경영학석사 학위논문

Empirical Study of CAPM

– A perspective from day and night returns on the Korean stock market –

CAPM 실증연구: 국내 주식시장의 일중 및 야간 수익률을 중심으로

2021년 8월

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남정현의 경영학석사 학위논문을 인준함

2021년 8월

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Abstract

I investigate the relationship between the stock returns and their betas when the market is closed for trading versus when the market is open. My findings confirm that in the Korean stock market, the stock prices behave very differently with respect to their beta exposures during overnight and intraday periods. I find that stock returns increase monotonically with respect to their sensitivity to beta overnight, but decrease monotonically with respect to their sensitivity to beta during day. These night−day relations remain robust when betas are estimated using either overnight returns or daily returns over 24−hour periods as well as when tested at individual stock level. I also find evidence that these results are driven by time−specific demands of heterogeneous investors.

Keyword : CAPM, Overnight return, Intraday return, SML, Investor heterogeneity
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Chapter 1. Introduction

Systematic risk should be priced. In contrast to this bold prediction stipulated by the capital asset pricing model (CAPM), many studies find no direct relationship between beta and returns in the cross-section of stocks. The early seminal work of Black et al. (1972) demonstrates the security market line (SML) for US stocks that is substantially flatter than the CAPM prediction. This finding is reinforced by Black (1993), Fama and French (1992, 2004) and Polk et al. (2006). However, systematic risk appears to be priced, at least when the market is closed for trading.

Stock returns are known to exhibit distinct characteristics during the intraday period when the market is open for trading versus during the overnight period when the market is closed for trading. This is because certain types of investors prefer to trade at specific periods and returns over these specific periods reflect preferences of the corresponding clientele. Specifically, information flow, price impact and trading costs within the stock market are different during the night versus during the day. Given that corporate disclosures are typically made after the market closes for trading, investors that are more sensitive to information flow are likely to initiate their trades near the close. On the other hand, in order to avoid higher opportunity costs associated with owning a stock over the night and a greater price impact of an execution during the same period, investors that are more sensitive to liquidity are likely to initiate their trades near the open. In light of this, investors with heterogeneous demands create the presence of overnight and intraday clienteles. Reflecting these time-specific demands, daily returns can be divided into two components: overnight returns and intraday returns.

Based on the notion of investor heterogeneity, the recent study of Hendershott et al. (2020) focused on the stock market's overnight returns to find the positive risk-return relation specifically during the period when the market is closed for trading. Meanwhile, intraday returns are found to be negatively related to the systematic risk. From the above observations, Hendershott et al. (2020) concludes that the standard findings on the failure of CAPM can be explained by the slope and intercept of SML differing between night and day.

In this paper, I follow the approach of Hendershott et al. (2020) to test CAPM using daily returns divided into two components: overnight returns (measured over 17.5h from market close to open) and intraday returns (measured over 6.5h from market open to close). I estimate daily stock market betas using 12 months rolling window and form 10 beta-sorted portfolios. I then estimate market betas of these portfolios using two methods. First, I estimate unconditional beta using the entire sample period, assuming that the market betas remain time-invariant over the sample period. I then plot the estimated unconditional beta against portfolio overnight and intraday returns to illustrate their directional relationships. Second, I adopt the Fama-MacBeth procedure to estimate time-varying beta using 12-month daily stock returns and regress overnight and intraday returns on portfolios' market beta. I also separately run day fixed effect panel regressions to examine differences in the night and day implied risk premia.

Consistent with the findings of Hendershott et al. (2020), I observe a strong positive relationship between beta and overnight returns and a strong negative relationship between beta and intraday returns in the Korean stock market over the sample period from 1999 to 2020. I find that an increase in 1 unit of unconditional beta is associated with an increase in the average overnight return of 28 bps and a decrease in the average intraday return of 47bps, both economically and statistically significant. These relationships are almost entirely explained by variation in market beta, with R^2s of 83.1% for overnight returns and 95.9% for intraday returns. Similarly, Fama-MacBeth regressions using time-varying betas show that the coefficients on beta are 15bps and -22bps during night and day, respectively for equal-weighted portfolios, and 13bps and -12bps during night and day, respectively for value-weighted portfolios. The pooled regressions confirm these findings. The observed day-minus-night risk premia are -37bps and -26bps for equal-weighted and value-weighted portfolios, respectively. These results hold regardless of whether beta is estimated using overnight or close-to-close returns. They remain robust after controlling for individual stocks' characteristics, including size, book-to-market and momentum.

Motivated by these results, I expand on Hendershott et al. (2020) to find evidence supporting that the observed risk-return relations are driven by investor heterogeneity. Provided that institutional investors generally exhibit characteristics of overnight investors while individual investors overall display characteristics of intraday investors, the slope of night and day SMLs should reflect characteristics of investors dominant in the market. Therefore, I test the steepness of SML using stock day samples sorted into stocks listed in KSE, where individual investors account for a relatively smaller portion of trades, and KOSDAQ, which is driven by individual investors. I find that the slope of the day SML is considerably steeper than that of the night SML in KOSDAQ while the two SMLs are roughly equal in KSE. This result is consistent with the hypothesis that the observed deviation between the risk-return relationship during night and day reflects the specific demand by the corresponding clienteles.

I also examine investor heterogeneity in light of Frazzini and Pederson (2014)'s leverage constraint explanation. While empirical evidence suggests that a greater degree of leverage constraints results in a flatter SML, constraints alone cannot explain the downward sloping SML. Comparing my findings to past studies on leverage constraints and SML, I therefore conjecture that marginal day traders are risk-loving speculators who are also facing tighter leverage constraints.

This paper extends on a series of efforts to explain the puzzling weak relation between beta and returns by focusing on subsets of trading days, demonstrating that the positive relation between beta and returns holds only during specific times. Tinic and West (1984) found the positive risk–return relation in January. Cohen et al. (2005), Savor and Wilson (2014) and Jylha (2018) likewise discovered such relations during months of low inflation, on days when macroeconomic announcements are scheduled to be made, and during months when investors are exposed to lower degree of borrowing constraints, respectively.

This paper is also related to the study of unconditional average returns over different time periods. Kelly and Clark (2011) and Branch and Ma (2012) discover a strong negative autocorrelation between overnight and intraday returns. Heston et al. (2010) report systematic outperformance of some stocks during specific half–hours of the trading period. Berkman et al. (2012) find that stocks that caught retail investors' attention show higher overnight returns and lower intraday returns. Lou et al. (2019) show that momentum profits and several other anomalies accrue solely overnight. Although their focus is mainly on momentum, they also show that high–beta stocks underperform low–beta stocks at night, but outperform during the day.

