The Early Exercise Risk Premium*

Kevin Aretz[†]
Manchester Business School
kevin.aretz@mbs.ac.uk

Ian Garrett[‡]
Manchester Business School
ian.garrett@mbs.ac.uk

Adnan Gazi[§]
Manchester Business School
adnan.gazi@mbs.ac.uk

This Draft: January 9, 2018

Abstract

We study the difference in expected returns between American and equivalent European put options to understand the asset pricing implications of the possibility to early exercise an option. Neoclassical finance theory suggests that the difference is positive, increases with option moneyness, and decreases with option time-to-maturity and the underlying asset's idiosyncratic volatility. Comparing the returns of exchange-traded single-stock American put options with the returns of equivalent synthetic European put options, our empirical work strongly supports these predictions. Our results are surprising given other studies often find investors' option exercising strategies to be non-rational.

Keywords: Empirical asset pricing; cross-sectional option pricing; put options; early exercise.

JEL classification: G11, G12, G15.

[†]Corresponding author, Booth Street, Manchester M15 6PB, UK, tel.: +44(0)161 275 6368.

[‡]Booth Street, Manchester M15 6PB, UK, tel.: +44(0)161 275 4958.

§Booth Street, Manchester M15 6PB, UK, tel.: +44(0)161 820 8344.

*We are indebted to Michael Brennan and seminar participants at Alliance Manchester Business School for many valuable and insightful suggestions.

1 Introduction

Recent empirical studies have started to identify factors pricing the cross-section of option returns. Among these factors are an option's strike price (Coval and Shumway, 2001) and the volatility of the asset underlying the option (Hu and Jacobs, 2016). Perhaps due to other studies downplaying its importance,[1] a so far neglected factor, however, is the possibility to early exercise an option. In this paper, we aim to close that gap in the literature. We offer theoretical and empirical analyses of the asset pricing implications of the possibility to early exercise an option. To this end, we contrast the expected returns of options allowing the owner to exercise the option at any time prior to and at maturity (American options) with those of equivalent options allowing the owner to exercise only at maturity (European options). We call the difference in expected returns between these options the "early exercise risk premium." Our evidence suggests that the possibility to early exercise an option has a first-order effect on the expected option return, both from a theoretical but also an empirical perspective.

We use the Longstaff and Schwartz (2001) Monte Carlo method to theoretically examine the expected return difference between American and European put options. Using that method, we simulate paths for the underlying asset value under both the physical and the risk-neutral probability measure over an option's time-to-maturity. Dividing the mean option payoff at maturity under the physical measure with the mean discounted option payoff at maturity under the risk-neutral measure, we obtain the expected return of the European option. Turning to the American option, we move backward from the option's maturity date to its initiation date, at each point in time and for each path comparing the option's early exercise payoff with its value calculated using an ordinary least-squares regression. Doing so, we delineate the early exercise boundary (i.e., the highest underlying asset value for which the option would be exercised) over the option's time-to-maturity. Dividing the mean of the compounded earliest option payoff under the physical measure with the mean of the discounted earliest option payoff under the risk-neutral measure, where the earliest payoff is the maturity payoff if there is no early exercise, we obtain the expected return of the American option.

In line with Barraclough and Whaley's (2012) intuition that early exercising a put option is equivalent to converting a risky asset into a risk-free asset, our theoretical results suggest

[1] Brennan and Schwartz (1977) and Broadie et al. (2007) offer theoretical evidence suggesting that American option prices do not greatly differ from European option prices under a wide variety of stochastic processes for the underlying asset value. Other studies, as, for example, Hu and Jacobs (2016) or Martin and Wagner (2017), have interpreted that evidence as implying that American option returns are likely to be almost identical to European option returns, so that "adjusting for early exercise has minimal empirical implications" (Hu and Jacobs (2016, p.10)). We find this interpretation surprising since a large number of empirical studies (to be reviewed below) show that American option prices significantly exceed European option prices.

that the expected returns of American put options are skewed toward the risk-free rate of return relative to those of equivalent European put options. Since the expected returns of European put options lie below the risk-free rate (Coval and Shumway, 2001), American put options thus have higher expected returns than equivalent European put options, yielding a positive early exercise risk premium. Our results further suggest that the early exercise risk premium increases with the likelihood that an American put option is early exercised. Thus, the early exercise risk premium is higher for deeper in-the-money (ITM) options, shorter time-to-maturity options, and options written on less volatile underlying assets.

We use data on exchange-traded American put options and equivalent synthetic European put options written on single stocks not paying out cash to test our theoretical predictions. We use synthetic European put options because U.S. exchanges only trade American (and not European) single-stock options. To form the synthetic options, we start from Merton's (1973) insight that it is never optimal to early exercise American call options written on assets not paying out cash. Thus, such American call options are effectively European call options. Similar to Zivney (1991), we then use the put-call parity relation to form a portfolio of one such American call option, one short share of the underlying stock, and some risk-free borrowing to replicate the equivalent European put option. We next calculate the monthly returns of the American put options as the ratio of the compounded early exercise payoff (if there is an early exercise) or the end-of-month option value (if there is no early exercise) to the start-of-month option value. We use a slightly modified version of Barraclough and Whaley's (2012) "market rule" to determine whether an early exercise occurs over the option holding period. Conversely, we calculate the monthly returns of the synthetic European put options as the percent change in the value of the replication portfolio from the start to the end of a month.

In line with our theoretical predictions, portfolio sorts and Fama-MacBeth (FM; 1973) regressions suggest a positive and both statistically and economically significant early exercise risk premium. For example, the mean spread return between short-lived ITM American put options and equivalent European put options is 19.0% per month (t-statistic: 16.54; an annualized mean spread return of 228.0%). Also in line with our theoretical predictions, the mean spread return rises with option moneyness, but drops with option time-to-maturity and the underlying asset's idiosyncratic volatility. For example, as we move the short-lived ITM options further out-of-the-money (OTM) while keeping other characteristics fixed, their mean spread return monotonically declines from 19.0% to 1.4% (t-statistic: 1.60). Similarly, as we increase the time-to-maturity of these options while keeping other characteristics fixed, their mean spread return monotonically declines from 19.0% to 0.9% (t-statistic: 2.25).

Although our empirical results on the mean spread returns between American and European put options are a striking success for neoclassical pricing theory, a separate look at the mean returns of the two types of options reveals a surprising finding. Consistent with theory, the mean returns of both American and European put options increase (i.e., become less negative) with option time-to-maturity and the underlying asset's idiosyncratic volatility. However, inconsistent with theory, they also both decrease with option moneyness. The negative relation with option moneyness is all the more surprising since it is well known that the mean returns of American index put options strongly increase with option moneyness (see, e.g., Coval and Shumway (2001), Bondarenko (2003), and Broadie et al. (2009), among others).

We next run robustness tests to address important concerns over our empirical results. An obvious concern is that, similar to other studies in our literature (as, e.g., Cao and Han (2013) and Hu and Jacobs (2016)), we only study options written on stocks ex-post known to not have paid out cash over the options' times-to-maturity, inducing look-ahead bias. To mitigate look-ahead bias, we repeat our main tests using only options written on stocks that never paid out cash over their entire history. Consistent with the idea that look-ahead bias is not severe, the early exercise risk premia estimates obtained in this robustness test are only marginally smaller than those obtained in our main tests. Another concern is that our empirical results are driven by illiquidity effects. To mitigate illiquidity effects, we sort the spread portfolios long American and short European put options into triple-sorted portfolios based on the liquidity of the assets included in the spread portfolios: the American call option, the American put option, and the stock on which the options are written. We also repeat our main tests using only options actively traded at the start of the option holding period. Both robustness tests suggest that, even when restricting our attention to liquid and actively traded stocks and options, the early exercise risk premium estimate is positive and highly significant.

We finally run time-series regressions of the American-versus-European put option spread portfolio return, the American put option portfolio return, or the European put option portfolio return on popular pricing factors, including the excess market return (i.e., the market return minus the risk-free rate of return). Consistent with theory, the European option returns are more negatively exposed to the excess market return than the American option returns, leading the spread portfolio return to be positively exposed to the excess market return. Interestingly, the European option returns are also more positively exposed to the high-minus-low book-to-market portfolio return (HML), leading the spread portfolio return to be negatively related to HML. In contrast, the spread portfolio return is not significantly related to the small-minus-big (SMB), the winners-minus-losers (MOM), the profitable-minus-unprofitable (PRF), or the non-investing/divesting-minus-investing (INV) portfolio return.

Our work is related to empirical studies investigating the spreads in prices between American options and equivalent European options ("early exercise premium"). Zivney (1991) compares the prices of traded American S&P 500 call or put options with those of equivalent synthetic European options derived from put-call parity. Closer to us, de Roon and Veld (1996) apply Zivney's (1991) methodology to American call and put index options for which it is never optimal to early exercise the call options, allowing them to more precisely estimate the early exercise premium. Similarly, Engström and Nordén (2000) apply the same methodology to Swedish single-stock call and put options for which it is never optimal to early exercise the call options. McMurray and Yadav (2000) compare the prices of traded American and European FTSE 100 options, keeping maturity times, but not strike prices constant. In line with theory, the studies find a significantly positive early exercise premium. In contrast, we study the spread in expected returns (not prices) between American and European options. Since the ability to early exercise affects both an option's expected payoff and its price, the expected return spread does not follow mechanically from the price spread. In fact, our results suggest that the sign of the expected return spread between the two types of options is opposite of what one would expect if expected returns were exclusively driven by prices.

