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Asset pricing: A tale of night and day☆

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ABSTRACT

The capital asset pricing model (CAPM) performs poorly overall, as market risk (beta) is weakly related to 24-h returns. This is because stock prices behave very differently with respect to their sensitivity to beta when markets are open for trading versus when they are closed. Stock returns are positively related to beta overnight, whereas returns are negatively related to beta during the trading day. These day-night relations hold for beta-sorted portfolios and individual stocks in the US and internationally as well as for industry and book-to-market portfolios and cash flow and discount rate beta-sorted portfolios. In addition to the change in slope of returns with respect to beta, the implied risk-free rate differs significantly between night and day. Consistent with this, returns on US Treasury futures differ significantly between night and day.

1. 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. For instance, in their early seminal work, Black et al. (1972) demonstrate that the security market line (SML) for US stocks is too flat relative to the CAPM prediction.

To explain the weak relation between returns and beta, studies have found that the risk-return relationship is positive only during specific times: in January (Tinic and West, 1984); during months of low inflation (Cohen et al., 2005); on days when news about inflation, unemployment, and Federal Open Markets Committee (FOMC) interest rate decisions are scheduled to be announced (Savor and Wilson, 2014); and during months when investors' borrowing constraints are slack (Jylha, 2018).

We extend testing time variation in the CAPM on specific days or months by examining the CAPM's 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,

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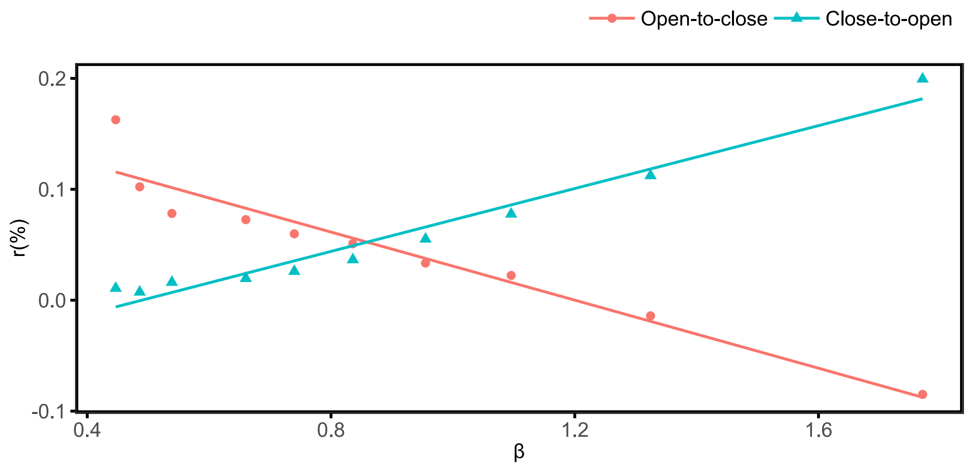

Fig. 1. US day and night returns for beta-sorted portfolios (1992–2016)
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Portfolios are formed every month, with stocks sorted according to beta, 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 estimates. Data are from CRSP..

beta is negatively related to returns when the market is open. Both these risk-return relations hold for beta-sorted portfolios of US stocks and international stocks, 10 industry and 25 book-to-market portfolios, both cash flow news betas and discount rate news betas, individual US stocks and international stocks, and various lengths of market closures.

Our main findings are summarized in Fig. 1. Following Savor and Wilson (2014), we estimate rolling 12-month daily stock market betas for all US stocks. Because our night and day returns decomposition requires opening prices, our sample period is 1992–2016. 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. Fig. 1 plots average realized percentage 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 monotonically positive[1]: an increase in beta of 1 is associated with an economically and statistically significant increase in average night return of 14 basis points (bps) (measured over the 17.5 h from close to open or longer for weekends and holidays). In contrast, the day points show a puzzling pattern: a negative relation between average returns and beta with an increase in beta of 1 is associated with a reduction in average day return of 15 bps (measured over the 6.5 h from open to close, except on days with early market closure), which is statistically and economically significant. Combining the day and night returns into close-to-close returns yields an empirical SML that is flat or slightly downward-sloping. Assuming the risk free rate is the three-month T-bill rate, the CAPM-implied market risk premium for our sample period is 7.5 bps per day.

For the beta-sorted portfolios, almost all variation in both day and night average beta-sorted portfolio returns is explained just by variation in market beta, with R^2s of 92.2% for day returns and 96.2% for night returns. When the day and night SMLs are combined together, the resulting 24-h SML is flat, as reported by multiple papers (see Fama and French, 2004, for a comprehensive review). When separating day and night, 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 Fig. 1 hold regardless of whether beta is estimated using day, night, or close-to-close returns. They also 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.

Motivated by these findings, we explore two "betting against and on beta" long-short 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 Fig. 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

[1] Patton and Timmermann (2010) propose a statistical test for whether returns are monotonically increasing in portfolios' betas. For Fig. 1, the Patton-Timmermann test rejects the hypothesis that the SML for night returns is not monotonically increasing and rejects the hypothesis that the SML for day returns is not monotonically decreasing.

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 0.79% 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 0.44%, 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 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. However, the intercept of the night SML is negative, implying that the risk-free rate is negative when the market is closed. The downward-sloping SML during times when the stock market is open for trading is contrary to the conventional risk-return relationship. This suggests that day investors choose the market portfolio on what is considered the inefficient part of the minimum variance frontier. Contrary to the night SML, the intercept of the day SML is positive. Together, these results indicate that the failure of the 24-h CAPM is related to the slope and intercept differing between night and day. One possibility is that relative to standard representative agents models, the market return is too low and the risk-free rate is too high during the day.

To directly examine whether the day versus night implied variation in the risk-free rate in Fig. 1 is plausible, we measure returns on front month five- and ten-year US Treasury futures. Treasury futures returns are approximately equal to the yield on the underlying Treasury bond net of the basis and therefore are an imperfect proxy for the risk free rate. However, they still offer useful insights about whether intra-day and overnight risk free rates are different. The results are striking: Treasury futures returns are positive and statistically significant during the day, and they are zero or negative during the night, with the day-night spread being both economically and statistically significant. The day/night patterns in Treasury futures are consistent with the patterns in the day/night risk-free rates implied by the intercepts of the day/night SMLs.

While not predicting a downward-sloping SML during the day, past literature suggests possible explanations for the empirical finding that the 24-h SML is too flat. Black (1972, 1992) points out that if the CAPM's assumption that investors can freely borrow and lend at the risk-free rate is violated, the SML will have a slope that is less than the expected market excess return.[2] This is because leverage-constrained investors can achieve the desired degree of risk by tilting their portfolios toward risky high-beta assets. As a result, high-beta assets require lower risk premium than low-beta assets.

Frazzini and Pedersen (2014) take Black's leverage-constraint idea further by deriving a "constraint" CAPM where the equity risk 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 a 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. He finds that during months when the margin requirement is low, the empirical SML has a positive slope close to the CAPM prediction, but during months with a high initial margin requirement, the empirical SML has a negative slope. Jylha's finding of variation in both the slope and intercept of the SML related to margin constraints is empirically similar to our day/night changes in the SML's slope and intercept. However, borrowing constraints do not produce negative risk premia, so they are not a satisfactory explanation.

Our paper is also related to the literature studying unconditional average returns over different time periods. Cliff et al. (2008), Branch and Ma (2008), Kelly and Clark (2011), and Branch and Ma (2012) report that aggregate US returns are, on average, higher overnight than intraday.[3] Heston et al. (2010) provide evidence that some stocks tend to perform systematically better than others during specific half hours of the trading day. Berkman et al. (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).

The two most closely related papers to our work are Lou et al. (2019) and Bogousslavsky (2019). Lou et al. (2019) show that momentum profits accrue solely overnight for US stocks from 1993 to 2013. While their main focus is on momentum, they also report intraday and overnight returns of several other factors/anomalies. Bogousslavsky (2019) shows substantial variation in the cross-section of returns throughout the trading day and overnight. Both papers report the difference in returns of the extreme beta-sorted portfolios for the trading day and overnight as well as cross-sectional regressions.

The Lou et al. (2019) and Bogousslavsky (2019) findings for US stocks are consistent with our results in that they also find that high-beta stocks underperform low-beta stocks at night, while the reverse is true during the day. However, Patton and Timmermann (2010) emphasize that reporting the return spread between the extreme portfolios does not adequately examine or test if

[2] Beyond borrowing constraints, several theoretical explanation exist for why the SML may be too flat. Beta may be mismeasured, or the true portfolio of risky assets is unobservable (Roll, 1977). Andrei et al. (2018) show theoretically that if there exists an information gap between the econometrician and the marginal investor, the CAPM holds unconditionally for the investor but appears flat to the empiricist, who uses the correct unconditional market proxy. As a consequence, the BaB strategy works because it bets on "true" beta according to the model in Andrei et al. (2018).

[3] Tao and Qiu (2008) report similar evidence for international aggregate returns.

returns monotonically vary with risk, which is the fundamental prediction of most asset pricing models. Unlike Lou et al. (2019) and Bogousslavsky (2019), and as suggested by Patton and Timmermann (2010), we explore the full cross-sectional relationship between the expected returns and beta. In addition, we examine stocks outside the US, industry and book-to-market portfolios in the US, and both cash flow news betas and discount rate news betas. Finally, we also provide evidence related to the day and night SML's implied risk-free rate. The intra day and overnight returns on US Treasury futures having differing signs provides additional insight into the failure of the 24-h CAPM.

The rest of the paper is organized as follows. Section 2 presents the data and methodology. Section 3 reports our main results, which we discuss in Section 4. Section 5 concludes.

2. Data and methodology

The data used in this paper come from several databases. Returns for the US stocks are obtained from the Center for Research in Security Prices (CRSP), while the firm-level balance sheet data come from Compustat. The data for foreign countries are obtained from Datastream. For all countries, we only use common stocks. The US 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 (2019). We end up with daily data for 39 foreign countries covering the 1990–2014 period and the US covering the 1992–2016 period.[4]

We follow Lou et al. (2019) in constructing the close-to-open or night returns on date t:

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

with $R_t^{\text{open-to-close}} = R_t^D = (Close_t - Open_t)/Open_t$ the day return. For the US 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 h.

To calculate the size and book-to-market ratio for US 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).[5] 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 US stocks is that the open price is available, which excludes data before 1992. We further drop 16 stock days with a day return over 1,000%. Datastream data are filtered as in Amihud et al. (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 12 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.[6]

For the regressions, we adopt the Fama-MacBeth procedure and compute coefficients separately for night and day returns:

$$R^{N/D}_{i,t+1} = \xi^{N/D}_0 + \xi^{N/D}_1 \hat{\beta}^p_{i,t} + \varepsilon^{N/D}_{i,t}, \tag{3}$$

where $\hat{\beta}^p_{i,t}$ is the asset i market beta for period t estimated in Eq. (2) and $R^{N/D}_{i,t+1}$ 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:

$$R_{i,t+1} = \xi_0 + f_{t+1} + \xi_1 \hat{\beta}^p_{i,t} + \xi_2 D_{t+1} + \xi_3 \hat{\beta}^p_{i,t} D_{t+1} + \varepsilon_{i,t+1}, \tag{4}$$

where $R_{i,t+1}$ is either the night or day return, 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

[4] For Fig. 8, we use TAQ intraday data for US stocks from 1993 to 2016. Sample periods vary across data sources because of available access. We verify that results are robust to restricting the sample to the one determined by having access to data from all required sources, including prices on Treasury futures from 1996 to 2013: see Appendix Table A.1.

