Erasmus School of Economics, Erasmus University Rotterdam

Short sales and price efficiency, evidence from the Hong Kong stock exchange

Dylan Rietveld

Abstract

In this paper, I examine the effect of short sales on price efficiency and the information content of stock prices. I find that short sales improve the price discovery process and reduce the relative amount of idiosyncratic information incorporated into the stock price. A subsequent analysis of how short sales improve price efficiency shows that this effect is driven by down market short sales. I conclude that short sales increase the price efficiency by incorporating negative market information into the stock price. I find no evidence for the notion that short sales decrease price efficiency.

July, 2018

Supervisor: Dr S. Obernberger

JEL classification: G14

Content

List of Tables

Acknowledgements

First of all, I want to thank my supervisor, for his patience, guidance, and quick responses. Furthermore, I am grateful for the love and support of my parents, W.M Kwakkelstein and JW Rietveld. Also my family members Y. Rietveld and T. Kwakkelstein, as well as my girlfriend S. De Graaf, deserve credits for their respective support, hospitable surroundings and love. This thesis has been the final hurdle to take in a process to complete my study at the Erasmus University. It has been a steep but rewarding learning curve.

1. Introduction

Short sales account for over twenty percent of the daily trading volume and are executed by a group of highly informed traders[1] (Boehmer, Johnes, and Zhang, 2008). Therefore, short sales can have a substantial impact on stock prices. The effect of short sales on stock prices is an ongoing debate dividing the literature. Some researchers believe that short sales decrease price efficiency by driving prices below fundamental values (cf. Shkilko, Van Ness, and Van Ness, 2008, Brunnermeier and Pedersen, 2005, Goldstein and Guembel, 2008, Mitchell, Pulvino, and Stafford, 2004). Predatory trading is believed to be the most common corresponding strategy to decrease price efficiency. In predatory trading, investors make use of other investors' needs to sell a stock and take a short position to drive down the price (Brunnermeier and Pedersen, 2005). After driving down the price, they buy back the shares and are left with a profit. The $6.2[2] billion loss of JP Morgan Chase in 2012, is an example of the harmful effects of predatory trading. The company's credit default swap portfolio grew so big that it revealed its position, thereby making it a target for other investors. As the financial post stated,

"The losses first became public in April 2012 when it was revealed Iksil's[3] group made outsized bets in an illiquid derivatives market and found themselves squeezed by competitors in the market.[4]"

Regulators seem to be concerned about the effects of short sales as well, as an SEC report of 2010 stated,

"We believe it is appropriate at this time to adopt a short sale-related circuit breaker because, when triggered, it will prevent short selling, including potentially manipulative or abusive short selling." Securities Exchange Act Release No. 34-61595 (February 26th, 2010)

While regulators openly pronounce their concerns about short sales, the most substantial part of literature finds short sales to be efficiency-enhancing (cf. Bris, Goetzmann, and Zhu, 2007, Saffi and Sigurdsson, 2011, Boehmer and Wu, 2013, Miller, 1977, Chang, Cheng, and Yu, 2007). Short sellers are believed to use their information to keep prices close to fundamental values.

Short sales are considered to enhance price efficiency by improving the speed or accuracy of the price discovery process (Boehmer and Wu, 2013).

---

[1] This research is conducted on the New York Stock Exchange.
[2] Financial Times https://www.ft.com/content/7d17a212-2659-11e5-bd83-71cb60e8f08c
[3] Iskil is the name of one of the traders at JP Morgan Chase back in 2012.
[4] Financial post http://business.financialpost.com/news/fp-street/former-jpmorgan-traders-charged-with-fraud-in-us6-2-billion-london-whale-scandal

My research builds on the work of Busch and Obernberger (2017), who study the impact of share repurchases on price efficiency in the US. In this paper, I try to answer the following question:

"Do short sales improve the speed and/or *accuracy of the price discovery process?"*

I address this question by researching the effect of short sales on price efficiency and the information content of stock prices. In line with Busch and Obernberger (2017), "information content" is defined as the amount of information that is incorporated into the stock price and "price efficiency" as the degree to which prices reflect all available information. I formulate two hypothesis, which I test using a Hong Kong dataset containing data on stocks that allow for short sales and stocks that do not. This dataset enables me to make a unique comparison between short sales and non short sales stocks. My primary result is in line with the most substantial part of literature, on average short sales increase price efficiency and the information content of stock prices.

