Asset Pricing: A Tale of Night and Day*

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Abstract

Stock prices behave very differently with respect to their sensitivity to market risk (beta) when markets are open for trading versus when they are closed. The capital asset pricing model (CAPM) performs poorly overall as beta is weakly related to 24-hour returns. This is driven entirely by trading-day returns, i.e., open-to-close returns are negatively related to beta in the cross section. The CAPM holds overnight when the market is closed. The CAPM holds overnight for the U.S. and internationally for: beta-sorted portfolios, 10 industry and 25 book-to-market portfolios, cash-flow and discount-rate beta-sorted portfolios, and individual stocks. These results are consistent with transitory beta-related price effects at the open and the close.

Introduction

Systematic market risk being priced is at the core of modern asset pricing. In the capital asset pricing model (CAPM) the market risk exposure of every asset is captured by its market beta. Individual assets' risk premia are simply their beta times the market risk premium. Therefore, the main cross-sectional implication of the CAPM is that if the market risk premium is positive, the individual assets' risk premia are proportional to their betas. But most empirical studies find little relation between beta and returns in the cross section of stocks. In the early seminal study Black, Jensen, and Scholes (1972) demonstrate that the security market line for U.S. stocks is too flat relative to the CAPM prediction.

Most recent studies show that the relationship between the assets' excess returns and their stock market beta is positive only during specific times:[1] during months of low inflation (Cohen, Polk, and Vuolteenaho, 2005); on days when news about inflation, unemployment, or Federal Open Markets Committee (FOMC) interest rate decisions are scheduled to be announced (Savor and Wilson, 2014); or during months when investors' borrowing constraints are slack (Jylha, 2018).

In this paper we extend testing the CAPM on specific days or months by examining its validity during different time periods within each day. Specifically, we show that the sign of the relation between beta and returns depends on whether markets are open for trading or closed. When the stock market is closed, beta is positively related to the cross section of returns. In contrast, beta is negatively related to returns when the market is open. Both these risk-return relations hold for: beta-sorted portfolios for U.S. stocks and international stocks, for 10 industry and 25 book-to-market portfolios, for both cash-flow news betas and discount-rate news betas, for individual U.S. stocks and international stocks, and regardless of how many nights the market is closed.

Our main finding is summarized in Figure 1. Following Savor and Wilson (2014) we estimate rolling 12-month daily stock market betas for all U.S. stocks. Because our night and day returns decomposition requires opening prices our sample period is 1990 to 2014. We then sort stocks into one of ten beta-decile equal-weighted portfolios. Portfolio returns are then averaged and post-ranking betas are estimated over the whole sample. Figure 1 plots average realized per cent returns for each portfolio against average portfolio market beta separately for when the market is open (Day, red points and line) and when the market is closed ($Night$, cyan points and line).

The relation between $Night$ returns and beta is strongly positive: an increase in beta of 1 is associated with an economically and statistically significant increase in average $Night$

[1] Tinic and West (1984) find evidence that the CAPM works in January.

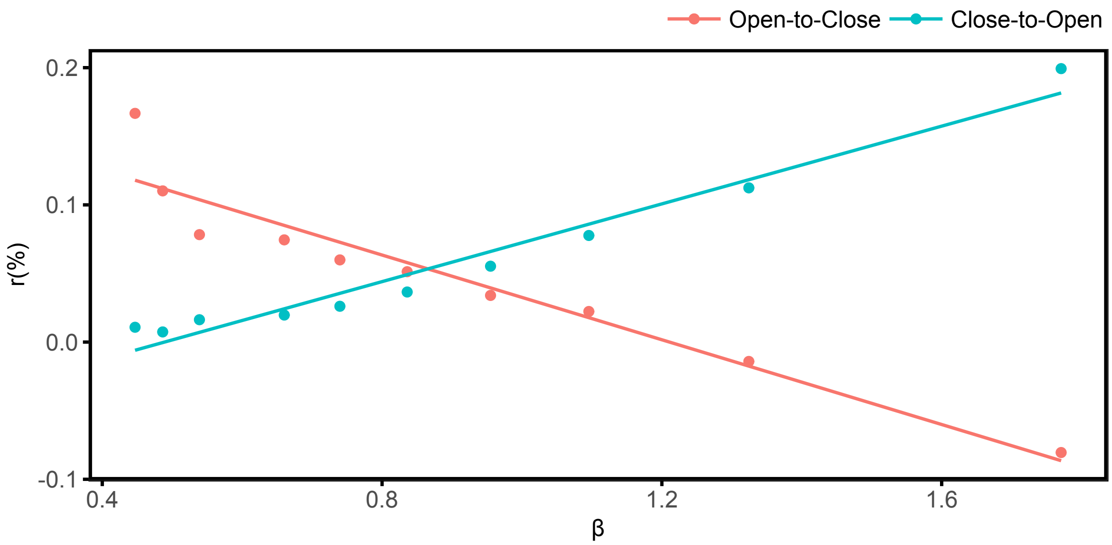

Figure 1 – U.S. day and night returns for beta-sorted portfolios
This figure shows average (equally-weighted) daily returns in per cent against market betas for ten beta-sorted portfolios of all U.S. publicly listed common stocks. Portfolios are formed every month, with stocks sorted according to beta, estimated using daily *night*-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (cyan). For both ways of measuring returns a line is fit using ordinary least square estimate. Data are from CRSP.

return of 14 bps (in general, measured over 17.5 hours except after weekends and holidays). In contrast and even more puzzling, the *Day* points show a negative relation between average returns and beta: an increase in beta of 1 is associated with a reduction in average *Day* return of 15 bps (in general, measured over 6.5 hours except on days on which the market closes early), both statistically and economically significant. Furthermore, the R^2s of each line are respectively 91.6% for *Day* returns and 96.3% for *Night* returns. For the beta-sorted portfolios, almost all variation in both *Day* and *Night* average returns is explained just by variation in market beta. When *Day* and *Night* security market lines (SMLs) are combined together, the resulting 24-hour SML is flat as has been reported by multiple papers (see Fama and French (2004) for a comprehensive review). Very intriguingly, the highest-beta portfolio has the lowest *Day* return (-8 bps) and also the highest *Night* return (20 bps), so that the very same portfolios exhibit very different performance during different time periods within the day.

These results are robust. The relations in Figure 1 hold regardless of whether beta is estimated using *Day*, *Night*, or close-to-close returns. Our findings hold when controlling for individual stocks' characteristics such as size, book-to-market, and past performance. The results do not depend on the length of market closures.

Our results suggest that when investors cannot trade, beta is an important measure of systematic risk. When assets are illiquid investors demand higher returns to hold higher-beta stocks. This is consistent with the basic premises of the CAPM that investors are long-term and do not rebalance their portfolios. The downward-sloping SML during times when the stock market is open for trading is much harder to rationalize using the conventional risk-return relationship. One possible explanation can be attributed to Black (1972, 1992) who points out that if the CAPM's assumption that investors can freely borrow and lend at risk-free rate is violated, the security market line will have a slope that is less than the expected market excess return. This is because leverage-constrained investors can achieve the desired degree of risk by tilting their portfolios towards risky high-beta assets. As a result, high-beta assets require lower risk premium than low-beta asset.

Frazzini and Pedersen (2014) take this idea further by deriving a "constraint" CAPM where the equityrisk premium is reduced by the Lagrange multiplier on the borrowing constraints. The betting against beta (BAB) CAPM allows for the negative slope if the Lagrange multiplier is greater than the stock market excess return. However, Frazzini and Pedersen (2014) point out that such scenario is highly unlikely - "While the risk premium implied by our theory is lower than the one implied by the CAPM, it is still positive." Jylha (2018) uses changes in the minimum initial margin requirement by the Federal Reserve as an exogenous measure of borrowing constraints. Contrary to the statement by Frazzini and Pedersen (2014), but consistent with their model, he finds that during months when the margin requirement is low the empirical SML has a positive slope close to the CAPM prediction, while during months with high initial margin requirement, the empirical SML has a negative slope.

When applied to our results, the BAB CAPM would imply that investors are more capital-constraint during the day than they are during the night. However, because it is harder to borrow during the night hours simply due to the limited supply of credit, the BAB CAPM is at odds with our findings. Instead, they are most consistent with the beta-conditional speculation during the trading hours. Specifically, the marginal day investor is a risk-loving speculator who measures asset's risk using its market beta. Speculators bid up high-beta stocks in the morning while hedging their purchases by shorting the low-beta stock and, therefore, pushing their prices down. Speculators find it costly to hold risky assets overnight and thus reverse their positions at the close. We incorporate beta-conditional speculation into a simple stylized statistical model of stock price dynamics as a transitory component to the stock price. This transitory price component is proportional to the stock's beta net of the sample average beta at the open but reverses its sign at the close. While the transitory price component does not affect stock's beta, it does affect the SML. The open-to-close SML will have the excess market return net of the speculators' expected compensation for risk while the close-to-open SML will have the excess market return gross of the speculators' expected compensation for risk. Therefore, as long as speculators expect higher compensation for risk than the excess market return, the slope of the day SML is negative.

Motivated by our findings, we consider two "betting against&on beta" zero-cost trading strategies. The first one uses individual stocks and requires going long in high-beta stocks by shorting low-beta stocks during the night or "betting on beta" and then reversing the position at the open by going long into low-beta stocks by shorting high-beta stocks or "betting against beta." Each stock's return is weighted by a difference between its market beta and the sample average beta during the night and its opposite during the day. The second trading strategy is portfolio-based and it is motivated by Figure 1. It entails going long in the highest-beta portfolio and hedging the position by shorting the lowest-beta portfolio during the night (betting on beta) and then reversing both positions during the day (betting against beta). While our betting against beta strategy during the day is similar to the one proposed by Frazzini and Pedersen (2014), it is not beta-neutral.

The first trading strategy generates an average daily return of 0.10% with the standard deviation equal to 0.78% and the Sharpe ratio equal to 0.13. When annualized, these numbers turn into an average return of 25.2% with a Sharpe ratio equal to 2.03. The portfolio-based strategy generates an average daily return of 0.43% with the standard deviation equal to 1.80% and the Sharpe ratio equal to 0.24. When annualized, these numbers turn into an average return of 108.4% with a Sharpe ratio equal to 3.78.

Our work is closely related to empirical papers testing the validity of the security market line. Cohen, Polk, and Vuolteenaho (2005) test the hypothesis that the stock market suffers from money illusion by examining the slope of the security market line during periods of high, moderate, and low inflation. They show that money illusion implies that when inflation is low or negative the compensation for one unit of beta among stocks is larger (and the security market line steeper) than the rationally expected equity premium. Conversely, when inflation is high, the compensation for one unit of beta among stocks is lower than expected equity premium thus implying that the security market line is too flat.

Hong and Sraer (2016) show theoretically and empirically that high-beta assets are overpriced compared to low-beta assets when disagreement about the mean of the common factor of firms' cash flows is high. The disagreement in Hong and Sraer (2016) comes from a fraction of heterogeneously informed investors who, in addition, cannot short. Hong and Sraer (2016) associate these investors with mutual funds, which in practice are prohibited from shorting by charter. The remaining investors are correctly and homogeneously informed, can short, and are interpreted to be hedge funds by Hong and Sraer (2016). In the context of our findings the disagreement must be pervasive only during the times when the market is open for trading and then disappear when the market closes. In other words, shorting constraints must be higher during the trading day than overnight.

Our paper is also related to the literature studying unconditional average returns over different time periods. Heston, Korajczyk, and Sadka (2010) provide evidence that some stocks tend to perform systematically better than others during specific half hours of the trading day. Berkman, Koch, Tuttle, and Zhang (2012) argue that buying by attention-constrained investors drives up the opening price of stocks with large fluctuations in the previous day (i.e., stocks who caught investors' attention). Lou, Polk, and Skouras (2017) show that momentum profits accrue solely overnight for U.S. stocks over 1993 to 2013. While their main focus is on momentum, they also report the intraday return and the overnight return of several other anomalies. Bogousslavsky (2016) documents substantial variation in the cross-section of returns over the trading day and overnight. All of these papers focus on "alpha"—the intercept in the CAPM—rather than the slope which is the main topic of our paper.

The rest of the paper is organized as follows. Section 1 presents the data and methodology. Section 2 reports our main results which we discuss in Section 3. Section 4 concludes.

1 Data and methodology

The data used in this paper comes from several databases. Returns for the U.S. stocks are obtained from the Center for Research in Security Prices (CRSP), while the firm-level balance-sheet data comes from COMPUSTAT. The data for foreign countries is obtained from Datastream. For all countries we only use common stocks. The U.S. common stocks are identified in CRSP as having a share code of 10 or 11. For foreign stocks we employ the list of common stocks compiled by Hou and van Dijk (2016). We end up with the daily data sample for 40 countries covering 1990-2014 period.[2]

We follow Lou, Polk, and Skouras (2017) in constructing the close-to-open or "night" returns on date t:

$$R_t^N = (1 + R_t^{\text{close-to-close}})/(1 + R_t^{\text{open-to-close}}) - 1. \tag{1}$$

For the U.S. stocks the close-to-close return is the corporate action adjusted holding period return (RET) provided in CRSP. For all other stocks, we construct the close-to-close return using the corporate action adjusted price index, field RI, provided in Datastream. In particular, foreign returns are calculated using local currency. Note that the close-to-close returns around holidays and weekends can be longer than 24 hours.

[2]Data for U.S. stocks are available up to 2016.

To calculate the size and book-to-market ratio for U.S. companies we follow Fama and French (1992) and Fama and French (1996): the book equity (BE) is the book value of stockholders' equity, plus balance sheet deferred taxes and investment tax credit (if available), minus the book value of preferred stock. Depending on availability, we use the redemption, liquidation, or par value (in that order) to estimate the book value of preferred stock. Stockholders' equity is the value reported by COMPUSTAT, if it is available. If not, we measure stockholders' equity as the book value of common equity plus the par value of preferred stock, or the book value of assets minus total liabilities (in that order).[3] Size for international companies is measured in USD, and the book-to-market ratio is calculated as one over the price-to-book ratio (Datastream field PTBV).

