The Case for Heterogeneous Investor Beliefs: Evidence from U.S. Seasoned Equity Offerings

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Abstract

This paper examines the effect of heterogeneous beliefs and short-sell constraints on the long-run post seasoned equity offering stock returns in the US. We find that SEOs with high abnormal trading volume prior to the offering and high relative offering size exhibit significant and negative returns after one year. Firms in the highest quartile of market adjusted turnover and relative offering size had an average abnormal buy and hold return of -19.18% one year after the issue date. These results further support the previous theoretical works that tried to show short-sale constrained stocks with high divergence in opinion were likely to be overvalued due to short-sellers being absent in the market.

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I. Introduction

A. Background

Modern financial economics assumes that investors have homogenous expectations but ignores the implications of investor divergence of opinion.[1] Mayshar (1983) points out that both William Sharpe and John Lintner thought heterogeneous beliefs could be closely approximated by homogeneity if it was the average investor's opinion that determined asset prices. The capital asset pricing model (CAPM) developed independently by Sharpe and Lintner has subsequently contributed to the prevailing view today that markets are efficient. Yet Mayshar (1983) also notes that earlier works by John Maynard Keynes and John Burr Williams had argued it was the marginal investor who determined asset prices and thus divergence of opinion should be essential to any financial theory. Intuitively, investors likely have different estimates of the future cash flows of a company as some investors are no doubt more optimistic than others about a company's future prospects which are veiled by uncertainty. Miller (1977) proposed that when there are short-sale constraints[2] preventing pessimistic investors from participating in price discovery, stock prices would reflect only the beliefs of the optimistic investors.

[1] Note: "divergence of opinion" and "heterogeneous beliefs" are used interchangeably throughout this paper as referring to a state where investors have different estimates of the value of a publicly traded company.

[2] Short selling involves borrowing a stock and selling it immediately at the market price with the intention to buy back the stock at, ideally, a lower future price to make a profit. Short-sale constraints exist when it is difficult to short sell due to high shorting costs, usually the result of limited availability of stocks to borrow.

If there is divergence of opinion, relaxing short-sale constraints through additional stock issuance should decrease stock prices as the additional supply is absorbed by less optimistic investors with lower estimates of stock value. This is the focus of our paper and we outline the research question in the following section.

B. Research Question and Approach

This paper seeks evidence of heterogeneous investor beliefs by examining stock returns in the weeks following a seasoned equity offering (SEO) in the United States from Jan 2002 to Jan 2015.[1] The SEO is a unique event that allows us to test Miller (1977) as the supply of stock increases significantly on a single day and thus relaxes short-sale constraints by making more shares available for shorting. This paper draws heavily on the empirical work by Cooney, Kato, and Suzuki (2012) on Japanese SEOs and also builds on the theoretical model of Hong, Scheinkman, and Xiong (2006). We differentiate our approach by using different proxies for divergence of opinion, using U.S. SEO data, and focusing on stock returns in the weeks following the SEO while previous literature examined only the following days.

C. Hypothesis

Based on Miller's theory, we hypothesize that in the presence of short-sale constraints:

i) The additional stock float from issuing equity will be negatively related to post-SEO stock returns:

$$H_0 : \beta_{RelativeOfferSize} = 0 \text{ vs. alternative } H_1 : \beta_{RelativeOfferSize} < 0$$

ii) The degree of opinion divergence will be negatively related to post-SEO stock returns:

$$H_0 : \beta_{Divergence} = 0 \text{ vs. alternative } H_1 : \beta_{Divergence} < 0, \text{ and}$$

iii) The interaction of opinion divergence and additional stock float will be negatively related to post-SEO stock returns; i.e. the greater the degree of opinion divergence, the greater the negative effects of issuing new equity on post-SEO stock returns:

$$H_0 : \beta_{RelOff*Div} = 0 \text{ vs. alternative } H_1 : \beta_{RelOff*Div} < 0.$$

D. Roadmap of Paper and Results

Section II outlines the relevant literature including an explanation of Miller (1977) and the contribution of this paper. Section III discusses our empirical approach and section IV describes our econometric model and variable descriptions. Section V describes the data, section VI presents our findings, and section VII concludes. In summary, we find strong supporting evidence for our hypothesis using a particular proxy of opinion divergence, market-adjusted turnover, and weaker evidence using the other two proxies, relative analyst spread and 6 month put implied volatility.

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[1] A seasoned equity offering is any equity issuance following the company's initial equity offering (IPO).

II. Existing Literature

A. Divergence of Opinion

Miller's theory (1977) is one of the earliest asset pricing models to incorporate heterogeneous beliefs and short-sale constraints. Miller's paper challenged the CAPM's assumption of homogeneous expectations by arguing that uncertainty about the future naturally creates diverging forecasts of a company's future cash flows and valuation. This results in a downward sloping demand curve for the stock of a company as investors have varying expectations of future returns from holding the stock (Figure 1). Furthermore, the degree of opinion divergence is represented by the slope where steeper slopes indicate higher divergence and flatter slopes indicate lower divergence.

