The Early Exercise Risk Premium

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Motivation

- Early exercise is a special feature of American options, quite downplayed by previous empirical option return literature in its importance (for example, "adjusting for early exercise has minimal empirical implications" (Hu & Jacobs (2016, p.10)));
- Empirical studies on option returns usually claim that the return difference between American and European options is negligible;
- This sentiment is usually defended on the grounds that:
  - Using a GBM process to model the stochastic evolution of the underlying asset, Brennan and Schwartz (1977) find similar American and European option prices;
  - Using more general processes, Broadie et al. (2007) also find similar prices;

Motivation

- It, however, ignores a large literature showing that, empirically, American option prices are significantly (5-10%) higher than European option prices;
  - Zivney (1991), de Roon and Veld (1996), and Engström and Nordén (2000) compare traded American option prices with equivalent synthetic European option prices;
- Adjusting for early exercise may have more than minimal implications....;
- These implications are important since, while our theories are almost always about European options, our tests almost always use American options;

Objective and Findings

- We study the difference in expected returns between American and equivalent European put options ("The Early Exercise Risk Premium") to understand the cross-sectional nature of option returns;
- The early exercise *risk premium* is not same as the early exercise premium;
- Our main conclusions on put options are:
  - Our theoretical and empirical work suggests that the early exercise risk premium is positive and economically meaningful;
  - It further shows that the premium is related to several option and underlying asset characteristics conditioning the probability of an early exercise happening;

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Theoretical Patterns

- We use the Longstaff and Schwartz (2001) Monte-Carlo simulation approach to calculate the Annualized expected returns of American and European put options written on non-cash paying primitive assets.
- Our calculation is based on 1 million primitive asset paths using discrete time-steps equal to option maturity days.
- We calculate option values under equivalent martingale measure $\mathcal{Q}$ using GBM and risk free rate.
- To calculate expected payoffs, we simulate asset price paths using expected rate of return under physical probability measure $\mathcal{P}$.

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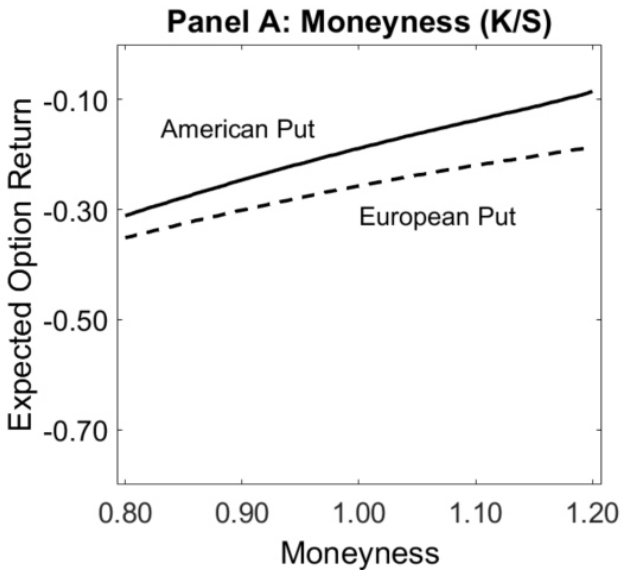
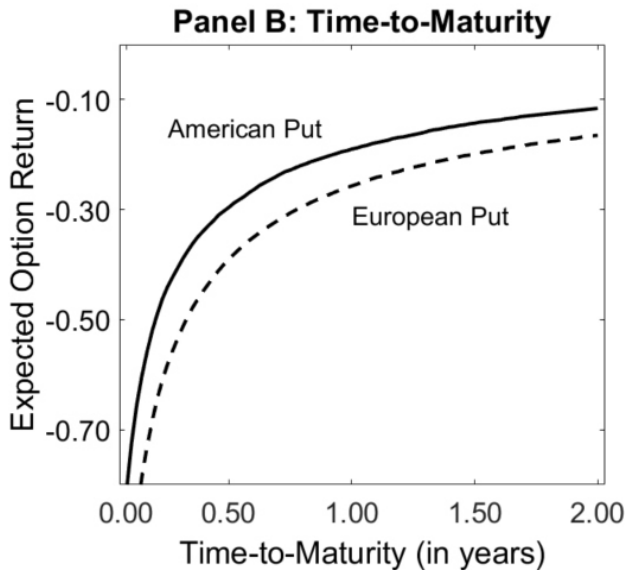
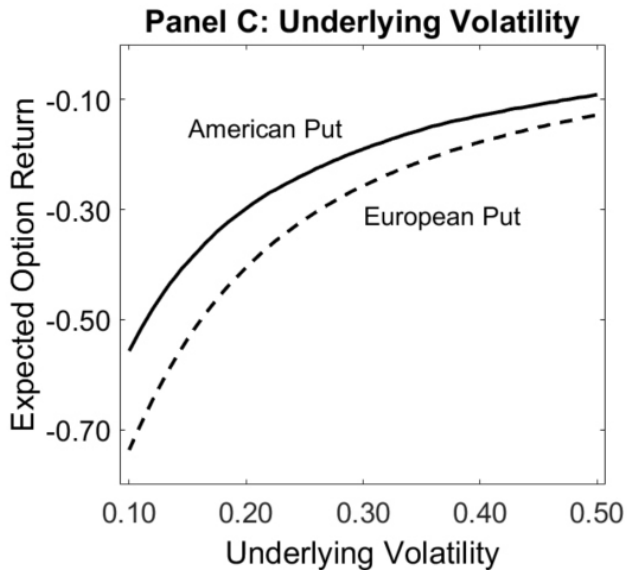
Theoretical Results: Comparative Statistics







