SUMMARY

Asset Pricing: A Tale of night and day

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Abstract

This paper studies how stock prices are related to beta when markets are open for trading and closed. We show that beta being weakly associated with returns is driven entirely by returns during the trading day. Systematic market risk being priced is at the core of

modern asset pricing. In the capital asset pricing model (CAPM), the market risk exposure is captured by its market beta. The night-minus-day stock market risk premium is even higher for equal-weighted portfolios.

Highlights

- Systematic market risk being priced is at the core of modern asset pricing
- Authors results show that the capital asset pricing model (CAPM) holds from close-to open in the sense that asset risk premia are increasing with asset market beta
- This paper studies how stock prices are related to beta when markets are open for trading and when they are closed
- Authors show that beta being weakly associated with returns is driven entirely by returns during the trading day
- 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
- Overnight returns are positively associated with the beta for individual US stocks and international stocks

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 is captured by its market beta. Individual assets' risk premia are their beta times the market risk premium. 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. To explain the conventional weak relation between returns and beta, studies have found that the risk-return relationship is positive only during specific times. The authors show that the relationship between beta and returns depends on whether markets are open for trading or closed. They extend testing time variation in the CAPM on specific days or months by examining the CAPM's validity during different periods within each day. When the stock market is closed, beta is positively related to the cross-section of returns.

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, ten industry and 25 book-to-market portfolios, both cash flow news betas and discount rate news betas, individual US stocks and global stocks, and various lengths of market closures.

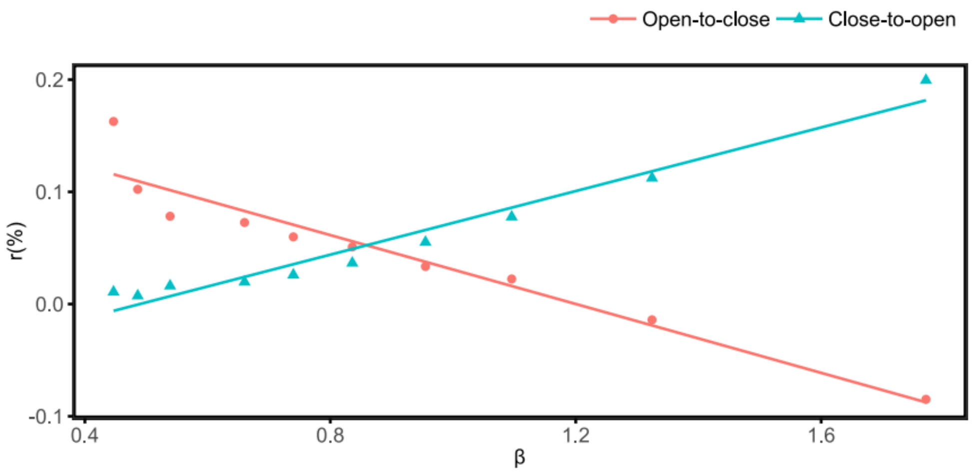

Fig. 1. US day and night returns for beta-sorted portfolios (1992–2016)
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Portfolios are formed every month, with stocks sorted according to beta,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

Combining the day and night returns into close-to-close returns yields an empirical SML flat or slightly downward-sloping.

Motivated by these findings, Authors explore two **"betting against and on beta"** long-short trading strategies. While the 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 equals 0.79%. These numbers turn into an average return of 25.2% with a **Sharpe Ratio of 2.03**. The portfolio-based strategy generates an average daily return of 0.44%, with the standard deviation equals 1.80% and the Sharpe ratio equal to 0.24. These numbers turn into an average return of 108.4% with a **Sharpe ratio equal to 3.78.**

Authors results suggest that when investors cannot trade, beta is an essential measure of systematic risk. The stock market is open for trading is contrary to the conventional risk-return relationship—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. **These results indicate that the failure of the 24-h CAPM is related to the slope and intercept differing between night and day.**

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. 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 a 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.

Jhyla(2018) shows that borrowing constraints don't produce negative risk premia, so they are not a satisfactory explanation.

However, Patton and Timmermann (2010) emphasize that reporting the return spread between the extreme portfolios does not adequately examine or test if returns monotonically vary with risk, which is the fundamental prediction of most asset pricing models.

Data and Methodology

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.

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

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

with $R_t^{open\text{-}to\text{-}close} = R_t^D = (Close_t - Open_t)/Open_t$ 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, Authors construct the close-to-close return using the corporate-action-adjusted price index, field RI, provided in Datastream.