We apply the following data filters. The only requirement on the U.S. stocks is that the open price is available, which excludes data before 1992. Datastream data is filtered as in Amihud, Hameed, Kang, and Zhang (2015), who study the illiquidity premia across 45 different countries. In particular, we only include stock-day data (i, t) if the trading volume is at least USD 100, the corporate action adjusted price index in Datastream (field RI) is above 0.01, and if the absolute value of the close-to-close return $(R_{i,t})$ is below 200%. In addition, if the return on day t or day $t-1$ is above 100% we only keep the stock-day if the return measured over a two day period is at least 50%, i.e., if $(1-R_{i,t})\times(1-R_{i,t-1})-1 > 50\%$. Since the focus of our paper is on the *night* returns, in addition to the above filters, we only include stock-days for which we have a positive open price. Finally, we exclude stock-days for which the absolute value of either the Day or the $Night$ return is above 200%.

We construct pre-ranked monthly betas for every stock i in month m, $\beta^p_{i,m}$, using daily $Night$ returns by regressing them against the market $Night$ returns, R^N_M, over twelve months rolling window with no less than 30 daily returns:

$$R^N_{i,m,t} = \alpha^N_{i,m} + \beta^p_{i,m} R^N_{M,m,t} + \varepsilon^N_{i,m,t}. \tag{2}$$

For each country, the market index is constructed as the value-weighted portfolio of all stocks from that country using no less than ten stocks on a given date.

Following Savor and Wilson (2014) we construct post-ranking portfolio betas differently for figures and tables. For tables we estimate time-varying monthly betas using daily $Night$ returns over rolling 12-months windows. For figures, we estimate the unconditional full-sample betas using daily $Night$ returns over the full sample.

For the regressions, we adopt the Fama-MacBeth procedure, and compute coefficients

[3] See Davis, Fama, and French (2000) for more details.

separately for night and day returns:

$$R_{i,t+1}^{N/D} = \xi_0^{N/D} + \xi_1^{N/D} \hat{\beta}_{i,t}^p + \varepsilon_{i,t}^{N/D}, \quad (3)$$

where $\hat{\beta}_{i,t}^p$ is the asset i market beta for period t estimated in (2) and $R_{i,t+1}^{N/D}$ is the asset i Night/Day return.

In addition to Fama-MacBeth regressions run separately for night and day returns, we also estimate a panel regression:

$$R_{i,t+1} = \xi_0 + f_{t+1} + \xi_1 \hat{\beta}_{i,t}^p + \xi_2 D_{t+1} + \xi_3 \hat{\beta}_{i,t}^p D_{t+1} + \varepsilon_{i,t+1}, \quad (4)$$

where $R_{i,t+1}$ is either the night or day return and D_{t+1} is an indicator variable equal to one for a day return and f_{t+1} is day fixed effect. This specification allows us to directly test whether the night and day implied risk premia are different.

2 Results

All reported night returns are measured over 17.5 hours and day returns are measured over 6.5 hours except after weekends and holidays or on days on which the market closes early.

2.1 Beta Portfolios

In this section we investigate the *Day* and *Night* security market line (SML). We start by estimating monthly stock market betas for all U.S. stocks according to (2) using one-year rolling windows of daily *Night* returns from 1990 to 2014. We then sort stocks into one of ten beta-decile equal-weighted portfolios. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample. Figure 1 plots average realized per cent returns for each portfolio against average portfolio market beta separately for *Day* (red points and line) and *Night* (cyan points and line). The *Day* points show a negative relation between average returns and beta: an increase in beta of 1 is associated with a reduction in average *Day* return of 15 bps, both statistically and economically significant.

In contrast, the relation between average *Night* returns and beta is strongly positive: an increase in beta of 1 is associated with an increase in average *Night* return of 14 bps. The relation is also very statistically significant. Furthermore, the R^2s of each line are respectively 91.6% for *Day* returns and 96.3% for *Night* returns. For the beta-sorted portfolios, almost all variation in both *Day* and *Night* average returns is explained just by variation in market beta. When *Day* and *Night* SMLs are combined together, the resulting 24-hour SML is flat

Table 1 – U.S. day and night returns
This table reports results from Fama-MacBeth and day fixed-effect panel regressions of daily returns (in per cent) on betas from ten beta-sorted test portfolios. Returns are measured during the *Day*, from open-to-close, and during the *Night*, from close-to-open. Portfolios are formed every month, with stocks sorted according to beta, estimated using daily *night*-returns over a one year rolling window. Panel A reports results from market capitalization weighted portfolios. Panel B reports results from equally weighted portfolios. t-statistics are reported in parentheses. Standard errors are based on Newey-West corrections allowing for 10 lags of serial correlation for Fama-MacBeth regressions. Standard errors are clustered at the day level for panel regressions. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively. Data are from CRSP.

Returns over	Fama-MacBeth regressions			Panel regressions			
	Intercept	Beta	Avg. R^2	Beta	Day	Day × Beta	R^2 [%]
Panel A: Value-Weighted							
Night	-0.008	0.064***	41.62	0.070***	0.178***	-0.159***	34.32
	(-1.44)	(7.77)		(6.17)	(10.79)	(-7.02)	
Day	0.155***	-0.079***	39.37				
	(14.96)	(-5.62)					
Panel B: Equally-Weighted							
Night	-0.052***	0.122***	39.64	0.115***	0.293***	-0.281***	5.43
	(-8.22)	(13.45)		(7.40)	(5.09)	(-13.12)	
Day	0.365**	-0.280**	45.54				
	(1.91)	(-1.95)					

as has been reported by multiple papers (see Fama and French (2004) for a comprehensive review). Very intriguingly, the highest-beta portfolio has the lowest *Day* return (-8 bps) and also the highest *Night* return (20 bps), so that the very same portfolio exhibits very different performance during different time periods within the same day.

Table 1 reports our regression results for both value-weighted and equal-weighted portfolios. Portfolio construction procedure is the same as the one used for Figure 1 except monthly portfolio betas are estimated using one year of daily returns then sorted into one of ten beta-decile value- or equal-weighted portfolios.

Panel A shows our results for value-weighted portfolios. When we estimate equation (3) using the Fama-MacBeth procedure we find that the slope for value-weighted *Day* returns is -7.9 bps with a t-statistic of -5.62, implying a negative risk premium, and the intercept is 15.5 bps with a t-statistic of 14.96. Standard errors are adjusted for serial correlations using Newey-West estimator with up to 10 lags. An increase in beta of 1 is associated with a reduction in average *Day* return of about 8 bps. The average R^2 for the *Day* regression is 39.37%.

The results are very different for the *Night* returns. The slope for value-weighted *Night* returns is 6.4 bps with a t-statistic of 7.77, implying a positive risk premium, and the intercept is -0.8 bps with a t-statistic of -1.44, thus making it not statistically significant. This result for the intercept is hard to interpret as we do not use excess returns on the left-hand-side of (3). An increase in beta of 1 is associated with an increase in average $Night$ return of about 6.4 bps. The net $Night$-Day stock market risk premium is 14.3 bps, both statistically and economically significant. The average R^2 for the $Night$ regression is 41.62%.

Panel B shows that the results are similar for equal-weighted portfolios: the slope is significantly negative for Day returns (-28 bps with a t-statistic of -1.95) and significantly positive for $Night$ returns (12.2 bps with a t-statistic of 13.45). Standard errors are adjusted for serial correlations using Newey-West estimator with up to 10 lags. Intercepts have the same signs as in the case of value-weighted portfolios and both are statistically significant. The net $Night$-Day stock market risk premium is even higher for equal-weighted portfolios at 40.2 bps, both statistically and economically significant.

Our findings are confirmed using pooling methodology to estimate the difference in the slope coefficients between $Night$ and Day security market lines in a single panel regression (4). Standard errors are clustered at the day level for panel regressions. The difference between the day and night SML slopes is captured by the regression coefficient on $Day \times \beta$. Panel A shows that for value-weighted portfolios it is equal to -15.9 bps with a t-statistic of -7.02. This difference is close to the value of -14.3 bps obtained using Fama-MacBeth procedure. The regression coefficient on β is equal to 7 bps with a t-statistic of 6.17. Thus the conditional SML has a much higher slope than the value of -1.5 bps obtained by adding the Day and $Night$ slopes from Fama-MacBeth regressions. The coefficient on the Day dummy capturing net $Day - Night$ alpha is equal to 17.8 bps which is close to the value of 16.3 bps obtained by subtracting Day and $Night$ alphas from Fama-MacBeth regressions. The R^2 for the pooled regression is 34.32%.

Panel B reveals similar results in the case of equal-weighted portfolios. The regression coefficient on $Day \times \beta$ is equal to -28.1 bps with a t-statistic of -13.12. Its magnitude is smaller than the value of -40.2 bps obtained using Fama-MacBeth procedure. The regression coefficient on β is equal to 11.5 bps with a t-statistic of 7.40. Thus once again the conditional SML has a much higher slope than the value of -15.6 bps obtained by adding the Day and $Night$ slopes from Fama-MacBeth regressions. The coefficient on the Day dummy capturing net $Day - Night$ alpha is equal to 29.3 bps which is pretty close to the value of 31.3 bps obtained by subtracting Day and $Night$ alphas from Fama-MacBeth regressions. One notable difference between equal- and value-weighted portfolios is that the average R^2s for the pooled regressions is much smaller in the former case at 5.43%.

Figure 1 and Table 1 demonstrate that stock prices depend on market betas both at the market open and close. During the day low beta stocks earn positive average returns while high beta stocks earn low average returns. This begs the question whether open and close prices are special or, in other words, whether the same pattern holds intraday? To address this question we plot in Figure 2 average equally-weighted 30-minute *Day* returns against market beta for ten beta-sorted portfolios of all U.S. publicly listed common stocks. Returns are estimated over every 30-minute interval within the continuous trading session from the first and last mid-quote within each interval, with the first interval from 9:30 till 10:00 o'clock and the last interval from 15:30 till 16:00 o'clock.[4] Portfolios are formed every month, with stocks sorted according to beta, estimated using daily *night*-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample, separately for each 30-minute interval.

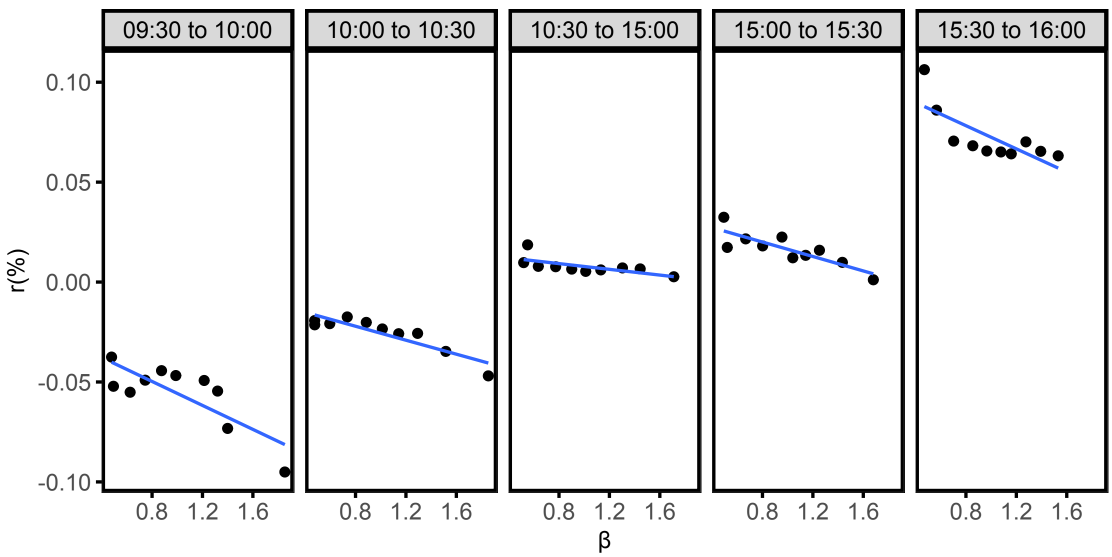

Figure 2 – U.S. intraday returns for beta-sorted portfolios
This figure shows average (equally-weighted) 30-minute portfolio returns in per cent against market betas for ten beta-sorted portfolios of all U.S. publicly listed common stocks. Returns are estimated from the first and last mid-quote within each interval. Portfolios are formed every month, with stocks sorted according to beta, estimated using daily *night*-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample, separately for each 30-minute interval. We estimate returns over every 30-minute interval within the continuous trading session, with the first interval from 9:30 till 10:00 o'clock and the last interval from 15:30 till 16:00 o'clock. Separately for each interval, we fit a line using ordinary least square estimate. To save space we report aggregated results from all intervals between 10:30 and 15:00 o'clock, with the individual results available in the Appendix. Data are from CRSP.

The relation between *Day* returns and market beta is strongly negative for all but the mid-day intervals. It is weakly negative for the mid-day interval constructed by aggregating

[4]For the sake of clarity we report aggregated results from all intervals between 10:30 and 15:00 o'clock, with the individual results available in the Appendix.

results from all intervals between 10:30 and 15:00 o'clock. Average portfolio returns are increasing throughout the day for all ten beta portfolios. Average returns are negative from 9:30 to 10:00, remain negative from 10:00 to 10:30, turn weakly positive from 10:30 to 15:00, and keep rising during the remaining two 30-minute intervals with the highest values reached from 15:30 to 16:00.

The pattern of intraday returns depicted in Figure 2 is consistent with the following investors' behavior. At the open, investors buy beta portfolios with the demand monotonically increasing with the portfolio's beta, i.e., investors' demand is highest for the highest beta portfolio and it is lowest for the lowest beta portfolio. This makes the first panel of Figure 2 consistent with Figure 1 which shows that $Night$ returns are positive across all beta-sorted portfolios. As a result prices overshoot their long-run mean values with the magnitude of the overshooting increasing with the market beta. At this point investors start selling to push prices back to their long-run mean values with the selling pressure increasing with the market beta. As a result, during the first hour of trading all beta-sorted portfolios earn negative expected returns with their magnitude increasing with the market beta. Two things happen at some time between 10:30 and 15:00 o'clock. First, investors shift from selling to buying since stock prices overshoot their long-run mean values. Second, investors' demand shifts from being increasing with the market beta to being monotonically decreasing with the market beta. Therefore, during the second half of the day average returns are positive for all beta-sorted portfolios with their magnitude decreasing with the market beta.

