Give me a break: What does the equity premium compensate for?

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Agenda

- Motivation
- Contribution & Key Findings
- Model Setting
- Empirical Analysis
- Conclusion

Motivation

Motivation I

Unresolved puzzle on the overall intertemporal risk-return relation

- Significant positive relation
  (e.g. Harvey 1989, Bali/Peng 2006, Hedegaard/Hodrick 2016 among many others).
- Weak or negative relation
  (e.g. Campbell 1987, Glosten et al. 1993, Hedegaard/Hodrick 2014 among many others).

What might be reasons for the controversial results?

- Specification of volatility (e.g. Guo/Neely 2008, Leon et al. 2007).
- Omission of Merton's (1973) hedging component (e.g. Sruggs 1998).
- Others, such as irrational investor behavior (Yu/Yuan 2011, Nagel/Xu 2022, Lochstoer/Muir 2022).

Motivation II

Why do trading breaks matter?

- Empirics:
  - Market volatility is lower during periodic trading breaks (e.g. French/Roll 1980, Stoll/Whaley 1990, Kelly/Clark 2011).
  - Significant contribution to the overall equity premium (e.g. Cliff et al. 2008, Perras/Wagner 2020, Hendershott et al. 2020, Boyarchenko et al. 2023).

- Controversial theories:
  - Investors are averse of holding stocks over non-trading periods due to the lack of marketability (Longstaff 1995) and 'clientele effects' (Lou et al. 2019, Bogusslavsky 2021, Akbas et al. 2022).
  - Decrease in information asymmetry over the trading day increases the stock price resulting in a lower expected return over trading breaks (Hong/Wang 2000).

Contribution & Key Findings

Contribution & Key Findings

How does this study contribute to literature?

$\Rightarrow$ Evidence on the risk-return relation considering trading breaks.
$\Rightarrow$ The impact of trading breaks on the market risk premium (MRP).
$\Rightarrow$ Distinct pricing of trading and non-trading conditional volatility/illiquidity.

Main empirical findings:

1. Positive relation between the overall MRP and conditional risk and illiquidity during market closures.
2. Conditional risk and illiquidity during trading hours play a minor role in explaining the MRP.
3. Lack of market functionality and liquidity during closures results in a premium demanded by investors.
4. Analysis of intraday quotes relates the trading break premium to a decline before the official market close.

Model Setting

Model Setting

Assume a price process $\{P_t\}_{t \geq 0}$ with jumps at deterministic points in time:

$$\begin{aligned} \frac{dP_t}{P_{t-}} &= \mu dt + \sigma dB_t + dX_t \\ \text{where } X_t &= \sum_{j=1}^{N_t} (e^{r_{co,j}} - 1), \end{aligned} \tag{1}$$

$\{B_t\}_{t \geq 0}$ is a standard Brownian motion, dX_t is the discontinuous part of the process, N_t is a deterministic process counting the number of scheduled market closures at $\{\tau_j\}_{j \geq 1}$, up to time t.

Asset prices hence are:

$$P_t = P_0 \exp \left[(\mu - \frac{1}{2}\sigma^2)t + \sigma B_t + \sum_{\tau_j \leq t} r_{co,j} \right]. \tag{2}$$

Intertemporal Pricing Equation

> *"In equilibrium, investors are compensated in terms of expected return, for bearing (systematic) market risk, and for bearing the risk of unfavorable shifts in the investment opportunity set."*
>
> — Merton (1973, p. 882)

Our basic model at the aggregate market level is given by

$$E_t[r_{M,t+1}] - r_{f,t+1} = \lambda_M E_t[\sigma^2_{M,t+1}] + \lambda_L E_t[L_{M,t+1}] + \lambda_{H,x} E_t[\sigma_{M\Delta x,t+1}]. \quad (3)$$

- λ_M implies that investors require compensation for bearing systematic market risk.
- λ_L represents the compensation for bearing aggregate market illiquidity.
- $\lambda_{H,x}$ accounts for the pricing of unfavorable shifts in the investment opportunity set associated with state variables x.

