1,i} = \beta_{3,i}\nu, \tag{10}$$

$$\nu = vec[\Lambda' - F'], \tag{11}$$

$$\beta_{3,i} = N_p(B_i' \otimes I_p). \tag{12}$$

With this random coefficient panel model setting, GOS present two-stage procedure to estimate factor risk premia. The first stage computes time-series OLS estimators $\hat{\beta}_i$ in Equation (6). To avoid unreliable estimates of $\hat{\beta}_i$, two trimming approaches are used. We only keep stocks for which 1) the time series is not too short(more than 36 months), and 2) the time-series regression is not badly conditioned as in Greene (2008). In the second stage, the cross-sectional parameter, $\hat{\nu}$, is computed by regressing the $\hat{\beta}_{1,i}$ on the $\hat{\beta}_{3,i}$ via multivariate WLS approach. Finally, the risk premia is estimated as $\hat{\lambda}_t = \hat{\Lambda} Z_{t-1}$, where $\hat{\Lambda}$ is from the relationship $vec[\hat{\Lambda}'] = \hat{\nu} + vec[\hat{F}']$. $\hat{F}$ is obtained by SUR regressions of factors f_t on lagged instruments Z_{t-1}.

Ⅲ. Data and Factor Portfolio Construction

In this section, we describe our dataset used in the empirical test.

1. Data and Sample Period

Our dataset includes monthly returns of common stock data listed in Korea Composite Stock Price Index (KOSPI), and Korea Securities Dealers Automated Quotation (KOSDAQ) traded in Korean Exchange. The sample period is set from January 2001 through June 2019 (222 monthly periods). Stocks of all firms are included, except financial industries, because financial firms have quite different characteristics than other industries. The firms identified financial firms with the first two-digit Korean Standard Industrial Classification (KSIC) codes 64, 65, or 66. For example, firms in the financial industry use a high level of debt in operating, which is not common in the other industry. Firms with less than one year of listing and without accounting information such as book equity and operating income are excluded.

Table 1 shows the summary statistics of firms in our test sample. During the sample period, the total number of firms in our samples is 2,483 unique firms. In Panel A, we illustrate the individual stocks' distribution concerning the number of observations in monthly frequency. During 18.5 years, 54% of firms have time-series observations of more than ten years, 75% of more than five years, and 90% of more than two years. Panel B presents the distribution of individual stocks across the industry. The two most frequent industry categories are Electronic Devise (753) and Chemicals, Plastics, and Petroleum (338), while the two less frequent ones are Agriculture, Forestry, Fishing, and Mining (11) and Utilities (19).

Data for several interest rates are collected from the Economic Statistics System (ECOS), provided by the Bank of Korea. We proxy the risk-free rate with the 91-day maturity certificate deposit (CD91) issued by AAA-rated banks to calculate the excess returns of individual stock returns and market returns for our empirical test. We take the instruments vector $Z_t = (1, DEF, TERM)$ where TERM

〈Table 1〉 Summary statistics of firms listed on the Korea Stock Exchange

Panel A. Distribution of individual stocks w.r.t. the number of observations (T_i)

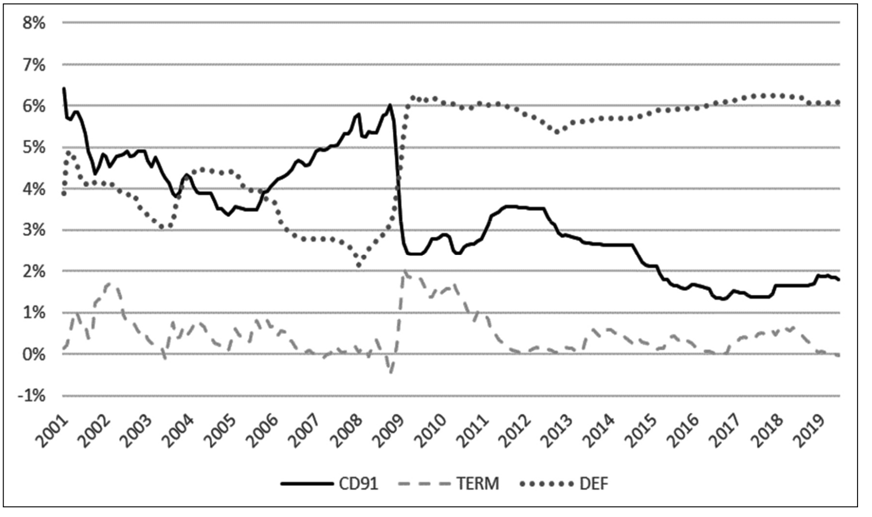
T_i	Frequency	Weight
1<12	99	3.99%
13<24	139	5.60%
25<60	391	15.75%
61<120	523	21.06%
121<240	1331	53.60%
Total	2,483	100.00%

Panel B. Distribution of individual stocks w.r.t. industry

Industry	Frequency	Weight
Agriculture, Forestry, Fishing, and Mining	11	0.44%
Manufacturing	1625	65.45%
Food/Beverage/Tobacco	76	3.06%
Textiles/Apparel	74	2.98%
Wood/Paper	34	1.37%
Chemicals/Plastics/Petroleum	338	13.61%
Metals	151	6.08%
Electronic Devices	753	30.33%
Motor Vehicles	129	5.20%
Other Manufacturing	70	2.82%
Construction	79	3.18%
Wholesale & Retail Trade	193	7.77%
Transportation	28	1.13%
Telecommunications	321	12.93%
Services	207	8.34%
Utilities	19	0.77%
Total	2,483	100.00%

Note: This table shows the summary statistics of firms listed on Korea Composite Stock Price Index (KOSPI) and Korea Securities Dealers Automated Quotation (KOSDAQ) traded in Korean Exchange from January 2001 to June 2019. Panel A presents the distribution of individual stocks concerning the number of observations in monthly frequency. Panel B presents the distribution of individual stocks for the industry. The total number of firms in our samples is 2,483 unique firms.

