### Asset pricing: A tale of night and day

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[1]Price Discovery without Trading: Evidence from Limit Orders(with Terrence Hendershott,

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[2]Short Selling and Price Discovery in Corporate Bonds(with Terrence Hendershott, Roman Kozhan, and Vikas Raman.). Journal of Financial and Quantitative Analysis.2018.

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[2]Relationship Trading in OTC Markets(with Terrence Hendershott, Dan Li, Dmitry Livdan, Norman Schürhoff.). Journal of Finance. Forthcoming





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[2]"Tick Size, Liquidity for Small and Large Orders, and Price Informativeness: Evidence from the Tick Size Pilot Program." (with Kee H. Chung and Albert J. Lee) Journal of Financial Economics, 2020, 136 (3): 879-899

- 2. Data and methodology
- 3. Results
- 4. Discussion
- **5.** Conclusion



## 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.



## Abstract

- 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.





- Question: Little relation between beta and returns in the cross-section of stocks.
- Studies: The risk-return relationship is positive only during specific times.



---- Open-to-close ---- Close-to-open





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.



• Finding

a. When the stock market is closed, beta is positively related to the cross-section of returns. In contrast, beta is negatively related to returns when the market is open.

b. 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.



- Contributions
- First, we explore the full crosssectional relationship between the expected returns and beta.
- Second, we examine stocks outside the US, industry and bookto-market portfolios in the US, and both cash flow news betas and discount rate news betas.
- Third, we also provide evidence related to the day and night SML's implied risk-free rate.





- Data
- a. Returns for the US stocks-CRSP
- b. The firm-level balance sheet-Compustat
- c. The data for foreign countries-Datastream
- d. Daily data for 39 foreign countries covering the 1990–2014 period and the US covering the 1992–2016 period.



• Methodology

Night returns-lou et al.(2019)

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

Day returns

 $R_t^{\text{open-to-close}} = R_t^D = (Close_t - Open_t)/Open_t$ 



- Data filters
- a. the open price is available(excludes data before 1992)
- b. drop 16 stock days with a day return over 1,000%
- c. the trading volume is at least USD 100
- d. the absolute value of the close-to-close return (Ri,t) is below200%

e. 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%



- Data filters
- f. positive open price

g. the absolute value of either the day or the night return is below 200%



- Regressions
- a. Fama-MacBeth procedure pre-ranking beta

$$R_{i,m,t}^{N} = \alpha_{i,m}^{N} + \beta_{i,m}^{p} R_{M,m,t}^{N} + \varepsilon_{i,m,t}^{N}$$
  
post-ranking beta

risk premium

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

(2)

(3)

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shanxi university

- Regressions
- b. Panel regression

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



### 3. Results



• procedure

 using one-year rolling windows of daily Night returns from 1992 to 2016

2. sorting stocks into one of ten beta decile equal-weighted portfolios

- 3. Portfolio returns are averaged
- 4. post ranking betas are estimated over the whole sample



#### • finding

1. The day points show a negative relation between average returns and beta.(-15 bps)

2. The relation between average night returns and beta is strongly positive.(14 bps)



#### 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 <sup>2</sup> | Beta              | Day     | Day × Beta | R <sup>2</sup> [%] |  |
| 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) |                     |                   |         |            |                    |  |



• Table 1





• Table 1

|                                   | the slope for day returns is -13.5 bps   |
|-----------------------------------|--|
| Panel B-equal-weighted portfolios | <ul> <li>the slope for night returns is 12.1 bps</li> </ul>  |
|                                   | The night-minus-day stock market risk premium is even higher for equal-weighted portfolios at 25.6 bps |



• Table 1





- 3. Results3.1. Beta portfolios
- potential concern 1

1. the US stocks are special and our findings are specific to the US stock market.

2. we perform the same set of tests on international stocks.

**EU**-France, Germany, Greece, Israel, Italy, Netherlands, Norway, Poland, South Africa, Spain, Sweden, Switzerland, and the United Kingdom

Asia-Australia, China, Hong Kong, India, Indonesia, Japan, Korea, New Zealand, Philippines, Singapore, and Thailand







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.)



- 3. Results3.1. Beta portfolios
- potential concern 1





#### 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  $\ddagger$ ,  $\ddagger$ , and \*, respectively. Data are from Datastream.

| Returns over            | Fama-MacBeth regressi | ons      |                     | Panel regres |         |            |                    |
|-------------------------|-----------------------|----------|---------------------|--------------|---------|------------|--------------------|
|                         | Country dummies       | Beta     | Avg. R <sup>2</sup> | Beta         | Day     | Day × Beta | R <sup>2</sup> [%] |
| 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-w        | reighted              |          |                     |              |         |            |                    |
| 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) |                     |              |         |            |                    |



• potential concern 1





- 3. Results3.1. Beta portfolios
- potential concern 2

1. Our results are driven by the fact that the stock market betas are estimated using exclusively night returns.

2. Redo Figs. 1 and 2 using close-to-close returns.







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.)