Our work is also related to studies identifying factors pricing the cross-section of option returns. Using a stochastic discount factor model, Coval and Shumway (2001) show that the expected returns of European call (put) options lie above (below) the risk-free rate of return and decrease (increase) with option moneyness. They further report that S&P 500 option data support these predictions. Using a Black and Scholes (1973) contingent claims framework, Hu and Jacobs (2016) show that the expected returns of European call (put) options decrease (increase) with the underlying asset's volatility. Using a stochastic discount factor model, Aretz et al. (2016), however, show that Hu and Jacobs (2016) conclusions only hold for variations in the underlying asset's volatility driven by idiosyncratic volatility. They note that variations driven by systematic volatility can either increase or decrease the expected returns of both European call and put options depending on option moneyness. Other studies focus on factors pricing the cross-section of *delta-hedged* option returns (i.e., option returns not driven by the stock price). Goyal and Saretto (2009) show that delta-hedged option returns increase with the difference between the realized and the implied volatility of the underlying asset. Cao and Han (2013) report that delta-hedged option returns decrease with the idiosyncratic volatility of the underlying asset. We add to these studies by focusing on another factor potentially pricing the cross-section of option returns: the ability to early exercise an option.

Our work is also relevant for studies evaluating investors' early exercise strategies. Overdahl and Martin (1994) show that the majority of early exercises of single-stock call and put options fall within theoretical early exercise boundaries, suggesting that early exercise policies are rational. In contrast, Brennan and Schwartz (1977) find that the early exercises of American put options often deviate from the optimal policies suggested by the Black and Scholes (1973) framework. Finucane (1997) shows that investors often early exercise call options written on non-cash paying underlying assets, conflicting with Merton's (1973) insight that such options should never be early exercised. Extending Finucane's (1997) analysis, Poteshman and Serbin (2003) show that only individual (but not institutional) investors sometimes early exercise the former call options. Pool et al. (2008) estimate that the total foregone profits from failing to optimally early exercise single-stock call options on ex-dividend dates amount to $491 million over the 1996-2006 period. Barraclough and Whaley (2012) show that the forgone profits from failing to optimally early exercise single-stock put options are similarly large. Eickholt et al. (2014) report that the failure to optimally early exercise putable German government bonds can be explained by investor irrationality, transaction costs, and a demand for liquidity and financial flexibility. More generally, Bauer et al. (2009) show that retail investors do not perform well in trading options. Given this evidence, it is an open question whether neoclassical finance theory has any power to correctly predict the asset pricing implications of the possibility to early exercise an option. Perhaps surprisingly, we find that it does.

We proceed as follows. Section 2 employs the Longstaff and Schwartz (2001) Monte-Carlo method to theoretically study the early exercise risk premium. In Section 3, we outline our data and methodology. Section 4 discusses our main empirical results obtained from portfolio sorts and FM regressions. In Section 5, we offers the results of robustness tests. Section 6 gives the results from time-series asset pricing tests. Section 7 summarizes and concludes.

2 Theory

In this section, we offer a theoretical analysis of the asset pricing implications of the possibility to early exercise a put option. We first explain how we use the Longstaff and Schwartz (2001) model to calculate the expected returns of American and European put options. We then study the difference in expected returns between these types of options, varying option moneyness, option time-to-maturity, and the volatility of the primitive (underlying) asset.

2.1 Calculating Expected Option Returns

We use the Longstaff and Schwartz (2001) Monte-Carlo simulation approach to calculate the expected returns of American and European put options written on non-cash paying primitive assets. To understand how this approach works, assume a primitive asset and an American or European put option written on that asset. Denote the initial (time = 0) value of the primitive asset by V_0. Under the physical (real-world) probability measure $\mathcal{P}$, assume that the value of the primitive asset evolves according to Geometric Brownian motion (GBM):

$$dV = \mu V dt + \sigma V dW, \tag{1}$$

where V, μ, and σ are the current value, expected return, and volatility of the primitive asset, respectively, and W is a Wiener process. Under the equivalent martingale measure $\mathcal{Q}$ (which rules out arbitrage opportunities), the value of the primitive asset also obeys Equation (1), but with μ replaced by the risk-free rate of return r. Denote the strike price of the option by K and its time-to-maturity by T. Finally, if the option is American, assume it can only be exercised at the finite number of times $0 = t_0 < t_1 < t_2 ... < t_{k-1}$, with $t_{k-1} < t_k = T$.

To value the two types of options, we simulate q paths for the primitive asset's value under the $\mathcal{Q}$ measure, observing the primitive asset's value at times $t_1, t_2, \ldots, t_{k-1}, t_k = T$. We next calculate the maturity payoff of the option for each path. The maturity payoff is $\max(K - V_T, 0)$, where V_T is the maturity value of the primitive asset. To value the European option, we take a simple average of its maturity payoffs. To value the American option, we move to time t_{k-1} and compare the early exercise payoff with the value of holding on to the option ("continuation value") for each path. The early exercise payoff is $\max(K - V_{t_{k-1}}, 0)$, where V_{k-1} is the value of the primitive asset at time t_{k-1}. To estimate the continuation value, we run a cross-sectional regression of the maturity payoffs discounted back to time t_{k-1} on some function (e.g., a higher-order polynomial) of the values of the primitive asset at time t_{k-1}, treating the fitted regression value as the continuation value.[2] The value of the American option for a path at time t_{k-1} is then the maximum of the early exercise payoff and the continuation value.

Moving to time t_{k-2}, we run a cross-sectional regression of the future American option payoff discounted back to time t_{k-2} on the functional form of the value of the primitive asset at time t_{k-2} to estimate the continuation value at that time. In this case, however, the future option payoff is either the early exercise payoff (if the option is early exercised at time t_{k-1}) or

[2]To avoid estimation bias, Longstaff and Schwartz (2001) recommend running the regression using only simulated values for which the American put option is ITM at time t_{k-1}.

the maturity payoff (if the option is held until maturity). As before, the value of the American option for a path at time t_{k-2} is then the maximum of the early exercise payoff and the continuation value. We proceed in that way until we reach time t_0, always regressing the discounted future early exercise payoff from the earliest early exercise (if there is an early exercise) or the discounted future maturity payoff (if there is no early exercise) on the functional form of the primitive asset value and choosing the maximum of the early exercise payoff and the fitted regression value as the option value for a path at that time. Doing so, we are able to delineate the optimal early exercise boundary (i.e., the highest primitive asset value for which the option would be early exercised) over the options' time-to-maturity.

Having valued the two types of options, it is easy to calculate their expected payoffs. To do so, we first convert each path for the primitive asset's value under the $\mathcal{Q}$ measure into its corresponding path under the $\mathcal{P}$ measure, recording the first time the converted primitive asset value drops below the optimal early exercise boundary. We then calculate the expected payoff of the European put option as the mean of the option's maturity payoff under the $\mathcal{P}$ measure. In the same vein, we also calculate the expected payoff of the American put option as the mean of its payoff under the $\mathcal{P}$ measure. In case of the American put option, the payoff is, however, either the earliest early exercise payoff compounded to maturity (if there is an early exercise) or the maturity payoff (if there is no early exercise). In either case, the expected option return is then the expected option payoff scaled by option value. We annualize the expected option return by scaling it by an option's time-to-maturity (in years).

In our simulations, we calculate the expected option return using one million simulated paths, each featuring a number of time steps equal to an option's days-to-maturity. We use a third-order polynomial to estimate the continuation value of the option.

2.2 The Early Exercise Risk Premium

Table 1 shows the expected payoffs, values, and annualized net expected returns of American and European put options calculated using the approach in Section 2.1. To calculate the table entries, we set the initial value of the primitive asset (V_0) to 40 and its expected return (μ) to 12% per annum. We vary the standard deviation of the primitive asset from 20% to 40% per annum, in 10% increments. The risk-free rate of return is 4% per annum. We vary the strike price of the options (K) from 36 to 44, in increments of four. We vary the time-to-maturity (T) of the options from half a year to one-and-a-half years, in increments of half a year. In line with other studies, we define an option's moneyness as the ratio of its strike price to the initial value of the primitive asset (K/V_0). We refer to options with a moneyness above one as in-the-money

("ITM") options, to options with a moneyness of one as at-the-money ("ATM") options, and to options with a moneyness below one as out-of-the-money ("OTM") options.

TABLE 1 ABOUT HERE

The table suggests that American put options have consistently higher (i.e., less negative) net expected returns than equivalent European put options, yielding a positive early exercise risk premium (see column (9)). The positive sign of the premium is the result of a trade-off between the different effects of the possibility to early exercise on the expected payoff and on the value of the options. The expected payoffs of the American options consistently exceed those of the equivalent European options, suggesting that the ability to exercise early allows investors to increase expected option payoffs (compare columns (1) and (4)). However, the values of the American options also consistently exceed those of the equivalent European options, consistent with the idea that an American option can be seen as a European option plus the right to exercise early (compare columns (2) and (5)). Recalling that the early exercise risk premium is the ratio of the expected American option payoff to the American option value (the gross expected return of the American put option) minus the ratio of the expected European option payoff to the European option value (the gross expected return of the European put option), the higher expected American option payoffs increase the premium, while the higher American option values decrease the premium. The positive effect induced through the higher expected payoffs, however, consistently dominates the negative effect induced through the higher values in our calculations, in turn producing a positive early exercise risk premium.