In Figure 1, the y-axis is each investor's estimate of stock value and the x-axis is the number of investors (Miller assumes each investor can only hold 1 unit of stock). GBH is the demand curve if investors have homogeneous expectations while ABC is the demand curve if investors have the opinion divergence. Given a limited supply of stock at N, the stock price is higher for the opinion divergence case at R compared to a stock price of G for homogenous expectations. This is because more optimistic investors will purchase the stock from less optimistic investors until the N most optimistic investors are the final owners at a price that is higher than the average expectation of value. In addition, the degree of opinion divergence is positively related to the stock price as greater divergence leads to higher prices paid by the N optimistic investors, as shown by FBJ and price of Q, while lower divergence leads to lower prices, as shown by DBE and price of M. In this framework, we can think of homogeneous expectations as a special case with zero opinion divergence and a perfectly flat slope.

The SEO is an opportunity to observe the change in stock price as the supply of stock increases past N (i.e. shifting the vertical line at N to the right). If the stock is short-sale constrained, Miller's theory predicts a negative change in stock prices because the marginal investor absorbs the additional stock float at a lower price. If investors have homogeneous expectations, then the theory predicts no change in stock prices because the marginal investor has the same estimate of value as the average investor.

B. Empirical Work

The most relevant empirical study is by Cooney, Kato, and Suzuki (2012) who examined the effects of opinion divergence and short-sale constraints on the stock prices of Japanese companies following their SEOs. The authors found that divergence of opinion was negatively related to stock returns on both the announcement date and the issue date for a sample of 830 SEOs from 1998 to 2011.[1] They also found that issue size was negatively related to stock returns on both dates and that this relationship was stronger for stocks with a higher divergence of opinion. These results are consistent with

[1] The announcement date is the day that the SEO is announced to the public. The issue date is the day on which the new shares begin trading on the stock exchange.

Figure 1 [reproduced from Miller (1977)]

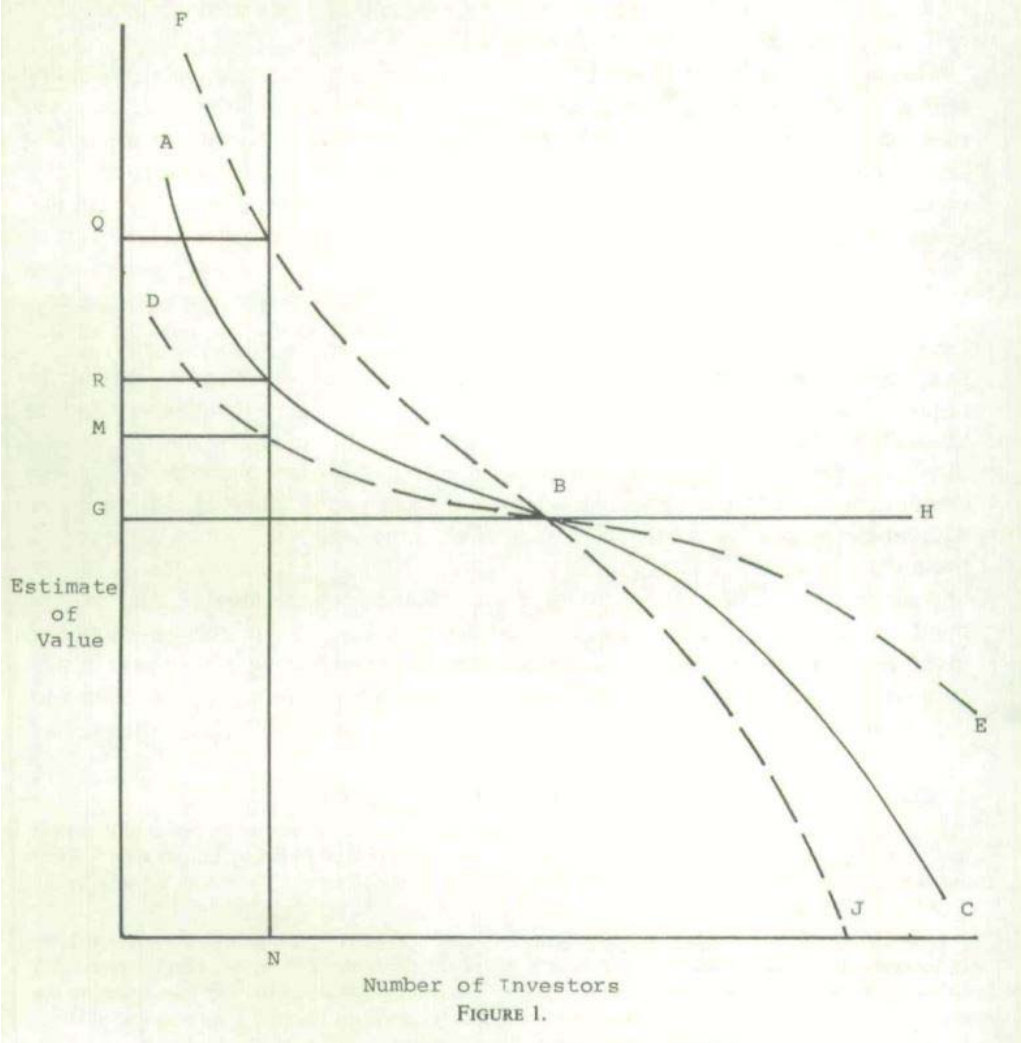


FIGURE 1.