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Theoretical Results: Explanation (i)

- We can understand the nature and behaviour of the early exercise risk premium by observing a dynamic replication portfolio of put option;
- Under no-arbitrage, put and its replication portfolio has equal expected returns;
- The early exercise of a put converts the option into cash, eliminating the need for replication portfolio to be short the primitive asset;
- Thus, upon an early exercise, the expected replication portfolio return changes to the risk-free rate of return;
- As the expected return of a put option is negative, this implies a positive early exercise risk premium;

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Theoretical Results: Explanation (ii)

- The relations between the early exercise risk premium and primitive asset and option characteristics follow from the characteristics of early exercise probability of put option;
- A higher option moneyness, a shorter option time-to-maturity, and a lower primitive asset volatility increase the probability of an option being early exercised, leading the expected American put option return to be more skewed toward the risk-free rate of return;

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Data

- Sample data ranges from January 1996 to April 2016.
- We use both call and put single-stock option data taken from Optionmetrics through WRDS.
- Option sample only consists options written on underlying assets which have not given any dividend within option time-to-maturity.
- We take options covering ITM, ATM and OTM options with short and reasonably long times-to-maturity.
- We impose similar filters as Goyal and Saretto (2009) and Cao and Han (2013).

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Empirical Methodologies

- Monthly EERP = Mean monthly return of put American options − Mean monthly return of *equivalent* **synthetic** put European options.

$$EERP^{Ami}_{i,K,t,T} = r^{Ami}_{i,K,t,T} - r^{synE}_{i,K,t,T}, \tag{1}$$

  - Put synthetic options are calculated using European put-call parity condition based on Merton (1973) as follows:

$$P^{synE}_{i,K,T} = C^{A}_{i,K,T} + Ke^{-rT} - V_i, \tag{2}$$

- We calculate monthly empirical option returns based on month-end holding period payoffs (for American and European options) or early exercise payoffs, compounded till month-end holding period (for American Options).