Overall, these findings reveal a U-shape in intraday prices of beta-sorted portfolios, i.e., prices are high at the market open and close and they are low at midday. Correspondingly, portfolio returns are monotonically increasing within the day, starting negative at the open and becoming positive at the close. These patterns are not consistent with a long-standing literature on intraday return patterns (e.g., Wood, McInish, and Ord (1985), Harris (1986), and Jain and Joh (1988)) showing that average returns tend to be higher at the beginning and end of the trading day. Instead, these finding are more in line with a recent work by Heston, Korajczyk, and Sadka (2010) who find significant continuation of returns at intervals that are multiples of a day and this effect lasts for over twenty trading days.

Second potential concern is that the U.S. stocks are special and our findings specific to the U.S. stock market. To alleviate this concern we perform the same set of tests on international stocks. Since stocks from several countries do not survive our data filters, we group foreign countries that survive them into two regions - "EU" and "Asia." The EU region consists of the following countries: France, Germany, Greece, Israel, Italy, Netherlands, Norway, Poland, South Africa, Spain, Sweden, Switzerland, and the United Kingdom. The Asia region consists of: Australia, China, Hong Kong, India, Indonesia, Korea, New Zealand, Philippines, Singapore, and Thailand. Our data comes from Datastream and covers time period from 1990 to 2014.

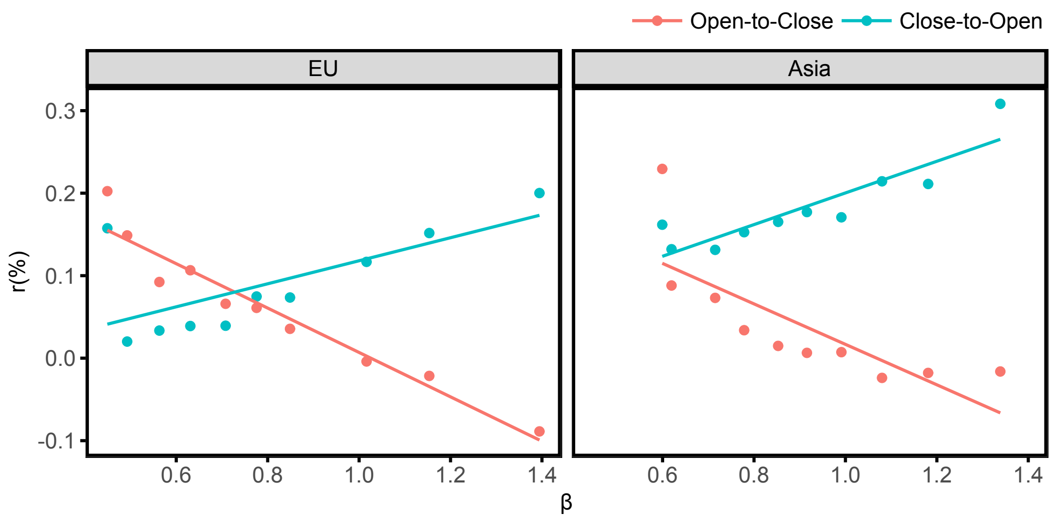

Figure 3 – International day and night returns for beta-sorted portfolios
This figure shows average (equally weighted) daily returns in per cent against market betas for ten beta-sorted portfolios of all publicly listed common stocks from the 39 (non-U.S.) countries in our sample. Portfolios are formed per country-month with stocks sorted according to beta, estimated using daily *Night*-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample for each country separately. Returns and betas per portfolio are averaged (equally weighted) across all countries within the region. The first region is EU: France, Germany, Greece, Israel, Italy, Netherlands, Norway, Poland, South Africa, Spain, Sweden, Switzerland, United Kingdom. The second region is Asia: Australia, China, Hong Kong, India, Indonesia, Korea, New Zealand, Philippines, Singapore, and Thailand. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (blue). For both ways of measuring returns a line is fit using ordinary least square estimate. Data are from Datastream.

We form pre-ranked portfolios for each country using the same methodology as we use for the U.S. stocks. All returns are calculated in local currency. Portfolio returns are averaged and post-ranking betas are estimated separately for each country over the whole sample when used in figures and over one-year rolling windows when used in tables. Returns and betas per portfolio are averaged (equally weighted) across all countries within the region.

Figure 3 plots average realized per cent returns for each portfolio against average portfolio betas separately for *Day* (red points and line) and *Night* (cyan points and line) for the EU region (left panel) and Asia region (right panel). The *Day* security market line is very similar across both regions – slopes for the EU and Asia regions are -27 and -25 bps and intercepts are 28 and 26 bps, respectively. While these values are higher than the comparable ones for the U.S., the *Day* CAPM is still very similar for the U.S. and international stocks – low beta portfolios earn highest average returns and high beta portfolios earn lowest average returns. One notable difference between the EU and Asia regions is that the R^2 is much higher (93.6% against 60.7%) for the former than for the latter.

Table 2 – International day and night returns
This table reports results from Fama-MacBeth and two dimensional country/day fixed-effect panel regressions of daily returns [in per cent] on betas from ten beta-sorted test portfolios. Returns are measured during the *Day*, from open-to-close, and during the *Night*, from close-to-open. Portfolios are formed every month, with stocks sorted according to beta, estimated using daily *Night*-returns over a one year rolling window. Panel A reports results from market capitalization weighted portfolios. Panel B reports results from equally weighted portfolios. t-statistics are in parentheses. Standard errors are clustered at the day level for panel regressions. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively. Data are from Datastream.

Returns over	Fama-MacBeth regressions			Panel regressions			
	Country Dummies	Beta	Avg. R^2	Beta	Day	Day × Beta	R^2 [%]
Panel A: Value-Weighted							
Night	Yes	0.079***	31.32	0.061***	0.135***	-0.174***	19.28
		(9.52)		(6.38)	(12.87)	(-12.51)	
Day	Yes	-0.127***	37.09				
		(-12.73)					
Panel B: Equally-Weighted							
Night	Yes	0.112***	32.97	0.084***	0.142***	-0.217***	21.91
		(14.92)		(9.00)	(14.13)	(-16.36)	
Day	Yes	-0.154***	38.28				
		(-16.92)					

Just like for the U.S. stocks, the relation between average *Night* returns and beta is strongly positive for both EU and Asia regions with the corresponding slopes equal to 14 and 19 bps. Quantitatively, these numbers are close to the U.S. slope of 0.14. The intercepts for both regions have different signs (negative for EU and positive for Asia) but are not statistically significant. Very intriguingly, the *Night* SML is better identified for Asia than for EU, since the former has higher R^2's (79.6% vs. 46.8%) than the latter. This result can potentially be attributed to regulatory differences regarding night versus day trading across these regions.

Table 2 reports our regression results for both value-weighted and equal-weighted portfolios of international stocks. Portfolio construction procedure is the same as the one used for Figure 3 except monthly portfolio betas are estimated using one year of daily returns. All international stocks are pooled together to increase power of our tests and we use country dummies to control for the country-specific variation in returns. We only report the stock market risk premium (the coefficient on beta) as the intercept does not carry much economic intuition as it mixes up risk free rates across different countries. Standard errors are clustered at the day level for panel regressions.

Panel A reports our estimates from value-weighted portfolios. For the Fama-MacBeth procedure the slope for value-weighted *Day* returns is -12.7 bps, which is almost twice the number for the U.S. stocks, with a t-statistic of -12.73, implying a strongly negative risk premium across international stocks. An increase in beta of 1 is associated with a reduction in average *Day* return of about 13 bps. The average R^2 is 37.09%, which is on par with the one reported for the U.S. stocks. The results are also very different for the *Night* returns for international stocks. The slope for value-weighted *Night* returns is 7.9 bps with a t-statistic of 9.52, implying a positive risk premium just like in the case of the U.S. stocks. An increase in beta of 1 is associated with an increase in average *Night* return of about 8 bps. The net *Night-Day* stock market risk premium is 20.6 bps, both statistically and economically significant. The average R^2 for the *Night* regression is 31.32%.

Similar results for the Fama-MacBeth procedure are found in Panel B for equal-weighted portfolios: the slope is significantly negative for *Day* returns (-15.4 bps with a t-statistic of -16.92) and significantly positive for *Night* returns (11.2 bps with a t-statistic of 14.92). The net *Night-Day* risk premium is, however, lower than for the U.S. stocks – 26.6 bps (international) vs. 40.2 bps (U.S.). The average R^2s are 32.97% and 38.28% for the *Night* and *Day* regressions respectively.

Our findings are confirmed using pooling methodology to estimate the difference in the slope coefficients between *Night* and *Day* security market lines in a single panel regression (4). The difference between the day and night SML slopes is captured by the regression coefficient on $Day \times \beta$. Panel A shows that for value-wighted portfolios it is equal to -17.4 bps with a t-statistic of -12.51. This difference is close to the value of -20.6 bps obtained using Fama-MacBeth procedure. The regression coefficient on β is equal to 6.1 bps with a t-statistic of 6.38. Thus the conditional SML has a much higher slope than the value of -4.8 bps obtained by adding the *Day* and *Night* slopes from Fama-MacBeth regressions. The coefficient on the *Day* dummy capturing net $Day - Night$ alpha is equal to 13.5 bps. The average R^2 for the pooled regression is 19.28%.

Panel B reveals similar results in the case of equal-weighted portfolios. The regression coefficient on $Day \times \beta$ is equal to -21.7 bps with a t-statistic of -16.36. Just like in the case of the U.S. stocks, its magnitude is smaller than the value of -36.6 bps obtained using Fama-MacBeth procedure. The regression coefficient on β is equal to 8.40 bps with a t-statistic of 9.00. Thus once again the conditional SML has a much higher slope than the value of -4.20 bps obtained by adding the *Day* and *Night* slopes from Fama-MacBeth regressions. The coefficient on the *Day* dummy capturing net $Day - Night$ alpha is equal to 14.2 bps which is pretty close to the value of 13.5 bps obtained using the Fama-MacBeth regressions. The average R^2 for the pooled regression is 21.91%.

It is noteworthy that we obtain quite consistent estimates between the Fama-MacBeth and panel regressions both for equal- and value-weighted portfolios. These results are different from the U.S. findings for which we find large differences between Fama-MacBeth and panel regressions as well as large differences in explanatory power between the *Day* and *Night* panel regressions for equal-weighted portfolios.

Our results indicate that the market risk premium has been positive at night and negative during the day during 1990 to 2014 period. This holds true both for the U.S. as well as international stocks. It is consistent with the fact that the marginal investor at night is a long-term investor who demands higher returns for holding stocks with higher market betas. But during the day high-beta stocks have earned the stock market discount. This fits well with the notion that the marginal day investor is a risk-loving speculator who demands stocks with high market betas.

One may be concerned that our results are driven by the fact that the stock market betas are estimated using exclusively night returns. We, therefore, redo Figure 1 and Figure 3 using close-to-close returns to construct stock market betas. Figure 4 shows our results for the U.S. stocks by plotting average realized per cent returns for each portfolio against average portfolio market beta separately for *Day* (red points and line) and *Night* (cyan points and line). *Day* returns have even stronger negative relation with the stock market beta than the one shown in Figure 1 – an increase in beta of 1 is associated with a reduction in average monthly *Day* return of 17 bps (15 bps in Figure 1).

Night returns have the same positive relation with the market beta the one shown in Figure 1: an increase in beta of 1 is associated with an increase in average annualized *Night* return of 14 bps. The relation is also very statistically significant. Furthermore, the R^2s of both lines are respectively 96% for *Day* returns and 96.8% for *Night* returns. In this case, the variation in either *Day* or *Night* average returns is even better explained by the variation in market beta than when betas are calculated using close-to-open returns.

Figure 5 plots average realized per cent returns for each portfolio against average portfolio betas calculated using close-to-close returns separately for *Day* (red points and line) and *Night* (cyan points and line) for the EU region (left panel) and Asia region (right panel). The results are both qualitatively and quantitatively similar to the ones reported in Figure 3 using betas calculated from *Night* returns. *Day* returns are negatively related to the stock market beta – slopes for the EU and Asia regions are -23 and -13 bps respectively, while the relation between average *Night* returns and beta is strongly positive for both EU and Asia regions with the corresponding slopes equal to 15 and 21 bps. Overall, our main results are robust to the choice of returns used for the market beta construction.

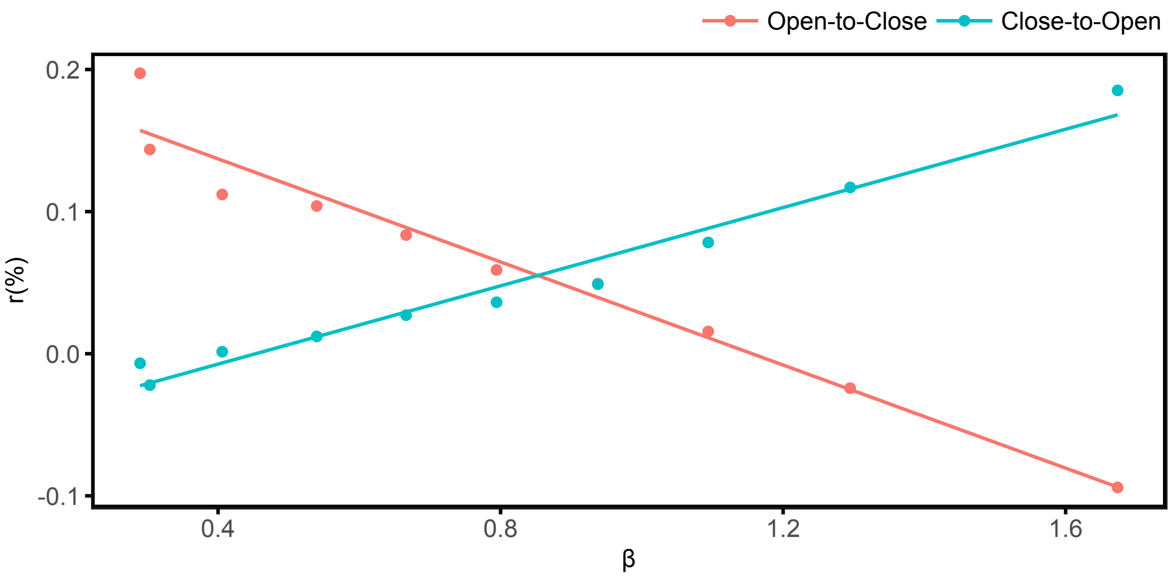

Figure 4 – U.S. day and night returns for beta-sorted portfolios, estimated from close-to-close returns
This figure shows average (equally-weighted) daily returns in per cent against market betas for ten beta-sorted portfolios of all U.S. publicly listed common stocks. Portfolios are formed every month, with stocks sorted according to beta, estimated using daily close-to-close returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (cyan). For both ways of measuring returns a line is fit using ordinary least square estimate. Data are from CRSP.