〈Figure 1〉 Risk-free rates and Instruments



Note: This figure illustrates the time variations of the risk-free rates, the term spreads, and the default spreads from January 2001 through June 2019 (a total of 222 monthly periods). CD91 indicates the 91-day maturity certificate deposit (CD91) issued by AAA-rated banks. The term spread (TERM) is defined as the difference in yield between a 5-year Treasury Bill and a 1-year Monetary Stabilization Bond, and the default spread (DEF) is defined as the difference in yield between a 3-year BBB- rated corporate bond and a 3-year AA-rated corporate bond. The interest rates are annualized and observed in monthly frequency.

is the term spread defined as the difference in yield between 5-year Treasury Bill and 1-year Monetary Stabilization Bond, and DEF is the default spread defined as the difference in yield between 3-year BBB- rated corporate bond and 3-year AA-rated corporate bond following GOS. The sample period is set from January 2001 through June 2019 (a total of 222 monthly periods), since 3-year BBB- rated corporate bond data, required for the default spread, is available after October 2000.

Figure 1 illustrates the time variations of the risk-free rates, the term spreads, and the default spreads in our sample periods. The interest rates are converted in annualized form and plotted in monthly frequency. This figure shows the time-variation of the interest rates, following the macroeconomy. Especially, CD91 are locally peaked Around the Global Financial Crisis in 2008 and sharply drop after the crisis, while the default spreads and term spreads sharply rise after the crisis.

2. Asset Pricing Models and Factor Construction Details

We consider four well-known linear factor models to examine time-varying risk premia, (i) the CAPM, (ii) the Fama and French (1993) three-factor model (FF3), (iii) the Carhart (1997) four-factor model (CAR), and (iv) the Fama and French (2015) five-factor model (FF5). All models are instrumented with default and term spreads for the conditional specification.

For the CAPM, we construct the market portfolio to calculate the excess market return. The proxy for the market portfolio return used in the analysis is the monthly value-weighted return on the final samples of 2,483 firms. The excess market return (MKT) is the value-weighted market return over the risk-free rate, where the proxy for the risk-free rate is CD91.

For the FF3 model, we follow the Fama and French (1992) method to construct the factor mimicking portfolio. We define book equity as same as Fama and French (1992), where the sum book value of common equity minus the book value of the preferred stock (if available) plus the balances-sheet deferred taxes. We use six value-weighted portfolios formed on size (market equity, ME) and book-to-market ratio (B/M) to construct double-sorted portfolios. At the end of June, in year t, all stocks in the sample are ranked according to market capitalization and split into two size groups, Small to Big (S to B), using the market capitalization breakpoints. Independently, the stocks are also ranked into three B/M groups, Low to High (L to H), based on the B/M breakpoints. We then form six portfolios from the intersection of the two sorts. In the sort for June of year t, the book equity at the year t-1 fiscal year-end and the market capitalization at year t-1 December end is used. Size breakpoint is the median KOSPI market equity. The breakpoints of other criteria are the 30^{th} and 70^{th} KOSPI percentiles. Denoting the 6 portfolios double-sorted based on ME and book-to-market (B/M) as SH, SM, SL, BH, BM, and BL, the return on SMB is calculated as [(SH+SM+SL)/3 – (BH+BM+BL)/3] and the return on HML is calculated as [(SH+BH)/2 – (SL+BL)/2].

In the CAR model, a momentum factor (UMD) is additionally considered in FF3. UMD is constructed by taking a difference between high momentum to low momentum, where momentum is measured by the cumulative return from prior twelve-month to prior two-month [t-12, t-2] (Carhart, 1997). Lastly, for the FF5 model, RMW and CMA are constructed with size and operating profitability and investment, respectively (Fama and French, 2015). Operating profitability is measured by dividing operating income with the book value of equity for the last fiscal year-end in t-1. Investment is measured by the change in total assets from the fiscal year ending in year t-2 to the fiscal year ending in t-1, divided by t-2 total assets at the end of each June using KOSPI breakpoints. We rebalance our double-sorted portfolio every July, and data is constructed in monthly frequency, while the momentum portfolios are reconstituted monthly. Table 2 shows the firm characteristics used for factor construction.