Miller's theory (1977) and support the theory of opinion divergence. We improve upon their research using data on U.S. SEOs in the following ways.

C. Contribution

Firstly, we use several new proxies for opinion divergence. Cooney, Kato, and Suzuki (2012) used the mean square error[1] (MSE) and daily return volatility over the thirty trading days ending 10 trading days before the announcement day as proxies for divergence of opinion. While we do not completely disagree with this approach,

[1] Computed as the deviation from the value predicted by the Fama and French three-factor model for the period from -70 days to -11 trading days before the announcement date.

Garfinkel (2009) found that the explanatory power of these proxies was inferior compared to other proxies such as change in market-adjusted turnover, deviation of analysts' forecasts divided by the stock price, and implied volatility of put options.[1] We test these three measures in our analysis to see if they can better explain post-SEO performance. We also believe qualitative factors such as industries can explain divergence of opinion. Stocks in industries where future outcomes vary drastically such as information technology or biotechnology are more likely to exhibit opinion divergence.

Secondly, Cooney, Kato, and Suzuki (2012) pointed out problems in the U.S. SEO data that we believe can be addressed in our paper. The pricing of SEOs in the U.S. is determined either on or a day before the issue date while pricing in Japan is determined at least five days before the issue date. Since the float begins trading on the same day that price is determined, the effects of opinion divergence cannot be distinguished from other factors such as information asymmetry and short-term pricing pressure. In our view, this issue is only relevant when examining returns on the issue date. In practice, the entire float does not immediately become available to short following the issue date because institutional buyers must transfer their shares to appropriate brokerages before the shares can be lent out for short sellers to borrow. This process takes several days to weeks depending on the buyers of the issue. In addition, for less followed stocks, it may take additional time for short sellers to realize that the float has increased and then decide to short the stock. Therefore, we expect a negative price change to persist for a longer time period following the issue date and this is why we examine weekly price changes whereas Cooney, Kato, and Suzuki (2012) examined only the 10 days surrounding the issue date.

III. Empirical Techniques

A. Regression

Our empirical analysis will focus on testing the theoretical model proposed by Hong, Scheinkman, and Xiong (2006). Their model estimates the change in stock price after an increase in stock float while assuming certain parameters for the degree of opinion divergence, discount rate, and risk bearing capacity of insiders.

The empirical approach we take is based on standard event study methodologies outlined in Lyon, Barber, and Tsai (2001). Our regression consists of cross-section data where the dependent variable is the cumulative buy and hold abnormal return (CBHAR) at time T after the event date and the independent variables are offering-specific characteristics before the event date. The CBHAR is the residual from a regression of stock returns for each company on factors from the Carhart four-factor model (Exhibit A).

[1] Avellaneda, Lipkin, and Trading (2009) derived an options pricing model that found hard to borrow stocks have higher prices for put options due to higher borrowing costs. Therefore, the implied volatility of put options measure both divergence in opinion and degree of short sale constraints.

B. Univariate Analysis

We also test our hypothesis by grouping offerings based on offering characteristics to see whether these groups earn significant abnormal returns. Our sample is first split into quartiles by relative offering size and we categorize the top quartile as the most short-sale constrained and the bottom quartile as the least short-sale constrained. Then we test whether the cumulative buy and hold abnormal return (CBHAR) for these groups are significantly different from zero. We follow a similar procedure for our proxies of opinion divergence. To study the interaction between short-sale constraints and divergence of opinion, we further split the most short-sale constrained quartile into two samples: one with the highest divergence of opinion and the other with the lowest divergence of opinion, again using quartiles. Our significance tests used skew-adjusted t-statistic developed by Johnson (1978) and refined by Hall (1992) to correct for the positive skew of CBHAR distribution (Exhibit B).