Intertemporal Pricing Equation

A modified version of the model captures the dynamics of trading and non-trading periods:

$$
\begin{aligned}
E_t[r_{M,cc,t+1}] - r_{f,t+1} = {} & \lambda_{M,oc} Var_t\left[r_{M,oc,t+1}\right] + \lambda_{M,co} Var_t\left[r_{M,co,t+1}\right] \\
& + \lambda_{M,occo} Cov_t\left[r_{M,oc,t+1}, r_{M,co,t+1}\right] \\
& + \lambda_{L,oc} E_t[L_{M,oc,t+1}] + \lambda_{L,co} E_t[L_{M,co,t+1}] \\
& + \lambda_{H,x} Cov_t\left[r_{M,cc,t+1}, \Delta x_{t+1}\right].
\end{aligned}
\tag{4}
$$

The expected equity market premium is then a linear function of

- Conditional trading volatility and conditional volatility of jumps induced by trading breaks,
- Conditional covariance between trading and non-trading returns,
- Conditional expectations associated with illiquidity in trading and non-trading periods,
- Conditional covariance associated with innovations in state variables x that predict changes in the investment opportunity set.

Empirical Analysis

- TAQ data from January 3, 2007 to December 29, 2023
- Major U.S. ETF: SPDR S&P 500 ETF
- Daily return series:
    - Total return ($r_{M,cc}$): Log-return from official market closure at 4:00 PM to official market closure at 4:00 PM the next day.
    - Trading return ($r_{M,oc}$): Log-return from official market opening at 9:30 AM to official market closure at 4:00 PM.
    - Non-trading return ($r_{M,co}$): Log-return from official market closure at 4:00 PM to the official market opening at 9:30 AM the next day.

Empirical Analysis: Illiquidity

- Per-minute bid-ask spreads during three distinct periods each day:
  - Pre-trading hours (*pre*): This period covers the time before the official market opening from 4:00 AM to 9:30 AM.
  - Market-trading hours (*market*): This period represents the official trading hours when the market is open from 9:30 AM to 4.00 PM.
  - Post-trading hours (*post*): This period includes the time after the market officially closes from 4:00 PM to 8:00 PM.

- Macroeconomic variables
    - Default spread (DEF): Difference between the yields on U.S. high-yield corporate bonds (Moody's Baa) and low-yield (Moody's Aaa) corporate bonds.
    - Term spread (TERM): Difference between the yields on the 10-year Treasury bond and 3-month Treasury bill.
- Option-implied volatility: VIX index Chicago Board Options Exchange
- Equity factors
    - Size (SMB) and value (HML) factor (Fama/French 1993)
    - Profitability (RMW) and investment (CMA) factor (Fama/French 2015)

Empirical Results: Return Statistics

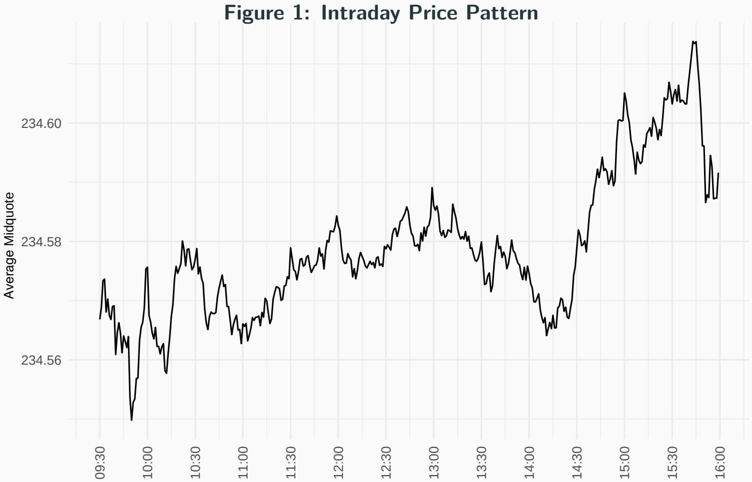
Table 1: Descriptive Statistics

Panel A: Descriptive Statistics	$R_{M,cc}$	$R_{M,oc}$	$R_{M,co}$
Min (%)	-12.3638	-8.2173	-11.7082
Mean (%)	0.0290	0.0140	0.0150
Max (%)	10.8385	7.3420	5.8557
Std. Dev. (%)	1.2573	0.9698	0.7591
Skewness	-0.4725	-0.3057	-1.7955
Kurtosis	14.5905	11.3805	30.4936
JB Statistics	24517	12801	139376
	(0.0000)	(0.0000)	(0.0000)
AB Statistic	8752895		
	(0.0000)		