⟨Table 2⟩ Characteristics of individual stocks

	Mean	Std. dev.	25th Pct.	Median	75th Pct.	N
Total Return	1.35	19.01	-7.61	-0.36	7.63	329,027
$r_{-12,-2}$	14.53	80.35	-24.75	-0.81	31.99	329,027
Market Equity	549,297	4,780,303	29,326	65,498	168,550	329,027
Book-to-Market	1.44	1.78	0.57	1.04	1.77	329,027
Total Asset	1,101,234	7,328,856	50,301	109,084	303,885	329,027
Book Equity	478,833	3,770,364	26,811	58,303	151,453	329,027
Sales	940,622	5,892,701	37,173	97,969	276,684	329,027
Operating Income	60,540	646,775	283	4,345	15,851	329,027

Note: This table describes the characteristics of individual firms in our sample. Total returns indicate the monthly stock returns, including dividend yield. $r_{-12,-2}$ is the cumulative monthly returns from prior twelve-month to prior two-month [t-12, t-2]. Total return and $r_{-12,-2}$ are presented in percent and accounting information are presented in millions of Korean Won (KRW). N denotes the number of firm-month observations.

Table 3 reports average returns and correlation matrix of factor portfolios. In this table, the significantly positive factors during the entire period are HML, RMW, and UMD. Although the sample period is not precisely matched from other papers, the results are similar to others. Hahn and Yoon (2016) find that HML and UMD factors are significant from 2002 to 2013 when the market is only considered the KOSPI market, while MKT and SMB are insignificant. Besides, Kang et al. (2019) test the FF5 model in Korean stock market by quarterly rebalancing and find evidence that HML and RMW are significant from July 2002 to June 2015. By dividing the period, the significant factors before the financial crisis are the same as HML, RMW, and UMD, and the factors that are significant after the financial crisis are SMB, HML, and UMD. The significance of the risk factors' mean return is graphically illustrated in Figure 2, which shows cumulative returns on the five-factors and momentum. The figure shows that the significance of HML appears firmly over the whole period, and UMD appears as well, while other factors have time-varying significance according to the period.

〈Table 3〉 Summary statistics of Risk Factors

Panel A: Monthly average return and t-statistics

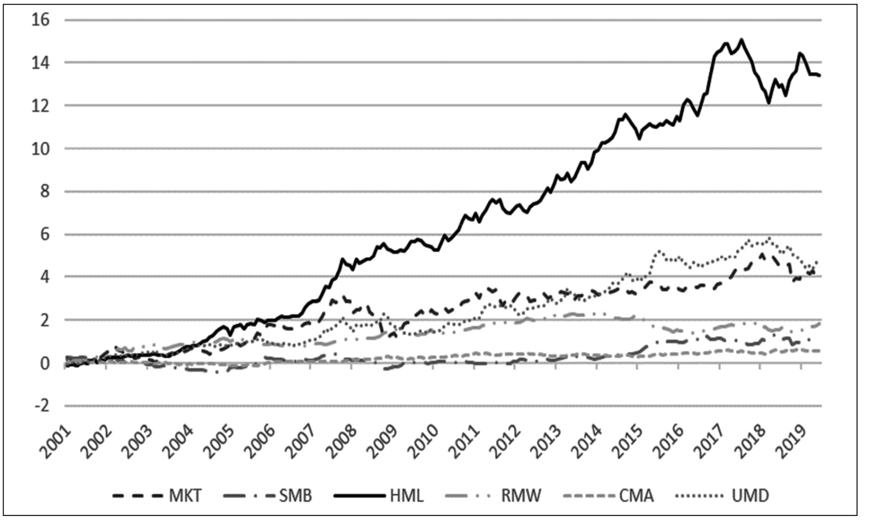
	MKT	SMB	HML	RMW	CMA	UMD
Sample Period: 2001.01-2019.06 (222 months)						
Mean	0.077	0.058	0.154	0.062	0.028	0.105
t-value	1.576	1.411	5.002	2.487	1.292	3.081
Sample Period: 2001.01-2009.12 (108 months)						
Mean	0.131	0.025	0.221	0.111	0.030	0.121
t-value	1.459	0.351	4.115	2.662	0.826	2.157
Sample Period: 2010.01-2019.06 (114 months)						
Mean	0.026	0.090	0.090	0.016	0.026	0.091
t-value	0.609	2.036	2.941	0.570	1.067	2.241

Panel B: Correlation matrix

	MKT	SMB	HML	RMW	CMA	UMD
Sample Period: 2001.01-2019.06 (222 months)						
MKT		0.526	0.000	-0.188	-0.098	-0.073
SMB			-0.205	-0.450	0.061	-0.128
HML				0.204	0.272	0.357
RMW					-0.299	0.158
CMA						0.075
Sample Period: 2001.01-2009.12 (108 months)						
MKT		0.556	-0.045	-0.256	-0.161	-0.104
SMB			-0.256	-0.497	0.003	-0.205
HML				0.280	0.267	0.535
RMW					-0.240	0.246
CMA						0.047
Sample Period: 2010.01-2019.06 (114 months)						
MKT		0.472	0.101	-0.048	0.072	-0.006
SMB			-0.058	-0.343	0.187	0.030
HML				-0.021	0.294	-0.022
RMW					-0.428	-0.010
CMA						0.127

Note: This table reports average returns and correlation matrix of risk factors. MKT denotes the value-weighted return of all stocks in excess of the risk-free rate (91-day CD). We use six value-weighted portfolios formed on size (market value of equity) and the other criterion to construct double-sorted portfolios. The size breakpoint is the median KOSPI market equity. The breakpoints of other criteria are the 30th and 70th KOSPI percentiles. Denoting the 6 portfolios double-sorted based on size and book-to-market (B/M) as SH, SM, SL, BH, BM, and BL, the return on SMB is calculated as [(SH+SM+SL)/3 - (BH+BM+BL)/3] and the return on HML is calculated as [(SH+BH)/2 - (SL+BL)/2]. Similarly, RMW, CMA, and UMD are constructed with size and operating profitability, investment, and momentum, respectively. Factor returns are expressed as an annualized percentage.