To calculate tUS companies size and book-to-market ratio, Authors 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. The authors use the redemption, liquidation, or par value to estimate preferred stock. Size for international companies is measured in USD and the book-to-market ratio is calculated.

Datastream data are filtered as in Amihud et al. (2015), who study the illiquidity premia across 45 different countries. In particular, Authors 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 (Ri,t) is below 200%. In addition, if the return on day t or day t − 1 is above 100%, Authors only keep the stock day if the return measured over two days is at least 50%(i.e., if (1 + Ri,t) × (1 + Ri,t−1) − 1 > 50%. Since the focus of Authors paper is on the night returns, in addition to the above filters, Authors only include stock days for which Authors have a positive open price. Finally, Authors exclude stock days for which the absolute value of either the day or the night return is above 200%. Authors construct pre-ranked monthly betas for every stock i in month m, $\beta_{i,m}^p$, using daily night returns by regressing them against the market night returns, R_M^N, over 12 months rolling window with no less than 30 daily returns:

$$R_{i,m,t}^N = \alpha_{i,m}^N + \beta_{i,m}^p . R_{M,m,t}^N + \varepsilon_{i,m,t}^N \qquad \text{...(2)}$$

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.

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

$$R_{i,t+1}^{N/D} = \xi_0^{N/D} + \xi_1^{N/D} \beta_{i,t}^p + \varepsilon_{i,t}^{N/D} \qquad \text{.. (3)}$$

where $ß_{i,t}^{p}$ is the asset i market beta for period t estimated in Eq. (2) and $R_{i,t+1}^{N/D}$ is the asset i night/day return. In addition to Fama-MacBeth regressions run separately for night and day returns, Authors also estimate a panel regression:

$$R_{i,t+1} = \xi_0 + f_{t+1} + \xi ß_{i,t}^{p} + \xi_2 D_{t+1} + \xi_3 ß_{i,t}^{p} D_{t+1} + \varepsilon_{i,t+1} \qquad \text{.......................................(4)}$$

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

Results

3.1) Beta Portfolio

Here authors investigate the day and night SML. They 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. The day points show a negative relationship between average returns and beta, while the relation between average night returns and beta is strongly positive. 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.

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)					

Panel A, shows Authors results for value-weighted portfolios. The results of day returns are very different from the night returns which is very evident from the table.

Panel B, shows that the results are similar for equal-weighted portfolios. The slope is significantly negative for day returns and is significantly positive for night returns. Intercepts have the same signs, as in value-weighted portfolios, and both are statistically significant. The night-minus-day stock market risk premium is even higher for equal-weighted portfolios.

Using the Pooling method it is estimated that, The difference between the day and night SML slopes is captured by the regression coefficient on Day × β. Panel A and Panel B both shows almost similar results, even in the case of the Pooling method. 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%.

Authors perform the same set of tests on international stocks in two categories Europe(EU) and Asia. Authors form pre-ranked portfolios for each country using the same methodology Authors use for the US stocks. All returns are calculated in local currency.

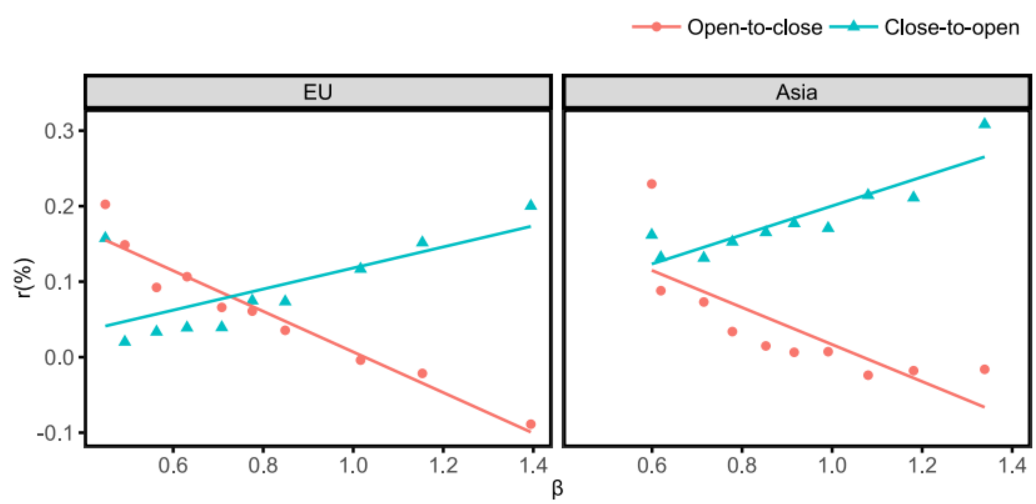

Fig. 2. International day and night returns for beta-sorted portfolios (1990–2014).
This figure shows average (equally weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all publicly listed common stocks from the 39 (non-US) countries in our sample. Portfolios are 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.)