Table 1 and Figure 1 suggest that the early exercise risk premium relates to both option and primitive asset characteristics. Panel A of the figure shows that the expected returns of American and European put options are similar at low moneyness levels and that both increase with the strike price. The expected returns of the American options, however, increase at a faster pace, causing the early exercise risk premium to be positively related to moneyness. For example, considering one-year options written on a primitive asset with a volatility of 0.30, Table 1 shows that the early exercise risk premium is 8.4% for options with a strike price-to-primitive asset price ratio of 1.10, 6.7% for options with a ratio of 1.00, and 5.3% for options with a ratio of 0.90 (all per annum; see Panels A, B, and C, respectively). Similarly, Panel B of Figure 1 shows that the expected returns of long-lived American and European put options are similar, but that the expected returns of American put options drop faster with decreases in the time-to-maturity than the expected returns of American options. Thus, the early exercise risk premium relates negatively to time-to-maturity. For example, considering ATM options

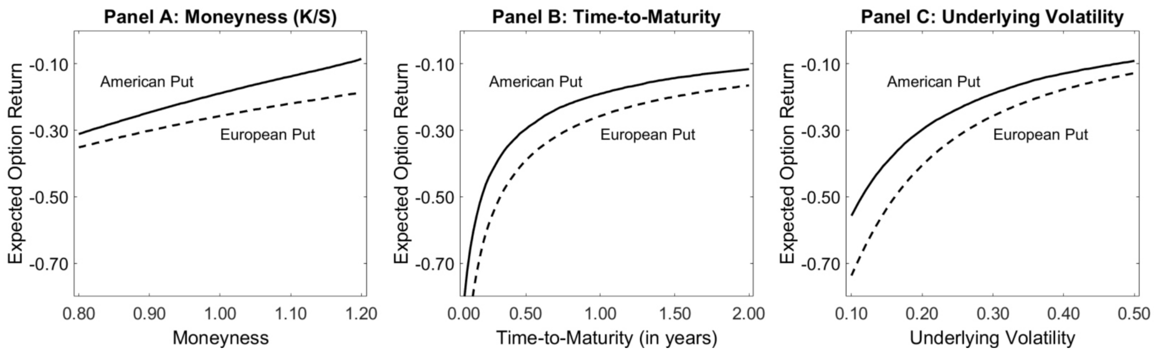

Figure 1: Comparative Statics The figure plots the expected returns of an American put option and an equivalent European put option against the options' moneyness (Panel A), their time-to-maturity (Panel B), and the idiosyncratic volatility of the underlying asset (Panel C). We use the following base case parameters: The initial value of the underlying asset is 40. The expected return of the underlying asset is 12% per annum, while its volatility is 30% per annum. The risk-free rate of return is 4% per annum. The options' strike price is 40 and their time-to-maturity one year. In Panel A, we let the strike price range from 32 to 48, leading moneyness (the strike price-to-stock price ratio) to range from 0.80 to 1.20. In Panel B, we let time-to-maturity range from 0.083 to two years. In Panel C, we let idiosyncratic volatility range from 10% to 50% per annum.

written on a primitive asset with a volatility of 0.30, Table 1 shows that the early exercise risk premium is 9.5% for half-a-year options, 6.7% for one-year options, and 5.6% for one-and-a-half year options (see Panel B). Panel C of Figure 1 finally suggests that the expected returns of American and European put options are similar for options written on volatile primitive assets, but that the expected returns of European drop faster with decreases in primitive asset volatility than the expected returns of American options. Thus, the early exercise risk premium relates negatively to primitive asset volatility. For example, considering one-year ATM options, Table 1 shows that the early exercise risk premium is 10.4% for a volatility of 0.20, 6.7% for a volatility of 0.30, and 4.8% for a volatility of 0.40 (see Panel B).

The nature and behavior of the early exercise risk premium is perhaps easiest to understand by thinking about the dynamic replication portfolio of a put option. At each point in time, this portfolio is long cash and short a fraction of the primitive asset, with the fraction shorted rising toward one the more the option moves ITM. In the absence of arbitrage, the expected put option return is equal to the expected return of the dynamic portfolio. The early exercise of a put option converts the option into cash, eliminating the need for the replication portfolio to be short the primitive asset. Thus, upon an early exercise, the replication portfolio is completely re-balanced toward cash, implying that the expected portfolio return changes to the risk-free rate of return. A positive probability of an early exercise therefore shifts the expected American put option return from the expected return of the equivalent European put option upward toward the risk-free rate of return, leading to a positive early exercise risk premium.

The relations between the early exercise risk premium and the primitive asset and option characteristics follow from the effects of the characteristics on the probability of an option being early exercised. A higher option moneyness, a shorter option time-to-maturity, and a lower primitive asset volatility all raise 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 and rendering the early exercise risk premium more positive.[3] That a higher primitive asset volatility leads to a lower probability of an early exercise is consistent with a large real options literature showing that uncertainty leads economic agents to adopt a "wait-and-see" policy (e.g., MacDonald and Siegel (1986), Dixit and Pindyck (1994), and Bloom (2009)).

3 Data and Methodology

In this section, we describe our data and methodology. We first introduce our option data and option data filters. We next explain how we calculate the returns of American and synthetic European put options, allowing for early exercise of the American options.

3.1 Data

We obtain daily data on American single-stock call and put options and on the single stocks underlying the options from Optionmetrics. For reasons described below, our data only include options written on single stocks not paying out a (cash) dividend up until the option maturity date. We retrieve risk-free rates of return from the zero coupon yield curves in Optionmetrics, always using the risk-free rate with maturity date closest to the date of a cash flow to compound or discount the cash flow. Our sample period is January 1996 to April 2016.

We follow Goyal and Saretto (2009) and Cao and Han (2013) in applying filters to our data. In particular, we exclude observations for which the option price violates standard

[3] We remind our readers that we examine the relations between *annualized* expected options returns and primitive asset and option characteristics. Because a longer time-to-maturity can make it more likely that an option is early exercised over the remaining time-to-maturity, the relation between the early exercise risk premium calculated from non-annualized expected option returns and time-to-maturity can possibly be positive. That the relation between the early exercise risk premium calculated from annualized expected option returns and time-to-maturity is consistently negative results from the fact that, while increasing the early exercise probability over the remaining time-to-maturity, a longer time-to-maturity always decreases the early exercise probability over the initial year. The lower probability over the initial year is driven by the fact that the longer time-to-maturity decreases the early exercise boundary at all times before maturity, but more pronouncedly at times further away from maturity (see, e.g., Shreve (2004, Chapter 9)).

arbitrage bounds (as, e.g., the bound that the call option price needs to exceed the value of the equivalent long forward contract). We further exclude observations (i) for which the option price is below $\$\frac{1}{8}$ or less than one-half of the option bid-ask spread; (ii) for which the option bid-ask spread is negative; or (iii) for which the underlying stock's price is missing.

3.2 Calculating Synthetic European Option Prices

We require the prices of both American and European single-stock put options to estimate the early exercise risk premium. While American single-stock options are traded in option exchanges, implying that their prices are directly observable, there are, unfortunately, no European single-stock options traded in exchanges.[4] To compute their prices, we thus create *synthetic* European single-stock put options by trading in single-stock call options, the underlying stock, and the money market. To understand how this works, recall that we restrict our sample to options written on stocks not paying out cash until the option maturity date. Since it is never optimal to early exercise American call options on such stocks (Merton, 1973), the American call options in our sample are equivalent to European call options, allowing us to treat their prices as European call option prices. We next combine the prices of the American call options in our sample with the prices of their underlying stocks and the options' discounted strike prices to calculate the prices of synthetic European put options on the same stock and with the same strike price and maturity time as the American call options using:

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

where $P^{synE}_{i,K,T}$ is the price of a synthetic European put option written on stock i and with strike K and maturity T, $C^{A}_{i,K,T}$ is the price of the exchange-traded American call option equivalent to a European call option, V_i is stock i's price, and r is the risk-free rate of return. The literature typically refers to Equation (2) as put-call parity for European options.

We impose several filters on the synthetic European put option prices. To mitigate market microstructure noise (including, e.g., Keim and Stambaugh (1984) bid-ask bounce producing unreasonably high synthetic option returns), we exclude synthetic options with a price below \$1, accounting for about 0.5% of our sample. We also exclude observations for which the synthetic European put option price exceeds the price of the equivalent American put option (suggesting a negative early exercise value) or violates standard arbitrage bounds.

[4] European single-stock options are traded over-the-counter.

3.3 Calculating Option Returns

We calculate option returns over the holding period from the end of month $t-1$ to the end of month t. Assuming that an option is not exercised early during the holding period, the option return is the percentage change in the option price over the period. Assuming that an option is exercised early, the option return is the ratio of the early exercise payoff compounded to the end of the holding period to the option price at the start of that period minus one.

To find out whether an option is exercised early, we look at the entire history of the option's and the underlying stock's end-of-trading-day prices over the holding period, essentially only allowing for early exercises at the end of the trading day. We next assume that an early exercise takes place when the early exercise payoff comes within a five percent interval around the option price. Mathematically, we assume an early exercise takes place if:

$$1.05 \times \max(K - V_t, 0) \geq P_t^A, \tag{3}$$

where $\max(K - V_t, 0)$ is the early exercise payoff and P_t^A the American put option price, both at the end of trading day t within the holding period. We scale up the early exercise payoff to be conservative in capturing early exercises. In an arbitrage-free market, an American option would never sell for less than its early exercise payoff. Given minimum tick size rules in stock and options markets, it is thus possible that the early exercise payoff never converges to the traded price of an American option. To avoid this problem, we thus only require the early exercise payoff to become sufficiently close to the American option price for us to assume that early exercise takes place. We later conduct robustness tests varying the scaling factor.

4 Main Results

In this section, we offer our main empirical results. We first give descriptive statistics analyzing the sign of the early exercise risk premium (i.e., the mean spread return between equivalent American and European put options). We next provide the results from portfolio sorts studying how the early exercise risk premium relates to option moneyness and time-to-maturity and the idiosyncratic volatility of the underlying stock. We finally assess the robustness of the results obtained from the portfolio sorts using Fama-MacBeth (1973) regressions.

4.1 The Sign of the Early Exercise Risk Premium

In Table 2, we offer descriptive statistics on the monthly returns of our American put options, of our synthetic European put options, and of spread portfolios long an American option and short its equivalent European synthetic option. The table also offers information about the moneyness (option strike price dividend by underlying stock's price) and time-to-maturity (in days) of the options. The descriptive statistics include the number of observations (Obs), the mean, the standard deviation (StDev), the t-statistic of the mean (M/StE), and the first, fifth, 25th, 50th (Median), 75th, 95th, and 99th percentiles. With the exception of the number of observations, the descriptive statistics are time-series averages of cross-sectional statistics taken by sample month. As a result, we can interpret the means of the return variables as the mean returns of equally-weighted portfolios invested into the American or the European options or the mean return of a spread portfolio long the equally-weighted American- and short the equally-weighted European option portfolio. In accordance, we can interpret the t-statistics of the mean return variables as statistical tests of the hypothesis that the mean portfolio or spread portfolio returns are significantly different from zero.