- 3. Results3.1. Beta portfolios
- potential concern 2







**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.)



Open-to-close ----- Close-to-open

- 3. Results3.1. Beta portfolios
- potential concern 2




- 3. Results3.1. Beta portfolios
- potential concern 3

1. 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.

2. Reestimate our results separately for returns over one, two, three, and four 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 regressi      | ons     |         |            |                    |
|------------------------|--------------------------|---------|---------------------|---------|---------|------------|--------------------|
|                        | Intercept                | Beta    | Avg. R <sup>2</sup> | Beta    | Day     | Day × Beta | R <sup>2</sup> [%] |
| Panel A: 4,536 1-night | t <u>returns</u>         |         |                     |         |         |            |                    |
| 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 re | turns                    |         |                     |         |         |            |                    |
| 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 i | eturns                   |         |                     |         |         |            |                    |
| 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) |                     |         |         |            |                    |



- 3. Results3.1. Beta portfolios
- potential concern 3





- 3. Results3.1. Beta portfolios
- potential concern 3





- 3. Results3.1. Beta portfolios
- potential concern 3





- 3. Results3.1. Beta portfolios
- potential concern 3-Finding

1. If we exclude the two-night returns, the night-implied stock market risk premium increases with the length of the market closure.

the risk-averse investor demanding higher premium for holding risky securities over longer nontrading periods.



- 3. Results3.1. Beta portfolios
- potential concern 3-Finding

2. 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 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

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  $\ddagger$ ,  $\dagger$ , and \*, respectively. Data are from Datastream.

| Returns over         | Fama-MacBeth regression | ns                  |                     | Panel regres | sions   |            |                    |
|----------------------|-------------------------|---------------------|---------------------|--------------|---------|------------|--------------------|
|                      | Country dummies         | Beta                | Avg. R <sup>2</sup> | Beta         | Day     | Day × Beta | R <sup>2</sup> [%] |
| Panel A: 4381 1-nigi | ht 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 <sup>‡</sup> | 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-nigl | ht 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-nigl | ht returns              |                     |                     |              |         |            |                    |
| Night                | Yes                     | 0.111*              | 28.56               | 0.162‡       | 0.158†  | -0.318‡    | 27.55              |
|                      |                         | (1.87)              |                     | (3.31)       | (2.04)  | (-3.59)    |                    |
| Dav                  | Yes                     | -0.228t             | 28.87               |              |         |            |                    |
|                      |                         | (-3.70)             |                     |              |         |            |                    |
|                      |                         | (                   |                     |              |         |            |                    |



## 3. Results3.1. Beta portfolios

### • potential concern 3





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

 adding 10 industry and 25 size and book-to-market sorted portfolios (25 Fama-French portfolios) to the 10 stock market beta-sorted portfolios







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.)



# 3. Results3.2. Industry, size, and book-to-market portfolios





## Results Industry, size, and book-to-market portfolios

#### 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  $\ddagger$ ,  $\ddagger$ , and  $\bullet$ , respectively. Data are from CRSP and Compustat.

| Returns over          | Fama-MacBeth regressions |         |                     | Panel regress | Panel regressions |            |                    |  |  |
|-----------------------|--------------------------|---------|---------------------|---------------|-------------------|------------|--------------------|--|--|
|                       | Intercept                | Beta    | Avg. R <sup>2</sup> | Beta          | Day               | Day × Beta | R <sup>2</sup> [%] |  |  |
| Panel A: Value-weight | ted                      |         |                     |               |                   |            |                    |  |  |
| 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-weight | ed                       |         |                     |               |                   |            |                    |  |  |
| 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) |                     |               |                   |            |                    |  |  |







# 3. Results3.3. Cash flow and discount rate news betas

• Campbell and Vuolteenaho (2004)







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.)



## 3. Results3.3. Cash flow and discount rate news betas





### 3. Results 3.4. Double-sorted portfolios



within each factor-sorted portfolio, stocks are sorted into five beta portfolios.



#### 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  $\ddagger$ ,  $\ddagger$ , 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 perc       | cent)    |          |          |          |          |  |  |  |  |
| 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) |  |  |  |  |



## 3. Results3.4. Double-sorted portfolios





#### 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  $\ddagger$ ,  $\ddagger$ , 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 perce      | ent)     |          |          |          |          |  |  |  |
| 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) |  |  |  |