Panel B: Correlations	$R_{M,cc}$	$R_{M,oc}$	$R_{M,co}$
$R_{M,cc}$	1		
$R_{M,oc}$	0.7976	1	
	(0.0000)		
$R_{M,co}$	0.6373	0.0434	1
	(0.0000)	(0.0040)	

Descriptive statistics for daily total market returns ($R_{M,cc}$), trading returns ($R_{M,oc}$) and non-trading returns ($R_{M,co}$) from January 3, 2007 to December 29, 2023 (4278 daily observations). Return calculation is based on the midquote between bid and ask prices. The Ansari-Bradley (AB) rank sum test of dispersion tests for differences in trading and non-trading return variance. P-values in parentheses.

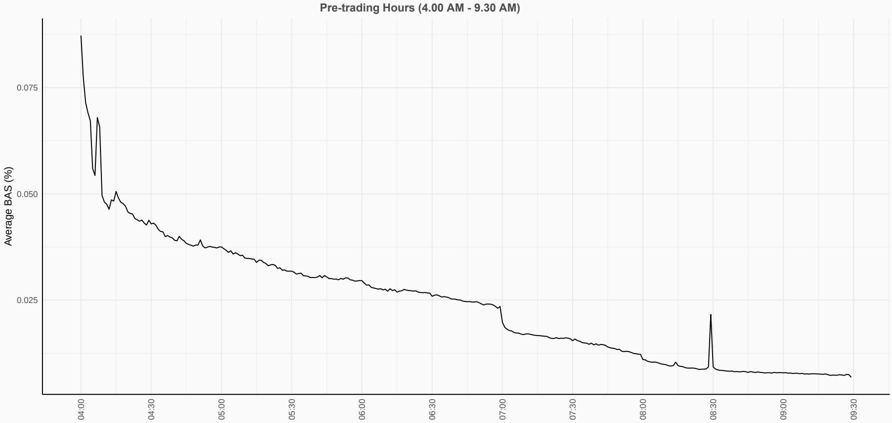
Empirical Results: Intraday Price Pattern



Average intraday midquotes from market opening at 9:30 AM to market closure at 4:00 PM. Midquotes are sampled in 1-minute intervals over the full sample period from January 3, 2007 to December 29, 2023.

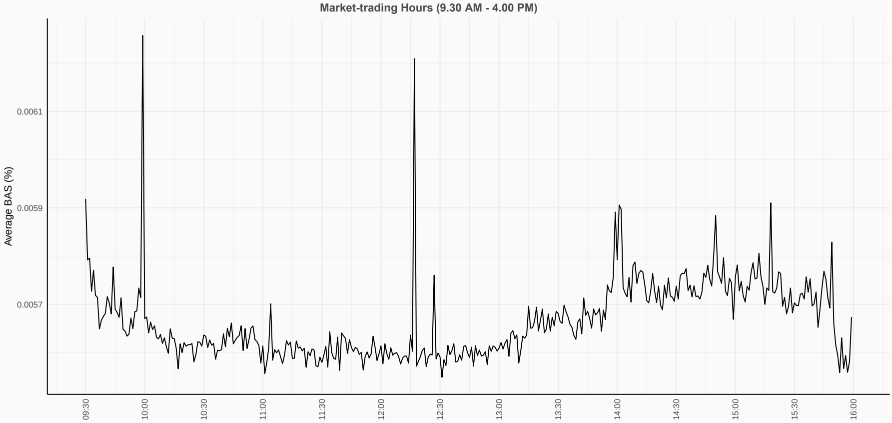
Empirical Results: Intraday Illiquidity Pattern

Figure 2: Intraday Illiquidity Pattern (Pre-trading)



Intraday bid-ask spreads during pre-trading hours. Spreads are sampled in 1-minute intervals.