Another potential concern is that our results are biased by using returns and betas that are not conditioned on the length of the market closure or the number of nights over which the returns are calculated. Therefore, we re-estimate our results separately for returns over one, two, three, and four nights. The beta-portfolios construction procedure is the same as in Table 1. While we consider only equal-weighted portfolios our findings are robust for value-weighted portfolios.

When the data is split into four groups based on the number of days the market is closed, we find that one-night returns are the largest group at $4,536$ events, followed by the two-day (three-night returns, representing a two-day weekend or a holiday) closures at $1,049$ events, followed then by the three-day (four-night returns, representing holiday extended weekends) closures at 148 events. The two-night returns, mostly representing middle-of-week holidays, are the smallest group at 53 events. Table 3 reports our findings.

Panel A reports both the Fama-MacBeth and panel regression results for the one-night returns. The slope for *Day* returns from the Fama-MacBeth procedure is -30.0 bps and only economically significant since its t-statistic of -1.63. For the *Night* returns Fama-MacBeth yields the slope of 11.7 bps with a t-statistic of 12.61. The net *Day-Night* risk premium

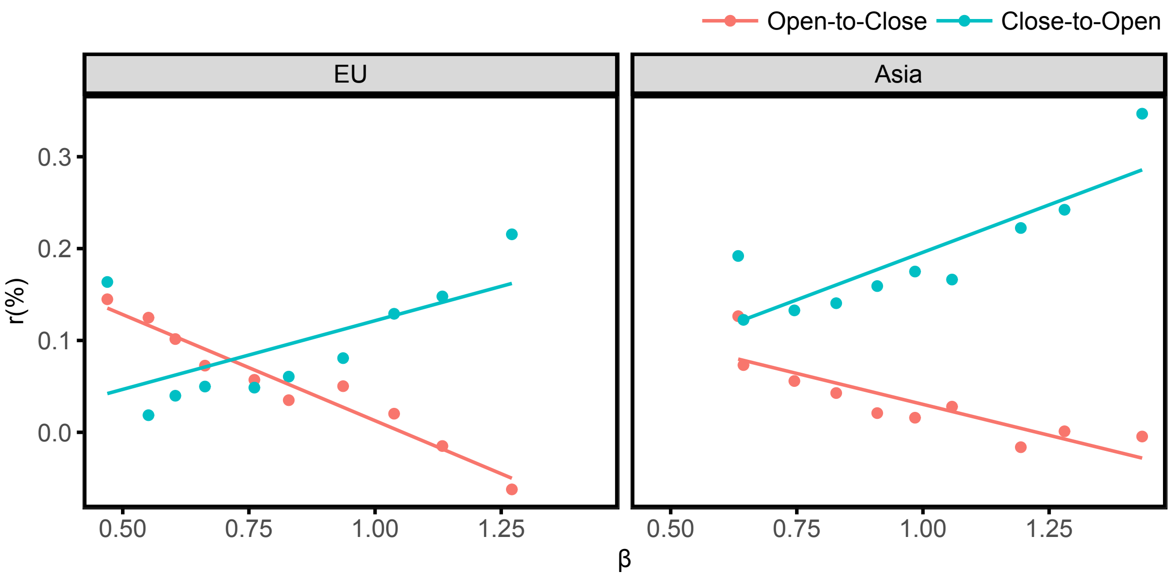

Figure 5 – International day and night returns for beta-sorted portfolios, estimated from close-to-close returns
This figure shows average (equally-weighted) daily returns in per cent against market betas for ten beta-sorted portfolios of all publicly listed common stocks from the 39 (non-U.S.) countries in our sample. Portfolios are formed per country-month with stocks sorted according to beta, estimated using daily close-to-close returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample for each country separately. Returns and betas per portfolio are averaged (equally weighted) across all countries within the region formed as in Figure 3. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (cyan). For both ways of measuring returns a line is fit using ordinary least square estimate. Data are from Datastream.

is equal to −41.7 bps while the net *Day*-*Night* alpha is equal to 48.6 bps. Both of these numbers are different from their counterparts from the pooled regression equal to −26 bps (t-statistic of −10.27) and 32.6 bps (t-statistic of 4.45) respectively. The average R^2 is equal to 39.84% for the *Night* regression, 45.62% for the *Day* regression, and only 5.30% for the pooled regression. Low R^2 in the case of the panel regression indicates that there exists a lot of cross-sectional variation in returns followed up by the single *Night* returns that the variation in the stock market beta fails to capture.

The slopes are not significant neither in the Fama-MacBeth procedure nor in the panel regression in the case of two-night returns presented in Panel B. This is because we only observe 53 two-night returns—53 days, which were preceded by exactly one non-trading day—thus diminishing the power of the tests.

Panel C paints a very similar picture for the three-night returns, which is the second largest group. The slope for *Day* returns from the Fama-MacBeth procedure is −22.5 bps with a t-statistic of −5.87 and it is equal to 13.6 bps with a t-statistic of 6.96 for *Night* returns. The net *Day*-*Night* risk premium is equal to −36.1 bps while the net *Day*-*Night*

Table 3 – U.S. day and night returns (by nights closed)
This table reports results from Fama-MacBeth and day fixed-effect panel regressions of beta-sorted, equally weighted portfolios from U.S. stocks daily returns [in per cent] on portfolios betas. Results are reported separately by how many nights the market was closed in between trading sessions. Panel A, Panel B, Panel C, and Panel D reports results when the market was closed for one, two, three, and four night, respectively. Returns are measured during the *Day*, from open-to-close, and during the *Night*, from close-to-open. Betas are estimated using daily *Night*-returns over a one year rolling window. t-statistics are in parentheses. Standard errors are based on the time series estimates for Fama-MacBeth regressions. Standard errors are clustered at the day level for panel regressions. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively. Data are from CRSP.

Returns over	Fama-MacBeth regressions			Panel regressions			
	Intercept	Beta	Avg. R^2	Beta	Day	Day × Beta	R^2 [%]
Panel A: 4,536 1-night returns							
Night	-0.053***	0.117***	39.84	0.106***	0.326***	-0.260***	5.30
	(-11.81)	(12.61)		(5.54)	(4.45)	(-10.27)	
Day	0.433*	-0.300	45.62				
	(1.77)	(-1.63)					
Panel B: 53 2-night returns							
Night	0.021	0.100	40.05	0.212**	0.495***	-0.133	54.76
	(0.44)	(1.25)		(2.66)	(5.10)	(-1.35)	
Day	0.490***	0.014	35.61				
	(6.14)	(0.14)					
Panel C: 1,049 3-night returns							
Night	-0.049***	0.136***	47.11	0.144***	0.148***	-0.357***	46.21
	(-4.90)	(6.96)		(7.91)	(5.41)	(-9.31)	
Day	0.097***	-0.225***	45.61				
	(5.39)	(-5.87)					
Panel D: 148 4-night returns							
Night	-0.060*	0.171***	42.99	0.194***	0.322***	-0.529***	39.21
	(0.94)	(2.42)		(3.34)	(3.69)	(-4.33)	
Day	0.138***	-0.207*	45.77				
	(3.54)	(-1.87)					

alpha is equal to 14.6 bps. Both of these numbers are very close to their counterparts from the pooled regression equal to -35.7 bps (t-statistic of -9.31) and 14.8 bps (t-statistic of 5.41) respectively. The average R^2 is equal to 47.11% for the *Night* regression, 45.61% for the *Day* regression, and 46.21% for the pooled regression.

Finally, our main findings gain further support in Panel D, which reports results for the four-night returns. The slope for *Day* returns from the Fama-MacBeth procedure is -20.7 bps with a t-statistic of -1.87 and it is equal to 17.1 bps with a t-statistic of 2.42 for *Night* returns. The net *Day-Night* risk premium is equal to -37.8 bps while the net *Day-Night* alpha is equal to 19.8 bps. Both of these numbers are different to their counterparts from the pooled regression equal to -52.9 bps (t-statistic of -4.33) and 32.2 bps (t-statistic of 3.69) respectively. The average R^2 is equal to 42.99% for the *Night* regression, 45.77% for the *Day* regression, and 39.21% for the pooled regression.

If we exclude the two-night returns, the *Night* stock market risk premium increases with the length of the market closure (the number of nights the return is calculated over). This is consistent with the risk-averse investor demanding higher premium for holding risky securities over longer non-trading periods. We find this using both the Fama-Macbeth and the panel regressions. For the *Day* returns, the stock market "discount" either declines or increase with the number of nights the return is calculated over if we use either the Fama-MacBeth or the panel regression. The increase in the stock market "discount" is consistent with the speculators being more eager to offload the high-beta asset, thus driving its price further down, in the anticipation of the longer market closure.

Table 4 extends our findings from Table 3 to international stocks. The beta-portfolios construction procedure is the same as in Table 2. For international stocks we have that one-night returns are still the largest group at $4,381$ events, followed by the three-night returns at $1,177$ events, followed by the four-night returns at $1,052$ events. The two-night returns are also the smallest group at 878 events, but much larger than in the case of the U.S. stock market.

Independent of the procedure used, all *Day* slopes are negative and statistically significant for Fama-MacBeth regressions, except for two-night returns, and all *Night* slopes are positive and statistically significant. The average R^2's range from 26.45% (two-night *Day* returns) to 37.94% (one-night *Day* returns). Unfortunately, using Fama-MacBeth procedure we do not find a clean monotonic relation between the stock market premium/discount and the length of the stock market closure in the case of international stocks. However, our pooled regression results indicate that the net *Night-Day* risk premium increases from 20.6 bps for one-night returns, to 26.4 bps for three-night returns, and finally to 31.8 bps for four-night returns. The average R^2's for pooled regressions range from 20.58% (two-night returns) to 27.55% (four-night returns).

Overall, our finding of the *Day* stock market discount and *Night* stock market premium hold for a large variety of countries and for different lengths of market closures. Next we investigate whether our results are robust to using individual stocks and portfolios formed on firm characteristics as test assets.

Table 4 – International day and night returns (by nights closed)
This table reports results from Fama-MacBeth and two dimensional country/day fixed-effect panel regressions of equally weighted portfolios from international stocks daily returns [in per cent] on portfolios betas. Results are reported separately by how many nights the market was closed in between trading sessions. Panel A, Panel B, Panel C, and Panel D reports results when the market was closed for one, two, three, and four night, respectively. Returns are measured during the *Day*, from open-to-close, and during the *Night*, from close-to-open. Betas are estimated using daily *Night*-returns over a one year rolling window. t-statistics are in parentheses. Standard errors are based on the time series estimates for Fama-MacBeth regressions. Standard errors are clustered at the day level for panel regressions. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively. Data are from Datastream.

Returns over	Fama-MacBeth regressions			Panel regressions			
	Country Dummies	Beta	Avg. R^2	Beta	Day	Day × Beta	R^2 [%]
Panel A: 4,381 1-night returns							
Night	Yes	0.113***	32.00	0.082***	0.158***	-0.206***	20.58
		(13.75)		(7.36)	(13.44)	(-13.23)	
Day	Yes	-0.149***	37.94				
		(-14.54)					
Panel C: 878 2-night returns							
Night	Yes	0.209***	28.27	0.099*	0.099	-0.093	26.84
		(2.94)		(1.93)	(1.57)	(-0.95)	
Day	Yes	-0.156	26.45				
		(-1.52)					
Panel D: 1,177 3-night returns							
Night	Yes	0.133***	33.61	0.084***	0.074***	-0.264***	25.37
		(4.19)		(5.26)	(3.81)	(-10.53)	
Day	Yes	-0.167***	37.65				
		(-6.28)					
Panel D: 1,052 4-night returns							
Night	Yes	0.111*	28.56	0.162***	0.158**	-0.318***	27.55
		(1.87)		(3.31)	(2.04)	(-3.59)	
Day	Yes	-0.228***	28.87				
		(-3.70)					

2.2 Industry, Size, and Book-to-Market Portfolios

In this section we extend our analysis by adding 10 industry and 25 size and book-to-market sorted portfolios (25 Fama-French portfolios) to the 10 stock market beta-sorted portfolios we have used so far. For the U.S. stocks we use the contemporaneous Fama and French 10 industry classification based on the CRSP field SICCD. For international stocks we use the static industry classification from FTSE (Datastream field ICBIN). Book-to-market portfolios are formed annually in June following Fama and French (1992) and French's website – the book-to-market ratio used to form portfolios in June of year t is book equity for the fiscal year ending in calendar year $t-1$ divided by market equity at the end of December of $t-1$. We also follow Fama and French (1992) to form size portfolios in June by using stock's current market equity. All U.S. stocks are sorted into size portfolios using only NYSE breakpoints to avoid overpopulating the small stock portfolio with Nasdaq stocks.

Figure 6 plots average realized per cent returns for each portfolio against its average market beta separately for *Day* (red points and line) and *Night* (cyan points and line). Stock market betas for each portfolio are calculated using procedure from Figure 1. In agreement with our results for beta-sorted portfolios from Figure 1 the *Day* average returns show a strong negative relation with the stock market beta: an increase in beta of 1 is associated with a reduction in average *Day* return of 17 bps, both statistically and economically significant and pretty close to the slope in the case of the beta-sorted portfolios equal to 15 bps. The R^2 for the regression equals to 64.3%, indicating that most of the variation in average *Day* returns of the 10 industry and 25 Fama-French portfolios is accounted for by their stock market betas.

Once again, the relation between average *Night* returns and the stock market beta is strongly positive, but not as large as in the case of beta-sorted portfolios: an increase in beta of 1 is associated with an increase in average *Night* return of 10 bps which is 4 bps less than in the latter case. The relation is also statistically significant. However, the variation in the stock market beta explains just 30% of the variation in the average *Night* returns for 10 industry and 25 Fama-French portfolios, which is much less than 96.3% of variation explained in the case of the beta-sorted portfolios. The net average market risk premium between *Day* and *Night* average returns is equal to 27 bps, both statistically and economically significant.