〈Figure 2〉 Cumulative return of the five factors and momentum



Note: This figure illustrates cumulative returns on double-sorted factor portfolios from January 2001 to June 2019. MKT denotes the excess market return, SMB is the size factor, HML is the value factor, RMW is the operating income factor, CMA is the profitability factor, and UMD is a momentum factor. For each factor l at month t, cumulative returns are calculated as follows:

$$cr_{l,t} = \prod_{\tau = t_0}^{t} (1 + r_{l,\tau}) - 1,$$

where $r_{l,\tau}$ is the arithmetic returns of factor l at month τ, and t_0 is January 2001, the start point of our sample period.

Ⅳ. Empirical Results

In this section, we first implement model diagnostic tests to search for a possibility of omitted factors in the specifications considered and to determine our workhorse model in Section IV.1. Then, we provide estimation results of time-varying risk premia in Section IV.2. Section IV.3 presents the results of asset pricing restrictions implied by no-arbitrage. Lastly, we implement a robustness test in Section IV.4.

1. Omitted factors

Before estimating factor risk premia and its time variation through the two-pass estimation described above, we should address the concern of model misspecification due to omitted factors. Since omitted factors lead to biased estimates for factor loadings, the estimated risk premia will also be biased, which leads to the false rejection of asset pricing restrictions derived from APT.

To search for any possibility of omitted factor problems in our proposed factor model specifications, we take advantage of recent econometric advances in the literature designed to identify such issues. Specifically, we employ the test diagnostics developed by Gagliardini et al. (2019), who show that the following statistics can detect omitted factors from the error terms of a given factor structure:

$$\xi = \mu_1\left(\frac{1}{nT}\sum_i 1_i^{\chi} \bar{\epsilon}_i \bar{\epsilon}_i'\right) - g(n, T). \tag{13}$$

Here, $\mu_1\left(\frac{1}{nT}\Sigma_i 1_i^{\chi} \bar{\epsilon}_i \bar{\epsilon}_i'\right) - g(n, T)$ denotes the largest eigenvalue of the residual covariance matrix, and $g(n, T)$ is the penalty term vanishing to zero for large n and T that aims to choose the parsimonious model by penalizing models with many parameters. The diagnostic criterion suggests that if ξ is negative, then the proposed factor structure is valid. On the other hand, the positive value implies that at least one factor is omitted from the specification. Intuitively, the diagnostic test validates a proposed factor structure when the largest eigenvalue is small enough so that the residual terms are only weakly cross-sectionally correlated. In this sense, this diagnostic test detectsomitted pricing factors in the APT of Ross (1976). Gagliardini et al. (2019) also provide statistics indicating how many factors are potentially omitted.

In Table 4, we present the number of non-trimmed stocks, the diagnostic criterion results, and the number of omitted factors (k). Starting with the conditional CAPM model, the statistics find statistical evidence for one omitted factor (i.e. $k=1$). Moreover, the systematic contribution of the omitted factor is non-negligible, which is 5.556% of the residual variance from the value of μ_1. This suggests that the CAPM model cannot be considered as the potential candidate for stock return dynamics.

〈Table 4〉 Diagnostic tests for omitted factors

Model	n_χ	μ_1	k	$\Sigma_{j=1}^{k}\mu_j$	μ_{k+1}	Penalty
CAPM	1,451	5.556	1	5.556	2.250	2.321
FF3	1,427	1.798	0	0	1.798	4.160
CAR	1,420	1.695	0	0	1.695	4.165
FF5	1,392	1.827	0	0	1.827	4.183

Note: The table shows the diagnostic statistics of Gagliardini et al. (2019). n_χ denotes the number of non-trimmed stocks. μ_1 denotes the contribution of the first eigenvalue to the variance of normalized residuals; k denotes the number of omitted factors; $\Sigma_{j=1}^{k}\mu_j$ denotes the contributions of the first k eigenvalues to the variance of normalized residuals; μ_{k+1} denotes the contributions of the $(k+1)$-th eigenvalues to the variance of normalized residuals; and the penalty term.

For the other models considered, however, we do not find any evidence of missing factors (i.e. $k=0$). The largest eigenvalue becomes smaller than the penalty score after size (SMB),and book-to-market (HML) factors are included in the specification. The marginal effect of momentum (UMD), profitability (RMW), and investment (CMA) factor seem small as there is no significant decrease in the large eigenvalue. From Table 5, we can conclude that the conditional FF3 is the most parsimonious specification that best describes stock returns in Korean market. For this reason, we estimate the time-varying risk premia relying on the FF3 in the following section.

2. Estimation Results of Time-varying Risk Premia

We estimate time-varying risk premia from large panel individual stock returns listed on KOSPI and KOSDAQ. After trimming, we use a total of 1,427 stocks for analysis. In Figure 3, we present the time-varying paths of the three risk premia.