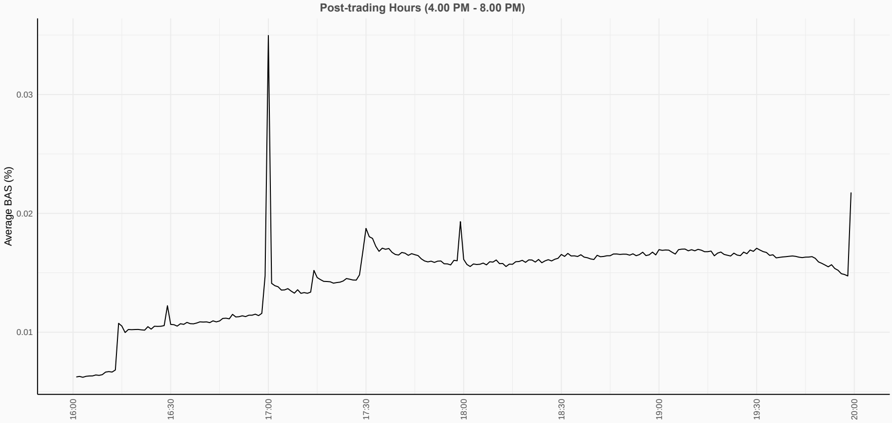
Figure 3: Intraday Illiquidity Pattern (Market-trading)



Intraday bid-ask spreads during market-trading hours. Spreads are sampled in 1-minute intervals.

Empirical Results: Intraday Illiquidity Pattern

Figure 4: Intraday Illiquidity Pattern (Post-trading)



Intraday bid-ask spreads during post-trading hours. Spreads are sampled in 1-minute intervals.

Empirical Results: Model Estimation

Table 2: Estimates of Risk Premia in Equation (4)

Model I	λ_0	$\lambda_{M,cc}$					$Adj.R^2$
	0.0003	0.8353					10.53%
	(0.0000)	(0.0001)					
Model II	λ_0	$\lambda_{M,oc}$	$\lambda_{M,co}$	$\lambda_{M,occo}$			$Adj.R^2$
	0.0003	1.2791	-				9.61%
	(0.0003)	(0.0000)	-				
	0.0003	-	1.8758				9.91%
	(0.0003)	-	(0.0000)				
	0.0003	0.5294	1.9085	-0.0186			10.66%
	(0.0003)	(0.4021)	(0.0000)	(0.0173)			
Model III	λ_0	$\lambda_{M,oc}$	$\lambda_{M,co}$	$\lambda_{M,occo}$	$\lambda_{L,oc}$	$\lambda_{L,co}$	$Adj.R^2$
	0.0009	0.6780	1.8844	-0.0366	0.0078	0.0468	11.39%
	(0.0000)	(0.2178)	(0.0000)	(0.0000)	(0.2462)	(0.0030)	

Modified ICAPM estimation results with $\lambda_{H,x} = 0$. Estimation is done by Maximum-likelihood, p-values based on heteroskedasticity and autocorrelation robust standard errors are in parentheses.

Empirical Results: Stochastic Investment Opportunities

Table 3: Risk-Return Trade-off under Stochastic Investment Opportunities

Panel A: Macro-economic Variables

λ_0	$\lambda_{M,oc}$	$\lambda_{M,co}$	$\lambda_{M,occo}$	$\lambda_{L,oc}$	$\lambda_{L,co}$	$\lambda_{H,Def}$	$\lambda_{H,Term}$	$Adj.R^2(\%)$
0.0001	0.5244	1.7279	-0.0362	0.0074	0.0473	-0.6889	-	11.42
(0.0000)	(0.4170)	(0.0006)	(0.0000)	(0.2549)	(0.0025)	(0.7534)	-	
0.0001	0.6686	1.8984	-0.0367	0.0071	0.0478	-	-0.0186	11.37
(0.0000)	(0.2309)	(0.0000)	(0.0000)	(0.2621)	(0.0053)	-	(0.9216)	
0.0001	0.5222	1.7145	-0.3620	0.0075	0.0469	-0.7118	0.0088	11.40
(0.0000)	(0.4219)	(0.0106)	(0.0000)	(0.2626)	(0.0086)	(0.7730)	(0.9675)	