[5] See Davis et al. (2000) for more details.

[6] In the Appendix we demonstrate that our results are robust to using either non overlapping or overlapping betas and returns (e.g., we sort stocks into beta portfolios within the estimation window for their betas).

Table 1
US day and night returns (1992–2016).
This table reports results from the Fama-MacBeth and day fixed effect panel regressions of daily returns (in percent) 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 ten 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‡	41.67	0.070‡	0.176‡	−0.159‡	34.87
	(−1.44)	(7.77)		(6.18)	(10.70)	(−7.00)	
Day	0.152‡	−0.077‡	39.41				
	(15.15)	(−5.52)					
Panel B: Equal-weighted							
Night	−0.052‡	0.121‡	39.65	0.128‡	0.234‡	−0.267‡	41.62
	(−8.16)	(13.39)		(14.82)	(18.83)	(−15.65)	
Day	0.169‡	−0.135‡	45.58				
	(18.91)	(−8.68)					

whether the night and day implied risk premia are different.

3. Results

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

3.1. Beta portfolios

In this section we investigate the day and night SML. We start by estimating monthly stock market betas for all US stocks according to Eq. (2) using one-year rolling windows of daily *Night* returns from 1992 to 2016. 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. Fig. 1 plots average realized percent 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 statistically significant. Furthermore, the R^2s of each line are, respectively, 92.2% for day returns and 96.2% 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-h SML is flat, as reported by multiple papers (see Fama and French, 2004, for a comprehensive review). Intriguingly, the highest beta portfolio has the lowest day return (−8 bps) and also has the highest night return (20 bps) so that the same portfolio exhibits very different performance during different time periods within the same day.

Table 1 reports our regression results for both value- and equal-weighted portfolios. Portfolio construction procedure is the same as the one used for Fig. 1, except monthly portfolio post ranking betas are estimated using rolling one year, instead of whole sample, daily night returns and are 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 Eq. (3) using the Fama-MacBeth procedure, we find that the slope for value-weighted day returns is −7.7 bps with a t-statistic of −5.52, implying a negative risk premium, and the intercept is 15.2 bps with a t-statistic of 15.15. Standard errors are adjusted for serial correlations using Newey-West estimator with up to ten 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 39.41%. 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 Eq. (3). An increase in beta of 1 is associated with an increase in average night return of about 6.4 bps. The night-minus-day implied stock market risk premium is 14.1 bps, both statistically and economically significant. The average R^2 for the night regression is 41.67%.

Panel B shows that the results are similar for equal-weighted portfolios: the slope is significantly negative for day returns (−13.5 bps with a t -statistic of −8.68) and is significantly positive for night returns (12.1 bps with a t-statistic of 13.39). Standard errors are adjusted for serial correlations using a Newey-West estimator with up to ten lags. Intercepts have the same signs, as in the case of value-weighted portfolios, and both are statistically significant. The night-minus-day stock market risk premium is even higher for equal-weighted portfolios at 25.6 bps, both statistically and economically significant.

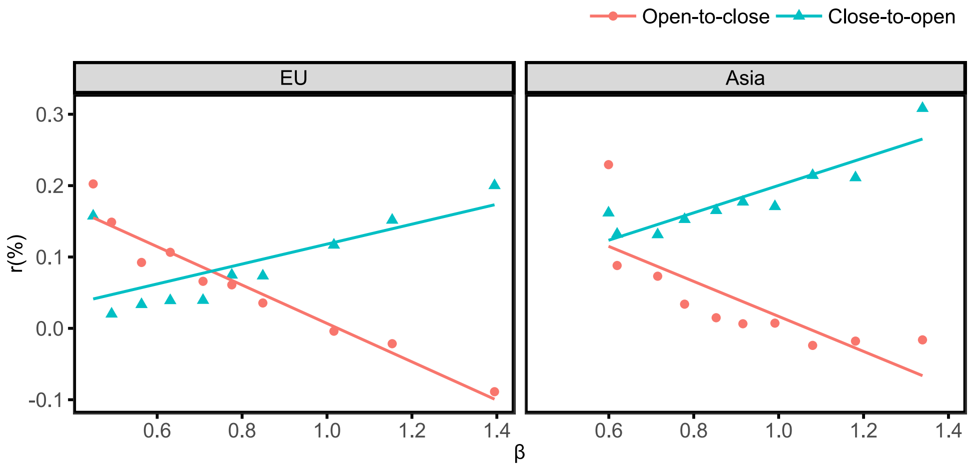

Fig. 2. International day and night returns for beta-sorted portfolios (1990–2014).
This figure shows average (equally weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all publicly listed common stocks from the 39 (non-US) countries in our sample. Portfolios are 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 the 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, Japan, 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 estimates. Data are from Datastream. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Our findings are confirmed using pooling methodology to estimate the difference in the slope coefficients between night and day SMLs 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* $\times$ β. Panel A shows that for value-weighted portfolios, it is equal to -15.9 bps with a *t*-statistic of -7.00. This difference is close to the value of -14.1 bps obtained using the Fama-MacBeth procedure. The regression coefficient on β is equal to 7 bps with a *t*-statistic of 6.18. Thus the conditional SML has a much higher slope than the value of -1.3 bps obtained by adding the day and night slopes from the Fama-MacBeth regressions. The coefficient on the day dummy capturing day-minus-night alpha is equal to 17.6 bps, which is close to the value of 16 bps obtained by subtracting day and night alphas from the Fama-MacBeth regressions. The R^2 for the pooled regression is 34.87%.

Panel B reveals similar results in the case of equal-weighted portfolios. The regression coefficient on *Day* $\times$ β is equal to -26.7 bps with a *t*-statistic of -15.65. Its magnitude is similar to the value of -25.6 bps obtained using the Fama-MacBeth procedure. The regression coefficient on β is equal to 12.8 bps with a *t*-statistic of 14.82. Thus, once again, the conditional SML has a much higher slope than the value of -0.14 bps obtained by adding the day and night slopes from the Fama-MacBeth regressions. The coefficient on the day dummy capturing day-minus-night alpha is equal to 23.4 bps, which is pretty close to the value of 22.1 bps obtained by subtracting day and night alphas from the Fama-MacBeth regressions. One notable difference between equal- and value-weighted portfolios is that the average R^2s for the pooled regressions is larger in the former case at 41.62%.

One potential concern is that the US stocks are special and our findings are specific to the US stock market. To alleviate this concern, we perform the same set of tests on international stocks. Since (for our figures) stocks from several countries do not survive our data filters, we group foreign countries that survive them into two regions—the“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, Japan, Korea, New Zealand, Philippines, Singapore, and Thailand. Our data come from Datastream and cover period 1990–2014.

We form pre ranked portfolios for each country using the same methodology we use for the US 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.

Fig. 2 plots average realized percent 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 SML 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 US, the day CAPM is still very similar for the US and international

Table 2
International day and night returns (1990–2014).
This table reports results from the Fama-MacBeth and two dimensional country/day fixed effect panel regressions of daily returns (in percent) 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: Equal-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)					

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.

Just like for the US stocks, the relation between average night returns and beta is strongly positive for both the EU and Asia regions, with the corresponding slopes equal to 14 and 19 bps. Quantitatively, these numbers are close to the US slope of 14 bps. The intercepts for both regions have different signs (negative for the EU and positive for Asia) but are not statistically significant. The night SML is better identified for Asia than for the EU, since the former has higher R^2s (79.6% versus 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- and equal-weighted portfolios of international stocks. Portfolio construction procedure is the same as the one used for Fig. 2, 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 implied 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 US 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 US 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 US stocks. An increase in beta of 1 is associated with an increase in average night return of about 8 bps. The night-minus-day implied 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 is significantly positive for night returns (11.2 bps with a t-statistic of 14.92). The night-minus-day risk premium is comparable to that for the US Stocks—26.6 bps (international) versus 25.6 bps (US). The average R^2 s 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 SMLs 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-weighted 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 the 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 the Fama-MacBeth regressions. The coefficient on the day dummy capturing day-minus-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. It is slightly larger than the value of −26.6 bps obtained using the 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 the Fama-MacBeth regressions. The coefficient on the day dummy capturing day-minus-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%.

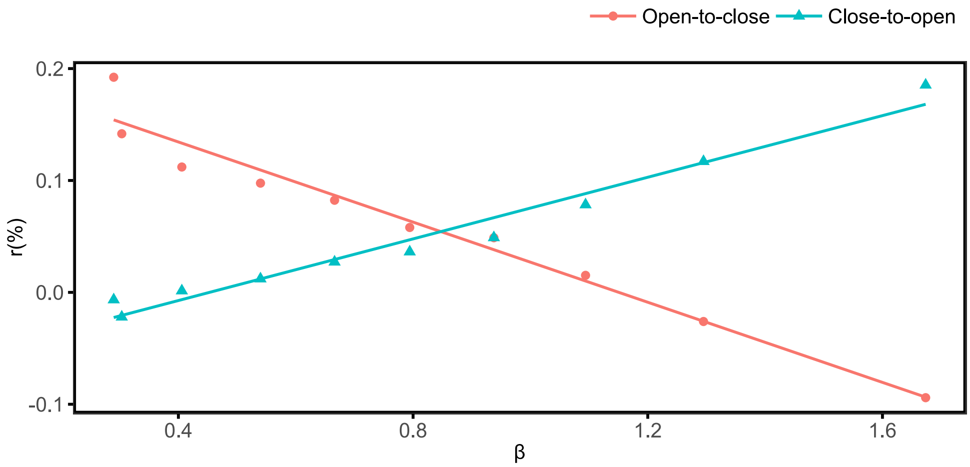

Fig. 3. US day and night returns for beta-sorted portfolios, estimated from close-to-close returns (1992–2016).
This figure shows average (equally-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Portfolios are formed every 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 postranking 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 estimates. Data are from CRSP. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Our results indicate that the market risk premium has been positive at night and negative during the day during the 1990 to 2014 period (1992 to 2016 for the US). This holds true both for the US 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" (i.e., a negative equity premium). 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 Figs. 1 and 2 using close-to-close returns to construct stock market betas. Fig. 3 shows our results for the US stocks by plotting average realized percent 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 an even stronger negative relation with the stock market beta than the one shown in Fig. 1—an increase in beta of 1 is associated with a reduction in average day return of 18 bps (15 bps in Fig. 1).

Night returns have the same positive relation with the market beta the one shown in Fig. 1: 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 both lines are, respectively, 96.2% 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.

Fig. 4 plots average realized percent 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 Fig. 2 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 the 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.