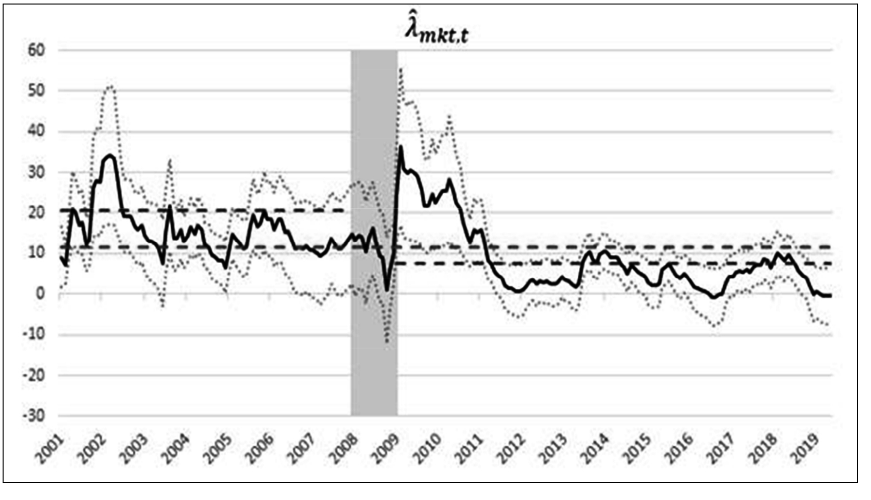
As shown in the Panel A of Figure 3, the estimated market risk premia is generally positive and hovers around the average over the period. In terms of magnitude, however, it becomes smaller after 2012. The size premia in Panel B shows both positive and negative signs, especially before the 2008 financial crisis indicated as the vertical shaded area. This weak size premia is consistent with Hahn and Yoon (2016), who also documents an insignificant size effect during this period when book-to-market is controlled for. The resurgence of size premia after the crsis may suggest the reversed cash-flow shocks to small and large firms,as discussed in Hou and Van Dijk (2018). Note that both MKT and SMB have increased at the period of crisis, consistent with the concept of risk premia.

Lastly, the value premia in Panel C has been consistently positive before the crisis, which has decreased after that. One possible explanation can be that growth firms being riskier than value firms after the financial crisis. A large portion of Korean economy depends on import and export relations with foreign countries. If the financial crisis originated from U.S. indirectly affects Korean firms'assets, while valuable growth opportunities disappear globally, the riskiness of growth firms may outweigh thedefault risk of value firms because growth option is no longer a hedge against assets in place. This result generates small value premia in terms of magnitude. This can also be the reason for the pro-cyclical behavior of HML during the crisis period, which is counter-intuitive to the notion of risk premia. Overall, the figure shows that the estimated premia do vary over time for all three risk factors considered. We also find a unique divergent pattern across three factors around the 2008 financial crisis, suggesting a structural break during this period.

To compare with the time-invariant case, we plot the time-invariant risk premia (dashed red horizontal linefor the full sample period, and two dashed blue horizontal lines that indicate risk premia before and after the global financial crisis).[6] Consistent with the patterns found in the time-varying specification, there is a structural change in premia in thetime-invariant setting as well. For example, MKT and HML premia decrease after the crisis, while SMB shows the opposite.

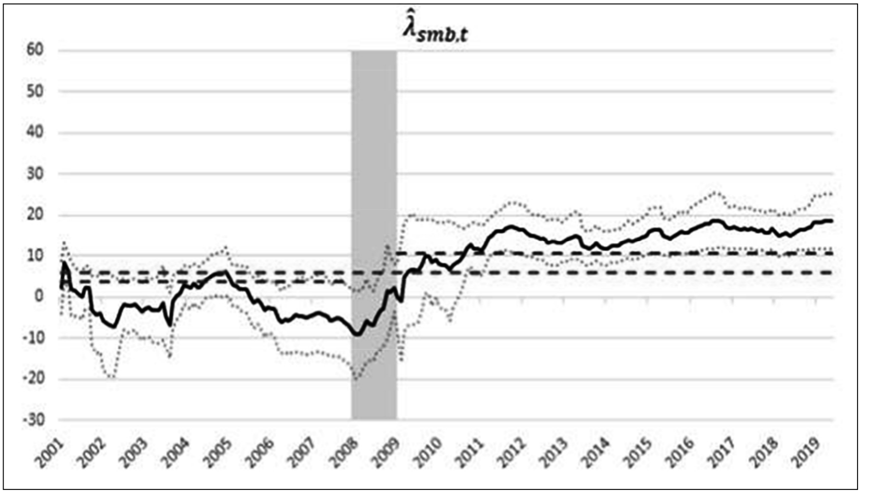
⟨Figure 3⟩ Path of Estimated Annualized Risk Premia with Individual Stocks in the Fama-French three-factor model

Panel A. The path of estimated annualized market risk premia ($\hat{\lambda}_{mkt,t}$)