1.1 Hypothesis 1

My baseline hypothesis proposes that short sales increase price efficiency, by increasing the speed and/or the accuracy with which information is incorporated into the stock price (Bris, Goetzmann, and Zhu, 2007, Saffi and Sigurdsson, 2011, Boehmer and Wu, 2013, Diamond, and Verrenchia, 1987, Chang, Cheng, and Yu, 2007). This hypothesis builds on the notion that short sellers are sophisticated traders, who use their information to trade efficiency enhancing (Diether, Lee and Werner, 2008, Boehmer, Johnes, and Zhang, 2008). Boehmer, Johnes, and Zhang (2008) report that institutional investors are responsible for seventy-five percent of all executed short sales, of this group only a part of the institutional investors is allowed to take a short position (Diether, Lee and Werner, 2008). Consequently, short sellers as a group are very sophisticated traders (Diether, Lee and Werner, 2008). Also, stocks that experience the highest level of short sales activity, experience significant negative abnormal returns (Desai, Ramesh, Thiagarajan, and Balachandran, 2002, Diether, Lee and Werner, 2008, Boehmer, Johnes, and Zhang, 2008). These returns are persistent and therefore show that these trades incorporate value relevant information into the stock price. Consequently, I expect short sales to increase the speed with which information is incorporated into the stock price. Also, if short sellers bring prices closer to fundamental values, I expect the information content in stock prices to increase and therefore the relative amount of noise or firm-specific information incorporated into the stock price to decrease (Busch and Obernberger, 2017). Since short sales can only be used to integrate negative information into the stock price, there are two possible channels through which short sales can positively contribute to price efficiency.

Firstly, short sales can be used to increase the speed and/or accuracy of the price discovery process, by directly incorporating negative market information into the stock price. This argument builds on the work of Busch and Obernberger (2017). If short sales are used to integrate negative market information into the stock price, I expect an increase in price efficiency in down markets. Also, I expect the relative amount of noise incorporated into the stock price to decrease.

Secondly, short sales can improve the price efficiency by increasing the accuracy with which positive information is integrated into the stock price. This argument builds on the findings of Diether, Lee, and Werner (2008) and Busch and Obernberger (2017), who base their argument on the model of Hong, Wang, and Yu (2008). According to Diether, Lee, and Werner (2008), short sellers know and act on short-term deviations of stock prices. The authors find that short sellers aid the price discovery process by correcting the short-term overreacting of stock prices to new information. Busch and Obernberger (2017) find that repurchases improve the incorporation of negative market information, by preventing the stock price from dropping below fundamental values. By bounding the stock price reaction at fundamental values, prices become more efficient and less noisy.

If short sellers help to correct the short-term overreaction to new information, as suggested by Diether, Lee, and Werner (2008), I expect short sellers to improve the price discovery process for positive market information. By providing an upper bound for the reaction of stock prices to positive information, price efficiency will improve, and the amount of firm-specific information or noise incorporated into the stock price will decrease. If short sales are used to improve the accuracy of the price reaction to positive market information, I expect increased efficiency in up markets. Note that the timing here is essential. If short sales are executed at or below fundamental values, the effect of short sales will be the opposite. The noise will increase, and the speed with which new information is integrated into the stock price will decrease.

1.2 Hypothesis 2

My alternative hypothesis is based on the opposite side of the literature and proposes that short sales decrease price efficiency by driving prices below fundamental values. This argument builds on the work of several researchers who all document non-informational trading strategies of short sellers to make a profit (cf. Brunnermeier and Pedersen, 2005, Goldstein and Guembel, 2008, Shkilko, Van Ness, and Van Ness, 2008). These trading strategies use short sales to increase the supply of stocks and, consequently, drive down the stock price. Given that those price drops are noninformational, these trading strategies make prices diverge from fundamental values and subsequently decrease both the information content of stock prices and the speed of the price discovery process. Although my two hypotheses seem to be opposite, they are not mutually exclusive as both can be true in different situations. I test my hypothesis using a dataset of stocks listed on the Hong Kong stock exchange (HKEX) over the period from January 2004 to December 2015. For my baseline analysis, I first obtain daily observations which I convert to monthly data. This dataset consists of 789 companies and 52,554 monthly short sales observations. I merge this dataset with an additional dataset containing data on 1,153 companies listed on the Hong Kong stock exchange, in which short sales are not allowed, this data is particularly useful for my additional analysis explained in section 3.3. My total dataset consists of 1,942 companies and 154,585 monthly delay observations.