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 on the number of nights over which the returns are calculated. Therefore, we reestimate 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 are 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, and are then followed 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 −11.6 bps and is economically and statistically significant. For the night returns, Fama-MacBeth yields the slope of 11.7 bps with a t-statistic of 12.61. The day-minus-night risk premium is equal to −23.3 bps, while the day-minus-night

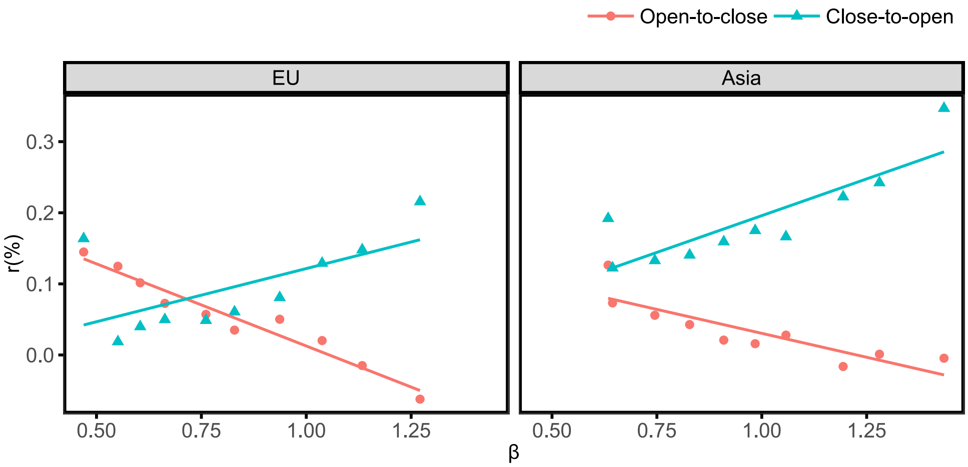

Fig. 4. International day and night returns for beta-sorted portfolios, estimated from close-to-close returns (1990–2014).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all publicly listed common stocks from the 39 (non-US) 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 postranking 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 Fig. 2. 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 estimates. Data are from Datastream. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 3
US day and night returns (by nights closed) (1992–2016).
This table reports results from the Fama-MacBeth and day fixed effect panel regressions of beta-sorted, equally weighted portfolios from US stocks daily returns (in percent) 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 nights, 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	0.123‡	0.252‡	−0.243‡	40.35
	(−11.81)	(12.61)		(12.58)	(17.91)	(−12.67)	
Day	0.186‡	−0.116‡	45.67				
	(23.63)	(−6.70)					
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‡	0.137‡	38.29	0.144‡	0.141‡	−0.351‡	47.11
	(−4.90)	(6.97)		(7.89)	(5.22)	(−9.23)	
Day	0.088‡	−0.215‡	45.65				
	(5.30)	(−5.82)					
Panel D: 148 4-night returns							
Night	−0.060*	0.171‡	42.99	0.194‡	0.318‡	−0.527‡	39.33
	(−1.96)	(2.88)		(3.35)	(3.66)	(−4.32)	
Day	0.135‡	−0.205*	45.95				
	(3.49)	(−1.86)					

alpha is equal to 23.9 bps. Both of these numbers are similar from their counterparts from the pooled regression, equal to −24.3 bps (*t*-statistic of −12.67) and 25.2 bps (*t*-statistic of 17.91), respectively. The average R^2 is equal to 39.84% for the night regression, 45.67% for the day regression, and 40.35% for the pooled regression.

The slopes are not significant in the Fama-MacBeth procedure nor in the panel regression (except for beta) 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 1 nontrading day—thus diminishing the power of the tests.

Table 4
International day and night returns (by nights closed) (1990–2014).
This table reports results from the Fama-MacBeth and two dimensional country/day fixed effect panel regressions of equally weighted portfolios from international stocks daily returns (in percent) 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 nights, 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: 4381 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: 1177 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: 1052 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)					

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 −21.5 bps with a *t*-statistic of −5.82, and it is equal to 13.7 bps with a *t*-statistic of 6.97 for night returns. The day-minus-night risk premium is equal to −35.2 bps, while the day-minus-night alpha is equal to 13.7 bps. Both of these numbers are very close to their counterparts from the pooled regression, equal to −35.1 bps (*t*-statistic of −9.23) and 14.1 bps (*t*-statistic of 5.22), respectively. The average R^2 is equal to 38.29% for the night regression, 45.65% for the day regression, and 47.11% 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 −20.5 bps with a *t*-statistic of −1.86, and it is equal to 17.1 bps with a *t*-statistic of 2.88 for night returns. The day-minus-night risk premium is equal to −37.6 bps, while the day-minus-night alpha is equal to 19.5 bps. Both of these numbers are different to their counterparts from the pooled regression, equal to −52.7 bps (*t*-statistic of −4.32) and 31.8 bps (*t*-statistic of 3.66), respectively. The average R^2 is equal to 42.99% for the night regression, 45.95% for the day regression, and 39.33% for the pooled regression.

If we exclude the two-night returns, the night-implied 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 nontrading periods and we find this using both the Fama-Macbeth and panel regressions. For day returns, the stock market discount increases with the number of nights the return is calculated over when said discount is estimated using panel regressions. The stock market discount declines slightly when going from three- to four-night returns when it is estimated using the Fama-MacBeth regressions. The increase in the stock market discount is consistent with the investors holding high-beta assets being more eager to offload them, thus driving its price further down, in 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 1177 events, followed by the four-night returns at 1052 events. The two-night returns are also the smallest group at 878 events but are much larger than in the case of the US 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^2s range from 26.45% (two-night day returns) to 37.94% (one-night day returns). Using the 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 night-minus-day risk premium increases from 20.6 bps for one-night returns, to 26.4 bps for three-night returns,

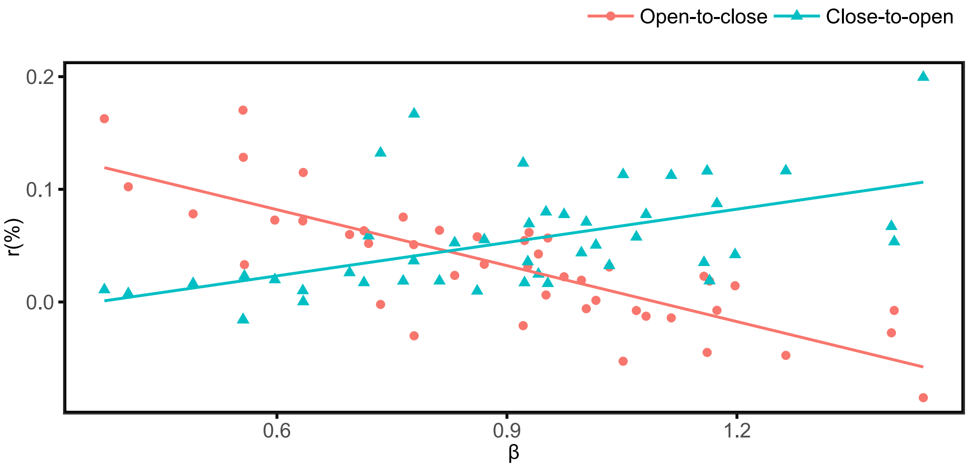

Fig. 5. US day and night returns for 10 beta-sorted, 10 industry, and 25 Size/BM portfolios (1992–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for 10 beta-sorted, 10 industry, and 25 size/BM portfolios of all US publicly listed common stocks. Beta portfolios 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. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

and to 31.8 bps for four-night returns. The average R^2s for pooled regressions range from 20.58% (one-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.

3.2. 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 US stocks, we use the contemporaneous Fama and French ten 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 stocks' current market equity. All US stocks are sorted into size portfolios using only NYSE breakpoints to avoid overpopulating the small stock portfolio with Nasdaq stocks.

Fig. 5 plots average realized percent 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 Fig. 1. In agreement with our results for beta-sorted portfolios from Fig. 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 is 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 63.7%, 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 is 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 the 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.[7]

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

Panel A reports our results for value-weighted portfolios. For the Fama-Macbeth procedure, the implied risk

[7] These results are robust to estimating the SML within only industry or only size/BM sorted portfolios. Further, beta explains 13% (28%) of variation in day (night) returns for the ten industry portfolios and 60% (17%) of variation in day (night) returns for the 25 size/BM portfolios (see Appendix Fig. A.8).

Table 5
US day and night returns for 10 beta-sorted, 10 industry, and 25 Size/BM portfolios (1992–2016).
This table reports results from the Fama-MacBeth and day fixed effect panel regressions of daily returns (in percent) 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 ten 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 Intercept	Beta	Avg. R^2	Panel regressions Beta	Day	Day × Beta	R^2 [%]
Panel A: Value-weighted							
Night	−0.027‡	0.081‡	21.92	0.085‡	0.200‡	−0.180‡	36.12
	(−5.79)	(10.11)		(5.70)	(7.16)	(−5.52)	
Day	0.147‡	−0.074‡	19.36				
	(14.36)	(−5.20)					
Panel B: Equal-weighted							
Night	−0.042‡	0.097‡	17.32	0.127‡	0.262‡	−0.291‡	39.57
	(−7.90)	(12.87)		(9.32)	(10.08)	(−9.69)	
Day	0.148‡	−0.117‡	17.32				
	(15.76)	(−8.46)					

premium for value-weighted day returns is −7.4 bps with a t-statistic of −5.20, and the intercept is 14.7 bps with a t-statistic of 14.36, with both estimates extremely close to the estimates for the beta-sorted portfolios. Standard errors are adjusted for serial correlations using a Newey-West estimator with up to ten lags. The average R^2 for the day regression is 19.36%.

The implied risk premium for value-weighted night returns is 8.1 bps with a t-statistic of 10.11, and the intercept is −0.027 bps with a t -statistic of −5.79. The night-minus-day implied market risk premium is 15.5 bps, both statistically and economically significant. The average R^2 for the night regression is 21.92%.

These findings are confirmed using pooling methodology to estimate the difference in the slope coefficients between night and day SMLs 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 −18.0 bps with a t-statistic of −5.52. This difference is close to the value of −15.5 bps obtained using the Fama-MacBeth procedure. The regression coefficient on β is equal to 8.5 bps with a t-statistic of 5.70. Thus, the conditional SML has a much higher slope than the value of 0.7 bps obtained by adding the day and night slopes from the Fama-MacBeth regressions. The coefficient on the day dummy capturing day-minus-night alpha is equal to 20 bps, which is close to 17.4 bps obtained using the Fama-MacBeth regressions. The R^2s for the pooled regression is 36.12%.

The results are similar for equal-weighted portfolios, as Panel B demonstrates. For the Fama-Macbeth procedure, the implied risk premium is negative for day returns (−11.7 bps with a t-statistic of −8.46) and is positive for *Night* returns (9.7 bps with a t-statistic of 12.87). The night-minus-day implied risk premium is equal to 21.4 bps, both statistically and economically significant. The average R^2s for the Fama-Macbeth procedure are 17.32% for both night and day returns.

Using panel regressions, the day-minus-night implied risk premium is equal to −29.1 bps with a t-statistic of −9.69. Its magnitude is larger than the value of −21.4 bps obtained using the Fama-MacBeth procedure. The regression coefficient on β is equal to 12.7 bps with a t-statistic of 9.32. Thus, once again, the conditional SML has a much higher slope than the value of −2 bps obtained by adding the day and night slopes from the Fama-MacBeth regressions. The coefficient on the day dummy capturing day-minus-night alpha is equal to 26.2 bps, which is slightly larger than the value of 19 bps obtained using the Fama-MacBeth regressions. The R^2s for the pooled regression is 39.57%.

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.