In Korea, a number of researchers approve the existence of a reversal effect between overnight and intraday returns. Consistent with Berkman et al. (2012), Choi and Hahn (2016) identifies a positive relation between retail investors' attention to stocks and their overnight returns. Oh (2020) likewise concludes that the observation made by Lou et al. (2019) on the overnight accrual of momentum profits holds in the Korean stock market.

The organization of my paper is as follows. In Section 2, I describe the data and empirical methodology. Section 3 presents my main results and robustness tests that I discuss in Section 4. Section 5 concludes.

Chapter 2. Data and Methodology

Data used in this paper are retrieved from Dataguide 5.0. I use daily opening and closing prices of all firms listed on the Korea Stock Exchange (KSE) and KOSDAQ to compute returns. These daily stock price data are corporate action adjusted prices available in Dataguide 5.0. I only use common stocks and compute daily returns covering the 1999–2020 period. I follow Lou et al (2019) and Hendershott et al (2020) to construct 24h, intraday and overnight returns:

$$R_t^{24h} = \left(\frac{Close_t}{Close_{t-1}}\right) - 1 \quad (1)$$

$$R_t^{D} = \left(\frac{Close_t}{Open_t}\right) - 1 \quad (2)$$

$$R_t^{N} = \left(\frac{1+R_t^{24h}}{1+R_t^{D}}\right) - 1 \quad (3)$$

The 24h return may be longer than 24 hours when the market closes over holidays or weekends.

I follow Fama and French (1992) to calculate the size and book–to–market ratio. The daily market capitalization data are retrieved from Dataguide 5.0 and are denominated in KRW. Due to the limited availability of data during the earlier sample periods, I calculate the book equity (BE) as the book value of assets minus total liabilities.

I apply the following data filters. I only include stocks with daily opening and closing prices available. For a given day, stocks with market capitalization below KRW 10 billion or penny stocks with opening price below KRW 2,000 are excluded from the sample in order to control the possibility that the test portfolios' returns are distorted by the micro–structural factors of the market. I further remove stocks with daily transaction volume below KRW 100,000. I also follow Hendershott et al (2020) to exclude stock days for which a 24h return is above 200% or below negative 100%. Using the filtered sample, I calculate the market return as the weighted average daily returns of all stocks listed on KSE and KOSDAQ combined.

Table 1 summarizes the descriptive statistics of the sample used for this study. The average of the total sample's 24h returns is 0.07%, which can be broken down into intraday component of −0.05% and overnight component of 0.13%. Therefore, daily returns over a 24-hour period are primarily driven by overnight returns and this observation holds in both KSE and KOSDAQ samples. However, the KOSDAQ market exhibits a greater degree of deviation between the mean overnight returns and intraday returns.

The main objective of this study is to examine the variation of the risk-return relation between overnight and intraday periods. To observe the variation, I construct pre-ranked monthly beta for stock i in month m, $\beta_{i,m}^{P}$, by regressing daily overnight returns, $R_{i,m,t}^{N}$, against the market overnight returns, $R_{M,m,t}^{N}$, over 12 months rolling window.

$$R_{i,m,t}^{N} = \alpha_{i,m}^{N} + \beta_{i,m}^{P} R_{M,m,t}^{N} + \varepsilon_{i,m,t}^{N} \quad (4)$$

On any particular day for a particular stock, if the number of observed days over rolling window is less than 30, the stock is dropped.

Following Wilson and Savor (2014) and Hendershott et al (2020), I construct post-ranked monthly beta in two different ways: time-varying betas for tables and unconditional betas for graphs. Time-varying betas are estimated using daily overnight returns over 12 months rolling window. Unconditional betas are estimated using daily overnight returns over the full sample, excluding the 12-month period used to compute pre-ranked betas.

To test the risk-return relation, I adopt the Fama-Macbeth procedure to regress returns against betas separately for overnight and intraday periods:

$$R_{i,t+1}^{N/D} = \gamma_0^{N/D} + \gamma_1^{N/D} \hat{\beta}_{i,t}^{P} + \varepsilon_{i,t}^{N/D}, \quad (5)$$

where $\hat{\beta}_{i,t}^{P}$ is the stock i's market beta for period t estimated in equation (4) and $R_{i,t+1}^{N/D}$ is the stock i's overnight/intraday returns for period t+1.

Separately, I run a panel regression to directly observe the difference in the day and night risk premia:

$$R_{i,t+1} = \gamma_0 + f_{t+1} + \gamma_1 \hat{\beta}_{i,t}^P + \gamma_2 D_{t+1} + \gamma_3 \hat{\beta}_{i,t}^P D_{t+1} + \varepsilon_{i,t+1}, \quad (6)$$

where $R_{i,t+1}$ is overnight and intraday returns, f_{t+1} is day fixed effect and D_{t+1} is a day dummy variable that takes the value of 1 for intraday returns and 0 for overnight returns.

Following the Fama-MacBeth procedure, the first portfolio formation period is January 2001, in which portfolios are sorted using returns data from January to December 1999 and betas of portfolios are estimated using returns data from January to December 2000. To ensure consistency, portfolios used for plotting graphs are formed based on data beginning from January 2001. In other words, portfolios are sorted using returns data from January to December 2000 and betas of portfolios are estimated using returns data from the entire 2000 to 2020 sample period.

<Table 1> Descriptive statistics

This table reports descriptive statistics for the variables used in the construction of the beta. The sample includes all stocks listed on KSE and KOSDAQ, excluding stocks with market capitalization below KRW 10 billion, opening price below KRW 2,000, and daily transaction volume below KRW 100,000. Column 1 and 2 report the average and standard deviation of variables. The remaining columns show percentiles. Sample period is 01/1999 to 12/2020. Returns are expressed in percentage.

				Percentiles				
		Mean	SD	Min	25th	50th	75h	Max
All (6,378,263)	Market cap. (KRW 1 bil.)	789	5,664	10	47	102	274	483,552
	R_t^{24h}	0.07	3.72	−93.10	−1.57	0	1.40	184.70
	R_t^D	−0.05	3.50	−60.00	−1.69	−0.12	1.39	94.83
	R_t^N	0.13	2.08	−91.73	−0.58	0	0.81	113.52
KSE (2,828,304)	Market cap. (KRW 1 bil.)	1,579	8,425	10	76	192	712	483,552
	R_t^{24h}	0.07	3.29	−45.24	−1.38	0	1.26	153.66
	R_t^D	0	3.09	−60	−1.43	0	1.28	86.79
	R_t^N	0.07	1.88	−44.68	−0.59	0	0.71	100.98
KOSDAQ (3,549,959)	Market cap. (KRW 1 bil.)	159	442	10	38	71	146	43,788
	R_t^{24h}	0.07	4.04	−93.10	−1.75	0	1.53	184.7
	R_t^D	−0.09	3.80	−51.74	−1.91	−0.18	1.49	94.83
	R_t^N	0.18	2.22	−91.73	−0.57	0	0.90	113.52

Chapter 3. Results

This section presents the results of a series of tests on the overnight and intraday risk premia. I adopt methodologies proposed by Hendershott et al (2020) to test the risk–return relation of stocks listed on KSE and KOSDAQ. For the purpose of estimating the assets' systematic risk, I use data from the 1999–2020 period. Overnight returns are measured over 17.5h when the market is closed, except when the market remains closed for a longer period due to weekends, holidays or early closure. All intraday returns are measured over 6.5h.