TABLE 2 ABOUT HERE

Table 2 shows that our sample contains an average of $3,303$ option observations in each sample month. Consistent with Coval and Shumway (2001), the mean returns of the American and European put options are significantly negative, with the American put options yielding a mean return of -7.4% (t-statistic: -4.41) and the European put options a mean return of -14.5% (t-statistic: -7.62), both per month. Supporting our theory, the spread between the two mean returns, our estimate of the early exercise risk premium, is positive (7.1%) and highly significant (t-statistic: 12.53). The high significance of the mean spread portfolio return compared to the significance of the mean returns of the American or European option portfolios is largely due to the spread portfolio return being less volatile than the return of either the American or the European option portfolio (annualized standard deviation of 31.2% compared to 58.9% and 62.9%, respectively). The relatively low volatility of the mean spread portfolio return indicates that the returns of the American and European option portfolios are highly positively correlated due to exposure to the same underlying stocks.

Figure 2 plots the cumulative profits from taking a one-dollar short position in American put options (Panel A), a one-dollar short position in synthetic European put options (Panel B), and a one-dollar long position in American put options and one-dollar short position in equivalent

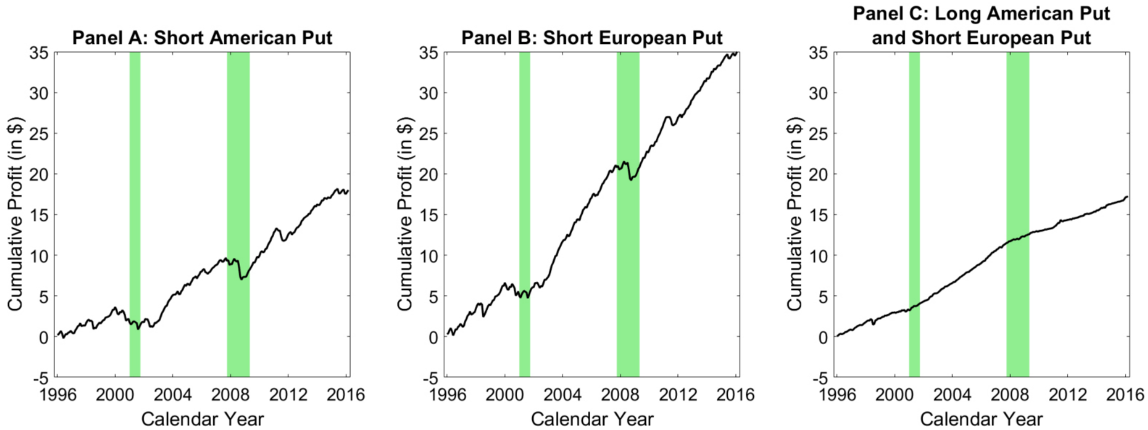

Figure 2: Cumulative Profits of American and European Put Options The figure plots the cumulative profits from taking a one-dollar short position in American put options (Panel A), a one-dollar short position in synthetic European put options (Panel B), or a one-dollar long position in American put options and a one-dollar short position in equivalent synthetic European put options (Panel C) at the start of each month in our sample period. We hold the short position or the position in the spread portfolio for one month. The green areas are NBER defined recessions periods.

synthetic European put options (Panel C) at the start of each sample month. We hold the short positions or the position in the spread portfolio for one month. The green shaded areas are NBER defined recession periods. Panels A and B confirm that selling either American or European put options is extremely profitable in most months. The exceptions are recession months in which the majority of put options are exercised against their sellers (see the 2000-2001 "burst of the Internet bubble" or the 2007-2008 global financial crisis periods). The accumulated profits from selling European options, however, greatly exceed those from selling American options, so that the spread portfolio also yields a significant profit (see Panel C). Consistent with our prior evidence, the profits obtained from trading the spread portfolio are, however, far less volatile than the profits from shorting either of the two types of options.

The final two columns in Table 2 show that most of our sample options are close to at-the-money. Despite that, a small number of options are either deep in-the-money or deep out-of-the-money. For example, about five percent of our options have a strike price-to-stock price ratio exceeding 1.50. About the same percent have a ratio falling short of 0.85. The median option has a time-to-maturity of about two-and-a-half months (80 calendar days), with the time-to-maturity of our sample options ranging from six weeks to about four months.

4.2 The Premium's Relations with Option Characteristics

In Table 3, we examine how the early exercise risk premium relates to the moneyness and time-to-maturity of an option. We do so as follows. At the end of each month $t-1$ in our sample period, we form spread portfolios long an American put option and short its equivalent synthetic European put option. We sort the spread portfolios into bivariately sorted portfolios according to the moneyness and time-to-maturity of the options in each spread portfolio. More specifically, we sort the spread portfolios into an ITM (strike price-to-stock price above 1.05), an ATM (0.95–1.05), and an OTM portfolio (below 0.95). Within each moneyness portfolio, we sort the spread portfolios into three time-to-maturity portfolios based on whether the options in a spread portfolio have a time-to-maturity below 60 days, between 60 and 90 days, and above 90 days. We equally-weight the spread portfolios in each bivariately sorted portfolio and hold the bivariately sorted portfolios over month t. The plain numbers in the table are the mean monthly portfolio returns; the numbers in square parentheses are t-statistics, calculated using Newey and West (1987) standard errors with a lag length of twelve months.

Table 3 About Here

Table 3 shows that most bivariately sorted portfolios yield a significantly positive early exercise risk premium. The exceptions are portfolios comprising OTM options with a long time-to-maturity, which can produce a significantly negative early exercise risk premium. For example, the portfolio of OTM options with a time-to-maturity above 90 days yields a –1.4% mean spread return per month (t-statistic: –3.84). Notwithstanding the often high significance of the negative mean spread returns, the negative mean spread returns are, in general, several magnitudes smaller than the largest positive returns. For example, while the most positive early exercise risk premium in the table is 19.0% per month (30-60 day ITM options), the most negative early exercise risk premium is only –1.4% (60-90 day OTM options).

Despite the possibility of a negative early exercise risk premium, the table confirms our theoretical predictions about the relations between the early exercise risk premium and the moneyness or time-to-maturity of an option. Keeping time-to-maturity constant, the early exercise risk premium monotonically declines as an option moves from ITM to OTM, with the premium, for example, dropping from 19.0% per month for 30-60 day ITM options (t-statistic: 16.54) to 1.4% for 30-60 day OTM options (t-statistic: 1.60). Keeping moneyness constant, the early exercise risk premium monotonically declines with an option's time-to-maturity, with the premium, for example, dropping from 9.3% per month for 30-60 day ATM options (t-statistic:

9.60) to –0.3% for 90-120 day ATM options (t-statistic: –1.24).

While the portfolio sorts confirm our theoretical predictions about how the early exercise risk premium relates to option characteristics, a closer look at the relations between the mean returns of the American or European options and the same characteristics reveals a surprising finding. Consistent with our simulation evidence in Table 1, the mean returns of both types of options become less negative with time-to-maturity. However, inconsistent with the simulation evidence and the seminal theoretical work of Coval and Shumway (2001), their mean returns also become more negative as the options move from ITM to OTM.

4.3 The Premium's Relations with Stock Characteristics

In Table 4, we investigate how the early exercise risk premium relates to the idiosyncratic volatility of the stock on which the options are written. We do so as follows. At the end of each month $t-1$, we sort the spread portfolios long an American put option and short the equivalent synthetic European put option into portfolios according to the quintile breakpoints of the underlying stock's idiosyncratic volatility in that month. The first portfolio ("Low") contains options written on stocks with a low idiosyncratic volatility, whereas the last portfolio ("High") contains options written on stocks with a high idiosyncratic volatility. We also form a spread portfolio long the last portfolio and short the first portfolio ("H–L"). We equally-weight the quintile portfolios and the spread portfolio and hold them over month t.

TABLE 4 ABOUT HERE

We estimate a stock's idiosyncratic volatility using either the market model (Panel A) or the Fama-French-Carhart (FFC; 1997) model (Panel B). In case of the market model, we obtain an estimate for stock i in month $t-1$ from the time-series regression:

$$R_{i,\tau} = \alpha_{i,t-1} + \beta_{i,t-1}^{mkt}(R_{\tau}^{mkt} - Rf_{\tau}) + \epsilon_{i,\tau}, \tag{4}$$

where $R_{i,\tau}$ is stock's i's return in month τ, $R_{\tau}^{mkt} - Rf_{\tau}$ is the excess market return (i.e., the market return minus the risk-free rate of return), $\alpha_{i,t-1}$ and $\beta_{i,t-1}^{mkt}$ are parameters, and $\epsilon_{i,\tau}$ is the residual. In case of the FFC model, we obtain an estimate from the regression:

$$R_{i,\tau} = \alpha_i + \beta_{i,t-1}^{mkt}(R_{\tau}^{mkt} - Rf_{\tau}) + \beta_{i,t-1}^{smb}R_{\tau}^{smb} + \beta_{i,t-1}^{hml}R_{\tau}^{hml} + \beta_{i,t-1}^{mom}R_{\tau}^{mom} + \epsilon_{i,\tau}, \tag{5}$$

where R_{τ}^{smb}, R_{τ}^{hml}, and R_{τ}^{mom} are the returns of spread portfolios on size, the book-to-market ratio, and the eleven-month (momentum) past return, respectively, and $\beta_{i,t-1}^{smb}$, $\beta_{i,t-1}^{hml}$, and $\beta_{i,t-1}^{mom}$ are additional parameters. We estimate the regressions using monthly data over the sample period from $\tau = t - 60$ to $\tau = t - 1$. The market and FFC model idiosyncratic volatilities of stock i in month $t - 1$ are then the volatilities of the residuals from regressions (4) and (5), respectively, calculated over the estimation period from $\tau = t - 60$ to $t - 1$.