3.3. 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,

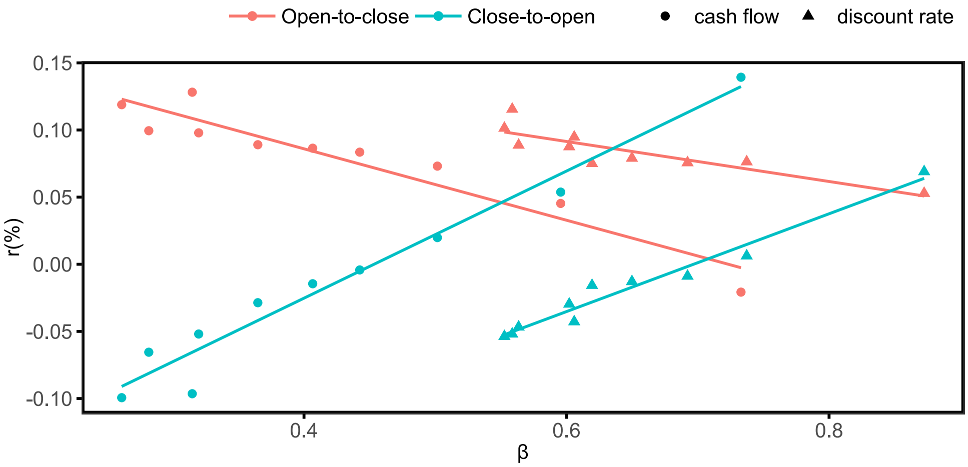

Fig. 6. US day and night returns for portfolios sorted by cash flow and discount rate beta (1992–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Following Campbell and Vuolteenaho (2004), 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. Postranking 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 covariance 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 estimates. Data are from CRSP. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

and then within each cash flow beta portfolio, we sort all stocks into ten discount rate beta portfolios. To calculate postranking 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 postranking covariance. Next we divide both covariances by the variance of market returns (see Eqs. (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.

Fig. 6 plots average realized percent 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 are equal to 96.2% for the cash flow news and 91%. The night-minus-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 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.

3.4. 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 2 to 11 months 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 US 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 a *t*-statistic of 22.72 for the size and 24.97 for the idiosyncratic volatility portfolios, respectively. Reversal portfolios earn the smallest HB-LB return of 10.8 bps (*t*-statistic of 16.77), followed by the mo-

Table 6
US day and night returns from double sorted portfolios (1992–2016).

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 2 to 11 months 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. Statistical significance at the 1%, 5%, and 10% level is indicated by ‡, †, and *, respectively. Data are from CRSP and Compustat.

	ME	BM	MOM	REV	IVOL
Panel A: Night returns (in percent)					
1 (Low beta)	0.017	0.022	0.013	0.014	-0.011
2	0.032	0.026	0.039	0.029	0.019
3	0.061	0.042	0.051	0.041	0.038
4	0.101	0.067	0.077	0.060	0.079
5 (High beta)	0.177	0.135	0.124	0.121	0.150
(5) - (1)	0.160‡	0.114‡	0.111‡	0.108‡	0.160‡
	(22.72)	(18.70)	(17.42)	(16.77)	(24.97)
Panel B: Day returns (in percent)					
1 (Low beta)	0.067	0.118	0.128	0.130	0.128
2	0.038	0.064	0.059	0.069	0.088
3	0.011	0.050	0.033	0.046	0.066
4	−0.037	0.022	0.011	0.033	0.023
5 (High beta)	−0.096	−0.019	−0.031	−0.023	−0.055
(5) - (1)	−0.163‡	−0.137‡	−0.159‡	−0.153‡	−0.183‡
	(−13.44)	(−13.83)	(−15.77)	(−14.67)	(−16.89)

mentum portfolios at 11.1 bps (*t*-statistic of 17.42), and the book-to-market portfolios at 11.4 bps (*t*-statistic of 18.70).

During the day, the idiosyncratic volatility and the size portfolios earn the smallest and the second smallest high-minus-low beta (HB-LB) portfolio returns of −18.3 bps with a *t*-statistic of −16.89 and −16.3 bps with a *t* -statistic of −13.44, respectively. The momentum portfolios earn the HB-LB return of −15.9 bps (*t*-statistic of −15.77), followed by the reversal portfolios at −15.3 bps (*t*-statistic of −14.67), and the book-to-market portfolios at −13.7 bps (*t*-statistic of −13.83).

The size night and day high-beta portfolios have the largest night-minus-day return of 27.3 bps, both statistically and economically significant, while the the reversal portfolios have the lowest net return of 14.4 bps. The results are different for the low-beta portfolios. The idiosyncratic volatility portfolios earn the smallest night-minus-day portfolio returns of −13.9 bps.

In summary, Table 6 shows that the following portfolios with high market betas do well during nights and do 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 US 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 are 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.

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 night-minus-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 US stocks, the results are different for the low-beta portfolios. The *IVOL* and the size portfolios earn the smallest and the second smallest night-minus-day portfolio returns of −11.5 bps and −11.4, respectively.

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

3.5. 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 US 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 US stocks reported in Table 8. In Panel A, we see that, in agreement with our

Table 7

International day and night returns from double sorted portfolios (1990–2014).

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 2 to 11 months 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. Statistical significance at the 1%, 5%, and 10% level is indicated by ‡, †, and *, respectively. Data are from CRSP and Compustat.

	ME	BM	MOM	REV	IVOL
Panel A: Night returns (in percent)					
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 percent)					
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)

Table 8

Day and night returns for individual US stocks (1992–2016).

This table reports results from the Fama-MacBeth and day fixed effect panel regressions of individual US stocks daily returns (in percent) 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* are estimated following Fama and French (1992). *PastReturn* is the cumulative return over the last 12 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 19,978,423)

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‡	-0.000	-0.006‡	1.54
	(1.48)	(11.37)		(5.06)	(-0.03)	(-5.28)	
Day	0.101‡	-0.068‡	0.63				
	(11.96)	(-8.55)					

Panel B: Firm characteristics as controls (days: 5,540; stock days: 12,667,193)

Fama-MacBeth regressions

	Intercept	Beta	Size	BM	Past return	Avg. R^2 [%]
Night	0.108‡	0.091‡	−0.009‡	−0.024‡	−0.010†	1.18
	(5.69)	(8.88)	(−4.96)	(−14.06)	(−2.34)	
Day	0.432‡	−0.090‡	−0.027‡	0.023‡	0.037†	1.73
	(14.93)	(−10.10)	(−10.50)	(10.72)	(6.53)	

Panel regressions with day fixed effects

	Day	Beta	Beta × Day	Size	Size × Day	BM	BM × Day	Past return	Past return × Day	R^2 [%]
Return	0.535‡	0.060‡	−0.118‡	0.001	−0.037‡	−0.001‡	0.003‡	0.0003‡	−0.0001	1.86
	(11.37)	(10.25)	(−11.80)	(0.42)	(−8.30)	(−6.84)	(6.58)	(4.29)	(−0.70)	

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 −6.8 bps (t-statistic of −8.55). 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 day-minus-night risk premium is only −0.6 bps with a t-statistic of −5.28, while this difference is equal to −13.1 bps in the Fama-MacBeth procedure. The regression coefficient on β is equal to 0.3

Table 9

Day and night returns for individual international stocks (1990–2014).

This table reports results from the Fama-MacBeth and two dimensional country/day fixed effect panel regressions of individual international stocks daily returns (in percent) 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* are estimated following Fama and French (1992). *PastReturn* is the cumulative return over the last 12 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 Country dummies	Beta	Avg. R^2	Panel regression 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	Beta × Day	Size	Size × Day	BM	BM × Day	Past return	Past return × Day	R^2 [%]
Return	0.114‡	0.055‡	−0.122‡	−0.030‡	−0.002	0.009‡	−0.014‡	0.0002†	−0.0004†	9.03
	(2.74)	(10.51)	(−14.31)	(−20.10)	(−0.73)	(8.17)	(−6.93)	(2.46)	(−2.49)	

bps with a t-statistic of 5.06. Thus the conditional SML for individual stocks has a similar slope than the value of -0.5 bps obtained by adding the day and night slopes from the Fama-MacBeth regressions. The coefficient on the day dummy capturing day-minus-night alpha is less than 1 bps and is not statistically significant. The average R^2 for the pooled regression is 1.54%.

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. Several other findings are not consistent with the standard results: book-to-market is strongly negatively related to average returns, and beta is strongly positively (9.1 bps with a t -statistic of 8.88), instead of being not statistically significant, related to average returns. During the day, the coefficient on *Size* stays statistical significant, book-to-market is positively related to average returns, the coefficient on past returns switches its sign from negative to positive but remains statistically significant, and the coefficient on beta switches to -9.0 bps and remains statistically significant with a t-statistic of -10.10.

We confirm these findings using pooled regression of the type similar to Eq. (4) with day fixed effects. The day-minus-night risk premium is -11.8 bps with a t-statistic of 11.80, while this difference is equal to -18.1 bps in the Fama-MacBeth procedure. The regression coefficient on β is equal to 6.0 bps with a t-statistic of 10.25. This number is higher than what we find using portfolio returns. The coefficient on the day dummy capturing day-minus-night alpha is equal to 53.5 bps with a t-statistic of 11.37. The coefficient on the size factor is weakly positive and is not statistically significant. The day-minus-night size premium is -3.7 bps with a t-statistic of -8.30. Therefore, large stocks tend to do better during the night than during the day. The coefficient on the book-to-market factor is weakly negative at -0.1 bps with a t-statistic of -6.84. The day-minus-night book-to-market premium is 0.3 bps with a t-statistic of 6.58. 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 0.03 bps with a t-statistic of 4.29. The day-minus-night past return premium is equal to -0.01 bps. The average R^2 for the pooled regression is 1.86%.

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

3.6. Trading strategy

Our findings suggests the following betting against and 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 low-beta stocks by shorting high-beta stocks or BaB. We choose 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

Table 10
Betting against and on beta trading strategy (1992–2016).
This table reports the average returns, standard deviations, and Sharpe ratios for the betting against and on beta zero-cost strategy using either stock's individual market betas (Panel A) or ten beta-sorted portfolios (Panel B). All US 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-yearrolling window. Portfolio returns are averaged, and postranking 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%	0.526%	0.095
Night	0.05%	0.446%	0.112
Day+Night	0.10%	0.791%	0.126
Panel B: Investing in extreme beta stocks			
Day	0.25%	1.526%	0.164
Night	0.19%	0.887%	0.214
Day+Night	0.44%	1.802%	0.244
Panel C: Beta-neutral BaB strategy from Frazzini and Pedersen (2014) during the day, reversed at night			
Day	0.39%	1.088%	0.359
Night	0.09%	0.835%	0.110
Day+Night	0.48%	1.433%	0.334

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 Fig. 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 BaB strategy during the day is similar to the one proposed by Frazzini and Pedersen (2014), it is not beta neutral.

Table 10 reports our results. We use all US 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 postranking 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 0.526% and 0.446%, respectively. The combined day plus night strategy generates an average daily return of 0.10%, with the standard deviation equal to 0.791% and the Sharpe ratio equal to 0.126. When annualized, these numbers turn into an average return of 25.2% with a Sharpe ratio equal to around 2.

Panel B reports our results for the portfolio-based trading strategy. It generates average daily returns of 0.25% and 0.19% during day and night, respectively, with the corresponding standard deviations equal to 1.526% and 0.887%. The combined day plus night strategy generates an average daily return of 0.44%, with the standard deviation equal to 1.802% and the Sharpe ratio equal to 0.244. When annualized, these numbers turn into an average return of 110.88% with a Sharpe ratio equal to 3.87.