3.1. Beta–sorted portfolios

I adopt the Fama–MacBeth procedure and start by estimating monthly pre–ranked beta for all stocks from 1999 to 2020 using 12–month rolling windows of daily overnight returns. For Figure 1, I sort stocks into 10 beta decile equal–weighted portfolios and average returns by each portfolio. I then estimate post–ranked betas over the whole sample period, excluding the 12–month period used to estimate pre–ranked betas. Figure 1 plots average realized overnight (blue dots and line) and intraday (orange triangles and line) returns of each beta–sorted portfolio against average portfolio market betas. The average intraday returns are negatively related to average betas. An increase in the average market beta of 1 corresponds to a decrease in the average intraday return of 47 bps. In contrast, the average overnight returns are positively related to average betas. An increase in the average market beta of 1 corresponds to an increase in the average overnight return of 28 bps. For both overnight and intraday returns of 10 beta–sorted portfolios, a significant portion of variation in returns are explained by variation in market beta, with R^2s of 83.1% for overnight returns and 95.9% for intraday returns.

As implied by the opposite directional risk–return relationship during overnight and intraday periods, the combined 24h SML is almost flat, consistent with prior studies on the CAPM. Interestingly, the difference between the average overnight returns and the average intraday returns increases proportionally with the portfolio market beta. The highest decile beta portfolio has the highest average overnight return of 0.24% and the lowest average intraday return of −0.17%. The difference, calculated by subtracting intraday returns from overnight returns, is 0.41%, demonstrating that the high−beta portfolios perform very differently during different time periods within the same day.

Table 2 reports the Fama−MacBeth and day fixed panel regressions of daily returns on market betas of ten beta−sorted portfolios. Portfolios are constructed using the same methodology used for figure 1, except post−ranked betas are estimated over 12 months rolling window instead of the whole sample. Portfolios are then sorted into one of ten beta decile portfolios, equal−weighted and value−weighted.

Panel A reports the regression results for equal−weighted portfolios. Using Fama−MacBeth regressions, I find that the intercept of equal−weighted overnight returns is 0.01 with a *t*−statistic of −0.59 and the slope is 15bps with a *t*−statistic of 7.19, implying a positive risk premium. On the other hand, the intercept of equal−weighted intraday returns is 14bps with a *t*−statistic of 5.58 and the slope is −22bps with a *t*−statistic of −9.04, implying a negative risk premium. Standard errors are calculated based on Newey−West correction, adjusted for serial correlation with up to ten lags. The average R^2 of the equal−weighted overnight and intraday regressions are 36% and 36%, respectively. Therefore, an increase in one unit of beta is associated with an increase in the average overnight return of 15bps and a decrease in the average intraday return of 22bps. The implied night−day risk premium is 37bps, which is both economically and statistically significant.

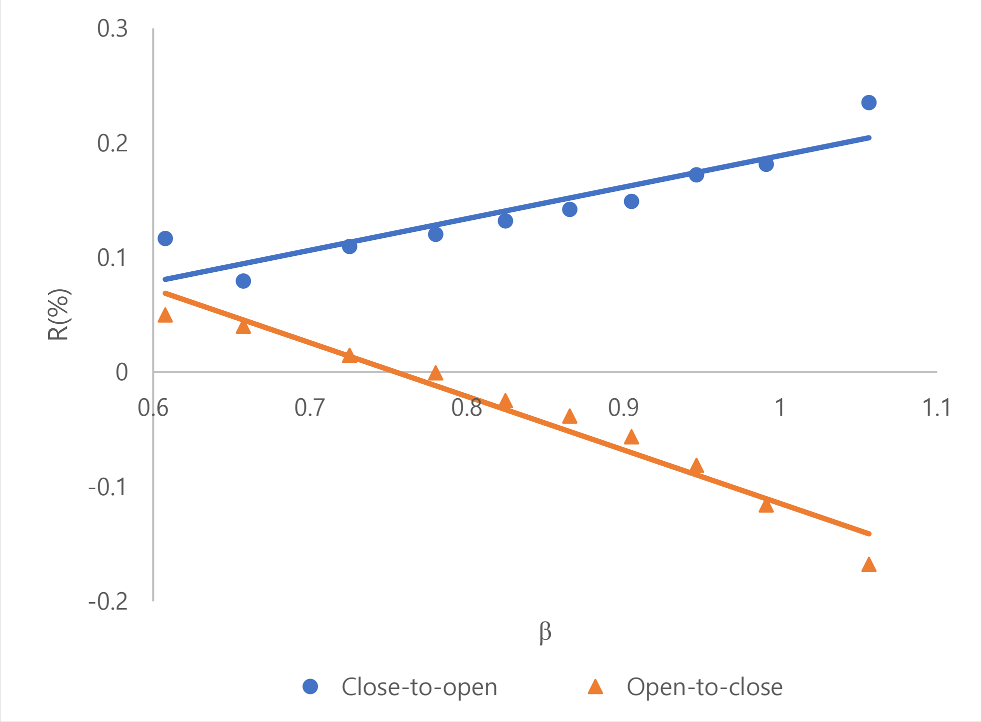
Panel B shows that the value−weighted regressions offer results largely consistent with equal−weighted regressions. I find that the intercept of value−weighted overnight returns is −6bps with a *t*−statistic of −3.22 and the slope is 13bps with a *t*−statistic of 5.84, implying a positive risk premium. In contrast, the intercept of value−weighted intraday returns is 16bps with a *t*−statistic of 7.16 and the slope is −12bps with a *t*−statistic of −6.18, implying a negative risk premium. Therefore, an increase in one unit of beta is associated with an increase in the average overnight return of 13bps and a decrease in the average intraday return of 12bps. Consistent with Hedershott et al. (2020), I observe puzzling overnight intercept values for value−weighted regression. Provided that I do not use excess returns for the left−hand−side of the regression, the negative intercept implies a negative overnight risk−free rate. More importantly, the intercepts of overnight and intraday regressions are statistically significantly different from zero in opposite directions, implying that the risk−free rates may be different when the market is closed for trading versus when the market is open.