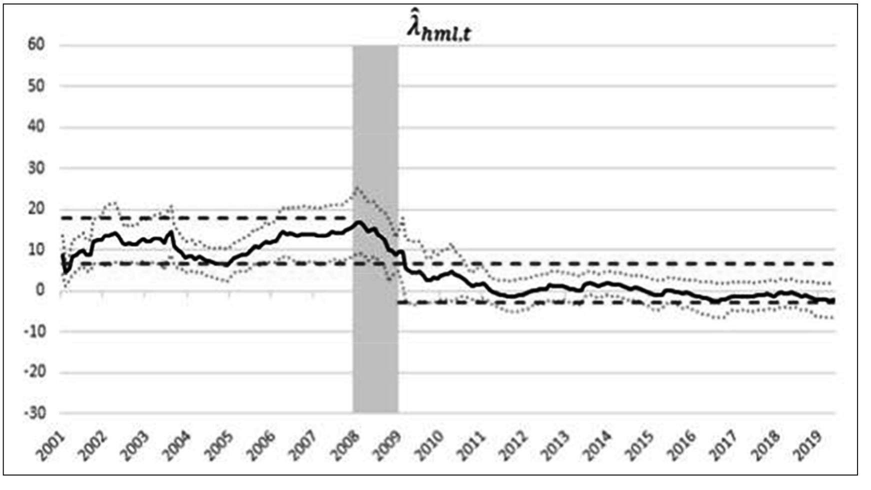


6) In the time-invariant case, the estimator of risk premia is $\hat{\lambda} = \hat{\nu} + \frac{1}{T}\Sigma_t f_t$.

Panel B. The path of estimated annualized size risk premia ($\hat{\lambda}_{smb,t}$)



Panel C. The path of estimated annualized value risk premia ($\hat{\lambda}_{hml,t}$)



Note: The figure plots the path of estimated annualized risk premia $\hat{\lambda}_{mkt,t}$, $\hat{\lambda}_{smb,t}$, and $\hat{\lambda}_{hml,t}$ and their confidence intervals at a 68% level in the Fama-French three-factor model. We use the returns of individual stocks. The vertical shaded areas denote the 2008 Global Financial Crisis. For comparison purposes, we report the risk premia estimated from the time-invariance model (dashed red horizontal line for full sample period, and two dashed blue horizontal line that indicate risk premia before and after the global financial crisis).

Since the variation of risk premia (λ) originates from the conditional expectation of the factors (via F) and the process ν, we distinguish two effects and report the estimation results in Table 5.

Starting with F, we find that the conditional mean is on average positive for all three-factors when default and term spreads are at their historical averages. The average HML is the largest in terms of magnitude, which is consistent with Figure 2. However, the conditional average MKT and SMB are marginally significant at a 10% level. The coefficient on default spread is significantly positive for SMB, reflecting its counter-cyclical nature, while the effect on HML is significantly negative. This negative effect is the primary driver of the pro-cyclical pattern found in Figure 3. The effect of term spread is positive for MKT and HML and negative for SMB, all insignificant at the conventional level.

〈Table 5〉 Estimated Annualized Components of Risk Premia in the Fama-French three-factor model

		F	ν	ν_{BM}
MKT	Const.	6.250	5.038	1.752
		(-1.370 13.870)	(1.917 8.159)	(0.399 3.105)
	DEF_{t-1}	0.400	-2.553	-1.758
		(-7.967 8.767)	(-7.206 2.099)	(-3.911 0.395)
	$TERM_{t-1}$	8.685	-0.620	-3.056
		(-0.434 17.804)	(-2.926 1.687)	(-4.378 -1.734)
SMB	Const.	5.041	2.156	0.278
		(-1.550 11.632)	(-0.042 4.355)	(-1.074 1.629)
	DEF_{t-1}	8.563	0.270	1.229
		(2.079 15.046)	(-1.808 2.348)	(0.042 2.417)
	$TERM_{t-1}$	-3.290	-0.053	0.596
		(-10.634 4.054)	(-1.691 1.585)	(-0.391 1.584)
HML	Const.	15.985	-10.724	-9.961
		(11.145 20.825)	(-13.665 -7.783)	(-11.284 -8.637)
	DEF_{t-1}	-8.765	3.057	3.949
		(-13.547 -3.982)	(0.463 5.652)	(2.408 5.489)
	$TERM_{t-1}$	3.564	-1.644	-3.094
		(-0.588 7.716)	(-3.844 0.555)	(-4.102 -2.087)

Note: The table shows the estimated annualized components of risk premia, $vec[F']$, ν and ν_{BM},and their confidence intervals at a 90% level (in parentheses). The default spread (DEF_{t-1}) and term spread ($TERM_{t-1}$) are standardized to have mean zero and standard deviation one.

Regarding the cross-sectional parameter estimated using individual stocks ν in the second column, we find significant coefficients on intercept for MKT and HML. Combined with F, the positive estimates on MKT explain the time-series average premia above 10, as found in Figure 3. Similarly, the partial offsetting effect from the negative estimate of -10.724 yields a positive average HML premia less than 10. The effect of default spread is only significant for HML, which is positive. The coefficients on term spread are negative but insignificantfor all risk factors, and their economic magnitude is small compared to the estimates on default spread.[7)]

3. Test of Asset Pricing Restrictions

In the multi-period economy with a continuum of assets with no-arbitrage restrictions, GOS show that Equation (2) should be hold. GOS also derive a test for the null hypothesis when the factors come from tradable assets (i.e. portfolio excess returns):

$$H_0 : \alpha(\gamma) = 0\,, \tag{14}$$

holds for almost all γ. GOS show that the restrictions can be tested properly only when error terms are weakly cross-sectionally correlated. As shown in Section IV.1, the time-varying FF3 satisfies the condition, validating any results from the asset pricing restriction tests.