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

$$\frac{r_L - r_f}{\beta_L} - \frac{r_H - r_f}{\beta_H}, \tag{5}$$

where subscripts L and H stand for the low- and high-beta corner portfolios. The BaB strategy is implemented during the day and is 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 0.39% and 0.09% during day and night, respectively, with the corresponding standard deviations equal to 1.088% and 0.835%. The combined day plus night strategy generates an average daily return of 0.48%, with the standard deviation equal to 1.433% and the Sharpe ratio equal to 0.334. When annualized, these numbers turn into an average return of 120.96% with a Sharpe ratio equal to 5.3.[8] While these returns and Sharpe ratios are economically large, implementing various BaB strategies would require significant trading in high-beta stocks at the open and close of each day. This could significantly diminish or even eliminate the strategies positive returns. 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 US stocks into 5 × 5 size and book-to-market portfolios. For each month and each of the 25 portfolios, stocks are additionally sorted into 5 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.

[8] These Sharpe ratios are comparable to other strategies based on daily data. Lou et al. (2019, p. 17) report an annualized Sharpe ratio for the overnight momentum strategy of 2.67 (sqrt(12) * 0.77).

Table 11
Betting against and on beta using triple-sorted portfolios (1992–2016).
This table reports the average daily betting against and 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 25 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%	−0.13%	−0.11%	−0.06%	−0.12%
		(−5.93)	(−5.23)	(−5.13)	(−2.85)	(−6.09)
Night		0.15%	0.11%	0.09%	0.07%	0.13%
		(6.74)	(7.01)	(6.67)	(5.91)	(8.97)
Day	2	−0.17%	−0.12%	−0.12%	−0.06%	−0.14%
		(−4.80)	(−3.91)	(−4.00)	(−1.88)	(−3.35)
Night		0.16%	0.10%	0.09%	0.07%	0.18%
		(8.48)	(6.66)	(6.13)	(4.37)	(7.68)
Day	3	−0.18%	−0.17%	−0.14%	−0.11%	0.01%
		(−5.00)	(−3.31)	(−4.18)	(−2.79)	(0.13)
Night		0.18%	0.17%	0.16%	0.14%	0.05%
		(8.98)	(9.48)	(8.88)	(6.79)	(1.41)
Day	4	−0.17%	−0.13%	−0.15%	−0.09%	−0.19%
		(−4.46)	(−3.68)	(−4.17)	(−2.17)	(−3.64)
Night		0.16%	0.16%	0.14%	0.10%	0.24%
		(7.24)	(7.84)	(6.66)	(4.23)	(7.15)
Day	Big	−0.14%	−0.17%	−0.07%	−0.10%	−0.16%
		(-3.69)	(−4.50)	(−1.49)	(−2.04)	(−2.52)
Night		0.13%	0.15%	0.08%	0.12%	0.19%
		(5.60)	(6.85)	(2.74)	(3.64)	(4.35)

Table 11 reports our results. High-minus-low market beta trading strategy earns negative returns during open-to-close periods (days) and earns 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 value portfolio in column 3, for which the high-minus-low market beta trading strategy earns positive, but not statistically significant, returns during both day (0.01%) and night (0.05%). The largest daily return of 0.43% is earned by BaB (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 fourth size decile.

4. Discussion

Our results show that the CAPM holds from close-to-open (nights) in the sense that asset risk premia are increasing with 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 US stocks and international stocks, 10 industry and 25 book-to-market portfolios, both cash flow and discount rate betas, and, finally, for individual US 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 reject multifactor models as a possible explanation of their findings. Given the commonality between our results and the results in Savor and Wilson (2014), all of the arguments rejecting multifactor 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.

4.1. Macroeconomic announcements

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-h SML on such days.[9] 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 are available only from 1992 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 1992. 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, while FOMC target interest rates are announced during the trading day.

Fig. 7 presents our findings. The relation between night returns and beta is strongly positive both on the announcement and nonannouncement days even though both PPI and unemployment are announced while the stock market is still closed. The returns are positive for all but the lowest beta portfolios. The relation between day returns and beta is strongly negative on nonannouncement days and are only weakly negative on announcement days. Moreover,

9 In the appendix we also report results outside and around individual stock earnings announcement periods (Figs. A.4 and A.5).

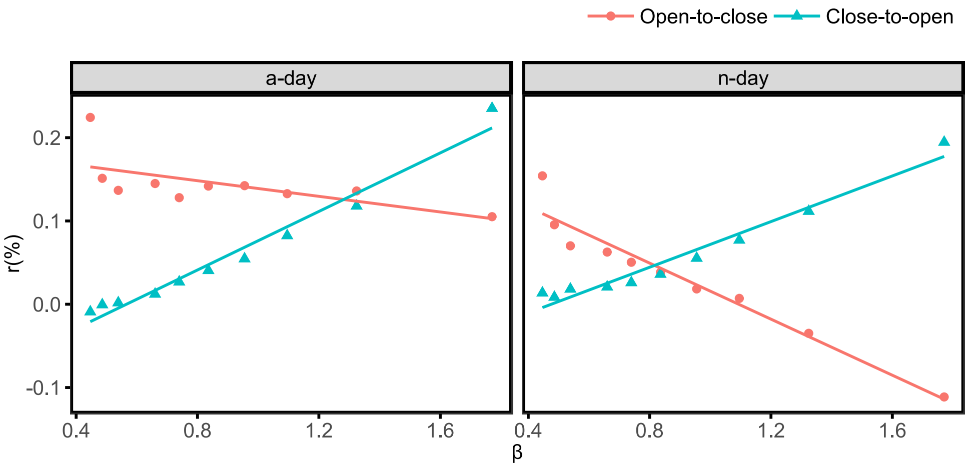

Fig. 7. US returns for beta-sorted portfolios on macroeconomic announcement days (1992–2016).
The left figure shows average (equal-weighted) returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks for announcement days or a-days (days on which inflation, employment, or Federal Open Market Committee interest rate decisions are scheduled to be announced). The right figure shows average (equal-weighted) returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks for nonannouncement 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 postranking 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 estimates. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

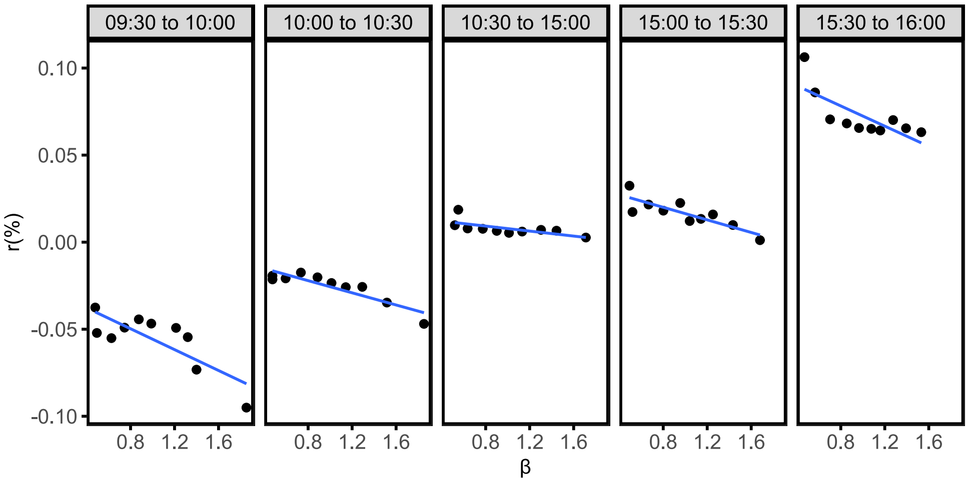

Fig. 8. US intraday returns for beta-sorted portfolios (1993–2016).
This figure shows average (equal-weighted) 30-min portfolio returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Returns are estimated from the first and last midquote within 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 postranking betas are estimated over the whole sample, separately for each 30-min interval. We estimate returns over every 30-min interval within the continuous trading session, with the first interval from 9:30 to 10:00 o'clock and the last interval from 15:30 to 16:00 o'clock. Separately for each interval, we fit a line using ordinary least square estimates. 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 TAQ.

high-beta portfolios earn negative day returns on nonannouncement 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 a risk-free rate is violated, the SML 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 toward risky high-beta assets. As a result, high-beta assets require lower risk premium than low-beta assets. 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

$$\mathrm{E}_t[r_{i,t+1}] - r_f = \psi_t + \beta_{i,t}(\mathrm{E}_t[r_{M,t+1}] - r_f - \psi_t), \tag{6}$$

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 a 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 SML 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.

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. On the other hand, during months with high initial margin requirement, the empirical SML has a negative slope. Because margin requirements have not been changed since September 1975, the natural experiment from Jylha (2018) cannot be directly used in our sample period. Comparing our findings to Jylha (2018) suggests that the investors could be more capital constrained during the day than they are during the night.

Fig. 1 shows that the average day returns monotonically decline with beta and are positive for all but two highest beta portfolios. The graph also shows that the average night returns monotonically increase with beta and are positive for all beta-sorted portfolios. These results are consistent with the prices for low-beta portfolios being low at the open or high at the close, while the opposite is true for the high-beta portfolios. While direct evidence is not available, such price behavior could arise from beta-conditional speculation where the marginal day investor is a risk-loving speculator who measures assets' risk using its market beta. This speculator buys higher beta stocks at the open and reverses her position approaching the close. In contrast, the long-term investor is the marginal night investor.

4.2. Intraday security market line

To examine whether such beta-conditional speculation could be occurring, Fig. 8 plots average equal-weighted 30-min day returns against market beta for ten beta-sorted portfolios of all US publicly listed common stocks. Returns are estimated over every 30-min interval within the continuous trading session from the first and last midquote within each interval, with the first interval from 9:30 to 10:00 o'clock and the last interval from 15:30 to 16:00 o'clock.[10] 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 postranking betas are estimated over the whole sample separately for each 30-min interval. Overall, Fig. 8 shows portfolio returns are monotonically increasing within the day, starting negative at the open and becoming positive at the close.[11]

The relation between day returns and market beta is negative for all but the midday intervals. It is weakly negative for the midday interval, constructed by aggregating 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 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-min intervals, with the highest values reached from 15:30 to 16:00.

The pattern of intraday returns depicted in Fig. 8 is consistent with beta-conditional speculation. 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 Fig. 8 consistent with Fig. 1, which shows that night returns are positive across all beta-sorted portfolios. As a result, prices at the open are above their long-run value, with the magnitude of the overshooting increasing with the market beta. At this point, statistical arbitrageurs start selling to push prices back to their long-run values, with the selling 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. Very little appears to happen between 10:30 and 15:00 o'clock. Approaching the close, statistical arbitrageurs start buying to cover the their short position from the morning. This raises market-wide returns. Approaching the close, the beta-loving speculators sell their higher beta stocks, which keeps those stocks from increasing as much as the rest of the market. While the above intuition is plausible, formal theoretical modeling (e.g., as in Hong and Sraer, 2016) is needed. In addition, direct empirical evidence identifying the beta-conditional speculator would be valuable.

The negative market risk premium during the day implies that day investors select the market portfolio on the inefficient part of the minimum variance frontier. Alternatively, the day average market return is too low, and/or the risk-free rate is too high. Indeed, the intercept of the day SML, which is the implied risk-free rate, is positive and larger than any one of beta portfolio returns. Correspondingly, night investors select the market portfolio on the efficient part of the minimum variance frontier. In this case, the puzzle boils down to the fact that the night risk-free rate is too low, and as Fig. 1 shows, the intercept of the night SML is negative. However, further explanation and study is needed for why and how investors switch between the efficient and inefficient frontiers and why the risk-free rate changes between the day and night.

[10] 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.

[11] These patterns are not consistent with long-standing literature on intraday return patterns (e.g., Wood et al., 1985; Harris, 1986; 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 recent work by Heston et al. (2010), who find significant continuation of returns at intervals that are multiples of a day, and this effect lasts for over 20 trading days.