The pooled regression results confirm my earlier findings. Panel A shows that for equal−weighted portfolios, consistent with the Fama−MacBeth regression result, the pooled regression coefficient on beta is 15bps with a *t*−statistic of 8.85. The difference in the slope of overnight and intraday SML, captured by the regression coefficient on Day×Beta, is −37bps with a *t*−statistic of −16.47. This is similar to the difference of −36bps estimated from the Fama−MacBeth regression coefficient on beta during night and day. Therefore, the result confirms a positive risk premium at night and a negative risk premium at day. The coefficient on the day dummy, which captures day−minus−night alpha, is 15bps. The average R^2 for the pooled regression is 39%.

Panel B reveals similar results for value−weighted portfolios. The pooled regression coefficient on beta is 12bps with a *t*−statistic of 8.60. The difference in the slope of overnight and intraday SML, captured by the regression coefficient on Day×Beta, is −26bps with a *t*−statistic of −13.08. The coefficient on the day dummy, which captures day-minus-night alpha, is 21bps, equal to 21bps obtained using the Fama-MacBeth regression. The average R^2 is 31%.

My result reveals that in the Korean stock market during 1999 to 2020 period, the market risk premium has been positive at night and contrastingly, negative at day. To offer a potential explanation to this interesting result, I adopt the notion of investor heterogeneity proposed by Lou et al. (2019). Hence, I view that different types of agents prefer to trade at different times during the day. Specifically, marginal day investors are risk-loving speculators that prefer high-beta stocks while marginal night investors are risk-averse long-term investors who demand proportionally higher returns for holding riskier high-beta stocks. Under this framework, the overnight and intraday returns are driven by the corresponding clienteles that prefer to trade at specific times during the day. As a result, the stock market will exhibit a negative risk premium during day and a positive risk premium during night. This is precisely what my result indicates.

<Figure 1> Overnight and intraday returns for beta−sorted portfolios



This figure shows average daily returns in percentage plotted against market betas for 10 equal−weighted beta−sorted portfolios. Portfolios are formed on a monthly basis and sorted according to pre−ranked betas, estimated using daily night returns over 12 months rolling window. Portfolio returns are averaged by overnight (close−to−open) and intraday (open−to−close) returns. Portfolio betas are the averaged value of post−ranked betas estimated over the whole sample period. The lines are fitted using ordinary least square estimates.

<Table 2> Overnight and intraday returns regression

This table reports Fama-MacBeth regressions of daily overnight and intraday returns (in percentage) on betas of ten beta-sorted portfolios. Overnight returns are measured from close-to-open and intraday returns are measured from open-to-close. The table also reports single pooled day fixed effect regressions for the same portfolios, when I add a day dummy (Day) and an interaction term between this dummy and market beta (Day×Beta). Portfolios are rebalanced on a monthly basis and sorted according to pre-ranked betas, estimated using daily night returns over 12 months rolling window. Portfolio returns are averaged and post-ranked betas are estimated using daily night returns over 12 months rolling window. Panel A and B report the result for equal-weighted and value-weighted portfolios, respectively. *t*-statistics are reported in parentheses. Standard errors are calculated based on the Newey-West method, corrected for ten lags of serial correlation for Fama-MacBeth regressions. For panel regressions, standard errors are clustered at the day level. Statistical significance at the 1% and 5% level is indicated by ** and *, respectively.

	Fama-MacBeth regressions			Panel regressions			
	Intercept	Beta	R^2	Beta	Day	Day × Beta	R^2
Panel A: Equal-weighted							
Night	0.01	0.15**	0.36	0.15**	0.15**	−0.37**	0.39
	(−0.59)	(7.19)		(8.85)	(8.25)	(−16.47)	
Day	0.14**	−0.22**	0.36				
	(5.58)	(−9.04)					
Panel B: Value-weighted							
Night	−0.06**	0.13**	0.23	0.12**	0.21**	−0.26**	0.31
	(−3.22)	(5.84)		(8.60)	(11.85)	(−13.08)	
Day	0.16**	−0.12**	0.17				
	(7.16)	(−6.18)					

3.2. 24h beta

A potential concern is that the results in figure 1 and table 2 are driven by betas that are estimated using overnight returns exclusively. To address this concern, in this section, I repeat the tests performed in Section 3.1. using betas estimated using 24h (close–to–close) returns. Therefore, both pre–ranked betas and post–ranked betas are constructed using the following equation:

$$R_{i,m,t}^{24h} = \alpha_{i,m}^{24h} + \beta_{i,m}^{P} R_{M,m,t}^{24h} + \varepsilon_{i,m,t}^{24h}, \quad (7)$$

where $R_{i,m,t}^{24h}$ is the 24h returns of asset i and $R_{M,m,t}^{24h}$ is the 24h returns of the market.

Figure 2 plots average realized overnight (blue dots and line) and intraday (orange triangles and line) returns of each beta–sorted portfolio against average portfolio market betas estimated using 24h returns. The average intraday returns are negatively related to average betas. An increase in the average market beta of 1 corresponds to a decrease in the average intraday return of 37 bps. In contrast, the average overnight returns are positively related to average betas. An increase in the average market beta of 1 corresponds to an increase in the average overnight return of 22 bps. For both overnight and intraday returns of 10 beta–sorted portfolios, a significant portion of variation in returns are explained by variation in market beta, with R^2 of 68.4% for overnight returns and 90.8% for intraday returns. The highest decile beta portfolio has the highest average overnight return of 0.21% and the lowest average intraday return of –0.14%. The difference, calculated by subtracting intraday returns from overnight returns, is 0.35%.