I use two types of measures to study the impact of short sales on price efficiency, the first measure being the Hou and Moskowitz (2005) delay measure. The idea behind this measure is that if prices are efficient, all available information should be incorporated into the stock price, therefore lagged market returns should not have explanatory power. The delay measure compares the simple market model with the extended model, which consists of the market model plus five lagged market returns. If the lagged market returns hold extra explanatory power, delay increases until this information is incorporated into the stock price entirely. Hou and Moskowitz (2005) find that firms which react delayed to new information are rewarded with a significant return premium, which appears to be caused by a lack of investors' attention. If short sales increase price efficiency and the information content of stock prices, I expect delay to decrease.

Secondly, I use the R-squared which measure the relative amount of market information incorporated into the stock price, according to Roll (1988). I use the R-squared of a market model regression and the Market Correlation as proxies for market synchrony. If relatively more market information is incorporated into the stock price, this increases the synchrony between a stocks return and the market return. Therefore, if short sales are used to integrate market information, I expect the market synchrony measures to increase. However, if short sales are used to incorporate firm-specific information or noise, I expect the R-squared and Market Correlation to decrease.

I use two different proxies that resemble short sales activity. Firstly, short interest reflects the outstanding short position in a stock divided by the trading volume, therewith it displays the current level of short sales. Secondly, I use change in short interest, which compares the current level of short interest with the level of short interest in the previous month. Hence, it reflects the change in short interest. Also, I include firm fixed effects and time fixed effects to minimize the impact of an omitted variable bias and to control for macroeconomic factors.

In my core analysis, I find that short sales improve price efficiency and the information content of stock prices. The results show that short sales increase the speed with which information integrates into the stock price, for both short sales proxies. Also, I find that short sales improve market synchrony by increasing the relative amount of market information incorporated into the stock price. The results present no evidence for the notion that short sales increase noise or idiosyncratic risk into the stock price.

In the subsequent part of this analysis, inspired by Busch and Obernberger (2017), I try to find out more about the channels through which short sales increase price efficiency. I use the market return as an indicator of positive or negative information coming to the market. The results reveal that short sales in down markets increase the price efficiency and information content. Similarly, down market short sales appear to increase the relative amount of market information incorporated into the stock price. This result is in line with the notion that short sales increase price efficiency by directly incorporating negative market information into the stock price. The results show no conclusive effect of short sales in up markets. Dependent on the research variable, I find weak evidence for the notion that up market short sales increase price efficiency as well as for the notion that up market short sales decrease price efficiency.

This thesis extends the research on the effect of short sales on price efficiency, by focusing on the channels through which short sales effect price efficiency, based on the key insights of Busch and Obernberger (2017). Another distinctive feature of this work is my additional analysis in section 4.1.2 and 4.2.2. This analysis holds a unique comparison between shares that can be sold short and stocks that cannot. I use a regression analysis similar to my baseline analysis. However, instead of using short sales data I use a short sales dummy which denotes one for firms that allow for short sales and zero for firms that do not. This way I try to find the impact of being able to sell short on the price efficiency of stocks.

In this analysis, I find weak evidence for the notion that the ability to sells short increases the speed and/or accuracy with which information is incorporated into the stock price. However, the results strongly support the notion that allowing for short sales decreases noise or firm-specific information incorporated into the stock price. In line with my core analysis, I again perform a subsequent study to see through which channels short sales affect price efficiency. The results of this analysis confirm the results of the core analysis. The evidence shows that down market short sales increase the price efficiency and information content. Again, this result is in line with the notion that short sellers increase price efficiency, by directly incorporating negative information into the stock price. However, different from the first analysis I find that up market short sales have no impact on the relative amount of noise incorporated into the stock price. This result shows that up market short sales do not increase the amount of noise incorporated into the stock price. In line with this result, I find that short sales contribute to a more normal return distribution. Nevertheless, I find some evidence that short sales in up markets decrease price efficiency.