Table 4 shows the mean monthly returns of the portfolios of spread portfolios sorted on idiosyncratic volatility, with t-statistics, calculated using Newey and West's (1987) formula with a lag length of twelve, in square parentheses. Supporting our theoretical predictions, the mean portfolio return (i.e., the mean spread return between American and equivalent European put options) monotonically declines with both market and FFC model idiosyncratic volatility. Using the market model to estimate idiosyncratic volatility, the mean portfolio return drops from 9.5% per month for options on low idiosyncratic volatility stocks (t-statistic: 11.28) to 4.3% for options on high idiosyncratic volatility stocks (t-statistic: 6.60). The difference is a highly significant −5.2% per month (t-statistic: −7.56). Using the FFC model to estimate idiosyncratic volatility, the difference is a highly significant −4.7% per month (t-statistic: −7.26).

Separately studying the American and European put options in the spread portfolios, the mean returns of both types of options monotonically increase with market and FFC model idiosyncratic volatility, consistent with our theoretical predictions. Our evidence that the mean returns of American put options increase with idiosyncratic volatility is in line with Hu and Jacobs (2016), who also find a positive relation. Despite that, a major difference between their work and ours is that they do not allow for early exercises of the American options.

4.4 Fama-MacBeth (1973) Regressions

In Table 5, we show the results of FM regressions studying the effects of option moneyness, option maturity, and underlying asset idiosyncratic volatility on the early exercise risk premium. The endogenous variable is either the return of a spread portfolio long an American put option and short the equivalent European put option (Panel A), the American put option return (Panel B), or the European put option return (Panel C). The returns are calculated over month t. The exogenous variables are subsets of option moneyness (the strike price-to-the stock price), option maturity (in years), and the FFC idiosyncratic volatility of the underlying stock, all measured using data until the end of month $t - 1$. We always include a constant. The plain numbers in the table are the mean estimates from cross-sectional regressions of returns on the exogenous variables; the numbers in square parentheses are t-statistics, calculated using

Newey and West (1987) standard errors with a lag length of twelve months.

TABLE 5 ABOUT HERE

The FM regressions corroborate the results from the portfolio sorts. Using only a constant as exogenous variable, the mean spread portfolio return is positive (7.1% per month) and highly significant (t-statistic: 12.66; see model (1)). Either separately or jointly adding option moneyness, option maturity, and idiosyncratic volatility, the mean spread portfolio return is consistently positively related to moneyness (t-statistic about 22.50), while it is consistently negatively related to time-to-maturity (t-statistic about –22.00) and idiosyncratic volatility (t-statistic –11.43; see models (2)–(3)). In the remaining models, we estimate the slope coefficients of the exogenous variables separately for the American and the European put options. The differences in the slope coefficients between the two types of options are, by construction, the slope coefficients of the spread portfolio. For example, the difference between the moneyness coefficient of the American options in model (5), –0.07, and the moneyness coefficient of the European options in model (8), –0.30, is the moneyness coefficient of the spread portfolios in model (2), 0.23. Consistent with our prior evidence and our theoretical predictions, the mean returns of the American and European put options increase with both option time-to-maturity and the idiosyncratic volatility of the underlying stock at high significance levels. The exception are the American options, which produce a positive, albeit insignificant relation with idiosyncratic volatility (t-statistic: 0.48). Consistent with our prior evidence but inconsistent with theory, the mean returns of both types of options also decrease with option moneyness, with only the European options, however, producing significant relations.

5 Robustness

In this section, we offer robustness tests to address several important concerns over our empirical results in Section 4. We first verify that our results continue to hold for the subset of options written on stocks that never paid out cash over their entire history. We next verify that our results continue to hold for subsets of highly liquid stocks and options. We finally verify that our results continue to hold for options actively traded at the start of the holding period.

5.1 Look-Ahead Bias

Similar to other studies in the cross-sectional option pricing literature (e.g., Cao and Han (2013) and Hu and Jacobs (2016)), we only use options written on stocks *ex-post known* to not have paid out cash over the options' times-to-maturity in our tests. As a result, our tests suffer from look-ahead bias. To assess the magnitude of the look-ahead bias, we next repeat the portfolio sorts in Table 3 on the subsample of options written on stocks that never paid out cash over their entire history up to the portfolio formation month $t-1$. To identify that subsample, we look at the monthly history of payout yields for each stock in our sample, defining the payout yield as the difference between the total return and the return excluding payouts (CRSP item *ret* minus CRSP item *retx*). We then choose only those options written on stocks for which the stocks' payout yields are consistently equal to zero up to month $t-1$, reducing our sample size from 802,584 to 546,395 observations (a reduction of about 32%).

Table 6 suggests that look-ahead bias only has a minor effect on our results. The design of the table is identical to that of Table 3, with plain numbers being mean monthly spread portfolio returns and the numbers in square parentheses t-statistics calculated using Newey and West's (1987) formula. Even after restricting our sample to options written on stocks that never paid out cash over their entire lifetime, the spread portfolios still yield early exercise risk premia close to those in Table 3. Moreover, the early exercise risk premia produce the same patterns with option moneyness and option time-to-maturity as in Table 3. For example, only considering 30-60 days-to-maturity options, the early exercise risk premium drops from 17.1% (t-statistic: 14.35) for ITM options to 1.0% (t-statistic: 1.18) for OTM options, almost identical to the corresponding drop in Table 3 (from 19.0% to 1.4%). As another example, only considering ATM options, the premium drops from 8.7% (t-statistic: 10.11) for 30-60 days-to-maturity options to -0.3% (t-statistic -0.85) for 90-120 days-to-maturity options, almost identical to the corresponding drop in Table 3 (from 9.3% to –0.3%).

TABLE 6 ABOUT HERE

5.2 Illiquidity Effects

Each synthetic European put option used in our tests is a portfolio of an American call option, a short share of the underlying stock, and some risk-free borrowing. Since stock and money markets are more liquid than option markets, it is thus likely that the replication portfolio is more liquid (in aggregate) than the asset with which we compare the portfolio: the American put option. Given that Amihud and Mendelson (1986), Brennan and Subrahmanyam (1996), and others find that expected asset returns decrease with liquidity, another concern is that the positive early exercise risk premium that we discover in our main tests simply reflects a lower liquidity of the American put options relative to the synthetic European put options.

To mitigate that concern, we sort the spread portfolios long an American put option and short its equivalent synthetic European put option into independently triple-sorted portfolios based on the liquidity of each asset in a spread portfolio. To immediately start from a subsample of liquid options, we restrict our attention to spread portfolios formed from 30-60 days-to-maturity ATM options at the end of month $t-1$. We then sort these spread portfolios into tercile portfolios based on the liquidity of the American put option. We simultaneously sort the spread portfolios into tercile portfolios based on the liquidity of the American call option and, then again, based on the liquidity of the underlying stock. We thus end up with $3 \times 3 \times 3 = 27$ triple-sorted portfolios. We equally weight the portfolios and hold them over month t.

We use two alternative variables to measure the liquidity of the two types of options. Our first variable is the scaled option open interest, $ScaledOpenInterest$, defined as:

$$ScaledOpenInterest_{i,t} = \frac{OpenInterest_{i,t}}{StockVol_{i,t}}, \tag{6}$$

where $OpenInterest_{i,t}$ is the open interest of option i at the end of month t, and $StockVol_{i,t}$ is the dollar trading volume of the stock underlying the option. Our second variable is the scaled option bid-ask spread, $BidAskSpread$, defined as:

$$BidAskSpread_{i,t} = \frac{Bid_{i,t} - Ask_{i,t}}{(Bid_{i,t} + Ask_{i,t})/2} \tag{7}$$

where $Bid_{i,t}$ is the bid price of option i at the end of month t, and $Ask_{i,t}$ is the ask price. We measure the liquidity of the stock using the Amihud (2002) proxy, $Iliqudity$, defined as:

$$Illiquidity_{i,t} = \frac{\sum_{d=1}^{n} |R_{i,d}|/Vol_{i,d}}{n}, \tag{8}$$

where $|R_{i,d}|$ is the absolute daily return of stock i over day d, $Vol_{i,d}$ is the dollar trading volume, and the sum is taken over the n trading days in month t. While a higher $ScaledOpenInterest$ indicates a higher option liquidity, a higher $BidAskSpread$ indicates a lower option liqudity and a higher $Illiquidity$ a lower stock liquidity (see Cao and Han (2013)).

Table 7 shows the mean monthly returns of the triple-sorted portfolios, with t-statistics calculated using Newey and West's (1987) formula with a lag length of twelve months in squared parentheses. Panel A uses open interest to measure an option's liquidity, while Panel B uses the bid-ask spread. The table suggests that the early exercise risk premium remains positive and both statistically and economically significant even when we consider spread portfolios formed from only (relatively) liquid assets. For example, Panel A shows that the early exercise risk premium is 5.0% (t-statistic: 4.70) when calculated from American call and put options with an open interest above the third tercile and stocks with an Amihud (2002) liquidity proxy value below the third tercile. Similarly, Panel B shows that the premium is 9.4% (t-statistic: 7.32) when calculated from American options with a bid-ask spread below the third tercile and stocks with an Amihud (2002) liquidity proxy value below the third tercile.

Table 7 About Here

5.3 Trading Volume Effects

Most studies in our literature only use the prices of options with a positive trading volume in their empirical work (see Goyal and Saretto (2009), Cao and Han (2013), and Hu and Jacobs (2016)). Despite the fact that these studies only require the price at the start of the option holding period and sometimes also the price at the end of that period, the restriction nonetheless eliminates almost 80% of all available option data. In contrast to the other studies, we require the whole history of daily prices over an American option's holding period to determine whether the option is optimally early exercised. Thus, if we followed other studies in only using the prices of options with a positive trading volume, we would eliminate an even significantly larger fraction of all available option data, motivating us to not impose that restriction in our main tests. However, to alleviate concern that our main results are driven by that choice, we now repeat the portfolio sorts in Table 3 on the subsample of options with a positive trading volume at the start of the option holding period.