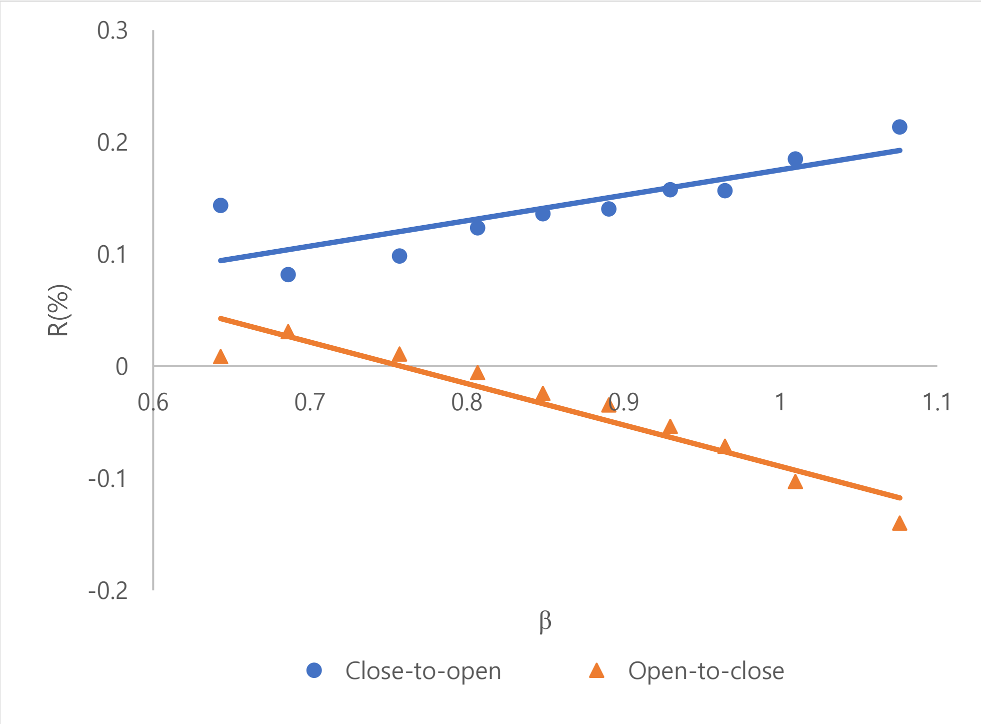
Table 3 reports Fama–MacBeth and day fixed panel regressions of daily returns on market betas of ten beta–sorted portfolios. Panel A reports the regression results for equal–weighted portfolios. For Fama–MacBeth regressions, I find that the intercept of equal–

weighted overnight returns is 1bps with a t−statistic of 0.45 and the slope is 12bps with a t−statistic of 6.16, implying a positive risk premium. The intercept of equal−weighted intraday returns is 12bps with a t−statistic of 4.00 and the slope is −19bps with a t−statistic of −7.47, implying a negative risk premium. Standard errors are calculated based on the Newey−West correction, adjusted for serial correlation with up to ten lags. The average R^2 of the equal−weighted overnight and intraday regressions are 31% and 29%, respectively. Panel B shows that the value−weighted regressions offer results consistent with equal−weighted regressions. I find that the intercept of value−weighted overnight returns is −6bps with a t−statistic of −3.20 and the slope is 13bps with a t−statistic of 6.39, implying a positive risk premium. In contrast, the intercept of value−weighted intraday returns is 16bps with a t−statistic of 7.80 and the slope is −12bps with a t−statistic of −6.28.

The pooled regression results, too, are in line with my earlier findings. Panel A shows that for equal−weighted portfolios, the pooled regression coefficient on beta is 11bps with a t−statistic of 6.48. The difference in the slope of overnight and intraday SML, captured by the regression coefficient on Day×Beta, is −27bps with a t−statistic of −15.54. The coefficient on the day dummy, which captures day−minus−night alpha, is 9bps with a t−statistic of 4.61. The average R^2 for the pooled regression is 40%. Panel B reveals similar results for value−weighted portfolios. The pooled regression coefficient on beta is 12bps with a t−statistic of 7.88. The difference in the slope of overnight and intraday SML, captured by the regression coefficient on Day×Beta, is −25bps with a t−statistic of −11.98. The coefficient on the day dummy, which captures day−minus−night alpha, is 21bps. The average R^2 is 31%.

Overall, I observe a positive sloped overnight SML and a negative sloped intraday SML. The implies risk−free rates for the two periods are different with the overnight implied risk−free rate being either insignificantly different from zero or negative. Therefore, the results using 24h betas confirm the results from Section 3.1 are not driven by betas estimated using overnight returns only.

<Figure 2> Overnight and intraday returns for beta−sorted portfolios (24h beta)



This figure shows average daily returns in percentage plotted against market betas for 10 equal−weighted beta−sorted portfolios. Portfolios are formed on a monthly basis and sorted according to pre−ranked betas, estimated using daily 24h (close−to−close) returns over 12 months rolling window. Portfolio returns are averaged by overnight (close−to−open) and intraday (open−to−close) returns. Portfolio betas are the averaged value of post−ranked betas estimated over the whole sample period. The lines are fitted using ordinary least square estimates.

<Table 3> Overnight and intraday returns regression (24h beta)

This table reports the Fama-MacBeth regressions of daily overnight and intraday returns (in percentage) on betas of ten beta-sorted portfolios. Overnight returns are measured from close-to-open and intraday returns are measured from open-to-close. The table also reports single pooled day fixed effect regressions for the same portfolios, when I add a day dummy (Day) and an interaction term between this dummy and market beta (Day×Beta). Portfolios are rebalanced on a monthly basis and sorted according to pre-ranked betas, estimated using daily 24h (close-to-close) returns over 12 months rolling window. Portfolio returns are averaged and post-ranked betas are estimated using daily 24h returns over 12 months rolling window. Panel A and B report the result for equal-weighted and value-weighted portfolios, respectively. *t*-statistics are reported in parentheses. Standard errors are calculated based on Newey-West method, corrected for ten lags of serial correlation for Fama-MacBeth regressions. For panel regressions, standard errors are clustered at the day level. Statistical significance at the 1% and 5% level is indicated by ** and *, respectively.

	Fama-MacBeth regressions			Panel regressions			
	Intercept	Beta	R^2	Beta	Day	Day×Beta	R^2
Panel A: Equal-weighted							
Night	0.01	0.12**	0.31	0.11**	0.09**	−0.27**	0.40
	(0.45)	(6.16)		(6.48)	(4.61)	(−15.54)	
Day	0.12**	−0.19**	0.29				
	(4.00)	(−7.47)					
Panel B: Value-weighted							
Night	−0.00**	0.13**	0.20	0.12**	0.21**	−0.25**	0.31
	(−3.20)	(6.39)		(7.88)	(10.87)	(−11.98)	
Day	0.16**	−0.12**	0.15				
	(7.80)	(−6.28)					

3.3. Individual stocks

In this section, I extend my analysis to repeat the tests on individual securities to evaluate the effectiveness of beta to explain the difference between intraday and overnight returns. I add as firm characteristic controls market capitalization (Size), book–to–market ratio (BM), and cumulative returns from the past 12 months (Momentum). Size and BM controls are calculated following Fama and French (1992) and Fama and French (1996). Size is measured annually in June of year *t* by using stocks' current market capitalization. BM is measured annually in June of year *t* by dividing book equity of the fiscal year ending in calendar year *t*–1 by market equity at the end of December of year *t*–1.