The day SML is very similar across both regions. While these values are higher than the comparable ones for the US, the day CAPM is still very similar for the US and international stocks—low-beta portfolios earn the highest average returns, and high-beta portfolios earn the lowest average returns. Likemore extended. Westocks, the relation between average night returns and beta is strongly positive for both the EU and Asia regions.

Table 2 reports Authors regression results for both value and equal-weighted portfolios of international stocks. The 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.

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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)					

Results of **Panel A(value-weighted portfolios)** implies a strongly negative risk premium across international stocks. The value-weighted night returns for international stocks implies a positive risk premium.

Results of **Panel B(equal-weighted portfolios)** shows the slope is significantly negative for day returns and is significantly positive for night returns. The night minus-day risk premium is comparable to that for the US Stocks. These all findings are confirmed by the 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 × β.

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. High-beta stocks have earned the stock market "discount".

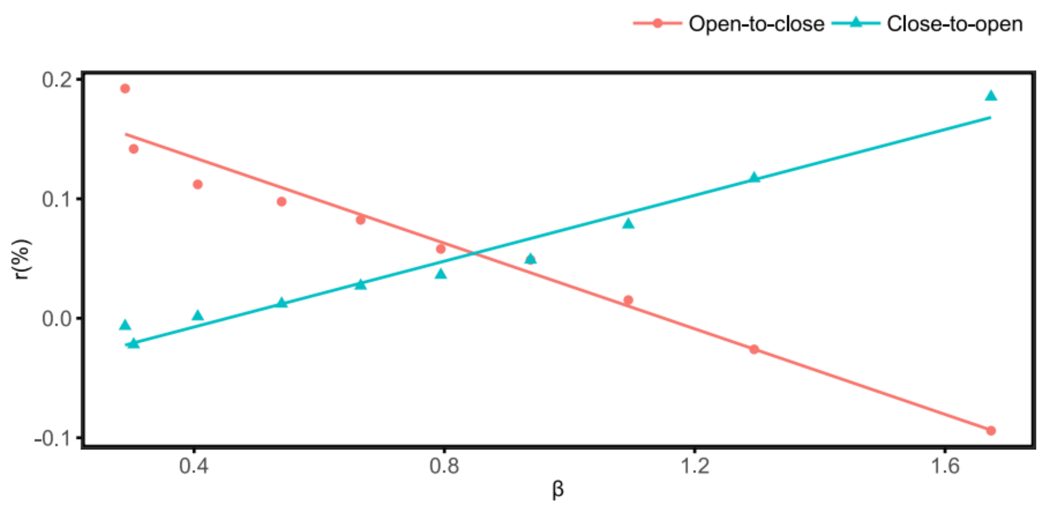

Fig. 3. US day and night returns for beta-sorted portfolios, estimated from close-to-close returns (1992–2016). This figure shows average (equally-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Portfolios are formed every 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.)

Fig. 4 plots average realized percent returns for each portfolio against average portfolio betas calculated using close-to-close returns separately for the 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.

Maybe the 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 results are reestimated separately for returns over one, two, three, and fAuthors nights.

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)					

Panel A reports both the Fama-MacBeth and panel regression results for the one-night returns. 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 Authorsre preceded by exactly 1 nontrading day—thus diminishing the power of the tests.

If Authors exclude the two-night returns, the night-implied stock market risk premium increases with the length of the market closure. This is consistent with the risk-averse investor demanding a higher premium for holding risky securities over longer nontrading periods and we find this using both the Fama-Macbeth and panel regressions. The stock market discount declines slightly when going from three- to fAuthors-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, driving its price further down, in anticipation of the longer market closure. This is consistent with the risk-averse investor demanding a higher premium for holding risky securities over longer nontrading periods.

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 Country dummies	Beta	Avg. R^2	Panel regressions 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)					

Table 4 extends Authors findings from Table 3 to international stocks. The beta portfolios construction procedure is the same as in Table 2.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. Using the Fama-MacBeth procedure, Authors 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.

Overall, Authors 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.