Using a design identical to that of Table 3, Table 8 suggests that, even after imposing the trading volume filter, the mean spread portfolio returns remain close to those in Table 3. Also, the patterns of the mean spread portfolio return over the moneyness and time-to-maturity portfolios are similar to those in Table 3. For example, only considering options with 30-60 days-to-maturity, the mean spread portfolio return drops from 19.9% (t-statistic: 15.86) for ITM options to 0.9% (t-statistic: 0.99) for OTM options, almost identical to the corresponding drop in table 3 (from 19.0% to 1.4%). In addition, only considering ATM options, the mean spread portfolio return drops from 8.6% (t-statistic: 9.38) for 30-60 days-to-maturity options to -0.1% (t-statistic: -0.19) for 90-120 days-to-maturity options, almost identical to the corresponding drop in Table 3 (from 9.3% to −0.3%). Overall, the robustness test thus suggests that trading volume effects only marginally affect our conclusions.

TABLE 8 ABOUT HERE

6 Time-Series Regressions

We finally study whether several well known stock pricing models, such as the CAPM, the Carhart (1997) model, or the Fama and French (2015) five-factor model are able to explain the early exercise risk premium. To do so, we run Black et al. (1972) time-series regressions of the month t return of the portfolio of spread portfolios long an American put option and short its equivalent European put option (Panel A), the American put option portfolio (Panel B), or the European put option portfolio (Panel C) on the month t returns of the pricing factors of each of the three models. The only pricing factor advocated by the CAPM is the excess market return (MKT). The Carhart (1997) model adds the returns of small-versus-large (SMB), value-versus-growth (HML), and winners-versus-losers spread portfolios (MOM). The Fama and French (2015) five-factor model leaves out the MOM spread portfolio return, but adds the returns of investing-versus-divesting (INV) and profitable-versus-unprofitable spread portfolios (PRF). We obtain the pricing factors from Kenneth French's website.

Table 9 shows the coefficient estimates from the time-series regressions as plain numbers, while reporting t-statistics calculated using Newey and West's (1987) formula with a lag length of twelve in square parentheses. The table suggests that the CAPM, the Carhart (1997) model, and the Fama and French (2015) five-factor model are all unable to explain the early exercise risk premium. Panel A reports that the mean spread portfolio return loads significantly positively on the excess market return (t-statistic: about five) and significantly negatively on the HML return (t-statistic: about minus three); the other factors play no significant roles. Despite the significance of the market and HML factors, the alpha estimates are, however, always close to 7% per month (t-statistics: above ten), similar to the unadjusted mean spread portfolio return of also close to 7% (see Table 2). Consistent with theory, Panels B and C show that both the American and European put option returns are significantly negatively exposed to the excess market return. The European options, however, attract more negative market exposures than the American options, leading to the positive market exposure of the spread portfolio. Similarly, both the American and European put option returns are significantly positively exposed to the HML return. The European options, however, attract more positive HML loadings than the American options, leading to the negative HML exposure of the spread portfolio. Interestingly, the two types of options also attract significantly positive SMB exposures. The exposures are, however, similar across the two types of options, so that the spread portfolio is not significantly exposed to SMB. No other factor prices the American or European put options.

Table 9 About Here

7 Conclusion

We study the asset pricing implications of the possibility to early exercise a put option. Using Longstaff and Schwartz's (2001) Monte Carlo simulation method, we show that the early exercise risk premium (i.e., the expected return difference between American put options and equivalent European put options) is positive. We also show that the early exercise risk premium increases with option moneyness (the strike price-to-underlying asset price ratio) and decreases with option time-to-maturity and the idiosyncratic volatility of the underlying asset. We use options written on single stocks not paying out cash over the options' time-to-maturity to test our theoretical predictions. To facilitate our empirical tests, we calculate the returns of exchange-traded American put options, allowing the options to be exercised early if they move sufficiently ITM. Conversely, we calculate the returns of equivalent synthetic European put options using the put-call parity relation. Our empirical evidence strongly supports our theoretical predictions. Further tests suggest that our empirical results are robust to look-ahead bias, stock and option illiquidity effects, and option trading volume effects. Time-series asset pricing tests suggest that the CAPM, the Carhart (1997) model, and the Fama and French (2015) five-factor model are all unable to explain the early exercise risk premium.

References

Amihud, Y., 2002. Illiquidity and stock returns: Cross-section and time-series effects. *Journal of Financial Markets*, 5(1), pp.31-56.

Amihud, Y. and Mendelson, H., 1986. Asset pricing and the bid-ask spread. *Journal of Financial Economics*, 17(2), pp.223-249.

Aretz, K., Lin, M.T. and Poon, S.H., 2016. Moneyness, volatility, and the cross-section of option returns. *Alliance Manchester Business School Working Paper Series*.

Barraclough, K. and Whaley, R.E., 2012. Early exercise of put options on stocks. *The Journal of Finance*, 67(4), pp.1423-1456.

Bauer, R., Cosemans, M. and Eichholtz, P., 2009. Option trading and individual investor performance. *Journal of Banking & Finance*, 33(4), pp.731-746.

Black, F., Jensen, M.C. and Scholes, M.S., 1972. The capital asset pricing model: Some empirical tests. *Studies in the Theory of Capital Markets*.

Black, F. and Scholes, M., 1973. The pricing of options and corporate liabilities. *Journal of Political Economy*, 81(3), pp.637-654.

Bloom, N., 2009. The impact of uncertainty shocks. *Econometrica*, 77(3), pp.623-685.

Bondarenko, O., 2003. Why are put options so expensive? *University of Illinois Working Paper Series*.

Brennan, M.J. and Schwartz, E.S., 1977. The valuation of American put options. *The Journal of Finance*, 32(2), pp.449-462.

Brennan, M.J. and Subrahmanyam, A., 1996. Market microstructure and asset pricing: On the compensation for illiquidity in stock returns. *Journal of Financial Economics*, 41(3), pp.441-464.

Broadie, M., Chernov, M. and Johannes, M., 2007. Model specification and risk premia: Evidence from futures options. *The Journal of Finance*, 62(3), pp.1453-1490.

Broadie, M., Chernov, M. and Johannes, M., 2009. Understanding index option returns. *The Review of Financial Studies*, 22(11), pp.4493-4529.

Cao, J. and Han, B., 2013. Cross section of option returns and idiosyncratic stock volatility. *Journal of Financial Economics*, 108(1), pp.231-249.

Carhart, M.M., 1997. On persistence in mutual fund performance. *The Journal of Finance*, 52(1), pp.57-82.

Coval, J.D. and Shumway, T., 2001. Expected option returns. *The Journal of Finance*, 56(3), pp.983-1009.

de Roon, F. and Veld, C., 1996. Put-call parities and the value of early exercise for put options on a performance index. *Journal of Futures Markets*, 16(1), pp.71-80.

Dixit, A.K. and Pindyck, R.S., 1994. *Investment Under Uncertainty.* Princeton University Press.

Eickholt, M., Entrop, O. and Wilkens, M., 2014. What makes individual investors exercise early? Empirical evidence from the fixed-income market. *University of Passau Working Paper Series.*

Engström, M. and Nordén, L., 2000. The early exercise premium in American put option prices. *Journal of Multinational Financial Management*, 10(3), pp.461-479.

Fama, E.F. and French, K.R., 2015. A five-factor asset pricing model. *Journal of Financial Economics*, 116(1), pp.1-22.

Fama, E.F. and MacBeth, J.D., 1973. Risk, return, and equilibrium: Empirical tests. *Journal of Political Economy*, 81(3), pp.607-636.

Finucane, T.J., 1997. An empirical analysis of common stock call exercise: A note. *Journal of Banking & Finance*, 21(4), pp.563-571.

Goyal, A. and Saretto, A., 2009. Cross-section of option returns and volatility. *Journal of Financial Economics*, 94(2), pp.310-326.

Hu, G. and Jacobs, K., 2016. Volatility and expected option Returns. *Working Paper.*

Keim, D.B. and Stambaugh, R.F., 1984. A further investigation of the weekend effect in stock returns. *The Journal of Finance*, 39(3), pp.819-835.

Longstaff, F.A. and Schwartz, E.S., 2001. Valuing American options by simulation: a simple least-squares approach. *The Review of Financial Studies*, 14(1), pp.113-147.

Martin, I. and Wagner, C., 2017. What is the expected return on a stock? *Copenhagen Business School Working Paper Series*.

McDonald, R. and Siegel, D., 1986. The value of waiting to invest. *The Quarterly Journal of Economics*, 101(4), pp.707-727.

McMurray, L. and Yadav, P.K., 2000. The early exercise premium in American option prices: Direct empirical evidence. *Working Paper*.

Merton, R.C., 1973. Theory of rational option pricing. *The Bell Journal of Economics and Management Science*, pp.141-183.

Newey, W.K. and West, K.D., 1987. Hypothesis testing with efficient method of moments estimation. *International Economic Review*, pp.777-787.

Overdahl, J.A. and Martin, P.G., 1994. The exercise of equity options: theory and empirical tests. *The Journal of Derivatives*, 2(1), pp.38-51.

Pool, V.K., Stoll, H.R. and Whaley, R.E., 2008. Failure to exercise call options: An anomaly and a trading game. *Journal of Financial Markets*, 11(1), pp.1-35.

Poteshman, A.M. and Serbin, V., 2003. Clearly irrational financial market behavior: Evidence from the early exercise of exchange traded stock options. *The Journal of Finance*, 58(1), pp.37-70.

Shreve, S.E., 2004. *Stochastic Calculus for Finance II: Continuous-time Models* (Vol. 11). Springer Science & Business Media.

Zivney, T.L., 1991. The value of early exercise in option prices: An empirical investigation. *Journal of Financial and Quantitative Analysis*, 26(1), pp.129-138.

Table 1: Theoretical Early Exercise Risk Premia

The table shows the expected payoffs, values, and (annualized) expected returns of American put options and equivalent European put options plus the differences in these variables across the two types of options. We calculate the options' expected payoffs and values using Longstaff and Schwartz' (2001) Monte Carlo method, using a number of time steps equal to the days to maturity and one million underlying asset value paths. We calculate the annualized expected return of an option as the ratio of the expected option payoff to the option value, scaled by the time-to-maturity (in years). The underlying asset's initial value is 40, and its expected return is 12% per annum. The risk-free rate is 4% per annum. In Panels A, B, and C, we study in-the-money (strike price-to-underlying asset value ratio: 1.10), at-the-money (ratio: 1.00), and out-of-the-money options (ratio: 0.90), respectively. Each panel considers three times-to-maturity (half-a-year, one year, and one-and-a-half years) and three underlying asset volatilities (20%, 30%, and 40%, all per annum).