2. Literature

In this paper, I try to answer my research question; Do short sales improve the speed and/or accuracy of the price discovery process? In this section, I describe the theoretical framework and touch upon the most relevant papers concerning short sales and price efficiency.

Short sales are studied long before the start of the 21st century, Miller (1977) is one of the first to come up with a model that captures the effects of short sales on stock prices. He reasons that stock prices will be biased upwards if short sales are not allowed since pessimistic investors leave the market. A later model by Diamond and Verrenchia (1987) reasons that short sales restrictions will not lead to upwards biased prices but a slower adjustment to new information. Short sales restrictions prevent the informed investors, who have access to all information (private and public), from directly incorporating information into the stock price which causes slower incorporation of information into the stock price.

In this paper, I only focus on the incorporation of public information into the stock price. Private information is mostly firm-specific. Therefore, trading on private information would increase the amount of firm-specific information incorporated into the stock price. However, I find the opposite result; short sellers increase the amount of market information incorporated into the stock price.

In line with Diamond and Verrenchia (1987), short sellers are more and more believed to be very well informed investors, who's trades incorporate information into the stock price, as severely shorted stocks experience negative abnormal returns (Boehmer, Johnes, and Zhang, 2008, Diether, Lee, and Werner, 2008).

Empirically, the effect of short sales on price efficiency is typically studied in two ways. Some studies research the impact of short sales restrictions (Bris, Goetzmann, and Zhu, 2007, Saffi and Sigurdsson, 2011), other studies examine the effect of an increase in short interest or shorting flow on price efficiency (Boehmer and Wu, 2013). For proxying price efficiency, there are two popular measures used in literature; the Hou and Moskowtiz (2005) delay measure and the R-squared. I will discuss the empirical results on those measures separately.

The Hou and Moskowitz (2005) delay measure, as discussed in the introduction, displays the speed with which information incorporates into the stock price; it compares the explanatory power of two models, the market model, and the extended market model. The difference in explanatory power between the two different models reveals the speed and accuracy with which new information assimilates into the stock price. The authors find in their research that delay is the most severe in firms that lack investors recognition; small firms that are not traded frequently.

Most of the empirical research is in agreement about the impact of short sales on delay, and finds that short sales or the ease of short sales restrictions lead to a decrease in delay and thus an increase in the speed with which information incorporates into the stock price (Boehmer and Wu, 2013, Bris, Goetzmann, and Zhu, 2007, Saffi, and Sigurdsson, 2011, Busch and Obernberger, 2017). The result of this paper, that short sales increase the speed of the price discovery process is in line with the literature.

The R-squared measure is extensively studied by Roll (1988). He finds that the R-squared displays the relative amount of market information incorporated into the stock price. An increase in firm-specific information incorporated into the stock price leads to a decrease in R-squared. Therefore, R-squared can be used to measure the synchrony between a stock and the market. In line with this notion, Morck, Yeung, and Yu (2000) research the difference in market synchrony between developed and emerging markets. The authors find that in emerging markets due to poor property rights it is harder to incorporate idiosyncratic information into the stock price. Therefore, synchrony between stocks is higher in emerging markets than in developed markets.

Bris, Goetzmann, and Zhu (2007) build on the results of Morck, Yeung, and Yu (2000) and use the R-squared measure as efficiency proxy with a low R-squared displaying higher efficiency and more firm-specific information incorporated into the stock price. The authors use a dummy variable that indicates if short sales are practiced and conclude that short sales restrictions are associated with a higher R-squared. However, Saffi and Sigurdsson (2011) find the opposite result; short sales restrictions are associated with a decrease in R-squared. Also, the result of Saffi and Sigurdsson (2011) seems more plausible since Bris, Goetzmann, and Zhu (2007) use a dummy variable based on interviews with government officials, while Saffi and Sigurdsson (2011) use actual lending supply data to indicate short sales restrictions. In this paper, I don't use the R-squared as an efficiency measure, but in line with Busch and Obernberger (2017), I use the R-squared as an indicator of the type of information that is incorporated into the stock price. In line with Busch and Obernberger (2017) and Saffi and Sigurdsson (2011), I find that short sales increase the relative amount of market information incorporated into the stock price. An increase in short sales activity is associated with a higher R-squared.