3.2) Industry, size and book-to-market portfolios

Here authors extend their analysis by adding 10 industry and 25 size and book-to-market sorted portfolios (25 Fama-French portfolios) to the 10 stock market betasorted portfolios they have used so far. 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.

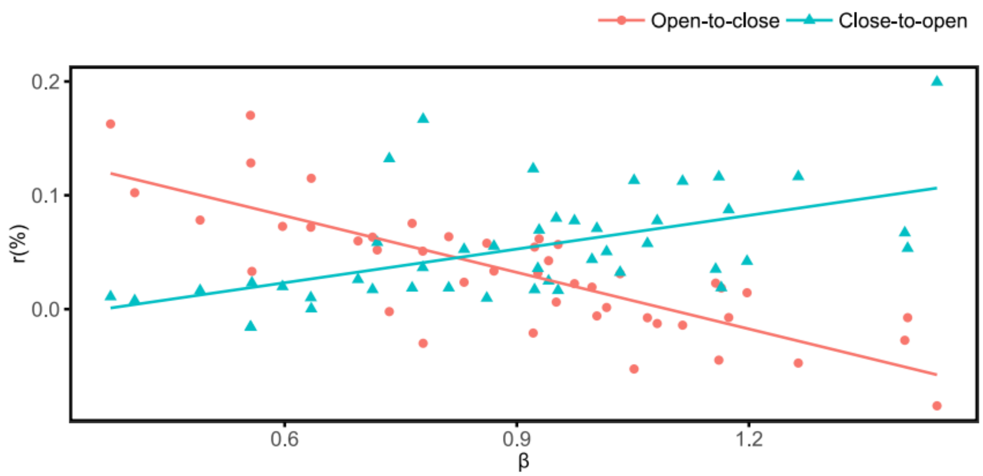

Fig. 5. US day and night returns for 10 beta-sorted, 10 industry, and 25 Size/BM portfolios (1992–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for 10 beta-sorted, 10 industry, and 25 size/BM portfolios of all US publicly listed common stocks. Beta portfolios 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.)

In agreement with their results for beta-sorted portfolios from Fig. 1, the day average returns show a strong negative relation with the stock market beta. 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.

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

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			Panel regressions			
	Intercept	Beta	Avg. R^2	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)					

These all findings in the table 5 are confirmed using pooling methodology to estimate the difference in the slope coefficients between night and day SMLs in a single panel regression Eq (4). Results are very similar for Panel A (value-weighted portfolios) and Panel B (equal-weighted portfolios) . Using Panel Regression we can see that conditional SML has a much higher slope than the value obtained by adding the day and night slopes from the Fama-MacBeth regressions. **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. 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. US day and night returns for portfolios sorted by cash flow and discount rate beta (1992–2016). Postranking betas are calculated over the whole sample as the co-variance of the cash flow or discount rate news with the weighted average monthly return of all stocks within each portfolio. Data are from CRSP.

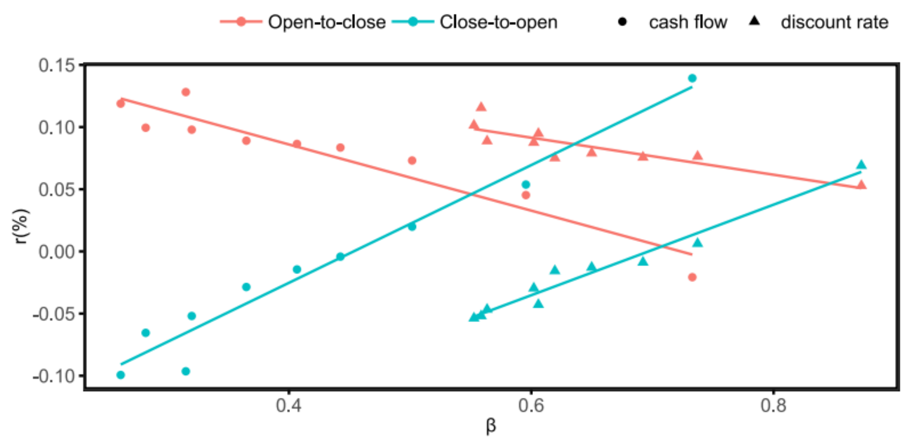

Fig. 6. US day and night returns for portfolios sorted by cash flow and discount rate beta (1992–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Following Campbell and Vuolteenaho (2004), 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.)

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. It also indicates 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. 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 founadtion for the main finding.