Table 5 reports our regression results for both value-weighted and equal-weighted portfolios. Portfolio construction procedure is the same as the one used for Figure 6 and Table 1.

Panel A reports our results for value-weighted portfolios. For the Fama-Macbeth procedure, the implied risk premium for value-weighted *Day* returns is -7.5 bps with a t-statistic of -5.26 and the intercept is 14.8 bps with a t-statistic of 14.58 with both estimates extremely close to the estimates for the beta-sorted portfolios. Standard errors are adjusted for serial correlations using Newey-West estimator with up to 10 lags. The average R^2 for the *Day* regression is 19.31%.

The implied risk premium for value-weighted *Night* returns is 8.1 bps with a t-statistic of 10.14 and the intercept is -0.027 bps with a t-statistic of -5.75. The net *Night*-*Day* implied market risk premium is 15.6 bps, both statistically and economically significant. The

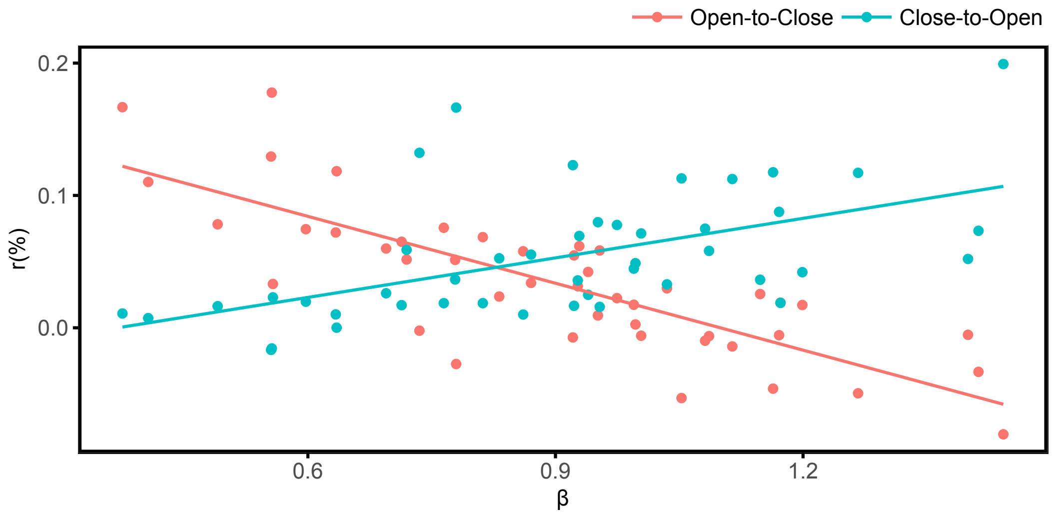

Figure 6 – U.S. day and night returns for 10 beta-sorted, 10 industry, and 25 Size/BM portfolios
This figure shows average (equally-weighted) daily returns in per cent against market betas for 10 beta-sorted, 10 industry, and 25 Size/BM portfolios of all U.S. publicly listed common stocks. Beta portfolios are formed every month, with stocks sorted according to beta, estimated using daily *night*-returns over a one year rolling window. Ten industry portfolios are formed according to the classification by Fama and French. Size/BM portfolios are formed annually as in Fama and French (1992). Portfolio returns are averaged and post-ranking betas are estimated over the whole sample. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (cyan). For both ways of measuring returns a line is fit using ordinary least square estimate. Data are from CRSP and COMPUSTAT.

average R^2 for the $Night$ regression is 21.93%.

These findings are confirmed using pooling methodology to estimate the difference in the slope coefficients between $Night$ and Day security market lines in a single panel regression, see Eq. (4). Panel A shows that for value-weighted portfolios the difference between the Day and $Night$ SML slopes is equal to -17.8 bps with a t-statistic of -5.53. This difference is close to the value of -15.6 bps obtained using Fama-MacBeth procedure. The regression coefficient on β is equal to 8.4 bps with a t-statistic of 5.74. Thus the conditional SML has a much higher slope than the value of 0.6 bps obtained by adding the Day and $Night$ slopes from Fama-MacBeth regressions. The coefficient on the Day dummy capturing net $Day - Night$ alpha is equal to 19.8 bps which is close to 17.5 bps obtained using Fama-MacBeth regressions. The average R^2s for the pooled regressions are 35.75%.

The results are similar for equal-weighted portfolios as Panel B shows. For the Fama-Macbeth procedure the implied risk premium is negative for Day returns (-11.9 bps with a t-statistic of -8.49) and positive for $Night$ returns (9.7 bps with a t-statistic of 12.86). The net $Night$-Day implied risk premium is equal to 20.6 bps, both statistically and economically significant. The average R^2s for the Fama-Macbeth procedure are 17.34% for $Night$ returns

Table 5 – U.S. day and night returns for 10 beta-sorted, 10 industry, and 25 Size/BM portfolios
This table reports results from Fama-MacBeth and day fixed-effect panel regressions of daily returns [in per cent] on betas from 10 beta-sorted, 10 industry, and 25 Fama-French test portfolios. Returns are measured during the *Day*, from open-to-close, and during the *Night*, from close-to-open. Portfolios are formed every month, with stocks sorted according to their characteristic. Betas are estimated using daily *Night*-returns over a one year rolling window. Industry is estimated contemporaneously using the ten industry classification from Fama and French. Book-to-market and size portfolios are formed following (Fama and French, 1992). Panel A reports results from market capitalization weighted portfolios. Panel B reports results from equally weighted portfolios. t-statistics are in parentheses. Standard errors are based on Newey-West corrections allowing for 10 lags of serial correlation for Fama-MacBeth regressions. Standard errors are clustered at the day level for panel regressions. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively. Data are from CRSP and COMPUSTAT.

Returns over	Fama-MacBeth regressions			Panel regressions			
	Intercept	Beta	Avg. R^2	Beta	Day	Day × Beta	R^2 [%]
Panel A: Value-Weighted							
Night	-0.027***	0.081***	21.93	0.084***	0.198***	-0.178***	35.75
	(-5.75)	(10.14)		(5.74)	(7.21)	(-5.53)	
Day	0.148***	-0.075***	19.31				
	(14.58)	(-5.26)					
Panel B: Equally-Weighted							
Night	-0.042***	0.097***	17.34	0.126***	0.260***	-0.287***	38.90
	(-7.82)	(12.86)		(9.40)	(10.16)	(-9.72)	
Day	0.152***	-0.119***	17.25				
	(16.30)	(-8.49)					

and 17.25% for *Day* returns.

The net *Day*-*Night* implied risk premium is equal to -28.7 bps with a t-statistic of -9.72. Its magnitude is larger than the value of -20.6 bps obtained using Fama-MacBeth procedure. The regression coefficient on β is equal to 12.6 bps with a t-statistic of 9.40. Thus once again the conditional SML has a much higher slope than the value of -2.20 bps obtained by adding the *Day* and *Night* slopes from Fama-MacBeth regressions. The coefficient on the *Day* dummy capturing net $Day - Night$ alpha is equal to 26.0 bps which is slightly larger than the value of 19.4 bps obtained using the Fama-MacBeth regressions. The average R^2s for the pooled regression are 38.90%.

Overall these results indicate that a lot of the variation in both *Night* and *Day* average returns of the 10 industry and 25 Fama-French portfolios is accounted for by their stock market betas.

2.3 Cash-flow and discount-rate news betas

Campbell and Vuolteenaho (2004) argue that returns on the market portfolio have two components – the value of the market portfolio may fall because investors receive bad news about either future cash flows or discount rates. Bad news about future cash flows imply that investors' wealth decreases and investment opportunities are unchanged, while the news about increasing cost of capital imply that investors' wealth decreases but future investment opportunities improve. Campbell and Vuolteenaho (2004) go on to decompose the market beta into the cash-flow news beta or "bad" beta and the discount rate news beta or "good" beta. Here we are going to check whether our results are driven by the "good" beta, "bad" beta, or both. Intuitively, if different investor types expose themselves to different market betas and also are the same types who choose to hold the stocks during the day or night we should see a different exposure by day and night returns to the different market beta components.

We follow Campbell and Vuolteenaho (2004) to construct the cash-flow news beta, $\beta_{i,CF}$, and discount-rate news beta, $\beta_{i,DR}$, for individual stocks. Every month we then sort all stocks into ten cash-flow beta portfolios and then within each cash-flow beta portfolio, we sort all stocks into ten discount-rate beta portfolios. In order to calculate post-ranking betas we compute covariance of monthly returns of each portfolio (calculated as the equally weighted average monthly return of each stock in the portfolio) against discount-rate news or cash-flow news over the whole sample to get a post-ranking co-variance. Next we divide both covariances by the variance of market returns (see Equations 4 and 5 in Campbell and Vuolteenaho (2004)) so that cash-flow news and discount-rate news betas add up to the stock market (CAPM) beta.

Figure 7 plots average realized per cent returns for each portfolio against average portfolio betas separately for Day (red points and line) and $Night$ (cyan points and line) for the cash-flow news beta (top panel, circles) and discount rate news beta (bottom panel, triangles). The results are quite striking. During the day, the cash-flow and discount-rate news risk premia are both negative and equal to -27 bps and -16 bps, respectively. Both numbers are statistically and economically significant. Moreover, the R^2s are equal to 91.5% for the cash-flow news and 85.3% for the discount-rate news indicating that these betas are capable of capturing the majority of variation in the realized day.

At night, the cash-flow and discount-rate news risk premia are both positive and equal to 47 bps and 35 bps, respectively. Both numbers are statistically and economically significant. R^2s are even higher in this case and equal to 96.2% for the cash-flow news and 91%. The net $Night - Day$ risk premium is equal to 74 bps for the cash-flow news and it is equal to 51 bps for the discount rate news. The $Night - Day$ effect is much stronger for the "bad"

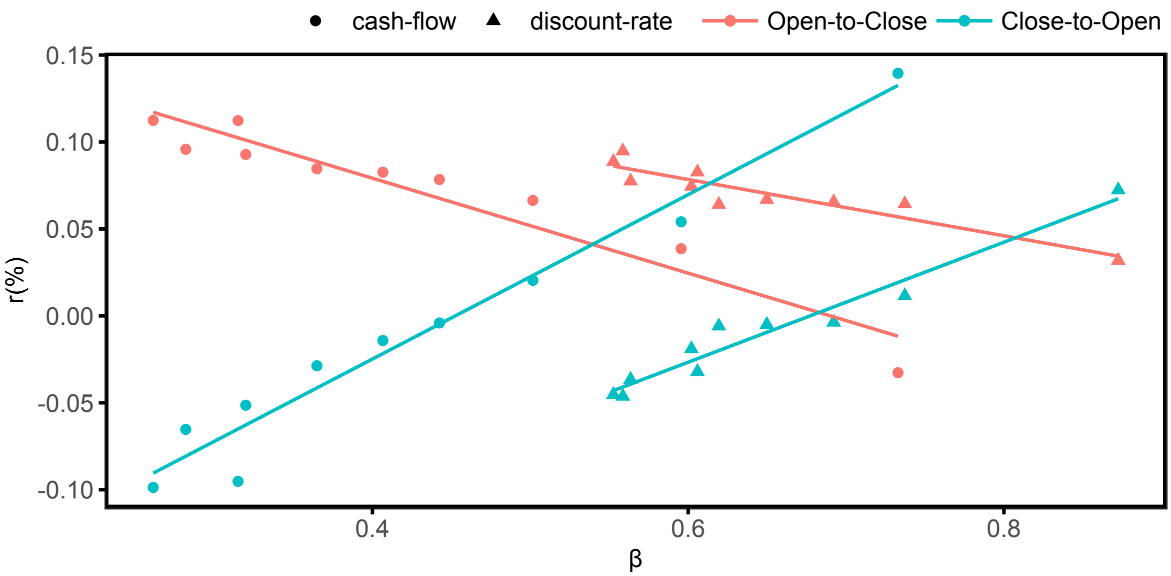

Figure 7 – U.S. day and night returns for portfolios sorted by cash-flow and discount-rate beta
This figure shows average (equally-weighted) daily returns in per cent against market betas for ten beta-sorted portfolios of all U.S. publicly listed common stocks. Following Campbell and Vuolteenaho (2004) we estimate cash-flow and discount-rate betas separately. Every month we sort all stocks into ten cash-flow beta portfolios, and within each cash-flow beta portfolio, we sort all stocks into ten discount-rate beta portfolios. Betas are estimated using monthly returns over a six year rolling window. Portfolio returns are averaged and post-ranking cash-flow (circles) and discount-rate betas (triangles) are estimated over the whole sample. Post-ranking betas are calculated over the whole sample as the co-variance of the cash-flow or discount-rate news (constructed as in Campbell and Vuolteenaho (2004)) with the equally weighted average monthly return of all stocks within each portfolio. All co-variance measures are then divided by the variance of the monthly market return over the whole sample. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (cyan). For both ways of measuring returns and for both betas a line is fit using ordinary least square estimate. Data are from CRSP.

beta thus laying some support that it is caused by the speculative trading which tends to concentrate more in the lottery-like assets Overall, these result provide strong support for our main finding.

2.4 Double-sorted portfolios

In this section, we compare the average realized Day and $Night$ returns from double sorted portfolios. For each month, we first sort stocks into five portfolios based on one of the following control factors: market capitalization (ME), book-to-market ratio (BM), cumulative returns from two month till eleven month before or "momentum" (MOM), cumulative returns from last month or "reversals" (REV), and idiosyncratic volatility (the volatility of the residuals in the regression to estimate the stock market beta) ($IVOL$). Then within each factor-sorted portfolio stocks are sorted into five beta portfolios. Finally, for each month and each beta portfolio returns are aggregated across the five factor portfolios. We use equal-weighted aggregation but our results are robust to using value-weighted aggregation.

Panels A and B of Table 6 report the average realized $Night$ and Day returns respectively for the U.S. stocks. The first obvious feature of the table is that the highest beta portfolio returns are positive during the night and negative during the day for all control factors. Moreover, night returns are monotonically increasing with the stock market beta and day returns are monotonically decreasing with the stock market beta for all control factors.

During the night, the size and the idiosyncratic volatility portfolios earn the largest high minus low beta (HB-LB) portfolio return of 16 bps with the t-statistic of 22.73 for the size and 24.90 for the the idiosyncratic volatility portfolios respectively. Momentum portfolios earn the smallest HB-LB return of 11.1 bps (t-statistic of 17.50), followed by the book-to-market portfolios at 11.3 bps (t-statistic of 18.67), and the reversals portfolios at 15.5 bps (t-statistic of 2.48).