## 3. Results3.4. Double-sorted portfolios





#### 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 | Fama-MacBeth regressions |                     |        | Panel regressions |            |                    |  |  |
|   | Intercept    | Beta                     | Avg. R <sup>2</sup> | Beta   | Day               | Day × Beta | R <sup>2</sup> [%] |  |  |
| 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

|              | Inter                 | cept                    | Beta                      |                 | Size                |              | BM                  |                  | Past return        |                    | Avg, R <sup>2</sup> [%] |
|--------------|-----------------------|-------------------------|---------------------------|-----------------|---------------------|--------------|---------------------|------------------|--------------------|--------------------|-------------------------|
| Night        | 0.10                  | 08‡<br>59)              | 0.091‡<br>(8.88)          | Γ               | -0.009‡<br>(-4.96)  |              | -0.024‡<br>(-14.06) |                  | -0.010†<br>(-2.34) |                    | 1.18                    |
| Day          | 0.43<br>(14.          | 32‡<br>93)              | -0.090‡<br>(-10.10)       | _               | -0.027‡<br>(-10.50) |              | 0.023‡<br>(10.72)   |                  | 0.037†<br>(6.53)   |                    | 1.73                    |
| Panel regres | sions with day<br>Day | fixed effects<br>Beta E | Beta                      | Size            | Size                | BM           |                     | BM               | Past               | Past               | R <sup>2</sup> [%]      |
|              |                       | >                       | < Day                     |                 | × Day               |              |                     | × Day            |                    | × Day              |                         |
| Return       | 0.535‡<br>(11.37)     | 0.060‡ -<br>(10.25) (   | - <mark>0.118‡</mark><br> | 0.001<br>(0.42) | -0.037‡<br>(-8.30)  | -0.0<br>(-6. | 01‡<br>84)          | 0.003‡<br>(6.58) | 0.0003‡<br>(4.29)  | -0.0001<br>(-0.70) | 1.86                    |



## 3. Results3.5. Individual stocks









- 3. Results3.6. Trading strategy
- beta zero-cost trading strategy based on individual stocks

-go long in high-beta stocks by shorting low-beta stocks during the night (betting on beta)

-at the open going long into low-beta stocks by shorting highbeta stocks (BaB)



- 3. Results3.6. Trading strategy
- A portfolio-based trading strategy

-going long in the highest beta portfolio and financing the position by shorting the lowest beta portfolio during the night (betting on beta)

-reversing both positions during the day (BaB)



#### 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),  $\frac{r_1-r_1}{\beta_n} - \frac{r_n-r_1}{\beta_n}$ , 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         |  |  |  |  |







## 3. Results3.6. Trading strategy





#### 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  $5 \times 5$  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%<br>(-5.93) | -0.13%<br>(-5.23) | -0.11%<br>(-5.13) | -0.06%<br>(-2.85) | -0.12%<br>(-6.09) |
| Night |       | 0.15% (6.74)      | 0.11% (7.01)      | 0.09% (6.67)      | 0.07% (5.91)      | 0.13% (8.97)      |
| Day   | 2     | -0.17%            | -0.12%            | -0.12%            | -0.06%            | -0.14%            |
| Night |       | 0.16%             | 0.10%             | 0.09%             | 0.07% (4.37)      | 0.18%             |
| Day   | 3     | -0.18%            | -0.17%            | -0.14%            | -0.11%            | 0.01%             |
| Night |       | 0.18% (8.98)      | 0.17% (9.48)      | 0.16% (8.88)      | 0.14% (6.79)      | 0.05% (1.41)      |
| Day   | 4     | -0.17%<br>(-4.46) | -0.13%<br>(-3.68) | -0.15%<br>(-4.17) | -0.09%<br>(-2.17) | -0.19%<br>(-3.64) |
| Night |       | 0.16%<br>(7.24)   | 0.16%<br>(7.84)   | 0.14%<br>(6.66)   | 0.10%<br>(4.23)   | 0.24% (7.15)      |
| Day   | Big   | -0.14%<br>(-3.69) | -0.17%<br>(-4.50) | -0.07%<br>(-1.49) | -0.10%<br>(-2.04) | -0.16%<br>(-2.52) |
| Night |       | 0.13%<br>(5.60)   | 0.15%<br>(6.85)   | 0.08%<br>(2.74)   | 0.12%<br>(3.64)   | 0.19%<br>(4.35)   |



# 3. Results3.6. Trading strategy





## 4. Discussion



### 4. Discussion

---- Open-to-close ---- Close-to-open





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.)



## 4. Discussion4.1. Macroeconomic announcements





### 4. Discussion



#### 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.


# 4. Discussion4.2. Intraday security market line





### 4. Discussion4.3. Variation in the risk-free rate

---- Close-to-close ---- Open-to-close ---- Close-to-open





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. Discussion4.3. Variation in the risk-free rate

#### 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%‡           |
|          | 2nd Front month | (3.59)<br>0.010%† | (-1.67)<br>-0.011%* | (3.46)<br>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)            |



## 4. Discussion4.3. Variation in the risk-free rate





#### 5. Conclusion



#### 5. Conclusion

- This paper studies how stock prices are related to beta when markets are open for trading and when they are closed.
- We examine the performance of the CAPM during night and day.
- Returns are positively related to beta overnight when the market is closed.

beta-sorted portfolios for US stocks and international stocks 10 industry and 25 book to market portfolios the cash flow news betas and discount rate news betas individual US stocks and international stocks



#### THANKS!