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7) Even though we find some significant coefficients on instruments that imply the time-variation of risk premia in Table 5, we also test whether all coefficients on instruments are statistically different from zero. The value of test statistics is 20.119 for F and 16.597 for ν, both of which reject the null hypothesis of time-invariance (i.e. all coefficients on instruments are zero) at the 5% level.

〈Table 6〉 Test Results of Asset Pricing Restrictions

Panel A: Main Sample		
	$H_0 : \alpha(\gamma) = b(\gamma)'\nu$	$H_0 : \alpha(\gamma) = 0$
T-statistic	1.021	1.058
p-value	(0.154)	(0.145)
Panel B: Alternative Specification with Asset-specific Instrument		
	$H_0 : \alpha(\gamma) = b(\gamma)'\nu$	$H_0 : \alpha(\gamma) = 0$
T-statistic	0.633	0.742
p-value	(0.263)	(0.229)

Note: This table shows the test statistics and their p-values (in parentheses) of the null hypothesis $H_0 : \alpha(\gamma) = b(\gamma)'\nu$ and $H_0 : \alpha(\gamma) = 0$.

In Panel A of Table 6, we report the test statistics for two asset pricing restrictions in Equation (2) and (8). In all, we do not reject the hypotheses at least at the conventional 10% level as both p-values are above 0.1. This result shows that the conditional Fama-French three-factor model is compatible with the no-arbitrage assumption, implying that the estimated betas well explain the alphas cross-sectionally.

4. Robustness Check with Additional Instrument

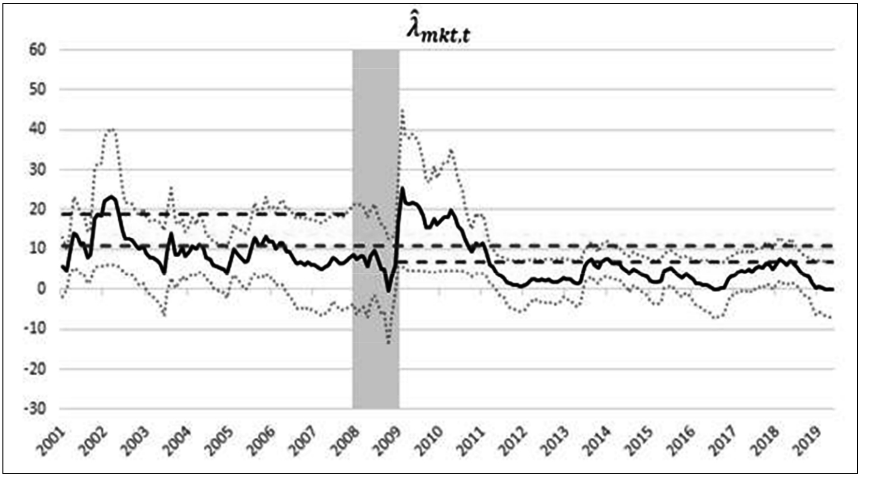
In the main empirical test, we utilize two economic-wide instrument variables such as default and term spreads to investigate the time-varying risk premia of factors. However, it may not be sufficient because some firm-specific characteristics can affect return premia in addition to macroeconomic factors. Thus, we implement a robustness check with an asset-specific instrument, strengthening the set of conditioning information $\mathbb{F}_{t-1}$. To avoid substantial loss of our sample, we only consider the lagged book-to-market ratio as an additional instrument. After the trimming approach, we use 1,089 stocks for analysis instead of 1,427 stocks used in the main analysis.

In Figure 4, we present the path of risk premia of three factors.

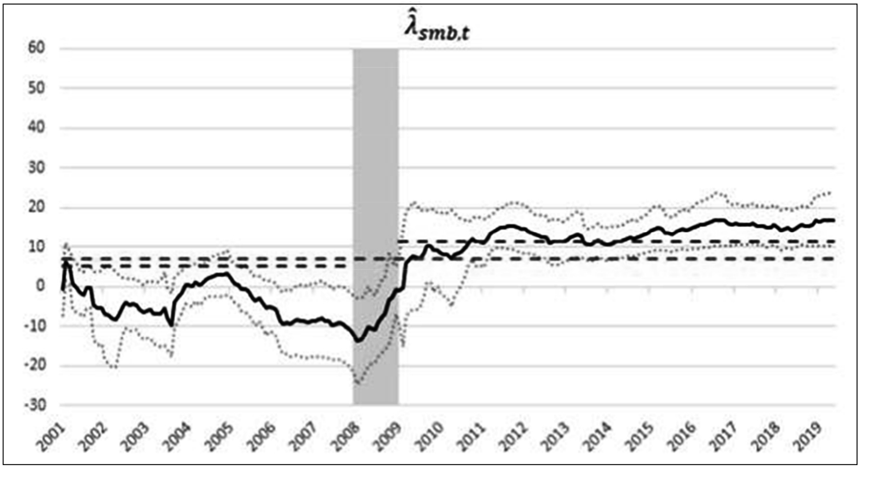
Overall, we find patterns very similar to our main result shown in Figure 3, while the time-variation of premia becomes less volatile, mainly for MKT and HML. We also report the estimated coefficients on macroeconomic instruments for cross-sectional parameter ν_{BM} in the last column of Table 5. After adding book-to-market as an