During the day, the reversals and the momentum portfolios earn the smallest and the second smallest high minus low beta (HB-LB) portfolio returns of -37.2 bps with the t-statistic of -1.68 and -35.6 bps with the t-statistic of -1.83, respectively. The idiosyncratic volatility portfolios earn the HB-LB return of -18.6 bps (t-statistic of -16.44), followed by the size portfolios at -16.4 bps (t-statistic of -13.5), and the book-to-market portfolios at -14.1 bps (t-statistic of -13.41).

The size high-beta portfolios have the largest net $Night - Day$ return of 25.7 bps, both statistically and economically significant, while the book-to-market and the momentum portfolios tie for the lowest net return of 15.5 bps. The results are opposite for the low-beta portfolios. The momentum and the reversals portfolios earn the smallest and the second smallest net $Night - Day$ portfolio returns of -36.2 bps and -31.5, respectively.

In summary, Table 6 shows that the following portfolios with high market betas do well during nights and badly during days: size, book-to-market, momentum, reversals, and idiosyncratic volatility. Likewise, the same portfolios but with low market beta do well during days and badly during nights.

Panels A and B of Table 7 report the average realized $Night$ and Day returns respectively for international stocks. The results mimic those for the U.S. stocks from Table 6 with one exception. The highest beta portfolio returns are positive both during the night and day for all control factors but the momentum and the idiosyncratic volatility for which the high-beta returns are weakly negative during the day and positive during the night. However, night returns are monotonically increasing with the stock market beta and day returns are monotonically decreasing with the stock market beta for all control factors.

Table 6 – U.S. day and night returns from double sorted portfolios
This table reports the average daily return for predictive double-sorted portfolios. For each month, stocks are first sorted into five portfolios based on one of the control variables (columns). For each month and each of the five portfolios, stocks are then sorted into five Beta portfolios (rows). For each month and each Beta portfolio returns are aggregated across the five portfolios based on the control variable. Panel A reports equally weighted average $Night$-returns and Panel B reports equally weighted average Day-returns. The control variables are market capitalization (ME), book-to-market ratio (BM), cumulative returns from two month till eleven month before (MOM), cumulative returns from last month (REV), and idiosyncratic volatility (the volatility of the residuals in the regression to estimate Beta) ($IVOL$). The row labeled "(5) - (1)" reports the difference in the returns between portfolios 5 and 1. The corresponding t-statistics are reported in parentheses. Data are from CRSP and COMPUSTAT.

	ME	BM	MOM	REV	IVOL
Panel A: Night returns [in per cent]					
1 (Low Beta)	0.016	0.022	0.013	0.009	-0.011
2	0.031	0.025	0.038	0.035	0.018
3	0.062	0.042	0.052	0.044	0.038
4	0.101	0.066	0.077	0.060	0.079
5 (High Beta)	0.177	0.135	0.124	0.165	0.149
(5) - (1)	0.160***	0.113***	0.111***	0.155**	0.160***
	(22.73)	(18.67)	(17.50)	(2.48)	(24.90)
Panel B: Day returns [in per cent]					
1 (Low Beta)	0.068	0.124	0.328	0.371	0.134
2	0.108	0.279	0.061	0.070	0.320
3	0.011	0.050	0.032	0.056	0.066
4	-0.036	0.023	0.012	0.046	0.024
5 (High Beta)	-0.097	-0.017	-0.028	-0.001	-0.053
(5) - (1)	-0.164***	-0.141***	-0.356*	-0.372*	-0.186***
	(-13.50)	(-13.41)	(-1.83)	(-1.68)	(-16.44)

HB-LB returns are all positive during the night (size portfolio has the largest return of 11.5 bps with a t-statistic of 19.14) and they are all negative during the day (idiosyncratic volatility portfolio has the smallest return of -18.1 bps with a t-statistic of -24.65). The book-to-market high-beta portfolios have the largest net $Night - Day$ return of 27.8 bps, both statistically and economically significant, while the reversals portfolios have the lowest net return of 25.5 bps. Just like in the case of the U.S. stocks, the results are opposite for the low-beta portfolios. The $IVOL$ and the size portfolios earn the smallest and the second smallest net $Night - Day$ portfolio returns of -11.5 bps and -11.4, respectively.

Taken together the numbers show that the high market beta stocks earn significant night

Table 7 – International day and night returns from double sorted portfolios
This table reports the average daily return for predictive double-sorted portfolios. For each month, stocks across all countries are first sorted into five portfolios based on one of the control variables (columns). For each month and each of the five portfolios, stocks across all countries are then sorted into five Beta portfolios (rows). For each month and each Beta portfolio returns are aggregated across the five portfolios based on the control variable. Panel A reports equally weighted average *Night*-returns and Panel B reports equally weighted average *Day*-returns. The control variables are market capitalization (ME), book-to-market ratio (BM), cumulative returns from two month till eleven month before (MOM), cumulative returns from last month (REV), and idiosyncratic volatility (the volatility of the residuals in the regression to estimate Beta) ($IVOL$). The row labeled "(5) - (1)" reports the difference in the returns between portfolios 5 and 1. The corresponding t-statistics are reported in parentheses. Data are from CRSP and COMPUSTAT.

	ME	BM	MOM	REV	IVOL
Panel A: Night returns [in per cent]					
1 (Low Beta)	0.060	0.067	0.065	0.057	0.058
2	0.079	0.075	0.066	0.071	0.084
3	0.085	0.089	0.073	0.078	0.083
4	0.104	0.104	0.090	0.098	0.099
5 (High Beta)	0.175	0.180	0.168	0.164	0.146
(5) - (1)	0.115***	0.113***	0.103***	0.107***	0.089***
	(19.14)	(19.42)	(18.67)	(18.62)	(14.72)
Panel B: Day returns [in per cent]					
1 (Low Beta)	0.174	0.165	0.152	0.155	0.173
2	0.092	0.070	0.073	0.073	0.075
3	0.096	0.060	0.053	0.059	0.064
4	0.070	0.029	0.042	0.030	0.022
5 (High Beta)	0.022	0.001	-0.008	0.007	-0.002
(5) - (1)	-0.152***	-0.165***	-0.160***	-0.148***	-0.181***
	(-15.11)	(-22.02)	(-20.14)	(-21.19)	(-24.65)

stock market risk premium and day stock market risk discount controlling for a number of factors. These results hold for both domestic and international stocks.

2.5 Individual stocks

Our results so far show that night returns are strongly positively related to market betas while day returns are strongly negatively related to market betas for a variety of stock portfolios both domestically and internationally. We next evaluate the ability of beta to explain the difference between day and night returns for individual stocks. In Tables 8 and 9, we run Fama-MacBeth (Panel A) and pooled panel regressions (Panel B) of realized returns on a firm's stock market beta for U.S. and international stocks respectively. In Panel B, we include as controls firm size ($Size$), book-to-market ratio (BM), and past one-year return ($PastReturn$).

We start with the results for the U.S. stocks reported in Table 8. In Panel A, we see that, in agreement with our portfolio findings, stock returns are positively related to the market beta during nights as the implied market risk premium is equal to 6.3 bps (t-statistic of 11.37) for the Fama-MacBeth procedure. Stock returns are negatively related to the market beta during days as the implied market risk premium is equal to 12 bps (t-statistic of -2.30). The R^2s are equal to 0.42% and 0.63% for the $Night$ and Day regressions respectively.

The results from pooled regression (4) are weaker than the Fama-MacBeth results. The net $Day - Night$ risk premium is only -0.6 bps with a t-statistic of -4.88 while this difference is equal to -18.3 bps in the Fama-MacBeth procedure. The regression coefficient on β is equal to 0.3 bps with a t-statistic of 4.85. Thus the conditional SML for individual stocks has a higher slope than the value of -5.7 bps obtained by adding the Day and $Night$ slopes from Fama-MacBeth regressions. The coefficient on the Day dummy capturing net $Day - Night$ alpha is equal to 3 bps and is not statistically significant. The average R^2 for the pooled regression is 0.03%.

The estimated regression coefficients and R^2 are much lower for the panel regression than for the Fama-Macbeth procedure most likely because the individual betas are estimated with more measurement error in the former than in the latter. This also potentially explains the difference in magnitudes between the implied risk premia estimates from Tables 1 and Tables 8.

In Panel B, we see that during the night some of our findings are consistent with the standard results found in the existing literature: size is strongly negatively related to average returns and past one-year return is negatively related to average returns. Several other findings are not consistent with the standard results: book-to-market is strongly negatively, instead of positively, related to average returns and beta is strongly positively (9.1 bps with a t -statistic of 8.91), instead of being not statistically significant, related to average returns. During the day, the coefficient on $Size$ loses its statistical significance, book-to-market is weakly positively related to average returns, the coefficient on past returns switches its sign from negative to positive but remains statistically significant, the coefficient on beta switches to -9.1 bps and remains statistically significant with a t-statistic of -2.54. Past winners tend to do a little better during the day while past losers do better during the night.

We confirm these findings using pooled regression of the type similar to (4) with day fixed effects. The net $Day - Night$ risk premium is -12 bps with a t-statistic of 11.14 while this difference is equal to -24.4 bps in the Fama-MacBeth procedure. The regression

Table 8 – Day and night returns for individual U.S. stocks

This table reports results from Fama-MacBeth and day fixed-effect panel regressions of individual U.S. stocks daily returns [in per cent] on individual stocks betas and other stock characteristics. Returns are measured during the *Day*, from open-to-close, and during the *Night*, from close-to-open. Betas are estimated using daily *Night*-returns over a one year rolling window. Book-to-market (BM) and $Size$ is estimated following Fama and French (1992). $PastReturn$ is the cumulative return over the last twelve months. t-statistics are in parentheses. Standard errors are based on the time series estimates for Fama-MacBeth regressions. Standard errors are clustered at the day level for panel regressions. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively. Data are from CRSP and COMPUSTAT.

Panel A: Beta only (days: 5,791; stock-days 19,978,437)

Returns over	Fama-MacBeth regressions			Panel regressions			
	Intercept	Beta	Avg. R^2	Beta	Day	Day × Beta	R^2 [%]
Night	0.008	0.063***	0.42	0.003***	0.030	-0.006***	0.03
	(1.47)	(11.37)		(4.85)	(0.96)	(-4.88)	
Day	0.196**	-0.120**	0.63				
	(2.11)	(-2.30)					

Panel B: Firm characteristics as controls (days: 5,540; stock-days: 12,667,458)

Fama-MacBeth regressions

	Intercept	Beta	Size	BM	Past Return	Avg. R^2 [%]
Night	0.106***	0.091***	-0.009***	-0.024***	-0.010**	1.19
	(5.64)	(8.91)	(-4.92)	(-14.00)	(-2.39)	
Day	1.36	-0.153**	-0.091	0.088	0.001**	1.73
	(1.49)	(-2.54)	(-1.45)	(1.38)	(2.02)	

Panel regressions with day fixed effects

	Day	Beta	× Day	Size	× Day	BM	× Day	Past Return	× Day	Avg. R^2 [%]
Return	.975**	.059***	-.120***	-.011	-.071**	-.009***	.033**	.0004***	.000	.04
	(2.11)	(10.03)	(-11.14)	(-0.99)	(-1.98)	(-7.04)	(2.26)	(3.56)	(0.14)	

coefficient on β is equal to 5.9 bps with a t-statistic of 10.03. This number is higher than what we have found using portfolio returns. The coefficient on the Day dummy capturing net $Day - Night$ alpha is equal to 97.5 bps with a t-statistic of 2.11. The coefficient on the size factor is weakly negative and not statistically significant. The net $Day - Night$ size premium is -7.1 bps with a t-statistic of -1.98. Therefore large stocks tend to do better during the night than during the day. The coefficient on book-to-market factor is weakly negative at -0.9 bps with a t-statistic of -7.04. The net $Day - Night$ book-to-market premium is 3.3 bps with a t-statistic of 2.26. Thus growth stocks do better during the day while value stocks do relatively better during the night. The coefficient on past returns is weakly positive at 0.04 bps with a t-statistic of 3.56. The net $Day - Night$ past return premium is equal to zero. The average R^2 for the pooled regression is 0.04%.

Table 9 confirms our findings from Table 8 for international stocks.

Table 9 – Day and night returns for individual international stocks
This table reports results from Fama-MacBeth and two dimensional country/day fixed-effect panel regressions of individual international stocks daily returns [in per cent] on individual stocks betas and other stock characteristics. Returns are measured during the Day, from open-to-close, and during the $Night$, from close-to-open. Betas are estimated using daily $Night$ returns over a one year rolling window. Book-to-market (BM) and $Size$ is estimated following (Fama and French, 1992). $PastReturn$ is the cumulative return over the last twelve months. t-statistics are in parentheses. Standard errors are based on the time series estimates for Fama-MacBeth regressions. Standard errors are clustered at the day level for panel regressions. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, and *, respectively. Data are from Datastream.

Panel A: Beta only (days: 5,476; stock-days 27,059,715)

Returns over	Fama-MacBeth			Panel Regression			
	Country Dummies	Beta	Avg. R^2	Beta	Day	Day × Beta	R^2 [%]
Night	Yes	0.059***	8.84	0.048***	0.070***	-0.128***	9.17
		(11.16)		(9.89)	(8.50)	(-16.54)	
Day	Yes	-0.087***	12.84				
		(-15.35)					

Panel B: Firm characteristics as controls (days: 5,476; stock-days: 22,524,869)

Fama-MacBeth regressions

	Country Dummies	Beta	Size	BM	Past Return	Avg. R^2 [%]
Night	Yes	0.071***	-0.033***	0.001	-0.004	8.96
		(13.53)	(-35.86)	(0.46)	(-1.51)	
Day	Yes	-0.073***	-0.035***	0.010***	0.000	12.67
		(-12.56)	(-23.06)	(5.86)	(1.48)	

Panel regressions with two dimensional country/day fixed effects

	Day	Beta	× Day	Size	× Day	BM	× Day	Past Return	× Day	Avg. R^2 [%]
Return	.114***	.055***	-.122***	-.030***	-.002	.009***	-.014***	.0002**	-.0004**	9.03
	(2.74)	(10.51)	(-14.31)	(-20.10)	(-0.73)	(8.17)	(-6.93)	(2.46)	(-2.49)	

3 Discussion

Our results show that the CAPM holds from close-to-open (Nights): asset risk premia equal stock market risk premia times asset market beta. By contrast, the slope of the SML is negative from open-to-close (Days). These results hold for beta-sorted portfolios for U.S. stocks and international stocks, 10 industry and 25 book-to-market portfolios, both cash-flow and discount-rate betas, and, finally, for individual U.S. stocks and international stocks.