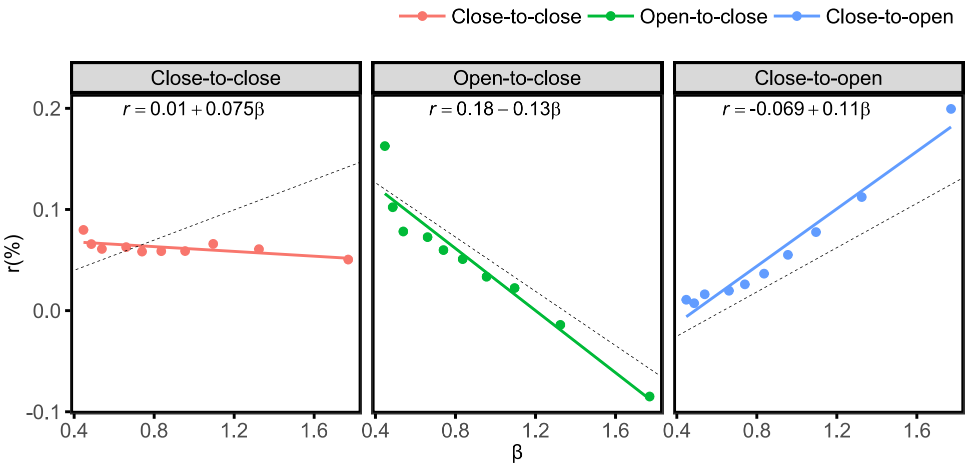

Fig. 9. US 24-h, day, and night returns for beta-sorted portfolios (1993–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. The solid line depicts the empirical security market line fit using ordinary least square estimates. The dashed line gives the theoretical security market line predicted by the CAPM and are reported at the top of each figure. 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 postranking betas are estimated over the whole sample. Each day, returns are measured over 24 h, from close-to-close (red), during the day, from open-to-close (green), and during the night, from close-to-open (blue). Data are from CRSP. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

4.3. Variation in the risk-free rate

The prior results indicate that the failure of the 24-h CAPM could potentially be attributed to the level of the risk-free rate switching from high during the day to low at night. We first illustrate how day/night variation in the implied risk-free rate from the empirical SML compares to CAPM-predicted SML. Fig. 9 graphs the empirical and CAPM-predicted SMLs for three time intervals: 24 h, day, and night. For close-to-close, the CAPM-predicted SML in Fig. 9 is done in the traditional way, as in Jylha (2018), using the empirical market return and the risk-free rate from Ken French's website (three-month T-bill rate). This 24-h empirical SML differs significantly from that predicted by the CAPM: the empirical SML is slightly downward-sloping. This is because the intercept of the 24-h empirical SML is significantly more positive than the traditional proxy for the risk-free rate.

If the risk-free rate is assumed to be similar during the day and night, then the slope of the CAPM-predicted SML for open-to-close and close-to-open will be similar to, although somewhat flatter, the close-to-close. Therefore, to explore whether variation in the risk-free rate during the day and night could help explain deviations from the theoretical SML, in Fig. 9 we use the empirical market return along with the risk-free rate implied by the empirical SML to construct day and night CAPM-predicted SMLs. In Fig. 9 both day and night CAPM-predicted SMLs closely match their empirical counterparts.

To examine whether the risk-free rate variation implied by intercepts of the day and night empirical SML is plausible, we analyze the returns on US Treasury futures. Chicago Board of Trade (CBOT) Treasury futures are standardized contracts for selling and buying US Treasuries for future delivery or settlement. They come in four tenors or maturities: 2, 5, 10, and 30 years.[12] Treasury futures offer several features beneficial to our objective. They are standardized, highly liquid, and transparent instruments. In addition, futures are a neutral security, which can be easily traded from the long or short sides. Finally, Treasury futures trade virtually around the clock, Sunday through Friday (Central Time).

One potential downside of using Treasury futures is that their returns are not directly equal to the risk-free rate level. Using a standard arbitrage argument and ignoring accrued interest, a time t price of a futures contract expiring at T_F on a US Treasury with a tenor T, $F(t, T_F; T)$, can be written as

$$F(t, T_F; T) = S(t; T)e^{(r(t)-c)(T_F-t)}, \tag{7}$$

where $S(t; T)$ is the spot price of the T-bond, c is the continuously compounded rate of discounted coupon payments on the underlying bond, and $r(t)$ is the repo rate. Using that $S(t+\Delta t; T) = S(t; T)e^{y_T(t)\Delta t}$, where $y_T(t)$ is the T-bonds's yield to maturity, the log-return on the Treasury futures over the interval $[t, t+\Delta t]$ can be approximated as

$$\log\left(\frac{F(t+\Delta t, T_F; T)}{F(t, T_F; T)}\right) \approx (y_T(t) - r(t) + c)\Delta t, \tag{8}$$

where $(r(t) - c)\Delta t$ is referred to as the carry or basis. Because c does not change at high frequency, Eq. (8) shows

[12] Additionally, CME Group offers ultra ten-year note and ultra T-bond futures. Each contract type is written on a basket of US Treasury notes and bonds with a range of maturities and coupon rates. For instance, the 30-year Treasury bond futures contract is written on a basket of bonds with maturities ranging from 15 to 25 years. Detailed notes on bond futures contracts are made available by the CME at https://www.cmegroup.com/trading/interest-rates/basics-of-us-treasury-futures.html.

Table 12
Day and night US Treasury futures returns (1996–2013).
This table reports the average daily day and night returns for the front month and second front month US Treasury futures contracts on five-year and ten-year T-bonds. Returns are winsorized at 1% and 99% levels. Statistical significance at the 1%, 5%, and 10% level is indicated by ‡, †, and *, respectively. Data are from TRTH.

		Day	Night	Day-Night
5 Years	Front month	0.010%‡	−0.006%*	0.016%‡
		(3.59)	(−1.67)	(3.46)
	2nd Front month	0.010%†	−0.011%*	0.022%‡
		(2.32)	(−1.83)	(2.69)
10 Years	Front month	0.009%†	−0.001%	0.010%*
		(2.25)	(−0.27)	(1.65)
	2nd Front month	0.013%‡	−0.007%	0.020%†
		(2.73)	(−1.16)	(2.57)

that over short horizons, variation in Treasury futures returns are essentially equal to variation in the spread between the long-term T-bond rate, $y_T(t)$, and a short-term repo rate, $r(t)$.

We get data on US Treasury futures from Thomson Reuters Tick History (TRTH) that consists of intraday five-minute prices from 1996 to 2013 for all existing tenors. Following Moskowitz et al. (2012), we calculate returns for the most liquid futures contracts: the front month and second front month five- and ten-year US Treasury bond futures; day and night returns for other maturities and returns for government securities for other countries are available in Table A.2 in the Appendix). We calculate returns from midquotes. Using midquotes avoids the bid-ask bounce in trade price returns and ensures that returns are computed over the same time interval despite potential differences in trading frequency. Prices on futures are based on a 6% yield-to-maturity bond and upon delivery are converted using a conversion factor specific to the details of the bond delivered. Returns are constructed as in Eq. (8) and are winsorized at 1% and 99% levels. We use the same designated day and night time intervals as in the case of the stock market when calculating day and night futures returns.

Table 12 reports our results. Consistent with the differing implied risk-free rates for day and night in Fig. 1, the difference between the day and night returns is both statistically and economically significant. This difference can be due to either the basis or to the yield to maturity changing between day and night or both. Average day futures returns are positive and statistically significant for both five- and ten-year T-bond futures, while night returns are negative but are statistically indistinguishable to zero.

Overall, these results provide independent evidence in support of the hypothesis that day and night risk free-rates are different. However, the variation in the day and night returns T-bond futures is smaller than the variation in the risk-free rate variation implied by intercepts of the day and night empirical SML.

5. 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 CAPM during night and day. We show 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). Returns are positively related to beta overnight when the market is closed. This is true overnight for beta-sorted portfolios for US stocks and international stocks. In addition, returns are positively related to beta for 10 industry and 25 book-to-market portfolios. For betas decomposed into the cash flow news betas and discount rate news betas, overnight returns are positively related to beta for both cash flow and discount rate betas. Finally, overnight returns are positively related to beta for individual US stocks and international stocks.

As with the SML having a negative slope in borrowing constrained months in Jylha (2018), the downward-sloping SML during the trading day likely requires a model with heterogeneous agents and time-varying constraints. In such a model, the marginal investor systematically switching between the day and night periods could generate negative risk premia, possibly even without borrowing constraints. This raises the question of whether heterogeneous agent models are required to understand the empirical failure of the CAPM.

On the empirical side, our results suggest further study of the appropriate risk-free rate may be important. For example, what is the correct proxy for the 24-h risk-free rate? How important is variation in the risk-free rate to investors and asset pricing models? Even intraday variation?

Appendix A

A.1. Additional robustness

Fig. 8 shows average equal-weighted 30-min day returns against market beta for ten equal-weighted beta-sorted portfolios of all US publicly listed common stocks. However, it lumps returns together into a single interval from 10:30 to 15:30. In Fig. A.1 we plot all 13 30-min intervals separately. The SML is flat between 11:00 and 14:00, and it is downward-sloping in all other time periods.

Fig. 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

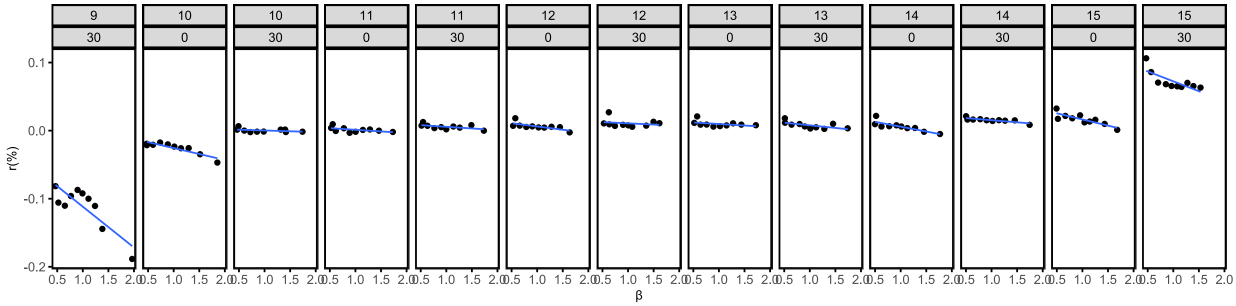

Fig. A.1. US intraday returns for beta-sorted portfolios (1993–2016).
This figure shows average (equal-weighted) 30-min portfolio returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Returns are estimated from the first and last midquote within 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 postranking betas are estimated over the whole sample, separately for each 30-min interval. We estimate returns over every 30-min interval within the continuous trading session, with the first interval from 9:30 to 10:00 o'clock and the last interval from 15:30 to 16:00 o'clock. Separately for each interval, we fit a line using ordinary least square estimates. Data are from CRSP..