IV. Econometric Model and Variable Description

Our empirical model is as follows:

$$CBHAR_{i,t} = \beta_0 + \beta_1 RelOff_i + \beta_2 SI_i + \beta_3 Div_i + \beta_4 \ln(Mktval)_i + \beta_5 Prestige_i + \beta_6 (RelOff_i * Div_i) + \beta_7 SpecInd_i + e_{i,t}$$

where *i* is the issuing company and *t* is the number of weeks following the issue date. As mentioned earlier, the dependent variable, cumulative buy and hold abnormal returns (*CBHAR*), is the residual from a regression using the Carhart four-factor model (Exhibit A).[1] The relative offer size (*RelOff*) is the number of new shares issued divided by the stock float one day prior to the announcement date and serves as a measure for the change in float. The short interest (*SI*) is defined as last reported total shares shorted divided by float size and measures the degree of short-sale constraints. We test three different proxies for divergence of opinion (*Div*) which are as follows:

1) Relative analyst estimate spread (*ASpread*) is defined as the difference between high and low analyst estimates of EPS divided by the share price one day prior to the stock offering date.

2) Market-adjusted turnover (*MATO*) is defined as $\left[\left(\frac{Vol_{i,t}}{Float_{i,t}}\right)_{Firm} - \left(\frac{Vol_{i,t}}{Float_{i,t}}\right)_{Market}\right]$, where $\left(\frac{Vol_{i,t}}{Float_{i,t}}\right)_{Firm}$ is the volume divided by float at time *t* for the firm and $\left(\frac{Vol_{i,t}}{Float_{i,t}}\right)_{Market}$ is the volume divided by float at time *t* for the S&P 500 index.

3) Implied volatility on 6 month at-the-money put options (*DVOL*) is defined as the implied volatility of the at-the-money put option with 6 months left until expiry.

[1] The Carhart model is an extension of the Fama-French 3 factor model by adding a momentum factor.

In addition, the natural logarithm of market capitalization (*ln(Mktval)*) is measured on the day before the offer date and adjusted for inflation using base year of 2005. This variable is used in previous literature to capture the effects of information asymmetry. The prestige of the underwriter (*Prestige*) is a dummy variable equal to 1 if the underwriting investment bank falls within our list of the top underwriters by deal size. Industry classification (*SpecInd*) is a dummy variable equal to 1 if the company falls in our list of speculative industries according to the GICS classification system.[1]

V. Data Description

A. Data Sources

Data on seasoned equity offerings were obtained from the Securities Data Company (SDC Platinum) from January 2002 to January 2015 for stocks trading on the NYSE, AMEX and NASDAQ exchanges. The sample was restricted to companies with a minimum market capitalization of $1 million and excluded real estate investment trusts, American Depository Receipts, and investment funds, as is standard in the literature. The final sample had 2328 observations in total. Data relating to share price, volatility, and analyst estimates were obtained from Wharton Research Data Services (WRDS) and Thomson Reuters. Stock float data were obtained from Capital IQ. Data relating to the calculation of CBHAR were obtained from CSRP and the Ken French Data Library.

B. Summary Statistics

The SEOs are fairly spread out over the time period with slightly more weighted toward the last 5 years (Table 1). There is also a good diversity of industries with healthcare being the most frequently occurring followed by high technology and financials (Table 2).

Table 1: Distribution of Offerings by Year

Year	Number of offerings
2002	123
2003	166
2004	196
2005	167
2006	188
2007	161
2008	62
2009	196
2010	223
2011	214
2012	203
2013	228
2014	201
Total	**2328**

Table 2: Distribution of Offerings by Industry

Industry	Number of Offerings
Consumer Products and Services	133
Consumer Staples	50
Energy and Power	201
Financials	377
Government and Agencies	1
Healthcare	614
High Technology	365
Industrials	180
Materials	86
Media and Entertainment	75
Real Estate	64
Retail	102
Telecommunications	80
Total	**2328**

[1] Examples include: Oil and Gas exploration, Metals and mining, Pharmaceuticals, Biotechnology, Life Sciences, Information Technology

Table 3 reports the summary statistics for each regression variable and the abnormal buy and hold returns in various time windows.

Table 3 Summary Statistics of Regression Variables

Firm Characteristics:	Mean	Min	Max	Standard Deviation	Number of Observations	Missing Values
Market Capitalization (millions)	1116.070	1.000	138352.100	4495.700	2328	0
RefOff	1.160	0.001	291.120	8.920	1728	600
SI (%)	8.460	0.011	118.000	10.370	1397	931
Divergence of Opinion-						
Analyst Estimate Spread	0.037	0.000	4.120	0.143	999	1329
Implied Volatility (%)	55.560	12.480	169.660	27.450	555	1773
MATO	0.124	-0.528	0.320	0.107	1467	861
SpecInd	0.421	0.000	1.000	0.494	2328	0
Prestige	0.2165	0.000	1.000	0.313	2328	0
Abnormal Buy and Hold Returns (%):						
t-30 through t-1	3.38%	-68.78%	377.88%	25.11%	2318	10
t-1 through t-0	-1.43%	-51.47%	66.32%	6.40%	2318	10
t-0 through t+7	0.32%	-41.48%	263.63%	12.10%	2318	10
t-0 through t+30	0.63%	-58.08%	305.89%	18.18%	2318	10
t-0 through t+90	0.66%	-145.64%	407.68%	32.51%	2318	10
t-0 through t+180	-0.31%	-159.95%	559.44%	47.75%	2318	10
t-0 through t+360	-5.91%	-434.81%	754.27%	71.47%	2318	10

VI. Presentation and Discussion of Findings

A. Presentation

The Table 1 below shows the ordinary least square regressions of our empirical model when analyst opinion spread is used as the proxy for opinion divergence.