We first start with an idea that there exist multiple priced risk factors whose covariance matrix varies between the day and night. The challenge faced by such models is that they have to explain why risk premia change while betas do not. This question has been discussed extensively in Savor and Wilson (2014) who rejected multi-factor models as possible explanation of their findings. Given the commonality between our results and the results in Savor and Wilson (2014), all of the arguments rejecting multi-factor models presented in Sections 4.1.1., 4.1.2, 4.1.3, and the Appendix of Savor and Wilson (2014) apply in our case.

What remains to be checked is that our findings are not driven by the macroeconomic announcement days as in Savor and Wilson (2014) who find an upward-sloping 24 hour SML on such days. We use the same announcement days as in Savor and Wilson (2014). However, our sample is different from the sample in Savor and Wilson (2014) since our stock price data is available only from 1990 onward. Inflation and unemployment announcement dates come from the US Bureau of Labor Statistics website (http://www.bls.gov). For inflation we use producer price index (PPI) since PPI numbers are always released a few days earlier than the numbers for the consumer price index (CPI) are released, which diminishes the news content of CPI numbers. The dates for the FOMC scheduled interest rate announcements are obtained from the Federal Reserve website (http://www.federalreserve.gov) from 1990. Unscheduled FOMC meetings are not included in the sample. In our sample both PPI and unemployment are announced before the market opens at 8:30 am, while FOMC target interest rates are announced during the trading day.

Figure 8 presents our findings. The relation between $Night$ returns and beta is strongly positive both on the announcement and non-announcement days even though both PPI and unemployment are announced while the stock market is still closed. The expected returns are positive for all but the lowest beta portfolios. The relation between Day returns and beta is strongly negative on non-announcement days and only weakly negative on announcement days. Moreover, high-beta portfolios earn negative expected returns on non-announcement days. Overall, these findings confirm that our main results are not driven by the macroeconomic announcements.

A possible explanation can be attributed to Black (1972, 1992) who points out that if the CAPM's assumption that investors can freely borrow and lend at risk-free rate is violated the security market line will have a slope that is less than the expected market excess return. Once investors are constrained in the leverage that they can take, they achieve the desired degree of risk by tilting their portfolios towards risky high-beta assets. As a result, high-beta

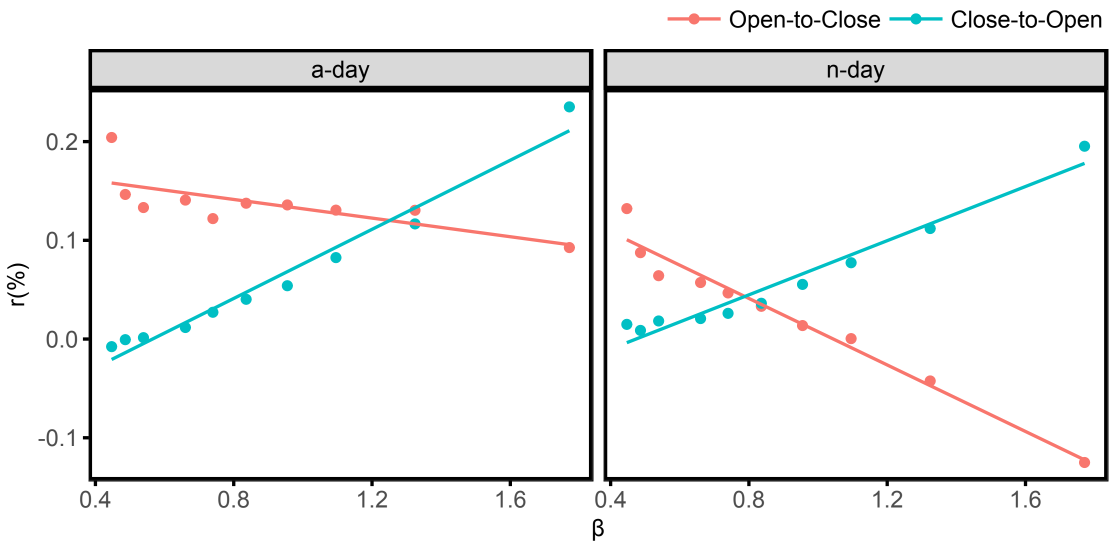

Figure 8 – U.S. returns for beta-sorted portfolios on macroeconomic announcement days Left figure shows average (equally-weighted) returns in per cent against market betas for ten beta-sorted portfolios of all U.S. publicly listed common stocks for announcement days or a-days (days on which inflation, employment, or Federal Open Market Committee interest rate decisions are scheduled to be announced). Right figure shows average (equally-weighted) returns in per cent against market betas for ten beta-sorted portfolios of all U.S. publicly listed common stocks for non-announcement days or n-days (all other days). Portfolios are formed every month, with stocks sorted according to beta, estimated using daily *Night*-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (blue). For both day types and both ways of measuring returns a line is fit using ordinary least square estimate.

assets require lower risk premium than low-beta asset. This idea has been further advanced by Frazzini and Pedersen (2014) who show that when investors face borrowing constraints the CAPM takes the following form

$$\mathrm{E}_t[r_{i,t+1}] - r_f = \psi_t + \beta_{i,t}(\mathrm{E}_t[r_{M,t+1}] - r_f - \psi_t), \tag{5}$$

where r_f is the risk-free rate, $r_{M,t+1}$ is the stock market return, and ψ_t is the Lagrange multiplier on the investors' borrowing constraints thus measuring their tightness. The "constraint" CAPM may have a negative slope if $\psi_t > \mathrm{E}_t[r_{M,t+1}] - r_f$. However, Frazzini and Pedersen (2014) point out that such scenario is highly unlikely - "While the risk premium implied by our theory is lower than the one implied by the CAPM, it is still positive." Indeed, borrowing constraints can only deliver a flatter SLM relative to the CAPM, not a downward-sloping one; investors would not bid up high-beta stock prices to the point of having lower returns than low-beta stocks. However, Jylha (2018) uses active management of the minimum initial margin requirement by the Federal Reserve as an exogenous measure of borrowing constraints and finds that during months when the margin requirement is low the empirical SML has a positive slope close to the CAPM prediction, while during months with high initial margin requirement, the empirical SML has a negative slope. However, since margin requirements have not been changed since September 1975, the natural experiment from Jylha (2018) cannot be used in our sample.

When mapped on our findings, the "constraint" CAPM implies that the investors are more capital-constraint during the day than they are during the night. However, since it is harder to borrow during the night hours simply due to the limited supply of credit, this story is at odds with our findings.

Our finding are most consistent with the beta-conditional speculation. Specifically, the marginal day investor is a risk-loving speculator who measures asset's risk using its market beta. We illustrate this story with a simple stylized model. Consider a stock market with N stocks each characterized by its beta, β_i. The time is discrete and alternates between the times when the stock market opens, t_o, and closes, t_c. For simplicity, we assume that the risk-free rate is equal to zero. The price of stock i is governed by the following processes:

$$p_{i,t} = \beta_i p_{M,t} + (\beta_i - 1)(1 + u_t),\ t \in \{t_o, t_c\}, \tag{6}$$

where the first term captures a CAPM-like common market-wide component of the price while the second term captures a transitory component of the price.[5] The transitory shock, u_t, is drawn at the open from:

$$u_{t_o} \propto \text{i.i.d.} U[0, a], \tag{7}$$

and it is drawn at the close from:

$$u_{t_c} \propto \text{i.i.d.} U[-a, 0], \tag{8}$$

where $U[-a, a]$ stands for the uniform distribution with $0 < a < 1$. Transitory shocks are i.i.d. across time, e.g., $Cov\left(u_{t_o}, u_{t_c}\right) = Cov\left(u_{t_o}, u_{t'_o}\right) = Cov\left(u_{t_c}, u_{t'_c}\right) = 0$. Clearly, $p_{M,t}$, is the price of the equal-weighted market portfolio, defined as:

$$\frac{1}{N}\sum_{i=1}^{N} p_{i,t} = p_{M,t}\left(\frac{1}{N}\sum_{i=1}^{N}\beta_i\right) + (1 + u_t)\left(\frac{1}{N}\sum_{i=1}^{N}(\beta_i - 1)\right) = p_{M,t}, \tag{9}$$

where we have used that the average beta is equal to one, i.e., $\frac{1}{N}\sum_{i=1}^{N}\beta_i = 1$. Under the

[5] We have assumed that the market beta is equal to one. It is straightforward to generalize our analysis to the case when the sample-average beta, $\overline{\beta} = \frac{1}{N}\sum_{i=1}^{N}\beta_i$, is used instead.

specification (6) the stock i's market beta, β_i, is independent of the transitory shocks:

$$\beta_i = \frac{\mathrm{Cov}(\Delta p_i, \Delta p_M)}{\mathrm{Var}(\Delta p_M)}.$$

The transitory demand is conditional on the firm's market risk captured by its beta. It can be attributed to risk-loving speculators who hold high-beta stocks during the day and close their positions at the end of the day. Speculators buy high-beta stocks at the market open and hedge their purchases by shorting the low-beta stocks.

Associating returns with price differences we have for a stock i:

$$\Delta p_i(t,t') \equiv p_{i,t'} - p_{i,t} = \Delta p_M(t,t') + (\beta_i - 1)\left(\Delta p_M(t,t') + u_{t'} - u_t\right), \tag{10}$$

where $\Delta p_M(t,t')$ is the equal-weighted market portfolio return. Consequently, the expected open-to-close return is equal to:

$$\mathrm{E}[\Delta p_i(t_o,t_c)] = a + \beta_i\left(\mathrm{E}[\Delta p_M(t_o,t_c)] - a\right), \tag{11}$$

while the expected close-to-open return is equal to:

$$\mathrm{E}[\Delta p_i(t_c,t_o)] = -a + \beta_i\left(\mathrm{E}[\Delta p_M(t_c,t_o)] + a\right), \tag{12}$$

Therefore, as long as $a \geq |\mathrm{E}[\Delta p_M(t_o,t_c)]|$ the open-to-close return is a non-increasing function of β_i while the close-to-open return is a non-decreasing function of β_i. Parameter a can be interpreted as an average return required by the speculators. If, on average, investors require a market premium for holding stocks overnight, then $a = 2\,|\mathrm{E}[\Delta p_M(t_c,t_o)]|$ thus leading to the expected open-to-close return being a strictly decreasing function of β_i.

Our simple model has several plausible implications born in the data. First, the expected open-to-open and close-to-close returns are not impacted by the transitory demand shocks since they are i.i.d. across time. Consequently, in agreement with Fama and French (2004) both open-to-open and close-to-close CAPMs are flat as can be seen from adding up relations (11) and (12). Second, the intercept is negative (positive) for the night (day) CAPM which is consistent with the findings from Figure 1. Third, the close-to-open risk premium is larger than the open-to-close risk premium as has been documented by Lou, Polk, and Skouras (2017).

Our model suggests the following "betting against&on beta" zero-cost trading strategy based on individual stocks: Go long in high-beta stocks by shorting low-beta stocks during the night or "betting on beta" and then reverse the position at the open going long into

Table 10 – Betting against&on beta trading strategy
This table reports average return, standard deviation, and Sharpe ratio for the "betting against&on beta" zero-cost strategy using either stocks' individual market betas (Panel A) or ten beta-sorted portfolios (Panel B). All U.S. publicly listed common stocks are used to implement the strategy. Portfolios are formed every month, with stocks sorted according to beta, estimated using daily *night*-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample. Each day, returns are measured during the day, from open-to-close, and during the night, from close-to-open. In Panel A we "bet on beta" by going long in high-beta stocks and short low-beta stocks during the night. Each stock has a weight equal to its beta in excess of the average beta. During the day we "bet against beta" by reverting our holdings with each stock having a weight equal to its beta in excess of the average beta, multiplied by minus one. In Panel B we only invest in extreme beta portfolios. During the night we go long in the highest beta portfolio (10) and short the lowest portfolio (1). During the day we revert our holdings. Since the strategy is zero-cost the Sharpe ratio is estimated as the ratio of average returns and standard deviations. Panel C reports results for the beta-neutral BaB strategy from Frazzini and Pedersen (2014), $\frac{r_L - r_f}{\beta_L} - \frac{r_H - r_f}{\beta_H}$, where subscripts L and H stand for the low- and high-beta corner portfolios. The BaB strategy is reversed during the night. We use post-ranked betas $\beta_L = 0.45$ and $\beta_H = 1.77$. Data are from CRSP.

	Average Returns	Standard Deviations	Sharpe Ratios
Panel A: Investing in the market			
Day	0.05%	0.00519	0.101
Night	0.05%	0.00445	0.108
Day+Night	0.10%	0.00784	0.128
Panel B: Investing in extreme Beta stocks			
Day	0.24%	0.01519	0.158
Night	0.19%	0.00887	0.212
Day+Night	0.43%	0.01795	0.238
Panel C: Beta-neutral BaB strategy from Frazzini and Pedersen (2014)			
Day	0.41%	0.01213	0.338
Night	0.097%	0.00853	0.113
Day+Night	0.507%	0.01552	0.327

low-beta stocks by shorting high-beta stocks or "betting against beta." We choose the stock i's portfolio weight equal to a difference between its market beta and the sample average beta, $\beta_i - \overline{\beta}$, during the night and it has the portfolio weight equal to $-(\beta_i - \overline{\beta})$ during the day. During the day we effectively take a long/short position in the stock with market beta greater than the sample average beta with the portfolio weight directly proportional to the difference between betas, and then reverse the position at night. The trading strategy is beta-neutral since the individual portfolio weights sum up to zero.

A portfolio-based trading strategy is motivated by Figure 1 and it entails going long in the highest-beta portfolio and financing the position by shorting the lowest-beta portfolio during the night (betting on beta) and then reversing both positions during the day (betting against beta). While our betting against beta strategy during the day is similar to the one proposed by Frazzini and Pedersen (2014), it is not beta-neutral.