		American Put Option			European Put Option			Difference		
Maturity (in years)	Vol	Expected Payoff (1)	Value (2)	Annualized Expected Return (3)	Expected Payoff (4)	Value (5)	Annualized Expected Return (6)	Expected Payoff (7)	Value (8)	Annualized Expected Return (9)
Panel A: ITM Options (Moneyness = 1.10)										
0.5	0.20	3.98	4.46	−0.22	3.28	4.24	−0.45	0.70	0.22	0.24
	0.30	4.93	5.43	−0.19	4.47	5.30	−0.31	0.45	0.13	0.13
	0.40	6.03	6.51	−0.15	5.67	6.41	−0.23	0.36	0.10	0.08
1.0	0.20	4.05	4.92	−0.18	3.03	4.55	−0.33	1.02	0.37	0.16
	0.30	5.54	6.40	−0.14	4.79	6.13	−0.22	0.75	0.27	0.08
	0.40	7.17	7.96	−0.10	6.54	7.73	−0.16	0.64	0.23	0.06
1.5	0.20	4.10	5.26	−0.15	2.81	4.74	−0.27	1.30	0.53	0.13
	0.30	5.96	7.10	−0.11	4.94	6.69	−0.18	1.03	0.41	0.07
	0.40	7.99	9.00	−0.08	7.09	8.63	−0.12	0.91	0.37	0.04

(continued on next page)

Table 1: Theoretical Early Exercise Risk Premia (cont.)

		American Put Option			European Put Option			Difference		
Maturity (in years)	Vol	Expected Payoff (1)	Value (2)	Annualized Expected Return (3)	Expected Payoff (4)	Value (5)	Annualized Expected Return (6)	Expected Payoff (7)	Value (8)	Annualized Expected Return (9)
Panel B: ATM Options (Moneyness = 1.00)										
0.5	0.20	1.48	1.93	−0.46	1.30	1.86	−0.61	0.18	0.06	0.15
	0.30	2.58	3.03	−0.30	2.39	2.97	−0.39	0.19	0.06	0.10
	0.40	3.70	4.13	−0.21	3.51	4.08	−0.28	0.18	0.05	0.07
1.0	0.20	1.79	2.55	−0.30	1.43	2.41	−0.40	0.35	0.15	0.10
	0.30	3.31	4.08	−0.19	2.93	3.94	−0.26	0.38	0.14	0.07
	0.40	4.89	5.61	−0.13	4.50	5.47	−0.18	0.38	0.14	0.05
1.5	0.20	1.95	2.98	−0.23	1.44	2.74	−0.32	0.51	0.24	0.09
	0.30	3.78	4.81	−0.14	3.21	4.58	−0.20	0.57	0.24	0.06
	0.40	5.71	6.66	−0.10	5.13	6.42	−0.13	0.59	0.24	0.04
Panel C: OTM Options (Moneyness = 0.90)										
0.5	0.20	0.36	0.56	−0.70	0.33	0.55	−0.79	0.03	0.01	0.09
	0.30	1.10	1.38	−0.41	1.04	1.37	−0.48	0.06	0.02	0.07
	0.40	1.99	2.31	−0.28	1.91	2.29	−0.33	0.08	0.02	0.06
1.0	0.20	0.62	1.06	−0.42	0.53	1.02	−0.48	0.09	0.05	0.07
	0.30	1.75	2.32	−0.25	1.58	2.26	−0.30	0.17	0.06	0.05
	0.40	3.07	3.67	−0.16	2.86	3.60	−0.20	0.21	0.08	0.04
1.5	0.20	0.77	1.43	−0.31	0.61	1.34	−0.36	0.16	0.09	0.06
	0.30	2.18	3.00	−0.18	1.90	2.88	−0.23	0.28	0.12	0.05
	0.40	3.84	4.66	−0.12	3.49	4.51	−0.15	0.35	0.15	0.03

Table 2: Descriptive Statistics

The table gives descriptive statistics on the monthly returns of American put options, equivalent synthetic European put options, and spread portfolios long an American put option and short the equivalent synthetic European put option. It also gives descriptive statistics on the moneyness and time-to-maturity of the option pair in each spread portfolio. *StDev* is the standard deviation, and *Mean/StError* the ratio of the mean to the standard error (the t-statistic of the mean). We calculate the mean, the standard deviation, and the seven percentiles as the time-series average of the cross-sectional statistic. We calculate the standard error as the time-series standard deviation of the cross-sectional mean scaled by the number of months in our sample period. *Observations* is the average number of observations per month.

	Monthly American Put Option Return	Monthly Synthetic European Put Option Return	Monthly Spread Portfolio Return	Moneyness Option Pair	Days to Maturity Option Pair
Mean	−0.07	−0.15	0.07	1.11	78
StDev	0.59	0.63	0.31	0.22	26
Mean/StError	−4.41	−7.62	12.53		
Percentile 1	−0.91	−0.96	−0.63	0.74	48
Percentile 5	−0.81	−0.86	−0.25	0.85	49
Quartile 1	−0.47	−0.55	−0.04	0.98	50
Median	−0.13	−0.25	0.01	1.07	80
Quartile 3	0.18	0.11	0.13	1.19	105
Percentile 95	0.89	0.88	0.62	1.50	111
Percentile 99	1.89	2.00	1.07	1.89	111
Observations	3,303	3,303	3,303	3,303	3,303

Table 3: Early Exercise Risk Premia: By Moneyness and Maturity

The table shows the mean returns of American put option portfolios, equivalent synthetic European put option portfolios, and spread portfolios long an American put option and short its equivalent European put option. At the end of each month $t-1$, we sort the American options, the European options, and the spread portfolio long an American option and short its equivalent European option into portfolios according to whether the strike price-to-stock price ratio ("moneyness") is below 0.95 (out-of-the-money options), between 1.05 and 0.95 (at-the-money options), or above 1.05 (in-the-money options). We independently sort the same assets into portfolios according to whether time-to-maturity is between 30-60, 60-90, or 90-120 days. We equally-weight the portfolios and hold them over month t. The plain numbers in the table are mean monthly portfolio returns, while the numbers in square parentheses are t-statistics calculated using Newey and West's (1987) formula with a lag length of twelve.

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	−0.19	−0.38	0.19
	[−10.74]	[−19.87]	[16.54]
60-90 Days	−0.08	−0.12	0.05
	[−6.83]	[−5.07]	[6.91]
90-120 Days	−0.04	−0.05	0.01
	[−2.97]	[−3.13]	[2.25]
Panel B: At-The-Money (Moneyness 0.95-1.05)			
30-60 Days	−0.14	−0.24	0.09
	[−4.83]	[−8.90]	[9.60]
60-90 Days	−0.06	−0.07	0.01
	[−2.44]	[−2.76]	[2.10]
90-120 Days	−0.03	−0.03	−0.00
	[−1.47]	[−1.25]	[−1.24]
Panel C: Out-Of-The-Money (Moneyness < 0.95)			
30-60 Days	−0.03	−0.04	0.01
	[−0.59]	[−0.89]	[1.60]
60-90 Days	−0.04	−0.02	−0.01
	[−1.04]	[−0.59]	[−2.64]
90-120 Days	−0.03	−0.01	−0.01
	[−0.84]	[−0.34]	[−3.84]

Table 4: Early Exercise Risk Premia: By Idiosyncratic Volatility
The table shows the mean returns of American put option portfolios, equivalent synthetic European put option portfolios, and spread portfolios long an American put option and short its equivalent European put option. At the end of each month $t-1$, we sort the American options, the European options, and the spread portfolio long an American option and short its equivalent European option into quintile portfolios according to the market model (Panel A) or Fama-French-Carhart model (Panel B) idiosyncratic volatility. We calculate idiosyncratic volatility by estimating the two models over the previous 60 months of monthly data. We also form a spread portfolio long on the highest quintile portfolio and short on the lowest (H–L). We equally-weight the portfolios and hold them over month t. The plain numbers in the table are mean monthly portfolio returns, while the numbers in square parentheses are t-statistics calculated using Newey and West's (1987) formula with a lag length of twelve.

	Idiosyncratic Stock Volatility					
	Low	2	3	4	High	H–L
Panel A: Market Model						
American Put Return	−0.09	−0.08	−0.07	−0.07	−0.06	0.03
	[−4.02]	[−3.52]	[−3.07]	[−3.08]	[−2.48]	[2.07]
European Call Return	−0.19	−0.16	−0.14	−0.13	−0.10	0.09
	[−7.47]	[−6.97]	[−5.99]	[−5.17]	[−3.82]	[4.07]
Spread Portfolio Return	0.10	0.09	0.08	0.06	0.04	−0.05
	[11.28]	[14.64]	[12.97]	[10.57]	[6.60]	[−7.56]
Panel B: Fama-French-Carhart Model						
American Put Return	−0.09	−0.08	−0.07	−0.07	−0.06	0.03
	[−3.81]	[−3.73]	[−2.96]	[−3.15]	[−2.70]	[2.00]
European Call Return	−0.18	−0.17	−0.14	−0.14	−0.10	0.08
	[−7.04]	[−7.16]	[−5.92]	[−5.35]	[−4.28]	[3.99]
Spread Portfolio Return	0.09	0.09	0.08	0.06	0.05	−0.05
	[10.69]	[14.80]	[12.89]	[11.55]	[7.66]	[−7.26]

Table 5: Fama-MacBeth (1973) Regressions
The table shows the results from Fama-MacBeth (1973) regressions of the month t returns of spread portfolios long an American put option and short its equivalent synthetic European put option (Panel A), American put options (Panel B), or equivalent synthetic European put options (Panel C) on subsets of stock and option characteristics plus a constant. The stock and option characteristics are measured at the end of month $t-1$ and include option moneyness (the strike price-to-stock price ratio), option time-to-maturity (in days), and idiosyncratic stock volatility. We calculate idiosyncratic stock volatility by estimating the Fama-French-Carhart model over the previous 60 months of monthly data. The plain numbers are the Fama-MacBeth (1973) risk premia estimates; the numbers in square parentheses are t-statistics calculated using the formula of Newey and West (1987) with a lag length of twelve.