Similar to Cooney, Kato, and Suzuki (2012), we find issue date returns (t-1 to t-0) are negatively impacted by relative offering size and positively impacted by market size. Post-event returns, however, are not significantly affected by divergence of opinion, relative offering, and prestige of the underwriter. For returns 180 days after the issue date, we find both the interaction term and the industry classification dummy are statistically significant and negative.

Table 2 below shows the ordinary least square regressions of our empirical model when market-adjusted turnover is used as the proxy for divergence in opinion.

Table 1: Analyst Spread

	(1) t-1 to t-0	(2) t-0 to t+7	(3) t-0 to t+30	(4) t-0 to t+90	(5) t-0 to t+180	(6) t-0 to t+360
Short Interest	0.000131	-0.0000507	0.000346	-0.000371	0.00114	0.00348
	(0.69)	(-0.20)	(0.82)	(-0.49)	(0.90)	(1.26)
Aspread	-0.0292	0.0624	-0.0434	0.0597	0.327	0.0210
	(-0.49)	(0.65)	(-0.32)	(0.18)	(0.82)	(0.05)
RelOff	-0.000749***	0.00486	0.00623	0.00701	0.00972*	0.00263
	(-3.27)	(0.97)	(0.74)	(1.09)	(1.52)	(0.53)
Aspread X RelOff	-0.00907	-0.0591	-0.0874	-0.105	-0.216**	-0.134*
	(-1.36)	(-1.05)	(-0.86)	(-1.29)	(-2.55)	(-1.45)
lnmktval	0.00295**	-0.00246	-0.00623*	-0.00903	-0.00448	0.0179
	(1.84)	(-1.08)	(-1.49)	(-1.22)	(-0.43)	(1.11)
Prestige	-0.0140***	-0.00936	-0.00855	0.0233	0.00353	0.0601
	(-3.42)	(-1.37)	(-0.71)	(1.25)	(0.11)	(1.33)
SpecInd	0.00339	0.00306	0.00319	-0.0425**	-0.0470*	-0.0682*
	(0.82)	(0.51)	(0.30)	(-2.01)	(-1.52)	(-1.49)
Constant	-0.0289***	0.0217	0.0487**	0.0770*	0.0222	-0.176*
	(-2.66)	(1.32)	(1.65)	(1.48)	(0.31)	(-1.59)
Observations	843	843	843	843	843	843

t statistics in parentheses

t statistics calculated using White's Heteroskedastic adjusted standard errors

* $p < 0.15$, ** $p < 0.10$, *** $p < 0.01$

In this regression, divergence in opinion, relative offering size, and industry classification are negative and statistically significant for returns after 180 days, consistent with our hypothesis. Although the sign of the interaction is negative, it fails to reach significance at the 15% confidence level.

Table 3 below shows ordinary least square regressions of our empirical model when implied volatility of put options is used as the proxy for divergence in opinion.

Except issue day returns and one week returns, most coefficients are statistically insignificant. The sign of the interaction term is negative for all time periods after the issue date which is consistent with our hypothesis.

B. Discussion

From the three different proxies used above, the market adjusted turnover regression produced the most significant coefficients. The other two proxies failed to produce significant results because they may be poor indicators of divergence in investors' opinions.

Table 2: Market Adjusted Turnover

	(1) t-1 to t-0	(2) t-0 to t+7	(3) t-0 to t+30	(4) t-0 to t+90	(5) t-0 to t+180	(6) t-0 to t+360
Short Interest	0.000201	0.000330	0.000565	0.000585	0.00252**	0.00774***
	(1.03)	(0.84)	(1.33)	(0.67)	(1.85)	(3.03)
Market Adjusted Turnover	0.0272	-0.0213	-0.0853**	-0.372***	-0.321**	-0.380**
	(1.22)	(-0.58)	(-1.67)	(-2.65)	(-2.14)	(-1.98)
RelOff	0.00186	-0.00596	0.00656	-0.0126	-0.0240*	-0.0328*
	(0.72)	(-0.91)	(0.69)	(-1.14)	(-1.45)	(-1.59)
MATO X RelOff	0.00648	-0.0251	0.00981	-0.0419	-0.0744	-0.0803
	(0.87)	(-0.93)	(0.25)	(-1.08)	(-1.24)	(-1.34)
lnmktval	0.00227*	-0.00851	-0.00167	-0.00706	-0.0237**	-0.00456
	(1.47)	(-1.22)	(-0.30)	(-0.84)	(-1.83)	(-0.28)
Prestige	-0.0123***	0.00350	-0.00378	0.0119	-0.00582	0.0257
	(-2.80)	(0.35)	(-0.27)	(0.55)	(-0.17)	(0.49)
SpecInd	0.000217	0.00608	-0.00963	-0.0333*	-0.0830**	-0.102**
	(0.05)	(0.76)	(-0.90)	(-1.45)	(-2.43)	(-2.06)
Constant	-0.0237**	0.0436	-0.00740	-0.0226	0.0911	-0.126
	(-1.99)	(1.20)	(-0.21)	(-0.43)	(1.07)	(-1.15)
Observations	1049	1049	1049	1049	1049	1049