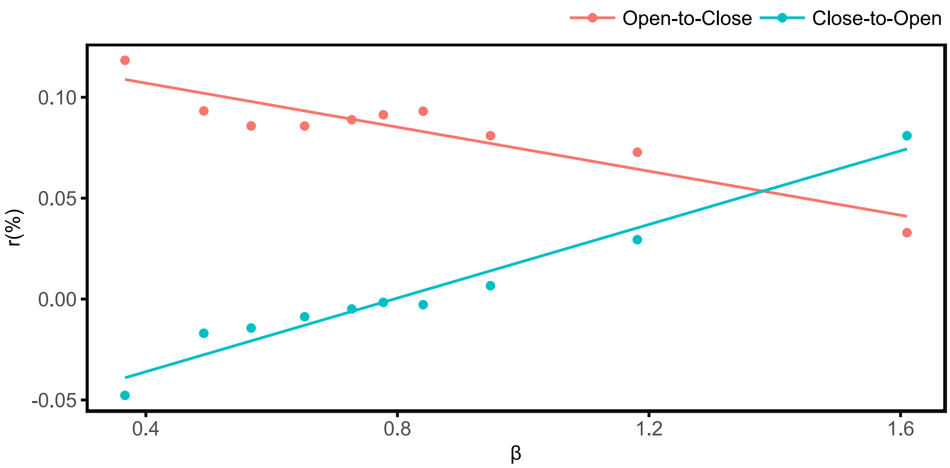

Fig. A.2. US day and night returns for beta-sorted portfolios (excluding low-priced stocks) (1992–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks priced above US$ 5. Portfolios are formed every month, with stocks sorted according to beta, estimated using daily night returns over a one-year rolling window. Portfolio returns are averaged, and postranking 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 estimates. Data are from CRSP. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

partially due to low-priced stocks (price less than US$5) with low betas. Fig. A.2 demonstrates for the US 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. Fig. A.3 demonstrates the same result for international stocks.

Figs. A.4 and A.5 plot average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios around earnings announcements for all domestic and international (39 countries) publicly listed common stocks, respectively. The pre-announcement window is defined as two weeks prior the earnings announcement, and the postannouncement window is defined as two weeks after the earnings announcement. For both figures, leftmost plots show average returns outside the earnings announcement window, while middle and rightmost plots show average returns during the pre- and postannouncement windows, respectively.

Figs. 1 and 2 are constructed using nonoverlapping betas and average returns, as stocks are sorted into beta portfolios outside the estimation window for their betas. We replicate Figs. 1 and 2 using overlapping betas and average returns. Specifically, every month m, we form beta-sorted portfolios using stocks sorted according to beta estimated from daily night returns over a one-year rolling window from month $m-11$ to month m. Figs. A.6 and A.7 report our results for domestic and international stocks, respectively.

Throughout the paper, we use data from various sources with various sample periods, depending on our available access. To ensure that our results are not driven by the various sample periods, we redo our main anal-

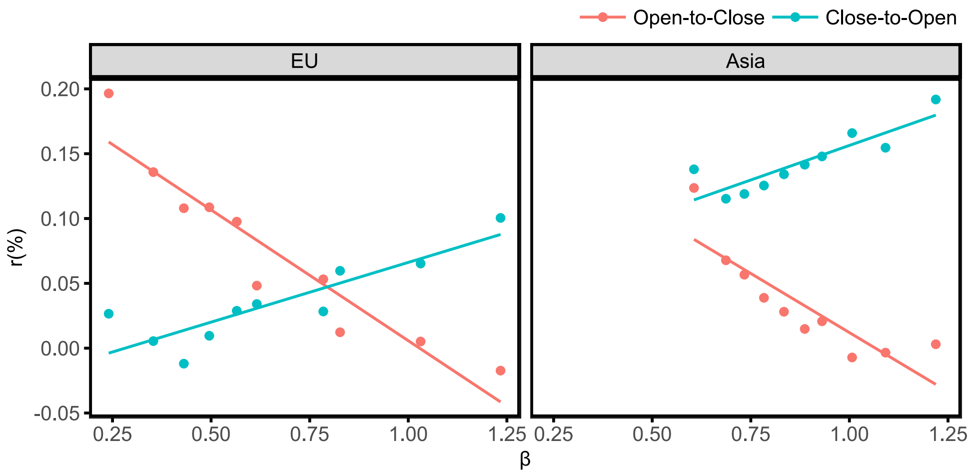

Fig. A.3. International day and night returns for beta-sorted portfolios (excluding low-priced stocks) (1990–2014).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all publicly listed common stocks (excluding low-priced stocks) from the 39 (non-US) 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 postranking 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 the EU: France, Germany, Greece, Israel, Italy, Netherlands, Norway, Poland, South Africa, Spain, Sweden, Switzerland, and the United Kingdom. The second region is Asia: Australia, China, Hong Kong, India, Indonesia, Japan, Korea, New Zealand, Philippines, Singapore, and Thailand. Each day, returns are measured 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 estimates. Data are from Datastream. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

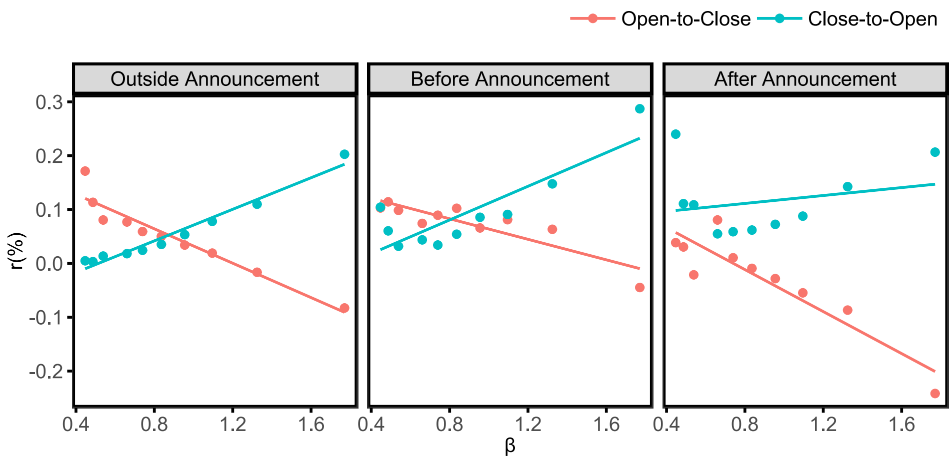

Fig. A.4. US returns for beta-sorted portfolios outside and around earnings announcement periods (1992–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. The left figure shows average returns over all days up to two weeks before and two weeks after earnings announcements. The middle and right figure shows average returns during the period of two weeks before and two weeks after earnings announcements, respectively. 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 postranking betas are estimated over the whole sample. Each day, returns are measured 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 estimates. Data are from CRSP. Quarterly earnings announcement dates are from IBES. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

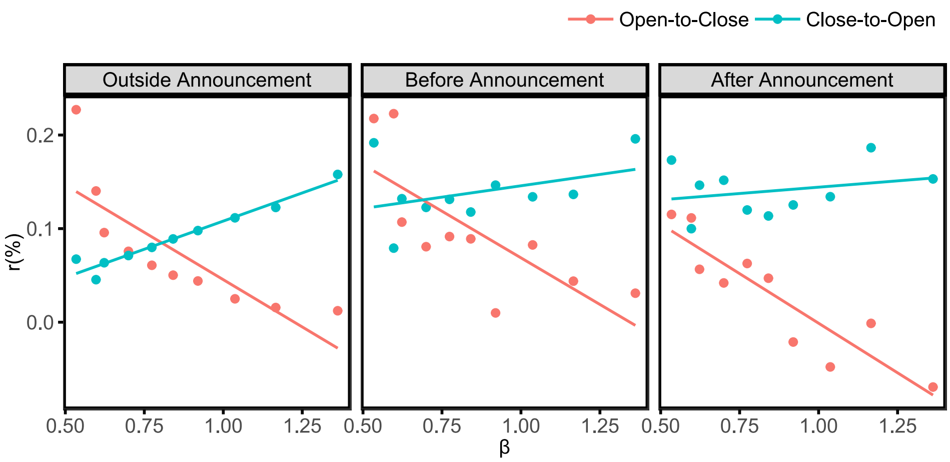

Fig. A.5. International returns for beta-sorted portfolios outside and around earnings announcement periods (1990–2014).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all publicly listed common stocks from the 39 (non-US) countries in our sample. The left figure shows average returns over all days up to two weeks before and two weeks after earnings announcements. The middle and right figure shows average returns during the period two weeks before and two weeks after earnings announcements, respectively. 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 postranking 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 sample. Each day, returns are measured 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 estimates. Data are from Datastream. Annual earnings announcement dates are from IBES. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

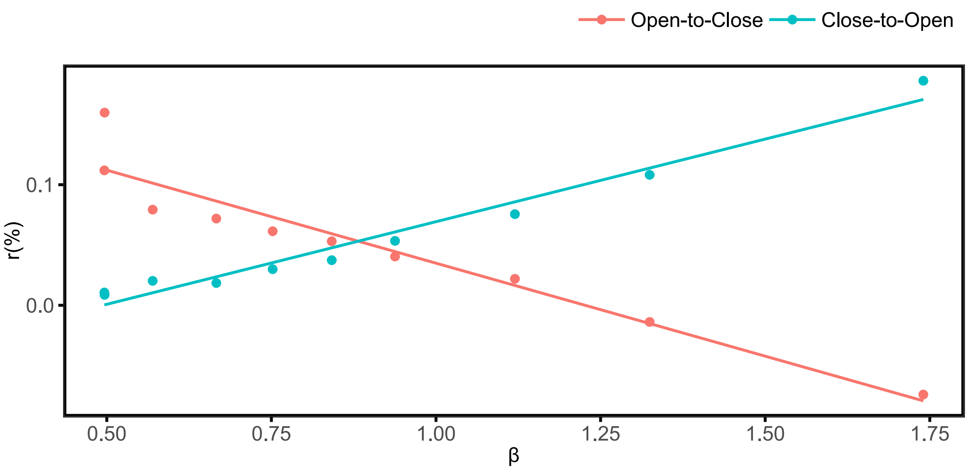

Fig. A.6. US day and night returns for beta-sorted portfolios (using returns in last month of beta estimation window) (1992–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Portfolios are formed every month m, with stocks sorted according to beta, estimated using daily night returns over a one-year rolling window from month $m-11$ to month m. Portfolio returns are averaged, and postranking 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 estimates. Data are from CRSP. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

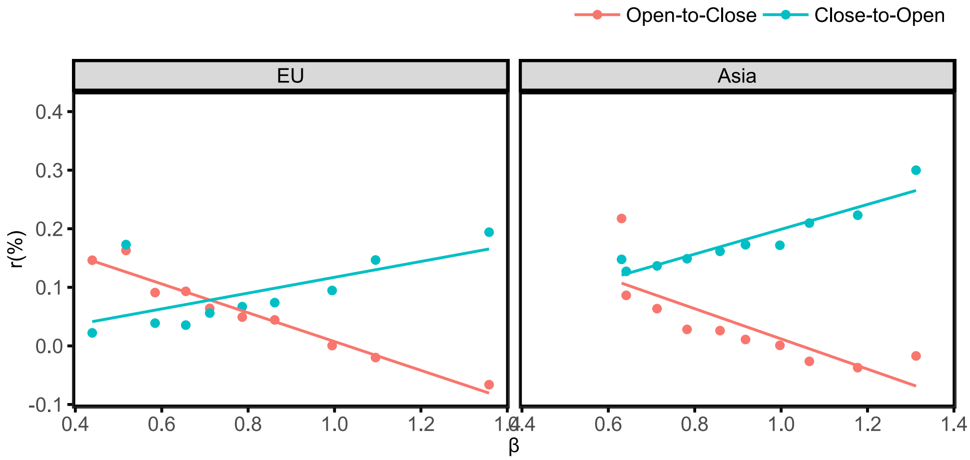

Fig. A.7. International day and night returns for beta-sorted portfolios (using returns in last month of beta estimation window) (1990–2014)
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all publicly listed common stocks from the 39 (non-US) countries in our sample. Portfolios are formed per country-month m, with stocks sorted according to beta, estimated using daily night returns over a one-year rolling window from month $m-11$ to month m. Portfolio returns are averaged, and postranking 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 the EU: France, Germany, Greece, Israel, Italy, Netherlands, Norway, Poland, South Africa, Spain, Sweden, Switzerland, and the United Kingdom. The second region is Asia: Australia, China, Hong Kong, India, Indonesia, Japan, 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 estimates. Data are from Datastream. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