3.4) Double-sorted portfolios

Here authors compare the average realized day and night returns from double-sorted portfolios. For each month, Authors 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 (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. Authors use equal-weighted aggregation, but Authors results are robust to using value-weighted aggregation.

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)

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. 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. 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.

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)

In short 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. So, all 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

Here the ability of beta to explain the difference between day and night returns for individual stocks is evaluated.

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)	

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)	

It can be observed that, in agreement with the portfolio findings, stock returns are positively related to the market beta during nights. Also The results from pooled regression (4) are weaker than the Fama-MacBeth results.

In Panel B, they see that during the night, some of their 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, 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. Even in the Pooled Regression the coefficient on the book-to-market factor is weakly negative. Table 9 confirms Authors findings from Table 8 for international stocks.

3.6) Trading Strategy

The trading strategy is beta neutral since the individual portfolio weights sum up to zero. The authors 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 reverse the position at the open.

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

Table 10 reports the results. Authors use all US publicly listed common stocks to implement both trading strategies. Authors 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, Authors use plain, instead of excess, returns to estimate their Sharpe ratios.

Panel A showing the first trading strategy when annualised it turns into an average return of 25.2% and Sharpe Ratio ≈ 2. Panel B showing the portfolio based trading strategy when annualised it turns into an average return of 110.88% and Sharpe Ratio ≈ 3.87

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

$(r_L - r_f)/\beta_L - (r_H - r_f)/\beta_H$ ....(5)

where subscripts L and H stand for the low- and highbeta corner portfolios. The BaB strategy is implemented during the day and is then reversed during the night. We use post-ranked betas βL = 0.45 and βH = 1.77. The strategy performs much better than the other two strategies. When annualized, these numbers turn into an average return of 120.96% with a Sharpe ratio equal to 5.3.

Then Authors calculate the average return on the betting on beta trading strategy after controlling for the size and book-to-market risk factors. Each month, Authors 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, Authors calculate the difference between average returns on high- and lowbeta equal-weighted portfolios during both day and night.

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 tells that High-minus-low market beta trading strategy earns negative returns during opento-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.

Discussion

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.

4.1) Macroeconomic announcements

What remains to be checked is that the 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.

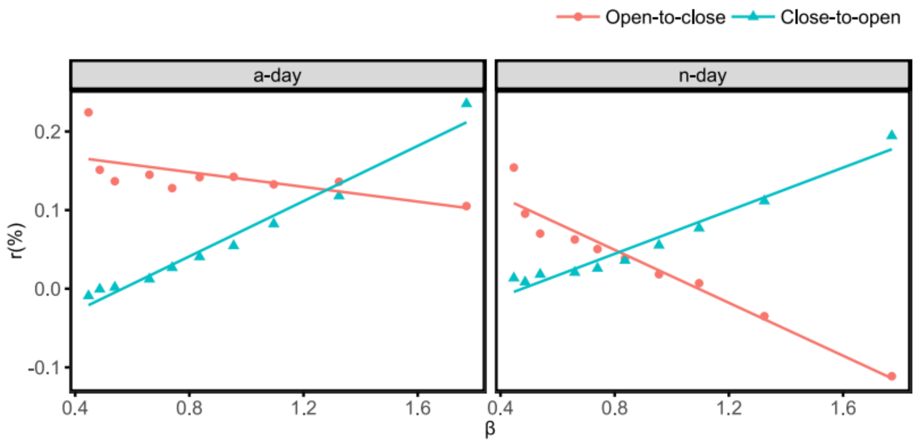

Fig. 7. US returns for beta-sorted portfolios on macroeconomic announcement days (1992–2016).
The left figure shows average (equal-weighted) returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks for announcement days or a-days (days on which inflation, 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.)

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, high-beta portfolios earn negative day returns on nonannouncement days. Overall, these findings confirm that Authors 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. 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. Because margin requirements have not been changed since September 1975, the natural experiment from Jylha (2018) cannot be directly used in Authors sample period. Comparing authors findings to Jylha (2018) suggests that the investors could be more capital constrained during the day than they are during the night. 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.