t statistics in parentheses

t statistics calculated using White's Heteroskedastic adjusted standard errors

* $p < 0.15$, ** $p < 0.10$, *** $p < 0.01$

Analyst estimates are typical opinions of an investment bank that issues research papers. Their estimates are likely to be biased upwards in order to generate underwriting fees for the investment bank. Indeed, Hong and Kubik (2003) found that analysts with more optimistic forecasts had better career outcomes. This bias will be even more prevalent when a company is planning to undergo a seasoned equity offering because multiple investment banks will be competing with each other to underwrite the deal. Therefore, all of the analyst estimates are likely to be overly optimistic, misrepresenting their actual opinions in the stock. In this case, the spread of their forecasts will bear less relationship with the spread in investors' opinions. In addition, the larger the offering, the larger the incentive to generate underwriting fees, which may introduce multicollinearity between analyst spread and relative offering.

Although implied volatility on put options explicitly measures uncertainty, the majority of companies in our sample did not have options' contracts available. This is likely due to a larger proportion of our sample being relatively small firms. Thus the implied volatility regression suffers from both a smaller sample size and a biased sample towards larger firms. This could have reduced the significance levels of our coefficients in the regression because larger firms are less likely to be short-sale constrained due to larger public stock float and lower insider ownership.

Table 3: 6 Month Put Implied Volatility

	(1) t-1 to t-0	(2) t-0 to t+7	(3) t-0 to t+30	(4) t-0 to t+90	(5) t-0 to t+180	(6) t-0 to t+360
Short Interest	0.000184	-0.000486*	-0.000208	-0.000890	0.000629	0.00170
	(0.61)	(-1.58)	(-0.44)	(-0.79)	(0.28)	(0.53)
6 Month Implied Put Volatility	-0.0000224	0.0000724	-0.000482*	-0.000116	0.0000354	-0.00179
	(-0.10)	(0.36)	(-1.59)	(-0.11)	(0.02)	(-0.91)
RelOff	0.0658*	0.0878**	0.0545	0.185	0.335	0.299
	(1.51)	(2.26)	(0.81)	(1.02)	(1.15)	(0.84)
Implied Vol X RelOff	-0.000771	-0.00101**	-0.000546	-0.00201	-0.00407	-0.00519
	(-1.30)	(-2.18)	(-0.70)	(-0.96)	(-1.15)	(-1.30)
lnmktval	0.00519*	-0.00214	-0.00987**	-0.0154	-0.00318	0.000785
	(1.57)	(-0.64)	(-1.97)	(-1.40)	(-0.17)	(0.03)
Prestige	-0.0200***	-0.00163	0.00240	0.0237	-0.0112	-0.00429
	(-3.37)	(-0.27)	(0.21)	(1.06)	(-0.27)	(-0.07)
SpecInd	0.0156**	0.00217	0.00934	-0.00609	0.00660	-0.0165
	(2.09)	(0.29)	(0.74)	(-0.28)	(0.16)	(-0.24)
Constant	-0.0540**	0.0102	0.0839**	0.104	-0.00655	0.0925
	(-1.74)	(0.33)	(1.79)	(0.87)	(-0.03)	(0.34)
Observations	441	441	441	441	441	441