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Empirical Methodologies: Early Exercise Rule

- We use the market rule of Barraclough and Whaley (2012) to be model-independent, but its not easy to use given price discreteness, minimum price increments, and bid-ask spreads;
  - An American options traded price can never lie below the early exercise payoff;
  - But price discreteness implies it will also never be exactly identical to that payoff;

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Empirical Methodologies: Early Exercise Rule

- Our solution is to assume that an early exercise happens when the early exercise payoff becomes sufficiently close to the options traded price (5%);
  - Our empirical results are virtually identical using a 1% or 2% threshold;
- To facilitate the market rule, we assume an option can only be exercised at the end of each day during an options one-month investment period;
  - Compare the end-of-day early exercise payoff with the options traded price;
  - An early exercise occurs the first time the two variables are within a 5% range;
  - Compound the early exercise payoff to the end of the investment period;

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Summary Statistics

	Monthly American Put Option Return	Monthly Synthetic European Put Option Return	Monthly Spread Portfolio Return	Moneyness Option Pair	Days to Maturity Option Pair
Mean	−0.074	−0.145	0.071	1.11	78
StDev	0.589	0.629	0.312	0.22	26
Mean/StError	−4.412	−7.615	12.529		
Percentile 1	−0.910	−0.958	−0.634	0.74	48
Percentile 5	−0.809	−0.864	−0.252	0.85	49
Quartile 1	−0.466	−0.549	−0.036	0.98	50
Median	−0.128	−0.245	0.014	1.07	80
Quartile 3	0.179	0.107	0.126	1.19	105
Percentile 95	0.891	0.882	0.617	1.50	111
Percentile 99	1.894	2.004	1.065	1.89	111
Observations	3.303	3.303	3.303	3.303	3.303

- The table shows descriptive statistics first calculated by month and then averaged over months, so the mean returns can be interpreted as those of equally-weighted portfolios;

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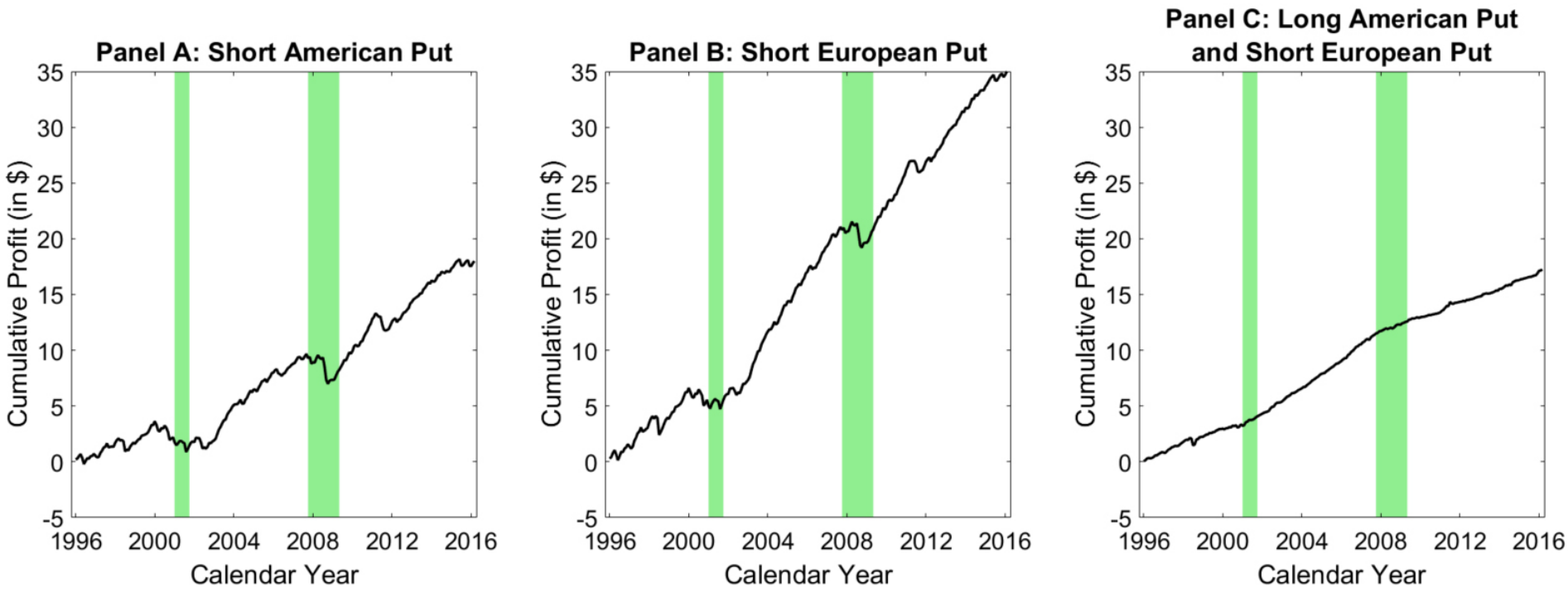
Cumulative Profits of American and European Put Options