In Table 4, Panel A reports the results for Fama–MacBeth regressions. Consistent with my earlier observations, the implied market premium is positive during nights and negative during days. Specifically, the intercept of individual stocks' overnight returns is 7bps with a *t*–statistic of 4.73 and the slope is 8bps with a *t*–statistic of 5.85, while the intercept of individual stocks' intraday returns is 8bps with a *t*–statistic of 3.23 and the slope is –15bps with a *t*–statistic of 8.02. However, unlike my earlier results, the pooled regression shows that the day–minus–night alpha, captured by the coefficient on the day dummy, at individual stock level is statistically insignificant. Nonetheless, the regression coefficient on beta is significantly positive with a coefficient value of 9bps and a *t*–statistic of 34.54. The day–minus–night risk premium, captured by the coefficient on the interaction of day dummy and beta, is–21bps with a *t*–statistic of–61.09. Therefore, the pooled regression result confirms the opposite sign of the implied market premium during day and night periods.

Panel B reports the results for Fama–MacBeth regressions and pooled regressions when I add controls. Consistent with the results found in existing literature, size is strongly negatively related to average returns, but this relationship is driven by overnight returns. The coefficient on size is −5bps with a t−statistic of −9.02 overnight, but switches to 2bps with a t−statistic of 2.95 during day. However, some results are not consistent with the standard results. Book−to−market is strongly negatively related to average returns during night (−5bps with a t−statistic of−5.95), but switches sign during day (3bps with a t−statistic of 3.72). In line with the standard findings on beta that observe statistically insignificant relationship between beta and average 24h returns, my results reveal that beta is strongly positively related to average returns during night and strongly negatively related to average returns during day. The coefficient on beta is 11bps with a t−statistic of 6.92 overnight and −15bps with a t−statistic of −8.10 during day. The statistical significance of beta remains robust even after controlling for size, BM and momentum characteristics.

These findings are confirmed using pooled regression with day fixed effects in Panel B. The day−minus−night risk premium, indicated by the coefficient on the interaction of day dummy and beta, is−21bps with a t−statistic of−55.50. The regression coefficient on beta is significantly positive with a coefficient value of 9bps and a t−statistic of 32.51. Interestingly, the day−minus−night alpha is significantly negative with the day dummy coefficient value of −117bps and a t−statistic of −43.85. This value is significantly smaller than the results using portfolio returns. This discrepancy is likely due to the intercept of regression on overnight returns being biased upward when estimated using individual stock returns. Likewise, the intercept of regression on intraday returns appears to be biased downward. The day−minus−night size premium is 5bps with a t−statistic of 43.79, implying that larger stocks perform better during the day than during the night. The day−minus−night book−to−market premium is 7bps with a t−statistic of 35.81, implying that value stocks perform better during the day than during the night. In all regressions, the coefficients on momentum are weakly negative.

The results are consistent with my prior findings, despite the potential presence of estimation error in individual stock betas. I conclude that stock returns are positively related to their betas during the night and negatively related to their betas during the day. These implications are consistent with the notion that day traders are risk-loving speculators, stocks that are more sensitive to beta.

<Table 4> Overnight and intraday returns for individual stocks

This table reports the Fama−MacBeth regressions of daily overnight and intraday returns (in percentage) on individual stocks. Overnight returns are measured from close−to−open and intraday returns are measured from open−to−close. Betas are estimated using daily night returns over 12 months rolling window. The table also reports the single pooled day fixed effect regressions for the same portfolios, when I add a day dummy (Day) and interaction terms between the dummy and market beta (Day × Beta) and between the dummy and controls (Day × Size, Day × BM and Day × Momentum). Size and Book−to−Market (BM) are measured following Fama and French (1992). Momentum is defined as the cumulative return over the past 12 months. t−statistics are reported in parentheses. Standard errors are calculated based on the Newey−West method, corrected for ten lags of serial correlation for Fama−MacBeth regressions. For panel regressions, standard errors are clustered at the day level. Statistical significance at the 1% and 5% level is indicated by ** and *, respectively.

Panel A: Beta only (Stock days: 6,034,540)							
	Fama−MacBeth regressions			Panel regressions			
	Intercept	Beta	R^2(%)	Beta	Day	Day×Beta	R^2(%)
Night	0.07**	0.08**	1.00	0.09**	0.00	−0.21**	6.08
	(4.73)	(5.85)		(34.54)	(0.19)	(−61.09)	
Day	0.08**	−0.15**	1.19				
	(3.23)	(−8.02)					

Panel B: Firm characteristics as controls (Stock days: 5,677,369)

Fama−MacBeth regressions

	Intercept	Beta	Size	BM	Momentum	R^2(%)
Night	1.35**	0.11**	−0.05**	−0.05**	−0.00*	3.88
	(9.34)	(6.92)	(−9.02)	(−5.95)	(−2.24)	
Day	−0.37*	−0.15**	0.02**	0.03**	−0.00**	3.16
	(−2.28)	(−8.10)	(2.95)	(3.72)	(−4.80)	

Panel regressions with day fixed effects

	Day	Beta	Day × Beta	Size	Day × Size	BM	Day × BM	Momentum	Day × Momentum	R^2(%)
Return	−1.17**	0.09**	−0.21**	−0.03**	0.05**	−0.05**	0.07**	−0.00**	−0.00**	6.02
	(−43.85)	(32.51)	(−55.50)	(−43.74)	(43.79)	(−32.94)	(35.81)	(−3.02)	(−8.87)	

Chapter 4. Discussions

My results show that CAPM holds specifically during overnight periods in a sense that the observed asset risk premia are positively related to asset market beta. In contrast, during intraday periods, asset risk premia are decreasing with asset market beta. These observations are consistent with the notion that marginal day investors are risk−loving speculators that prefer high−beta stocks while marginal night investors are risk−averse long−term investors who demand proportionally higher returns for holding riskier high−beta stocks. In this section, I present the results of cross−market analysis to provide additional support for the notion of investor heterogeneity. I further explore investor heterogeneity in light of liquidity constraints advanced by Frazzini and Pederson (2014).

4.1. Agent−based approach to investor heterogeneity

The critical assumption behind Lou et al. (2019)'s investor heterogeneity in asset markets is the presence of different agents that tend to trade at different times during the day. This is because information flow, price impact and trading costs differ when the market is closed for trading as opposed to when the market is open for trading. In other words, the overnight and intraday returns are components of asset returns that reflect the preference of specific clienteles. Considering that a significant proportion of corporate disclosures are made when the market is closed, agents that are more sensitive to information flow are likely to initiate their trades near the close and trade throughout the night. In contrast, agents that are more sensitive to liquidity are likely to initiate their trades near the open and trade throughout the day, because both opportunity costs associated with owning a stock and price impact of an execution is greater when the market is closed for trading. Hence, closing and opening prices of stocks reflect time−specific demand of these night and day investors. In general, stocks preferred by night investors should show higher closing prices and lower opening prices relative to stocks less preferred by these investors while stocks preferred by day investors should show higher opening prices and lower closing prices relative to stocks less preferred by these investors. In other words, stocks preferred by night investors show lower overnight returns, reflecting specific demands from these clienteles, and higher intraday returns as these demands dissipate and the opposing clientele dominates market activity. Likewise, stocks preferred by day investors show higher overnight returns and lower intraday returns.