t statistics in parentheses

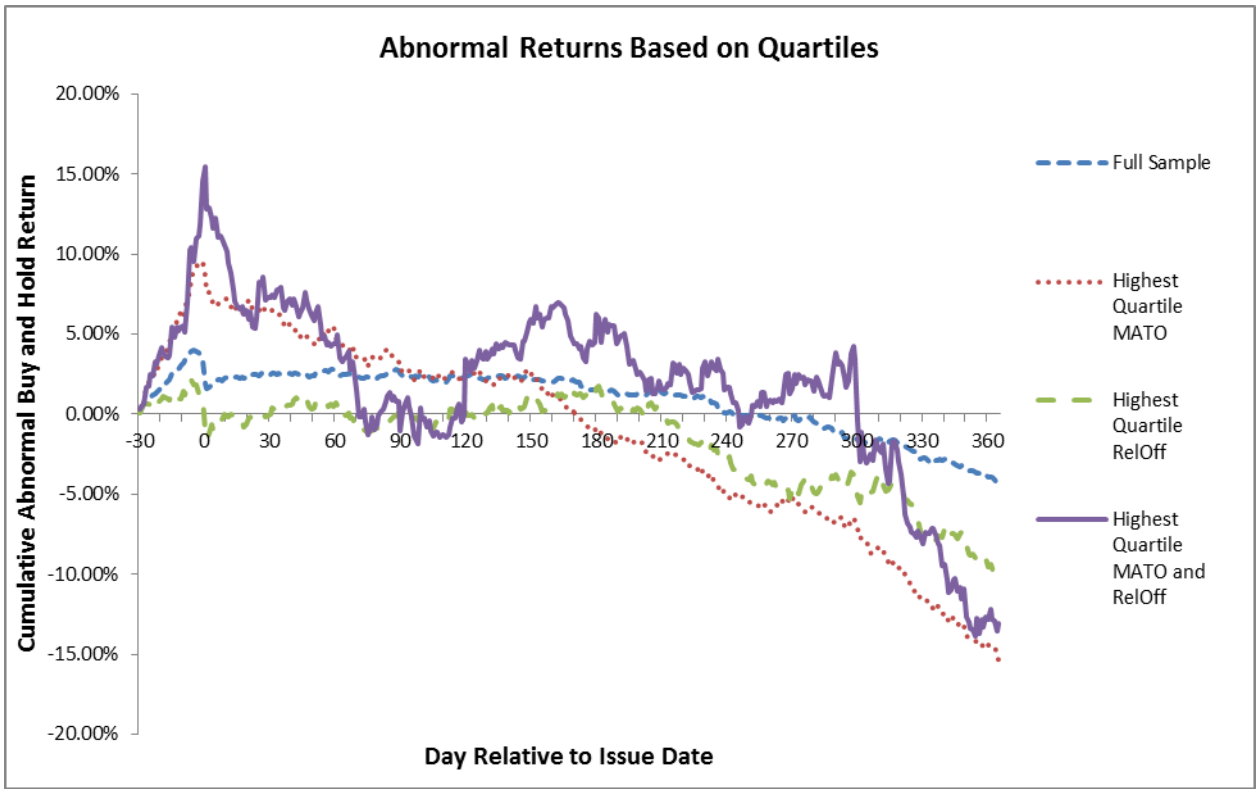
t statistics calculated using White's Heteroskedastic adjusted standard errors

* $p < 0.15$, ** $p < 0.10$, *** $p < 0.01$

The market adjusted turnover regression was the most consistent with our hypotheses (*i, ii, iii*). Relative offering size, divergence of opinion, and the interaction term were all significant and negative for returns after one week. This might indicate that abnormal trading volume is a good proxy for divergence opinion. Indeed, frequent trading implies frequent changes of shares between different investors, indicating changes in the expectations of individual investors. The industry classification dummy was also both statistically and economically significant. The coefficient estimate infers that a company operating in a speculative industry such as biotechnology and information technology experience on average 10.2% lower annual returns than a company that did not operate in such industries after a SEO. The above impacts could be due to that fact that speculative firms are more likely to be short-sale constrained due to their binary nature - the company either discovers a drug or technological breakthrough that generates a large amount of profits in the future, or fails and earns zero profits. The possibility of the company being worth zero creates a high demand for short-sales.

C. Univariate Analysis

The following chart shows the cumulative abnormal returns of different portfolios split by different quartiles of divergence of opinion and relative offer size.



The following table shows abnormal returns relative to the issue date and their t-statistic based on a hypothesis test where the null is that the abnormal return is equal to zero (Exhibit B).[1]

	Highest Quartile MATO		
Period	CBHAR	Cross T-stat	Skew T-stat
t-30 to t-1	9.50%	4.63	6.88
t-1 to t-0	-1.34%	-3.55	-3.32
t-0 to t+7	-0.54%	-1.15	-1.13
t-0 to t+30	-1.27%	-1.52	-1.49
t-0 to t+90	-3.54%	-2.38	-2.37
t-0 to t+180	-7.00%	-3.18	-3.01
t-0 to t+360	-19.11%	-6.02	-5.38

[1] Four, three, two, and one dot represent significance levels at , 0.01%, 0.025%, 0.05%, and 0.1% respectively.