Table 11 – "Betting against&on beta" using triple-sorted portfolios
This table reports the average daily "betting against&on beta" return spread for predictive double-sorted portfolios. For each month, stocks are first sorted into 5 × 5 Size/Book-To-Market portfolios. For each month and each of the twenty-five portfolios, stocks are then sorted into five Beta portfolios. The table reports the return difference between the equally weighted average return of the high beta and low beta portfolio for each Size/Book-To-Market portfolio. Each day, returns are measured during the day, from open-to-close, and during the night, from close-to-open. The corresponding *t*-statistics are reported in parentheses. Data are from CRSP and COMPUSTAT.

		Growth	2	3	4	Value
Day	Small	-0.17% (-8.03)	-0.13% (-7.07)	-0.11% (-5.94)	-0.07% (-3.44)	-0.12% (-7.23)
Night		0.15% (7.47)	0.11% (8.90)	0.09% (8.41)	0.07% (6.99)	0.13% (11.29)
Day	2	-0.16% (-7.25)	-0.11% (-6.04)	-0.12% (-6.06)	-0.06% (-3.11)	-0.14% (-4.34)
Night		0.16% (11.86)	0.10% (9.38)	0.09% (8.80)	0.07% (6.05)	0.19% (9.49)
Day	3	-0.18% (-7.18)	-0.16% (-7.09)	-0.15% (-5.70)	-0.12% (-3.73)	0.01% (0.15)
Night		0.18% (11.82)	0.16% (11.67)	0.17% (11.81)	0.14% (8.12)	0.03% (0.94)
Day	4	-0.17% (-6.19)	-0.13% (-4.76)	-0.15% (-4.81)	-0.06% (-1.59)	-0.18% (-3.40)
Night		0.16% (9.38)	0.16% (9.41)	0.13% (7.67)	0.09% (4.29)	0.23% (7.07)
Day	Big	-0.15% (-5.19)	-0.16% (-5.13)	-0.06% (-1.43)	-0.10% (-2.13)	-0.12% (-1.42)
Night		0.13% (7.68)	0.15% (8.09)	0.07% (2.61)	0.13% (4.28)	0.15% (2.76)

Table 10 reports our results. We use all U.S. publicly listed common stocks to implement both trading strategies. We form market beta-sorted stock portfolios every month, with betas estimated using daily *night* returns over a one year rolling window. Portfolio returns are then averaged and post-ranking betas are estimated over the whole sample. Since both strategies are zero-cost, we use plain instead of excess returns to estimate their Sharpe ratios.

Panel A reports our results for the first trading strategy. During either "Day" or "Night" the strategy generates an average daily return of 0.05% with the standard deviations equal to 0.519% and 0.445%, respectively. The combined "Day+Night" strategy generates an average daily return of 0.10% with the standard deviation equal to 0.784% and the Sharpe ratio equal to 0.128. When annualized, these numbers turn into an average return of 25.2% with a Sharpe ratio equal to 2.032.

Panel B reports our results for the portfolio-based trading strategy. It generates average daily returns of 0.24% and 0.19% during "Day" and "Night" respectively, with the corresponding standard deviations equal to 1.519% and 0.887%. The combined "Day+Night" strategy generates an average daily return of 0.43% with the standard deviation equal to 1.795% and the Sharpe ratio equal to 0.238. When annualized, these numbers turn into an average return of 108.36% with a Sharpe ratio equal to 3.778.

Finally in Panel C reports results for the beta-neutral BaB strategy from Frazzini and Pedersen (2014):

$$\frac{r_L - r_f}{\beta_L} - \frac{r_H - r_f}{\beta_H}, \tag{13}$$

where subscripts L and H stand for the low- and high-beta corner portfolios. The BaB strategy is implemented during the day and then reversed during the night. We use post-ranked betas $\beta_L = 0.45$ and $\beta_H = 1.77$. The strategy performs much better than the other two strategies. It generates average daily returns of 0.41% and 0.09% during "Day" and "Night" respectively, with the corresponding standard deviations equal to 1.213% and 0.853%. The combined "Day+Night" strategy generates an average daily return of 0.51% with the standard deviation equal to 1.552% and the Sharpe ratio equal to 0.327. When annualized, these numbers turn into an average return of 127.76% with a Sharpe ratio equal to 5.165.

Next, we calculate the average return on the "betting on beta" trading strategy after controlling for the size and book-to-market risk factors. Each month we sort all U.S. stocks into 5×5 size and book-to-market portfolios. For each month and each of the twenty-five portfolios, stocks are additionally sorted into five market beta portfolios. Finally, for each size and book-to-market portfolio we calculate the difference between average returns on high- and low-beta equal-weighted portfolios during both "Day" and "Night".

Table 11 reports our results. High-minus-low market beta trading strategy earns negative returns during open-to-close periods (days) and positive returns during close-to-open periods (nights) across all but one size and book-to-market portfolios. The only exception is the medium size (3) value portfolio for which the high-minus-low market beta trading strategy earns positive but not statistically significant returns during both day (0.01%) and night (0.03%). The largest daily return of 0.42% is earned by betting against beta (short high and long low market beta portfolios) during the day and betting on beta during the night (long high and short low market beta portfolios) for value stocks in the forth size decile.

4 Conclusion

This paper studies how stock prices are related to beta when markets are open for trading and when they are closed. Using recent data we examine the performance of the capital asset pricing model (CAPM) during night and day. We document that beta being weakly related to returns is driven entirely by returns during the trading day, e.g., open-to-close returns are negatively related to beta in the cross section. The CAPM holds overnight when the market is closed. The CAPM holds overnight for beta-sorted portfolios for U.S. stocks and international stocks. The CAPM holds overnight for 10 industry and 25 book-to-market portfolios. For betas decomposed into the cash-flow news betas and discount-rate news betas, the CAPM holds overnight for both cash-flow and discount-rate betas. Finally, the CAPM holds overnight for individual U.S. stocks and international stocks.

Appendix

Additional Robustness

Figure 2 shows average equally-weighted 30-minute *Day* returns against market beta for ten equally-weighted beta-sorted portfolios of all U.S. publicly listed common stocks. However, it lumps returns together into a single interval from 10:30 to 15:30. In Figure A.1 we plot all 13 30-minute intervals separately. The SML is flat between 11:00 and 14:00, and it is downward sloping in all other time periods.

Figure 1 shows that the portfolio with the lowest beta earns an abnormally high average Day return. This feature is also common across all other plots of excess returns against market betas. These abnormally high returns are partially due to low-priced stocks (price less than US$5) with low betas. Figure A.2 demonstrates for the U.S. stocks that the expected return on the lowest beta portfolio is much lower once stocks with prices below US$5 are excluded from the portfolio. Figure A.3 demonstrates the same result for international stocks.

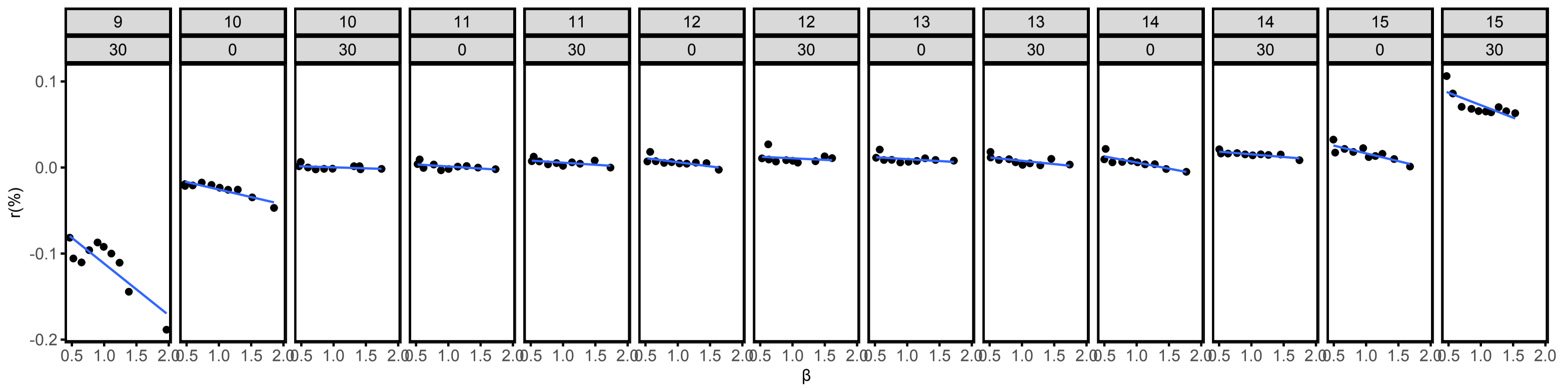

Figure A.1 – U.S. intraday returns for beta-sorted portfolios
This figure shows average (equally-weighted) 30-minute portfolio returns in per cent against market betas for ten beta-sorted portfolios of all U.S. publicly listed common stocks. Returns are estimated from the first and last mid-quote within each interval. Portfolios are formed every month, with stocks sorted according to beta, estimated using daily *night*-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample, separately for each 30-minute interval. We estimate returns over every 30-minute interval within the continuous trading session, with the first interval from 9:30 till 10:00 o'clock and the last interval from 15:30 till 16:00 o'clock. Separately for each interval, we fit a line using ordinary least square estimate. Data are from CRSP.

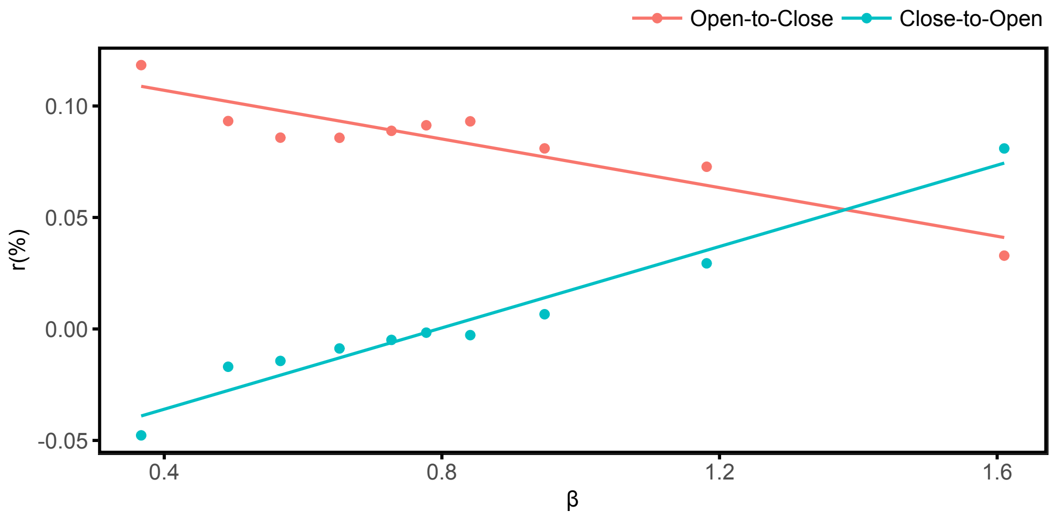

Figure A.2 – US day and night returns for beta-sorted portfolios (excluding low priced stocks)

This figure shows average (equally-weighted) daily returns in per cent against market betas for ten beta-sorted portfolios of all U.S. publicly listed common stocks priced above US$ 5. Portfolios are formed every month with stocks sorted according to beta, estimated using daily *night*-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (cyan). For both ways of measuring returns a line is fit using ordinary least square estimate. Data are from CRSP.

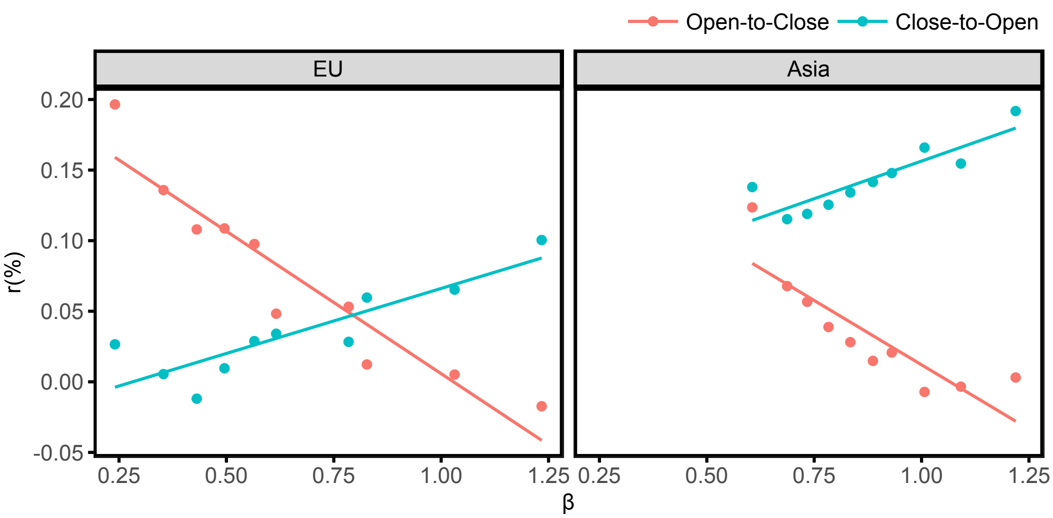

Figure A.3 – **International day and night returns for beta-sorted portfolios (excluding low priced stocks)**
This figure shows average (equally weighted) daily returns in per cent against market betas for ten beta-sorted portfolios of all publicly listed common stocks (excluding low priced stocks) from the 39 (non-U.S.) countries in our sample. Portfolios are formed per country-month with stocks sorted according to beta, estimated using daily $Night$-returns over a one year rolling window. Portfolio returns are averaged and post-ranking betas are estimated over the whole sample for each country separately. Returns and betas per portfolio are averaged (equally weighted) across all countries within the region. The first region is EU: France, Germany, Greece, Israel, Italy, Netherlands, Norway, Poland, South Africa, Spain, Sweden, Switzerland, United Kingdom. The second region is Asia: Australia, China, Hong Kong, India, Indonesia, Korea, New Zealand, Philippines, Singapore, and Thailand. Each day, returns are measured over during the day, from open-to-close (red), and during the night, from close-to-open (blue). For both ways of measuring returns a line is fit using ordinary least square estimate. Data are from Datastream.

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