To specify characteristics of night and day investors, Lou et al. (2019) notes that large trades made by institutions are concentrated near the close while small trades executed by individuals are concentrated near the open. [①] In addition, Oh (2020) finds other investor characteristics that likely direct agents to prefer specific trading periods. Institutional investors have natural needs to trade near the close as they invest inflow of funds accumulated during the day and rebalance their positions. Meanwhile, individual investors have a natural preference for trading near the open, before daily working hours. Therefore, institutional investors exhibit characteristics of night investors while individual investors exhibit characteristics of day investors. Hendershott et al. (2020) follows this notion of investor heterogeneity to offer an explanation to the opposing risk-return relationship observed during night versus during day.

If the agent-based explanation holds, markets should be driven by institutional long-term investors over the night and by individual speculators over the day. Provided that individual speculators are likely to exhibit properties of noise traders that prefer riskier

[①] Park (2010) observes a similar pattern in the Korean stock market, in which individual investors place larger volumes of long order near the open and reverse the position near the close. Foreign and domestic institutional investors take the opposite position.

investments, if a particular stock market is dominated by individual investors, the market should exhibit lower overnight returns and higher intraday returns overall. The corresponding SML should be flatter during the night, reflecting weaker time−specific demands, and steeper during the day, reflecting stronger negative risk premium, relative to each other. If the night and day risk−return relationship observed in markets with varying degree of institutional or individual participation is consistent with the above conjecture, this result would support the agent−based explanation.

Following this logic, I divide my stock day sample into two markets with different degrees of individual participation: KSE and KOSDAQ. According to the Korea Stock Exchange (KRX) trading data, individual investors accounted for approximately 66% and 88% of total trading volumes for KSE−listed and KOSDAQ−listed stocks, respectively, in 2020.[②] Foreign and domestic institutional investors are responsible for the rest of the trading volumes. I then repeat the regressions from Table 2 using the two subsamples. The results are summarized in Table 5.

Panel A reports the regressions result for the KSE market, which has a greater degree of institutional participation. The slopes of Fama−MacBeth regressions are 18bps and −21bps, with *t*−statistics of 9.11 and −9.14, during night and day respectively for equal−weighted portfolios. For value−weighted portfolios, the slopes are 13bps and −11bps, with *t*−statistics of 6.07 and −5.11, during night and day respectively. The differences between absolute values of night and day SMLs are 3bps for equal−weighted portfolios and 2bps for value−weighted portfolios. As expected, these differences are

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② The trade participation of individual investors in KSE was substantially higher in 2020 than in previous years due to a significant increase in the fresh inflow of individual investors into the equity market and an increase in the overall use of leverage by individual investors. In 2019, individual investors accounted for approximately half of the trades executed in KSE and 90% of the trades executed in KOSDAQ.

marginal.

Panel B reports the regressions result for the KOSDAQ market, which has a greater degree of individual participation. The slopes of Fama−MacBeth regressions are 7bps and −17bps, with *t*−statistics of 3.20 and −7.21, during night and day respectively for equal−weighted portfolios. For value−weighted portfolios, the slopes are 14bps and −18bps, with *t*−statistics of 5.34 and −7.16, during night and day respectively. The differences between absolute values of night and day SMLs are 10bps for equal−weighted portfolios and 4bps for value−weighted portfolios. Day SMLs are much steeper than night SMLs in both cases. Consistent with my expectation, these differences are considerably larger than the results from Panel A.

The pooled regressions confirm the findings. In Panel A, the coefficients on interaction of beta and day dummy are −41bps and −26bps with *t*−statistic of −21.40 and −13.42 for equal−weighted and value−weighted portfolios, respectively. The coefficients on beta are 18bps and 13bps with *t*−statistic of 13.24 and 9.5 for equal−weighted and value−weighted portfolios, respectively. In Panel B, the coefficients on interaction of beta and day dummy are −16bps and −28bps with *t*−statistic of −5.56 and −9.52 for equal−weighted and value−weighted portfolios, respectively. The coefficients on beta are 4bps and 10bps with *t*−statistic of 1.59 and 4.75 for equal−weighted and value−weighted portfolios, respectively. For both equal−weighted and value−weighted portfolios, the size of day−minus−night risk premia are much larger than the night risk premia in KOSDAQ than in KSE.

I find that the steepness of slopes of day and night SMLs are only marginally different for the KSE market. In contrast, in the KOSDAQ market, day SML is considerably flatter than night SML. Overall, these findings provide evidence in support of the hypothesis that the observed deviation between the risk−return relationship during night and day reflects the specific demand by the corresponding clienteles.

<Table 5> Overnight and intraday returns regressions on stocks listed on KSE and KOSDAQ markets

This table reports the Fama−MacBeth regressions of daily overnight and intraday returns (in percentage) on betas of ten beta−sorted portfolios formed separately, using stocks listed on KSE and separately those listed on KOSDAQ. Overnight returns are measured from close−to−open and intraday returns are measured from open−to−close. The table also reports the single pooled day fixed effect regressions for the same portfolios, when I add a day dummy (Day) and an interaction term between this dummy and market beta (Day×Beta). Portfolios are rebalanced on a monthly basis and sorted according to pre−ranked betas, estimated using daily overnight (close−to−open) returns over 12 months rolling window. Portfolio returns are averaged and post−ranked betas are estimated using daily overnight returns over 12 months rolling window. Panel A and B report the result for equal−weighted and value−weighted portfolios sorted using stocks listed on KSE and KOSDAQ, respectively. *t*−statistics are reported in parentheses. Standard errors are calculated based on the Newey−West method, corrected for ten lags of serial correlation for Fama−MacBeth regressions. For panel regressions, standard errors are clustered at the day level. Statistical significance at the 1% and 5% level is indicated by ** and *, respectively.