Panel B: Option-implied Volatility

λ_0	$\lambda_{M,oc}$	$\lambda_{M,co}$	$\lambda_{M,occo}$	$\lambda_{L,oc}$	$\lambda_{L,co}$	$\lambda_{H,VIX}$		$Adj.R^2(\%)$
0.0001	1.19523	2.8231	-0.0468	0.0089	0.0356	0.0558		13.73
(0.0000)	(0.1572)	(0.0000)	(0.0000)	(0.1749)	(0.0228)	(0.0154)		

Modified ICAPM estimation results with $\lambda_{H,x} \neq 0$. Conditional covariances between market returns and innovations in state variables are estimated by the DCC model of Engle (2002). Robust p-values in parentheses.

Table 3 Cont.: Risk-Return Trade-off under Stochastic Investment Opportunities

Panel C: Equity Factors

λ_0	$\lambda_{M,oc}$	$\lambda_{M,co}$	$\lambda_{M,occo}$	$\lambda_{L,oc}$	$\lambda_{L,co}$	$\lambda_{H,SMB}$	$\lambda_{H,HML}$	$\lambda_{H,RMW}$	$\lambda_{H,CMA}$	$Adj.R^2(\%)$
0.0001	1.1823	2.4231	-0.0468	0.0090	0.0363	0.0580	-	-	-	12.73
(0.0000)	(0.0572)	(0.0000)	(0.0000)	(0.1749)	(0.0228)	(0.0154)	-	-	-	
0.0001	1.3854	2.7709	-0.0379	0.0074	0.0680	-	-0.0234	-	-	13.11
(0.0000)	(0.0095)	(0.0000)	(0.0000)	(0.3254)	(0.0002)	-	(0.0520)	-	-	
0.0001	-0.0509	1.4750	-0.0386	0.0089	0.0368	-	-	-0.4498	-	12.16
(0.0000)	(0.9315)	(0.0003)	(0.0000)	(0.1744)	(0.0165)	-	-	(0.1176)	-	
0.0001	0.3060	1.7333	-0.0406	0.0070	0.0587	-	-	-	-0.0367	11.68
(0.0000)	(0.5942)	(0.0015)	(0.0000)	(0.2725)	(0.0020)	-	-	-	(0.2621)	
0.0001	1.9739	3.4078	-0.0462	0.0086	0.0579	0.0626	-0.0246	-	-	14.67
(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.2418)	(0.0030)	(0.0093)	(0.0447)	-	-	
0.0001	1.3104	3.1497	-0.0456	0.00871	0.0592	0.0523	-0.0246	-0.0236	-0.0165	14.90
(0.0000)	(0.1727)	(0.0000)	(0.0000)	(0.2128)	(0.0012)	(0.1147)	(0.0479)	(0.5701)	(0.5701)	

Estimation results with $\lambda_{H,x} \neq 0$. Conditional covariances between market returns and innovations in state variables are estimated by the DCC model of Engle (2002). Fama-French (1993, 2015) factors : Small-minus-big (SMB), high-minus-low (HML), robust-minus-weak (RMW), conservative-minus-aggressive (CMA). Robust p-values in parentheses.

Summary & Conclusions

The equity premium compensates primarily for bearing risk and illiquidity during market closures.

$\Rightarrow$ Conditional volatility and illiquidity during trading hours play only a minor role in shaping the intertemporal risk-return relationship.

Why?

- Expected costs of non-marketability induce a discount prior to the official closure in line with Longstaff's (1995) theory.
- Higher risk aversion of investors during market closures with reduced marketability and increased information asymmetry.
- Intraday patterns suggest a potential 'clientele effect': Assets change owners.

Thank you for your attention!

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