- We short \$1 of the American put option portfolio (Panel A) or the synthetic European put option portfolio (Panel B) at the end of month t 1 and hold the short position over month t;

Does Early Exercise Risk Premium Exist?

Portfolio Sort Results: By Moneyness and Maturity

Time-to-Maturity	American Put Option Return	European Put Option Return	Spread Portfolio Return
Panel A: In-The-Money (Moneyness $>$ 1.05)			
30-60 Days	−0.190	−0.380	0.190
	[−10.74]	[−19.87]	[16.54]
60-90 Days	−0.079	−0.124	0.045
	[−6.83]	[−5.07]	[6.91]
90-120 Days	−0.044	−0.054	0.009
	[−2.97]	[−3.13]	[2.25]
Panel B: At-The-Money (Moneyness 0.95-1.05)			
30-60 Days	−0.143	−0.237	0.093
	[−4.83]	[−8.90]	[9.60]
60-90 Days	−0.062	−0.071	0.009
	[−2.44]	[−2.76]	[2.10]
90-120 Days	−0.031	−0.028	−0.003
	[−1.47]	[−1.25]	[−1.24]
Panel C: Out-Of-The-Money (Moneyness $<$ 0.95)			
30-60 Days	−0.026	−0.040	0.014
	[−0.59]	[−0.89]	[1.60]
60-90 Days	−0.037	−0.023	−0.014
	[−1.04]	[−0.59]	[−2.64]
90-120 Days	−0.025	−0.011	−0.014
	[−0.84]	[−0.34]	[−3.84]

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Does Early Exercise Risk Premium Exist?

Portfolio Sort Results: By Idiosyncratic Volatility

	Idiosyncratic Stock Volatility					
	Low	2	3	4	High	H–L
Panel A: Market Model						
American Put Return	−0.091	−0.079	−0.069	−0.071	−0.058	0.033
	[−4.02]	[−3.52]	[−3.07]	[−3.08]	[−2.48]	[2.07]
European Call Return	−0.186	−0.163	−0.144	−0.131	−0.101	0.085
	[−7.47]	[−6.97]	[−5.99]	[−5.17]	[−3.82]	[4.07]
Spread Portfolio Return	0.095	0.085	0.075	0.061	0.043	−0.052
	[11.28]	[14.64]	[12.97]	[10.57]	[6.60]	[−7.56]
Panel B: Fama-French-Carhart Model						
American Put Return	−0.088	−0.083	−0.067	−0.073	−0.059	0.029
	[−3.81]	[−3.73]	[−2.96]	[−3.15]	[−2.70]	[2.00]
European Call Return	−0.180	−0.168	−0.142	−0.137	−0.104	0.076
	[−7.04]	[−7.16]	[−5.92]	[−5.35]	[−4.28]	[3.99]
Spread Portfolio Return	0.092	0.085	0.075	0.064	0.045	−0.047
	[10.69]	[14.80]	[12.89]	[11.55]	[7.66]	[−7.26]

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Fama-MacBeth (1973) Regressions