While the bigger part of literature believes that short sales increase price efficiency, some researchers document that short sales decrease price efficiency, by driving down the stock price below fundamental values. In the model of Brunnermeier and Pederson (2005) short selling in the form of predatory trading can lead to overshooting, forced liquidation and even to a financial crisis. Goldstein and Guembel (2008) reason that speculative short sales can lead to a drop in firm value. Shkilko, Van Ness, and Van Ness (2008) find that short sellers worsen liquidity-driven price declines by increasing short sales activity. A non-informational price drop, caused by short selling pressure, would decrease the information content and price efficiency since prices move away from fundamental values. My results are not in agreement with the notion that short sellers increase short selling to manipulate prices since I find that short sales improve the price discovery process and increase the amount of market information incorporated into the stock price.

3. Data & Methodology

In this section, the sample construction and descriptive statistics of my dataset are discussed. I also describe my two main analysis and the most important variables used.

3.1 Sample collection & composition

The starting point of my research is a short sales dataset obtained from Bloomberg containing 863,825 daily short sales observations on 1,283 companies, over the period from 2004 to 2015. I exclude 152 non-equity companies from my dataset which costs me 18,585 observations. Since I examine the Hong Kong stock market, I primarily use Datastream and Worldscope for my control variables. Also, I use Datastream to gather price index data, which is essential to make my price efficiency proxies.

My key research variable, delay, is constructed on a monthly bases. Therefore, I convert my short sales dataset and control variables data to monthly values. For my Short Interest variable, I keep the last observation of every month. For the other variables, I take the monthly average of my daily observations as my monthly values. After conversion, I have 55,129 monthly short interest observations and 1,131 companies. Due to missing values for the delay measure, I lose 826 firm-months of short sales data and 46 companies. After restricting the data to firms with a least 12 months of short sales data, I lose another 1636 firm-months and 296 companies. Finally, I drop observations with missing market return data, which is essential for my subsequent analysis, this costs me 113 firm-months. This leaves me with 52,667 observations and 789 companies.

For the additional part of my dataset, I gather data on 1,478 companies, listed on the Hong Kong stock exchange, that do not allow for short sales. For this dataset, I have 222,012 monthly (delay) observations. I lose 119,428 firm-months and 325 companies due to missing delay data. After that, I drop 553 companies with missing market return data, which leaves me with 102,031 observations and 1,153 companies.

After merging the two datasets, my total dataset consists of 1942 companies and 154,585 monthly observations. I winsorize my variables at the one percent threshold, to remove outliers. This procedure holds replacing the one percent most extreme observations on both sides with the threshold value. Also, I take the natural logarithm if variables display high degrees of skewness.

3.2 Core Analysis

For the core of my research, I will regress a price efficiency proxy on a short sales proxy, along with some control variables.

$$Efficiency_{i,t} = \alpha + \delta Efficiency_{i,t-1} + \beta Short_{i,t-1} + l = \sum_{l=1}^{l=k} Control_{i,l,t} + \mu_i + \eta_t + u_{i.t} \quad (1)$$

$$Idiosyncratic\ Risk_{i,t} = \alpha + \delta Efficiency_{i,t-1} + \beta Short_{i,t} + l = \sum_{l=1}^{l=k} Control_{i,l,t} + \mu_i + \eta_t + u_{i.t} (2)$$

In the first equation, $Efficiency$ is proxied by the Hou and Moskowitz (2005) delay measure, which will be explained in section 3.4. In the second equation, the dependent variable is replaced by $Idiosyncratic\ Risk$, which is proxied by either *R-squared* or M*arket Correlation*. $Short$ denotes the degree of short selling, for which I will use S*hort Interest* and the *Change in Short Interest* as proxies. *Short Interest* reflects the outstanding short position in a stock divided by the trading volume, therewith it displays the current level of short sales. *Change in Short Interest* compares the current level of short interest with the level of short interest in the previous month. Consequently, *Change in Short Interest* reflects the in or decrease in short sales activity in the current month. The work of Saffi and Sigurdsson (2011) shows, that high levels of *Short Interest* can be problematic as a proxy for short sales activity. Since high levels of *Short Interest* can restrict short sellers from incorporating information into the stock price (Saffi and Sigurdsson, 2011). Therefore, we could wrongfully find a correlation between high levels of *Short Interest* and high degrees of *Delay*. By using *Change in Short Interest*, we circumvent this problem, since the *Change in Short Interest* in such stocks will be close to zero.