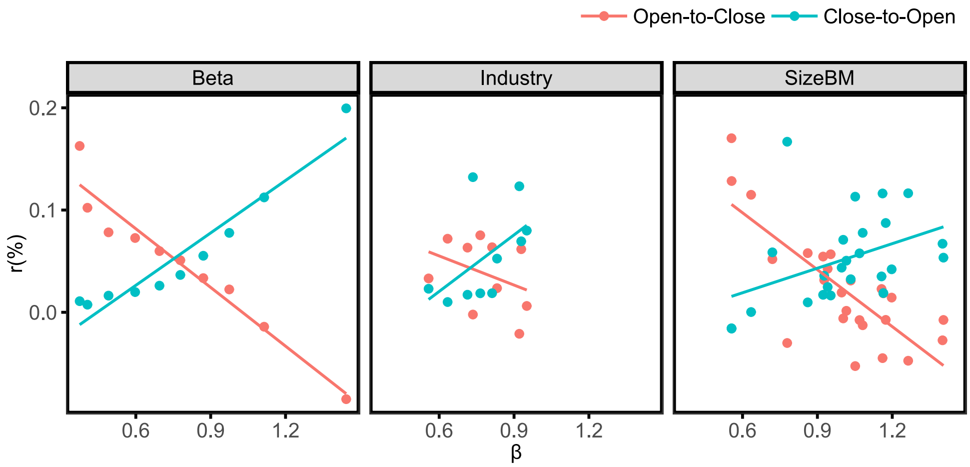

Fig. A.8. US day and night returns separately for 10 beta-sorted, 10 industry, and 25 Size/BM portfolios.
This figure shows average (equal-weighted) daily returns in percent against market betas for 10 beta-sorted, 10 industry, and 25 size/BM portfolios of all US publicly listed common stocks. Beta portfolios 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 postranking 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 estimates. Data are from CRSP and Compustat. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

ysis using only years for which we have access to all data sources (i.e., 1996 to 2013). We report the results in Table A.1. In Table A.2 we report day and night returns on Treasury futures for other maturities (Panel A) and ten-year Treasury futures from the next four biggest economies based on GDP as of 2016 (Panel B).

Table A.1
US and international day and night returns (1996–2013).

This table reports results from the Fama-MacBeth and fixed effect panel regressions of daily returns (in percent) 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. Panels A and C reports results from market-capitalization-weighted portfolios. Panels B and D reports results from equal-weighted portfolios. t-statistics are reported in parentheses. Standard errors are based on Newey-West corrections, allowing for ten 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 Datastream.

Returns over	Fama-MacBeth regressions			Panel regressions			
	Intercept	Beta	Avg. R^2	Beta	Day	Day × Beta	R^2 [%]
Panel A: US Value-Weighted							
Night	−0.007	0.068‡	43.51	0.069‡	0.171‡	−0.159‡	35.08
	(−1.26)	(7.16)		(5.25)	(9.32)	(−5.98)	
Day	0.151‡	−0.078‡	40.20				
	(13.21)	(−4.71)					
Panel B: US Equally-Weighted							
Night	−0.065‡	0.152‡	42.42	0.154‡	0.261‡	−0.324‡	42.22
	(−9.10)	(14.46)		(15.50)	(18.75)	(−15.95)	
Day	0.187‡	−0.160‡	48.28				
	(18.44)	(−8.84)					
Panel C: International Value-Weighted							
Night	Yes	0.082‡	31.23	0.064‡	0.112‡	−0.176‡	20.43
		(9.44)		(6.15)	(11.01)	(−12.68)	
Day	Yes	−0.127‡	34.27				
		(−12.65)					
Panel D: International Equally-Weighted							
Night	Yes	0.108‡	32.71	0.085‡	0.116‡	−0.215‡	22.74
		(13.33)		(11.23)	(12.87)	(−15.42)	
Day	Yes	−0.146‡	38.28				
		(−15.19)					

Table A.2
Day and night futures returns (1996–2013).

This table reports the average daily day and night returns for the front-month and second front-month futures contracts on a number maturities and countries. Returns are winsorized at 1 and 99% levels. Statistical significance at the 1%, 5%, and 10% level is indicated by ‡, †, and *, respectively. Data are from TRTH.

		Day	Night	Day-Night
Panel A: Additional maturities				
2 Years	Front-Month	0.001%	0.000%	0.001%
		(0.75)	(0.20)	(0.33)
	2nd Front-Month	0.003%	−0.002%	0.005%
		(1.48)	(−0.58)	(1.08)
Long	Front-Month	0.012%†	−0.003%	0.015%
		(2.01)	(−0.35)	(1.61)
	2nd Front-Month	0.001%	0.007%	−0.006%
		(0.18)	(0.91)	(−0.60)
Ultralong	Front-Month	0.033%	−0.011%	0.045%
		(1.48)	(−0.49)	(1.38)
	2nd Front-Month	0.175%‡	−0.133%†	0.309%‡
		(3.46)	(−2.46)	(3.37)
Panel B: Additional countries				
UK	Front-Month	0.020%‡	−0.013%‡	0.032%‡
		(3.94)	(−4.14)	(5.29)
	2nd Front-Month	0.013%†	−0.004%	0.018%†
		(2.43)	(−1.07)	(2.54)
Germany	Front-Month	0.009%*	−0.003%	0.012%†
		(1.85)	(−0.91)	(2.01)
	2nd Front-Month	0.009%*	−0.002%	0.012%†
		(1.90)	(−0.82)	(2.00)
China	Front-Month	0.010%‡	0.002%	0.009%
		(2.62)	(0.41)	(1.38)
	2nd Front-Month	0.013%†	0.001%	0.011%
		(2.09)	(0.15)	(0.96)
Japan	Front-Month	0.009%‡	−0.003%	0.012%‡
		(3.31)	(−1.37)	(3.35)
	2nd Front-Month	0.012%‡	−0.005%	0.017%‡
		(3.57)	(−1.30)	(3.09)

References

Amihud, Y., Hameed, A., Kang, W., Zhang, H., 2015. The illiquidity premium: international evidence. J. Financ. Econ. 117, 350–368.

Andrei, D., Cujean, J., Wilson, M., 2018. The Lost Capital Asset Pricing Model.. Unpublished working paper. McGill University.

Berkman, H., Koch, P.D., Tuttle, L., Zhang, Y.J., 2012. Paying attention: overnight returns and the hidden cost of buying at the open. J. Financ. Quant. Anal. 47 (4), 715–741. doi:10.1017/S0022109012000270.

Black, F., 1972. Capital market equilibrium with restricted borrowing. J. Bus. 45 (3), 444–455.

Black, F., 1992. Beta and return. J. Portfolio Manag. 20, 8–18.

Black, F., Jensen, M., Scholes, M., 1972. The Capital Asset Pricing Model: Some Empirical Tests. Praeger Publishers Inc., New York, NY.

Bogousslavsky, V., 2019. The Cross-section of Intraday and Overnight Returns.. Unpublished working paper. Boston College.

Branch, B., Ma, A., 2008. The Overnight Return, one More Anomaly.. Unpublished working paper. University of Massachusetts.

Branch, B., Ma, A., 2012. Overnight return, the invisible hand behind intraday returns. J. Financ. Markets 2, 90–100.

Campbell, J.Y., Vuolteenaho, T., 2004. Bad beta, good beta. Am. Econ. Rev. 94 (5), 1249–1275.

Cliff, M., Cooper, M., Gulen, H., 2008. Return Differences Between Trading and Non-trading Hours: Like Night and Day.. Unpublished working paper. Virginia Tech.

Cohen, R.B., Polk, C., Vuolteenaho, T., 2005. Money illusion in the stock market: the Modigliani-Cohn hypothesis. Q. J. Econ. 120 (2), 639–668.

Davis, J.A., Fama, E.F., French, K.R., 2000. Characteristics, covariances, and average returns: 1929–1997. J. Financ. 55, 389–406.

Fama, E.F., French, K.R., 1992. The cross-section of expected stock returns. J. Financ. 47, 427–465.

Fama, E.F., French, K.R., 1996. Multifactor explanations of asset pricing anomalies. J. Financ. 51, 55–84.

Fama, E.F., French, K.R., 2004. The capital asset pricing model: theory and evidence. J. Econ. Perspect. 18, 25–46.

Frazzini, A., Pedersen, L.H., 2014. Betting against beta. J. Financ. Econ. 111 (1), 1–25. doi:10.1016/j.jfineco.2013.10.005.

Harris, L., 1986. A transaction data study of weekly and intradaily patterns in stock returns. J. Financ. Econ. 16, 99–117.

Heston, S.L., Korajczyk, R.A., Sadka, R., 2010. Intraday patterns in the cross-section of stock returns. J. Financ. 65, 1369–1407.

Hong, H., Sraer, D.A., 2016. Speculative betas. J. Financ. 71 (5), 2095–2144. doi:10.1111/jofi.12431.

Hou, K., van Dijk, M., 2019. Resurrecting the size effect: firm size, profitability shocks, and expected stock returns. Rev. Financ. Stud. 32, 2850–2889.

Jain, P.C., Joh, G.-H., 1988. The dependence between hourly prices and trading volume. J. Financ. Quant. Anal. 23, 269–283.

Jylha, P., 2018. Margin constraints and the security market line. J. Financ. 73, 1281–1321.

Kelly, M., Clark, S., 2011. Returns in trading versus non-trading hours: the difference is day and night. J. Asset Manag. 12, 132–145.

Lou, D., Polk, C., Skouras, S., 2019. A tug of war: overnight versus intraday expected returns. J. Financ. Econ. 134, 192–213.

Moskowitz, T.J., Ooi, Y.H., Pedersen, L.H., 2012. Time series momentum. J. Financ. Econ. 104, 228–250.

Patton, A.J., Timmermann, A., 2010. Monotonicity in asset returns: new tests with applications to the term structure, the CAPM, and portfolio sorts. J. Financ. Econ. 98, 605–625.

Roll, R., 1977. A critique of the asset pricing theory's tests, part I: on past and potential testability of the theory. J. Financ. Econ. 4, 128–176.

Savor, P., Wilson, M., 2014. Asset pricing: a tale of two days. J. Financ. Econ. 113, 171–201.

Tao, C., Qiu, M., 2008. The International Evidence of the Overnight Return Anomaly.. Unpublished working paper. Massey University.

Tinic, S.M., West, R.R., 1984. Risk and return: January vs. the rest of the year. J. Financ. Econ. 13, 561–574. doi:10.1016/0304-405X(84)90016-3.

Wood, R.A., McInish, T.H., Ord, K.J., 1985. An investigation of transactions data for NYSE stocks. J. Financ. 40, 723–739.