Highest Quartile RelOff			
Period	CBHAR	Cross T-stat	Skew T-stat
t-30 to t-1	0.92%	0.59	0.66
t-1 to t-0	-2.20%	-5.26	-5.20
t-0 to t+7	1.09%	1.06	1.24
t-0 to t+30	1.44%	1.19	1.30
t-0 to t+90	1.47%	0.69	0.74
t-0 to t+180	3.34%	1.04	1.11
t-0 to t+360	-7.99%	-1.73	-1.59

Highest Quartile MATO and RelOff			
Period	CBHAR	Cross T-stat	Skew T-stat
t-30 to t-1	14.54%	2.03	2.81
t-1 to t-0	-1.00%	-0.76	-0.72
t-0 to t+7	-1.66%	-1.46	-1.60
t-0 to t+30	-3.66%	-1.51	-1.55
t-0 to t+90	-6.89%	-1.74	-1.70
t-0 to t+180	-3.45%	-0.49	-0.43
t-0 to t+360	-19.18%	-1.97	-1.59

Full Sample			
Period	CBHAR	Cross T-stat	Skew T-stat
t-30 to t-1	3.38%	6.35	8.05
t-1 to t-0	-1.43%	-10.56	-10.21
t-0 to t+7	0.32%	1.24	1.36
t-0 to t+30	0.63%	1.63	1.73
t-0 to t+90	0.66%	0.96	0.99
t-0 to t+180	-0.31%	-0.31	-0.30
t-0 to t+360	-5.91%	-3.90	-3.62

Similar to our regression analysis, higher MATO and relative offering size leads to statistically significant negative abnormal returns that are greater than the full sample average. The interaction of the two variables, however, do not lead to a significant difference when compared with the highest MATO quartile group alone – both groups experience approximately -19% abnormal returns after one year. Therefore, the univariate analysis is also consistent with our hypotheses (*i*, *ii*).

VII. Conclusion

This paper finds supporting evidence for heterogeneous beliefs in the presence of short-sale constraints using the market-adjusted turnover as the proxy for divergence of opinion. The remaining proxies: relative analyst estimate spread and 6 month put implied volatility, are not found to be significant. In addition, the interaction of relative offer size and opinion divergence is significant and negative, as shown in both the regression and univariate results.

The implications of Miller (1977)'s asset pricing theory are enormous for academics and financial market participants. It provides a simple explanation of how divergence of opinion can produce persistently overvalued stock prices and provides insight into asset bubbles. It implies that investors can improve portfolio returns by avoiding stocks with high divergence of opinion following a secondary equity offering, which suggests a continuing role for active management.

We hope our empirical analysis of seasoned equity offerings in the U.S. from 2002 to 2015 has shed more light on the effects of heterogeneous beliefs and short-sale constraints on stock prices.

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Appendix

Exhibit A: Cumulative Buy and Hold Abnormal Return Calculation

Our dependent variable, Cumulative Buy and Hold Abnormal Returns (*CBHAR*), is the residual from a regression using the Carhart four-factor model. Abnormal return is defined as:

$$R_{i,t} = \hat{\alpha}_i - \hat{\beta}_i RM_t - \hat{s}_i SMB_t - \hat{h}_i HML_t - \hat{w}_i WML_t$$
$$CBHAR_{i,t} = \prod_{t=T_1}^{T_2}(1 + R_{i,t}) - \prod_{t=T_1}^{T_2}(1 + E[R_{i,t}]),$$

where $R_{i,t}$ is the return of the stock on day *t* for company *i*, *RM* is the value-weighted return of all listed firms or a large aggregate index such as S&P 500, *SMB* (small minus big) is the difference between the returns on diversified portfolios of small stocks and big stocks, *HML* is the difference between the returns on diversified portfolios of high book-to-market (value) stocks and low book-to-market (growth) stocks, and *WML* is the difference between the returns on diversified portfolios of the winners and losers of the past year.[1]The coefficients $\hat{\alpha}_i, \hat{\beta}_i, \hat{s}_i, \hat{h}_i, \hat{w}_i$ are estimated using an OLS regression of stock returns for company *i* on *RM*, *SMB*, *HML*, and *WML* for an out-of-sample period between -130 and -30 days before the issue date. $CBHAR_{i,t}$ is the cumulative average buy and hold abnormal return assuming the investor holds the stock from T_1 to T_2.

Exhibit B: Calculation of t-statistics

Specifically, the cross sectional t-statistic is defined as:[2]

$$t_{ACBHAR} = \sqrt{N}\frac{ACBHAR}{S_{ACBHAR}} \quad where \quad S^2_{ABHAR} = \frac{1}{N-1}\sum_{i=1}^{N}(CBHAR - ACBHAR)^2$$

where ACBHAR is the average cumulative buy and hold abnormal return,

and the skew adjusted t-statistic is defined as:

$$t_{skew} = \sqrt{N}\left(S + \frac{1}{3}\gamma S^2 + \frac{1}{27}\gamma S^3 + \frac{1}{6N}\gamma\right)$$
$$where \quad S = \frac{ACBHAR}{S_{ACBHAR}} \quad and \quad \gamma = \frac{N}{(N-1)(N-2)}\sum_{i=1}^{N}(CBHAR - ACBHAR)^3 S^{-3}_{ABHAR}$$

For the majority of our ACBHARs, the skew adjustment does not change our results. The skew adjustment generally increases the t-statistic so our negative ACBHARs become less statistically significant and our positive ACBHARs become more statistically significant.

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[1] For further information, see Carhart (1997).
[2] For further information, see Lyons, Barber, and Tsai (1997).