〈Figure4〉 Path of Estimated Annualized Risk Premia with Individual Stocks in the Fama-French three-factor model: Alternative Specification with Asset-specific Instrument

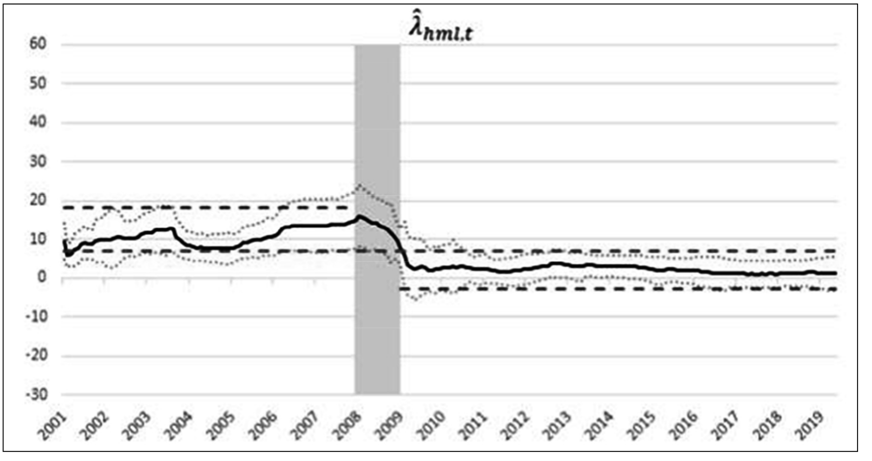
Panel A. The path of estimated annualized market risk premia ($\hat{\lambda}_{mkt,t}$)



Panel B. The path of estimated annualized size risk premia ($\hat{\lambda}_{smb,t}$)



Panel C. The path of estimated annualized value risk premia ($\hat{\lambda}_{hml,t}$)



Note: The figure plots the path of estimated annualized risk premia $\hat{\lambda}_{mkt,t}$, $\hat{\lambda}_{smb,t}$, and $\hat{\lambda}_{hml,t}$ and their confidence intervals at a 68% level in the Fama-French three-factor model with book-to-market as asset-specific instrument. We use the returns of individual stocks. The vertical shaded areas denote the 2008 Global Financial Crisis. For comparison purposes, we report the risk premia estimated from the time-invariance model (dashed red horizontal line for full sample period, and two dashed blue horizontal line that indicate risk premia before and after the global financial crisis).

asset-specific instrument, we find more significant coefficientsfor default and term spreads across risk factors. For example, the coefficients on default spread are significantly positive for SMB and HML, suggesting the counter-cyclical premia. However, the magnitude is insufficient to offset the pro-cyclicality of conditional HML returns, as shown in the first column.

Lastly, we present the test results for asset pricing restrictions in Panel B of Table 6. Consistent with our main result, we do not find any supportive evidence of rejecting the hypotheses. It turns out to be that the addition of book-to-market as an instrument tightens the asset pricing restrictions as the test-statistics being smaller compared to the statistics shown in Panel A. In sum, the relatively more complete set of conditioning information does not necessarily alter the time-variation of risk premia.

Ⅴ. Concluding Remark

In this paper, we investigate the time-varying risk premia in Korean stock market estimated using a large panel of individual stocks from 2001 to 2019. Our workhorse asset pricing model, the conditional FF3, is free from the omitted factor concern, validating any results obtained from the specification considered. We show that estimated risk premia exhibit a significant time-variation while there is a divergence between size and value premia around the 2008 financial crisis period. The asset pricing restrictions implied by the no-arbitrage hold for individual stocks. The analysis shows novel empirical evidence on the magnitude and time-series path of risk premia, which has not been documented in Korean stock market studies. Our results also provide important implications for future research, especially about the structural changes of risk premia around the recession.

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한국 주식 시장에서의 시간가변적 위험 프리미엄: 대형 패널을 중심으로*

조 원 호** · 김 용 준***

논문초록

본 연구는 개별 자산 수익률을 사용하여 Gagliardini et al.(2016)의 방법론을 따라 한국 주식 시장의 시간가변적(time-varying) 위험을 추정한다. 먼저, 다양한 요인 모형들을 대상으로 누락된 위험요인(omitted risk factor)이 존재하는지 검증한 결과, CAPM은 누락된 요인이 있는 반면 그 외 다른 모형들은 누락된 요인이 없는 것으로 나타난다. 또한, CAPM에서 규모 및 가치 요인을 추가로 고려할 때 잔차 분산(residual variance)의 감소가 큰 반면, 모멘텀, 영업수익성, 자본투자를 고려할 때 감소하는 효과가 미비하여, 한국 주식시장의 움직임을 가장 잘 설명하는 모형은 Fama-French 3요인 모형으로 보인다. 따라서, 본 연구에서는 기간스프레드와 신용스프레드를 도구변수로 사용한 조건부 Fama-French 3요인 모형을 사용하여 시간가변적 위험 프리미엄을 추정한다. 해당 모형을 사용하여 추정된 위험 프리미엄은 유의미한 시간가변성을 보이며, 특히 2008년 금융위기 전후로 두드러지는 결과를 보인다. 마지막으로, 무차익거래 가정에서 유추된 모형 제약조건들은 기각되지 않음을 확인하였다.

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