Model	Constant	Moneyness	Time To Maturity	Idiosyncratic Volatility
Panel A: Spread Portfolio Return				
1	0.07			
	[12.66]			
2	0.00	0.23	−0.00	
	[0.12]	[22.36]	[−22.31]	
3	0.02	0.25	−0.00	−0.08
	[0.85]	[23.11]	[−22.00]	[−11.43]
Panel B: American Put Option Return				
4	−0.07			
	[−4.39]			
5	−0.14	−0.07	0.00	
	[−2.03]	[−1.53]	[15.61]	
6	−0.15	−0.06	0.00	0.01
	[−2.18]	[−1.42]	[15.36]	[0.48]
Panel C: Synthetic European Put Option Return				
7	−0.15			
	[−7.58]			
8	−0.14	−0.30	0.00	
	[−2.12]	[−6.96]	[40.67]	
9	−0.16	−0.32	0.00	0.08
	[−2.51]	[−7.24]	[39.81]	[4.69]

Table 6: Robustness Test: Stocks That Never Paid Dividends

The table shows the mean returns of American put option portfolios, equivalent synthetic European put option portfolios, and spread portfolios long an American put option and short its equivalent European put option. At the end of each month $t-1$, we sort the American options, the European options, and the spread portfolio long an American option and short its equivalent European option into portfolios according to whether the strike price-to-stock price ratio ("moneyness") is below 0.95 (out-of-the-money options), between 1.05 and 0.95 (at-the-money options), or above 1.05 (in-the-money options). We independently sort the same assets into portfolios according to whether time-to-maturity is between 30-60, 60-90, or 90-120 days. We exclude options written on stocks that paid out at least one dividend over their entire history. We equally-weight the portfolios and hold them over month t. The plain numbers in the table are mean monthly portfolio returns, while the numbers in square parentheses are t-statistics calculated using Newey and West's (1987) formula with a lag length of twelve.

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	−0.20	−0.37	0.17
	[−10.46]	[−17.22]	[14.35]
60-90 Days	−0.09	−0.12	0.04
	[−5.38]	[−6.74]	[5.38]
90-120 Days	−0.05	−0.05	0.01
	[−2.70]	[−2.62]	[1.11]
Panel B: At-The-Money (Moneyness 0.95-1.05)			
30-60 Days	−0.15	−0.24	0.09
	[−5.10]	[−8.96]	[10.11]
60-90 Days	−0.06	−0.07	0.01
	[−2.31]	[−2.63]	[1.82]
90-120 Days	−0.03	−0.02	−0.00
	[−1.12]	[−0.96]	[−0.85]
Panel C: Out-Of-The-Money (Moneyness < 0.95)			
30-60 Days	−0.02	−0.47	0.01
	[−0.47]	[−0.67]	[1.18]
60-90 Days	−0.03	−0.01	−0.02
	[−0.81]	[−0.29]	[−3.39]
90-120 Days	−0.02	0.01	−0.03
	[−0.57]	[0.32]	[−2.04]

Table 7: Robustness Test: Stock and Option Illiqudity

The table shows the mean returns of spread portfolios long an American put option and short its equivalent European put option separately by stock and option liqudity. At the end of each month $t-1$, we sort the spread portfolios into tercile portfolios according to the liquidity of the American put option. We independently sort them into tercile portfolios according to the liquidity of the American call option in the European put option replication portfolio. We finally independently sort them into tercile portfolios according to the liquidity of the stock in the European put option replication portfolio. We either use the scaled option option interest (Panel A) or the scaled option bid-ask spread (Panel B) to proxy for option liquidity. We use the Amihud (2002) measure to proxy for stock liquidity. We only include options with a strike price-to-stock price ratio above 1.05 and a time-to-maturity between 30-60 days in these portfolio sorts. We equally-weight the portfolios and hold them over month t. The plain numbers in the table are mean monthly portfolio returns, while the numbers in square parentheses are t-statistics calculated using Newey and West's (1987) formula with a lag length of twelve.

	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	0.11	0.09	0.11	0.07	0.07	0.07	0.06	0.06	0.06
	[5.24]	[3.73]	[6.27]	[4.27]	[4.93]	[5.33]	[4.25]	[3.32]	[2.86]
Middle	0.11	0.09	0.08	0.07	0.06	0.08	0.07	0.06	0.06
	[7.46]	[6.49]	[5.60]	[4.93]	[6.10]	[7.47]	[5.36]	[5.14]	[6.27]
High	0.10	0.07	0.09	0.07	0.09	0.05	0.08	0.06	0.05
	[8.80]	[5.86]	[7.69]	[5.48]	[5.54]	[3.50]	[5.43]	[4.33]	[4.70]
Panel B: Option Liquidity = Option Bid-Ask Spread									
Low	0.11	0.11	0.09	0.13	0.09	0.07	0.12	0.10	0.06
	[5.46]	[5.25]	[4.03]	[7.80]	[6.63]	[5.26]	[6.92]	[5.96]	[2.73]
Middle	0.07	0.08	0.08	0.11	0.10	0.08	0.09	0.10	0.08
	[4.60]	[4.77]	[6.78]	[8.87]	[7.63]	[6.16]	[7.52]	[7.55]	[6.56]
High	0.08	0.10	0.09	0.10	0.10	0.09	0.10	0.10	0.09
	[5.65]	[7.33]	[6.25]	[6.86]	[6.74]	[6.38]	[8.40]	[7.62]	[7.32]

Table 8: Robustness Test: Trading Volume Filter

The table shows the mean returns of American put option portfolios, equivalent synthetic European put option portfolios, and spread portfolios long an American put option and short its equivalent European put option. At the end of each month $t-1$, we sort the American options, the European options, and the spread portfolio long an American option and short its equivalent European option into portfolios according to whether the strike price-to-stock price ratio ("moneyness") is below 0.95 (out-of-the-money options), between 1.05 and 0.95 (at-the-money options), or above 1.05 (in-the-money options). We independently sort the same assets into portfolios according to whether time-to-maturity is between 30-60, 60-90, or 90-120 days. We exclude options with a zero trading volume on the last trading day of month $t-1$. We equally-weight the portfolios and hold them over month t. The plain numbers in the table are mean monthly portfolio returns, while the numbers in square parentheses are t-statistics calculated using Newey and West's (1987) formula with a lag length of twelve.

Time-to-Maturity	American Put Option Return	European Put Option Return	Spread Portfolio Return
Panel A: ITM (Moneyness > 1.05)			
30-60 Days	−0.29	−0.49	0.20
	[−14.94]	[−27.56]	[15.86]
60-90 Days	−0.21	−0.27	0.06
	[−11.13]	[−14.20]	[8.50]
90-120 Days	−0.18	−0.20	0.02
	[−9.01]	[−9.59]	[5.03]
Panel B: ATM (Moneyness 0.95-1.05)			
30-60 Days	−0.24	−0.33	0.09
	[−9.08]	[−14.37]	[9.38]
60-90 Days	−0.15	−0.16	0.01
	[−6.55]	[−6.93]	[2.04]
90-120 Days	−0.11	−0.11	−0.00
	[−5.45]	[−5.04]	[−0.19]
Panel C: OTM (Moneyness < 0.95)			
30-60 Days	−0.07	−0.08	0.01
	[−1.70]	[−1.89]	[0.99]
60-90 Days	−0.05	−0.03	−0.02
	[−1.56]	[−0.77]	[−3.22]
90-120 Days	0.00	−0.02	−0.02
	[0.05]	[−0.52]	[−3.16]

Table 9: Time-Series Asset Pricing Tests

The table shows the results from time-series regressions of the month t return of a portfolio of spread portfolios long an American put option and short its equivalent synthetic European put option (Panel A), an American put option portfolio (Panel B), and a synthetic European put option portfolio (Panel C) on subsets of stock pricing factors measured over month t. The stock pricing factors include the market return minus the risk-free rate of return (the "excess market return;" MKT); the return of a spread portfolio long small stocks and short large stocks (SMB); the return of a spread portfolio long high book-to-market stocks and short low book-to-market stocks (HML); the return of a spread portfolio long winner stocks and short loser stocks (MOM); the return of a spread portfolio long profitable stocks and short unprofitable stocks (PRF); and the return of a spread portfolio long investing stocks and short non-investing/divesting stocks (INV). Each model also includes a constant. The plain numbers are the parameter estimates, while the numbers in square parentheses are t-statistics calculated using Newey and West's (1987) formula with a lag length of twelve.

Model	MKT	SMB	HML	MOM	PRF	INV	Cons.
Panel A: Spread Portfolio Return							
1	0.77						0.07
	[6.76]						[12.70]
2	0.71	0.01	−0.58				0.07
	[6.14]	[0.06]	[−3.55]				[13.22]
3	0.69	0.20	−0.62	−0.14	0.39	−0.37	0.07
	[4.90]	[1.09]	[−2.51]	[−1.38]	[1.58]	[−1.13]	[12.68]
Panel B: American Put Option Return							
4	−4.56						−0.05
	[−20.39]						[−4.70]
5	−4.15	−2.02	1.00				−0.05
	[−20.38]	[−7.13]	[3.49]				[−5.28]
6	−4.15	−1.83	0.56	−0.37	0.44	0.33	−0.05
	[−16.57]	[−5.63]	[1.29]	[−2.01]	[1.00]	[0.57]	[−5.10]
Panel C: Synthetic European Put Option Return							
7	−5.33						−0.12
	[−22.24]						[−10.43]
8	−4.86	−2.03	1.58				−0.12
	[−22.74]	[−6.83]	[5.24]				[−12.16]
9	−4.84	−2.03	1.18	−0.23	0.05	0.70	−0.12
	[−18.35]	[−5.93]	[2.57]	[−1.17]	[0.10]	[1.15]	[−11.63]