	Fama−MacBeth regressions			Panel regressions			
	Intercept	Beta	R^2	Beta	Day	Day×Beta	R^2
Panel A: KSE							
Equal−weighted							
Night	−0.08**	0.18**	0.38	0.18**	0.27**	−0.41**	0.37
	(−4.03)	(9.11)		(13.24)	(17.85)	(−21.40)	
Day	0.18**	−0.21**	0.33				
	(6.79)	(−9.41)					
Value−weighted							
Night	−0.07**	0.13**	0.22	0.13**	0.24**	−0.26**	0.29
	(−4.09)	(6.07)		(9.50)	(14.14)	(−13.42)	
Day	0.16**	−0.11**	0.17				
	(6.89)	(−5.11)					
Panel B: KOSDAQ							
Equal−weighted							
Night	0.10**	0.07**	0.16	0.04	−0.09**	−0.16**	0.38
	(3.43)	(3.20)		(1.59)	(−3.73)	(−5.56)	
Day	0.07*	−0.17**	0.16				
	(2.04)	(−7.21)					
Value−weighted							
Night	0.04	0.14**	0.15	0.10**	0.08**	−0.28**	0.31
	(1.56)	(5.34)		(4.75)	(2.76)	(−9.52)	
Day	0.15**	−0.18**	0.13				
	(5.29)	(−7.16)					

4.2. Borrowing constraints and SML

A potential explanation to alternating signs of overnight and intraday SML slopes can be attributed to Frazzini and Pederson (2014), who extends on Black (1972) and derive the CAPM when investors face leverage constraints. In the standard unconstrained CAPM world where unlimited borrowing is possible in the risk-free asset, an investor with very low risk aversion borrows heavily at the risk-free rate and invests in the risky market portfolio. However, if the maximum amount of leverage is limited by borrowing constraints, these investors can no longer achieve the desired level of risk by leverage and instead do so by investing in a portfolio with market beta greater than one. Therefore, in reality, the presence of leverage constraints creates demand for high-beta stocks as constrained investors seek higher portfolio risks. In equilibrium in the constrained world, this results in higher (lower) prices or lower (higher) expected returns for high (low) beta stocks. The resulting SML will be flatter in the presence of leverage constraints.

Formally, Frazzini and Perderson (2014) show that when investors face leverage constraints, the CAPM is expressed as:

$$E_t[r_{i,t+1}] = r_f + \psi_t + \beta_{i,t}(E_t[r_{M,t+1}] - r_f - \psi_t), \tag{8}$$

where r_f is the risk-free rate, $r_{M,t+1}$ is the market return and ψ_t is the Lagrange multiplier measuring leverage constraints. In theory, the constraint SML may have a negative slope if ψ_t exceeds $E_t[r_{M,t+1}] - r_f$. However, assuming that investors are on average risk averse, they would not bid up high-beta stocks to the point of having lower returns than low-beta stocks. Therefore, Frazzini and Perderson (2014) acknowledge that the risk premium implied by their theory is still positive, though lower than the one implied by the CAPM. Leverage constraints alone cannot deliver a downward sloping SML.

Jylha (2018) provides empirical support to Frazzini and

Pederson (2014)'s leverage constraint explanation. Using the Federal Reserve's active management of minimum margin requirement between October 1934 and September 1974 as an exogenous proxy for leverage constraints, Jylha (2018) discovers that tighter leverage constraints result in a flatter security market line. Specifically, the slope of SML is positive during the months when the margin requirement is low and negative during the months when the margin requirement is high. Interestingly, in contrast to Frazzini and Pederson (2014)'s assumption on implied positive risk premium, the SML exhibits negative slope during the period of high leverage constraints. This implies the presence of investors who bid up high-beta stocks to the point of having lower returns than low-beta stocks when facing leverage constraints. In other words, these investors are constrained investors who exhibit risk-loving properties.

In my context of investor heterogeneity based on investors' preferred time of trades, findings of Jylha (2018) suggest that investors could be more leverage constrained during the day relative to the night. Hence, if marginal day traders are leverage constrained risk-loving speculators, prices of stocks preferred by these investors (high-beta stocks) should be bid up near the open and reversed near the close when the opposing investors take control of the market. Consistent with this expectation, I observe lower returns for high-beta portfolios during the day and the opposite during the night.

Chapter 5. Conclusion

This paper studies how the market risk is related to stock returns during different time periods. Using the Korean stock market data, I divide daily returns into overnight and intraday return components. I then examine the performance of CAPM during the respective periods.

My results show that the risk–return relation is strongly negative during the day, explaining the overall failure of CAPM during the 24h period.[③] In contrast, CAPM holds specifically during overnight periods. This is true when betas are estimated using both overnight returns and 24h returns. Consistent with the main results, overnight returns are positively related to betas for individual stocks in the Korean stock market.

As with Jylha(2018) and Hendershott et al.(2020), who find downward–sloping SML during the months of borrowing constraints and during the trading day, respectively, my results require a model with heterogeneous agents whose trading preferences are contingent on time. This model assumes a systematic switch between marginal investors during night and day periods. I provide evidence suggesting that the reversal of night and day SML slopes reflects the trading period preference of specific clienteles. Specifically, I find that the day SML is much steeper than the night SML in the market dominated by marginal day investors.

In this paper, I make several contributions to the study of asset pricing. First, I provide additional evidence to explain the overall failure of the CAPM observed in standard research. Second, I provide justifications for high–frequency decompositions of returns in the context of asset pricing. In particular, I show that the characteristics

③ As discussed in Section 1, the standard studies on CAPM using close-to-close stock returns document weak relations between the market risk and asset returns.

of asset returns are different during the night versus during the day. Third, I highlight the importance of a specific form of investor heterogeneity (institutional versus individual) in understanding the failure of the CAPM.

On the empirical side, an important question still remains to be addressed. As with Hendershott et al.(2020), my findings leave a puzzling deviation in the risk-free rates observed during night and day periods. This suggests a need for further study on the implications of time-varying risk-free rates to asset pricing models.

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국문요약

본 연구는 주식 거래가 정지된 야간 시간대와 거래가 가능한 일중 시간대 별로 개별 주식의 수익률과 베타의 관계를 검증하였다. 실증분석 결과 국내 주식 사장에서 주가는 야간 및 일중 시간대에 따라 베타에 대한 반응이 상이함을 관찰하였다. 야간 시간대에서는 주식 수익률과 베타가 일률적인 양(+)의 상관관계를 가지지만 일중 시간대에서는 반대로 일률적인 음(−)의 상관관계를 가지는 것으로 나타남을 확인하였다. 이러한 야간/일중 관계는 야간 및 24시간 수익률으로 측정한 두가지의 베타에 대하여 모두 성립하는 것을 확인하였으며 포트폴리오가 아닌 개별 주식 수준의 테스트에서도 강건함을 확인하였다. 추가적으로 이러한 결과는 거래 시간대에 따라 구분되는 야간 및 일중 투자자들의 비균질성에 따른 특정 시간대에서의 수요에 의하여 발생한다는 증거를 제시하였다.

주요어 : 자산가격결정모델, 야간수익률, 일중수익률, 증권시장선, 투자자 비균질성

학번 : 2016−20564