Model	Constant	Moneyness	Time To Maturity	Idiosyncratic Volatility
Panel A: Spread Portfolio Return				
1	0.071			
	[12.66]			
2	0.002	0.234	−0.002	
	[0.12]	[22.36]	[−22.31]	
3	0.015	0.251	−0.002	−0.077
	[0.85]	[23.11]	[−22.00]	[−11.43]
Panel B: American Put Option Return				
4	−0.074			
	[−4.39]			
5	−0.138	−0.068	0.002	
	[−2.03]	[−1.53]	[15.61]	
6	−0.146	−0.064	0.002	0.007
	[−2.18]	[−1.42]	[15.36]	[0.48]
Panel C: Synthetic European Put Option Return				
7	−0.145			
	[−7.58]			
8	−0.140	−0.302	0.004	
	[−2.12]	[−6.96]	[40.67]	
9	−0.162	−0.315	0.004	0.084
	[−2.51]	[−7.24]	[39.81]	[4.69]

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Robustness Check: Look-Ahead Bias

Time-to-Maturity	American Put Option Return	European Put Option Return	Spread Portfolio Return
Panel A: In-The-Money (Moneyness $>$ 1.05)			
30-60 Days	−0.195	−0.366	0.171
	[−10.46]	[−17.22]	[14.35]
60-90 Days	−0.088	−0.124	0.036
	[−5.38]	[−6.74]	[5.38]
90-120 Days	−0.045	−0.050	0.005
	[−2.70]	[−2.62]	[1.11]
Panel B: At-The-Money (Moneyness 0.95-1.05)			
30-60 Days	−0.150	−0.237	0.087
	[−5.10]	[−8.96]	[10.11]
60-90 Days	−0.057	−0.065	0.008
	[−2.31]	[−2.63]	[1.82]
90-120 Days	−0.025	−0.022	−0.003
	[−1.12]	[−0.96]	[−0.85]
Panel C: Out-Of-The-Money (Moneyness $<$ 0.95)			
30-60 Days	−0.019	−0.470	0.010
	[−0.47]	[−0.67]	[1.18]
60-90 Days	−0.026	−0.010	−0.016
	[−0.81]	[−0.29]	[−3.39]
90-120 Days	−0.017	0.012	−0.029
	[−0.57]	[0.32]	[−2.04]

- We use CRSP data to identify stocks that never paid out any cash over their entire history;

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Robustness Check: Illiquidity Effects

	American Put Liquidity								
	Low European Call Liquidity			Middle European Call Liquidity			High European Call Liquidity		
Stock Liquidity	Low	Middle	High	Low	Middle	High	Low	Middle	High
Panel A: Option Liquidity = Option Open Interest									
Low	0.106	0.088	0.106	0.074	0.066	0.067	0.055	0.062	0.055
	[5.24]	[3.73]	[6.27]	[4.27]	[4.93]	[5.33]	[4.25]	[3.32]	[2.86]
Middle	0.108	0.091	0.081	0.071	0.060	0.078	0.066	0.059	0.062
	[7.46]	[6.49]	[5.60]	[4.93]	[6.10]	[7.47]	[5.36]	[5.14]	[6.27]
High	0.097	0.074	0.087	0.066	0.087	0.054	0.079	0.061	0.050
	[8.80]	[5.86]	[7.69]	[5.48]	[5.54]	[3.50]	[5.43]	[4.33]	[4.70]

- We use option open interest scaled by dollar stock volume (or alternatively: bid-ask spreads) to proxy for option liquidity and the Amihud (2002) estimate to proxy for stock liqudity;
- For simplicity, we only use short-lived ITM options in the liquidity tests;

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Robustness Check: Trading Volume Effects