To accurately determine the effect of short sales on price efficiency, it is crucial to include control variables, denoted with $Control$ in the equation. More on control variables will be discussed in section 3.5, in the next section, I will explain my additional analysis.

3.3 Short sales dummy Analysis

For this analysis I regress a price efficiency proxy on a short sales dummy along with control variables. In line with the core analysis, *Efficiency* is proxied by the Hou and Moskowitz (2005) delay measure and *Idiosyncratic Risk* is proxied by either *R-squared* or *Market Correlation.*

$$Efficiency_{i,t} = \alpha + \delta Efficiency_{i,t-1} + \beta Dum_{i,t} + l = \sum_{l=1}^{l=k} Control_{i,l,t} + \mu_i + \eta_t + u_{i.t} \quad (1)$$

$$Idiosyncratic\ Risk_{i,t} = \alpha + \delta Efficiency_{i,t-1} + \beta Dum_{i,t} + l = \sum_{l=1}^{l=k} Control_{i,l,t} + \mu_i + \eta_t + u_{i.t} (2)$$

In line with Chang, Cheng, and Yu (2007), I use a unique feature of the Hong Kong stock exchange, the list of designated securities that can be sold short[5], hereafter referred to as the list. In line with my core analysis described in the previous section, in the first equation *Efficiency* is proxied by the Hou and Moskowitz (2005) delay measure and in the second equation *Idiosyncratic risk* is proxied by the market synchrony measures; *Market Correlation and R-squared. Dum* is a short sales dummy denoting one for stocks in which short sales are allowed and zero for stocks in which short sales are not. The short sales dummy captures the effect of the possibility to short a stock. Again, control variables are essential and denoted with *Control.* More on control variables in section 3.5, in the next section I explain the delay measure.

3.4 Delay measure

In line with Busch and Obernberger (2017), I will use two variations of the Hou and Moskowitz (2005) delay measure, the “regular” delay measure and the coefficient-based delay measure. The delay measures display the speed or accuracy with which information incorporates into the stock price, by comparing the explanatory power of the lagged market returns of the extended model to the simple market model. To estimate the measures I use daily returns as in Busch and Obernberger (2017).

$$r_{i,t} = \alpha_i + \beta_i^0 r_{m,t} + \varepsilon_{i,t} \qquad \text{Base model} \qquad (1)$$

$$r_{i,t} = \alpha_i + \beta_i^0 r_{m,t} + \sum_{n=1}^{5} \beta_i^n r_{m,t-n} + \varepsilon_{i,t} \qquad \text{Extended model} \qquad (2)$$

Here $r_{i,t}$ denotes the return of firm i on day t. In the first equation, the stock return is regressed on the market return $r_{m,t}$ which gives me the Beta β_i^0. In the extended model, I add the lagged market returns $r_{m,t-n}$, of which the effect is denoted β_i^n. If prices are efficient β_i^n is zero and the explanatory power of both models will be equal. Nevertheless, if information is not timely or accurately incorporated into

[5] For exemptional purposes like hedging or liquidity provision stocks not on the list can still be sold short. For a detailed description of the exceptions: https://www.hkex.com.hk/-/media/HKEX-Market/Services/Trading/Securities/Overview/Regulated-Short-Selling/sch-11_eng.pdf?la=en.

the stock price, β_i^n is bigger than zero and the extended market model will have more explanatory power than the base model. I use five lags in the extended model to resemble the number of business days in a week. the first variant of the Hou and Moskowitz (2005) delay measure, divides the $R^2$of the base model, R^2_{base} by the R^2 of the extended model, $R^2_{extended}$.

$$Delay = 1 - \frac{R^2_{base}}{R^2_{extended}} \tag{3}$$

If prices are efficient, the explanatory power of the two models is identical and *Delay* is zero. If prices are inefficient, the extended model holds more explanatory power than the base model and *Delay* is bigger than zero. *Delay* takes a value between 0 and 1 and decreases in price efficiency. The second *Delay* measure is based on the regression coefficients.