4.2. Intraday security market line

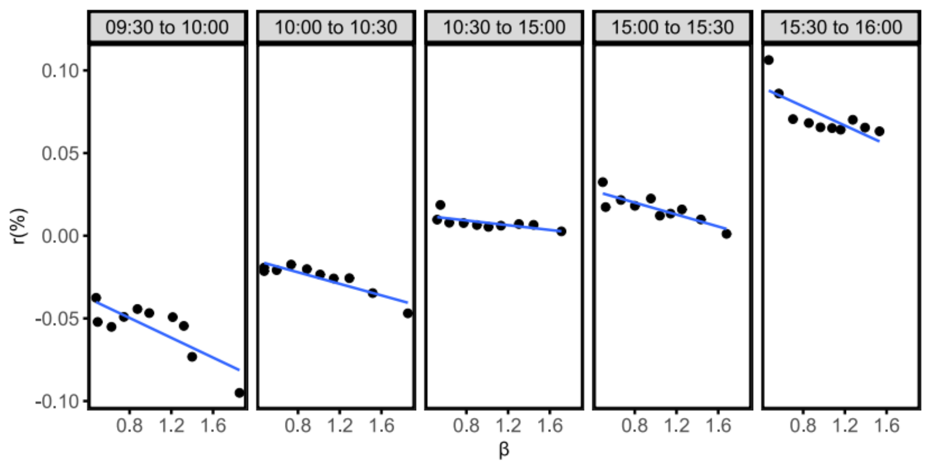

Fig. 8. US intraday returns for beta-sorted portfolios (1993–2016).
This figure shows average (equal-weighted) 30-min portfolio returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. Returns are estimated from the first and last midquote within 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.

Fig. 8 shows portfolio returns are monotonically increasing within the day, starting negative at the open and becoming positive at the close. The pattern of intraday returns depicted in Fig. 8 is consistent with beta-conditional speculationPrices at the open are above their long-run value, with the magnitude of the overshooting increasing with the market beta 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 hAuthors of trading, all betasorted portfolios earn negative expected returns, with their magnitude increasing with the market beta. 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.

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.

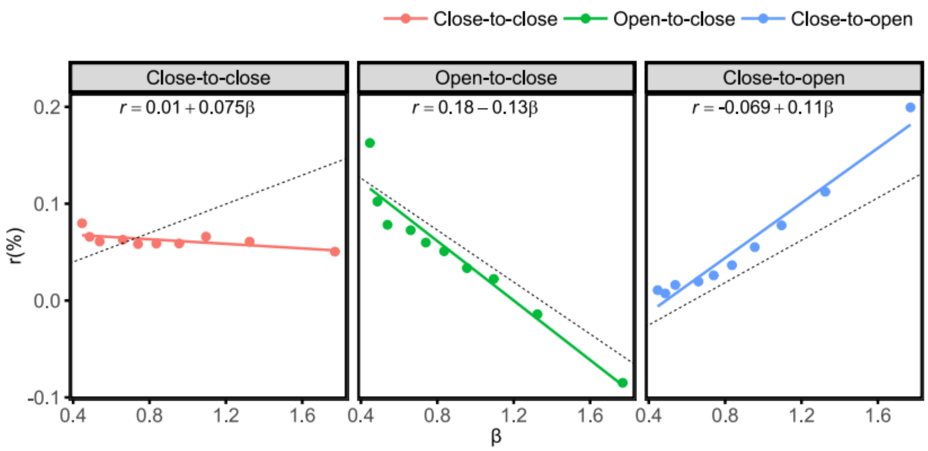

Fig. 9. US 24-h, day, and night returns for beta-sorted portfolios (1993–2016).
This figure shows average (equal-weighted) daily returns in percent against market betas for ten beta-sorted portfolios of all US publicly listed common stocks. The solid line depicts the empirical security market line fit 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.)

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.

Now to examine whether the risk-free rate variation implied by intercepts of the day and night empirical SML is plausible, Authors analyze the returns on US Treasury futures.Treasury futures are standardized contracts for selling and buying US Treasuries. They come in fAuthors tenors or maturities: 2, 5, 10, and 30 years. They trade virtually around the clock, Sunday through Friday (Central Time). Though one potential problem is that their returns are not directly equal to the risk-free rate level.

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

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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)

Table 12 is 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. These results provide independent evidence in support of the hypothesis that day and night risk free-rates are different. 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. Authors examine the performance of the CAPM during night and day. Authors also show that beta being weakly related to returns is driven entirely by returns during the trading day. 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. Overnight returns are positively related to beta for individual US stocks and international stocks.

When it's comes to the question of failure of CAPM in night and day scenario it can be concluded 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.

6. Further Studies

Emperical results suggest further study of the appropriate risk-free rate may be important. For example,

1) what is the correct proxy for the 24-h risk-free rate?
2) How important is variation in the risk-free rate to investors and asset pricing models? Even intraday variation?