Time-to-Maturity	American Put Option Return	European Put Option Return	Spread Portfolio Return
Panel A: ITM (Moneyness $>$ 1.05)			
30-60 Days	−0.291	−0.491	0.199
	[−14.94]	[−27.56]	[15.86]
60-90 Days	−0.212	−0.272	0.060
	[−11.13]	[−14.20]	[8.50]
90-120 Days	−0.175	−0.198	0.023
	[−9.01]	[−9.59]	[5.03]
Panel B: ATM (Moneyness 0.95-1.05)			
30-60 Days	−0.241	−0.327	0.086
	[−9.08]	[−14.37]	[9.38]
60-90 Days	−0.148	−0.155	0.007
	[−6.55]	[−6.93]	[2.04]
90-120 Days	−0.114	−0.113	−0.001
	[−5.45]	[−5.04]	[−0.19]
Panel C: OTM (Moneyness $<$ 0.95)			
30-60 Days	−0.068	−0.077	0.009
	[−1.70]	[−1.89]	[0.99]
60-90 Days	−0.052	−0.029	−0.023
	[−1.56]	[−0.77]	[−3.22]
90-120 Days	0.002	−0.015	−0.016
	[0.05]	[−0.52]	[−3.16]

- At the beginning of each month t, we only include those options in our sample for which we have positive trade volume;

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Accounting for Transaction Costs

Time-to-Maturity	Monthly Spread Portfolio Return (mid Price)	Monthly Spread Portfolio Return (S=0.10)	Monthly Spread Portfolio Return (S=0.25)	Monthly Spread Portfolio Return (S=0.50)
Panel A: ITM (Moneyness $>$ 1.05)				
30-60 Days	0.190	0.163	0.121	0.050
	[16.54]	[13.14]	[8.45]	[2.67]
60-90 Days	0.045	0.010	−0.042	−0.126
	[6.91]	[1.27]	[−4.40]	[−9.02]
90-120 Days	0.009	−0.028	−0.083	−0.171
	[2.25]	[−5.51]	[−11.56]	[−15.14]
Panel B: ATM (Moneyness 0.95-1.05)				
30-60 Days	0.093	0.031	−0.066	−0.259
	[9.60]	[3.33]	[−4.91]	[−6.23]
60-90 Days	0.009	−0.055	−0.161	−0.291
	[2.10]	[−10.10]	[−11.55]	[−9.43]
90-120 Days	−0.003	−0.066	−0.168	−0.119
	[−1.24]	[−14.15]	[−15.89]	[−0.42]

- Buy at midpoint plus S times bid-ask; sell at midpoint minus S times bid-ask;

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Black-Jensen-Scholes (1972) Time-Series Tests

Model	MKT	SMB	HML	MOM	PRF	INV	Cons.
Panel A: Spread Portfolio Return							
1	0.772						0.067
	[6.76]						[12.70]
2	0.707	0.009	−0.578				0.068
	[6.14]	[0.06]	[−3.55]				[13.22]
3	0.692	0.200	−0.615	−0.143	0.392	−0.370	0.068
	[4.90]	[1.09]	[−2.51]	[−1.38]	[1.58]	[−1.13]	[12.68]
Panel B: American Put Option Return							
4	−4.560						−0.048
	[−20.39]						[−4.70]
5	−4.151	−2.018	1.004				−0.048
	[−20.38]	[−7.13]	[3.49]				[−5.28]
6	−4.149	−1.833	0.561	−0.371	0.440	0.332	−0.049
	[−16.57]	[−5.63]	[1.29]	[−2.01]	[1.00]	[0.57]	[−5.10]
Panel C: Synthetic European Put Option Return							
7	−5.333						−0.115
	[−22.24]						[−10.43]
8	−4.858	−2.027	1.581				−0.116
	[−22.74]	[−6.83]	[5.24]				[−12.16]
9	−4.841	−2.033	1.176	−0.228	0.048	0.703	−0.117
	[−18.35]	[−5.93]	[2.57]	[−1.17]	[0.10]	[1.15]	[−11.63]

Concluding Remarks

- Our theoretical and empirical work suggests that return difference between American and its equivalent European option, which we call "Early Exercise Risk Premium", is significantly positive.
- The premium also produces predicted relations with option moneyness and time-to-maturity and idiosyncratic volatility of the underlying stock;