$$Coefficient - based\ Delay = \frac{\sum_{n=1}^{5} n * \frac{abs(\beta_i^n)}{se(\beta_i^n)}}{\frac{abs(\beta_i^0)}{se(\beta_i^{n0})} + \sum_{n=1}^{5} \frac{abs(\beta_i^n)}{se(\beta_i^n)}} \tag{4}$$

The *Coefficient-based Delay* measure sums the absolute value of the weighted coefficients of the lagged market return, scaled by their standard errors and divides them by the absolute sum of all coefficients scaled by their standard errors. Similar to the *Delay* measure, *Coefficient-based Delay* decreases in price efficiency, since the lagged coefficients hold less explanatory power when prices are more efficient.

3.5 Control variables

To isolate the effect of short sales on price efficiency, I include several control variables in the regression analyses. As suggested by previous studies, I control for the *Market Capitalization* and *Relative Spread*. The *Relative Spread* is the difference between the execution price and the midpoint price multiplied by two and divided by the midpoint price. *Relative Spread* is an important variable to control for as this variable since it indicates the costs of short sales. If executing short sales is relatively more expensive, it possibly discourages traders from performing arbitrage in mispriced stocks, thereby negatively affecting the price efficiency (Boehmer and Wu, 2013). Moreover, I control for *Market Capitalization*, *Trading Volume,* and *Book to Market* as these variables are associated with investors recognition and thus correlated with *Delay* (Hou and Moskowitz, 2005). Furthermore, I control for the number of analysts covering a stock since this can positively affect the price discovery process (Brennan and Subrahmayam, 1995).

3.6 Considerations

In my core analysis in section 3.2, Unobserved factors could exogenously determine Short Interest. If short sales are conducted to improve the price discovery process, the short sales intensity is endogenously defined by the unobserved counterfactual of price efficiency. In this framework, I don't observe the level of price efficiency in the absence of short sales. Therefore, I could wrongfully conclude that there is no relationship between short sales and price efficiency, while in fact, there is a positive relationship between the two variables. So, reverse causality and endogeneity concerns are high if short sales are used to correct for mispricing. I deal with this in three ways; firstly I include Fixed effects, Time fixed effects and the lagged independent variable. Also, I lag the independent variables to minimize reverse causality issues. Finally, I perform an additional analysis described in section 3.3 in which I make use of a dummy variable. By including Fixed Effects, I make sure that my results do not suffer from an omitted variable bias. Also, I add time fixed effects to control for factors that might alter my dependent or independent variable over time. By including the lagged dependent variable, I make sure that my results are not affected by efficiency timing. Would the level of short sales be dependent on the current level of efficiency, the lagged dependent variable controls for this. In my additional analysis.

In my further study, I again include fixed effects, time fixed effects, and the lagged dependent variable. Since the dummy variable indicating that short sales are allowed is determined beforehand, the concern of reverse causality in this analysis is low. Also if short sales are used to correct price efficiency, the dummy will still capture the difference in price efficiency between short sales stocks and non-short sales stocks. However, a possible problem can arise if firms on the short sales list, don't experience enough short sales activity. In this case, the dummy variable will not observe a significant difference. Also to get on the eligible for short sales list stocks have to meet certain criteria. Two examples of those criteria are cited below:

(a) "all constituent stocks of indices which are the underlying indices of equity index products traded on the Exchange"...

(f) "stocks with market capitalization of not less than HK$3 billion and an aggregate turnover during the preceding 12 months to market capitalization ratio of not less than 60%".

Most of the criteria to get on the list are comparable to the ones above and have a strong connection with either the size or the liquidity of the stocks. Consequently, firms on the list are relatively larger and more liquid firms which is why in this analysis control variables are again essential. Another possible problem is that firms not on the list can still experience exemptional short selling for hedging purposes or liquidity provision. These short sales could possible distort the observed difference between the two groups.

3.7 Descriptive Statistics

As Table 3 reports, my total sample consist of 154,585 monthly observations and over the 52,554 months in my dataset, the median dollar amount of shares short is 1.3 million HK$. This amount is equivalent to 4.8 percent of the monthly trading volume and 0.45 percent of the median Market Capitalization. The average short sales percentage, however, is somewhat bigger; 8.7 percent, which is caused by positive skewness. In line with the results of Asquith, Pathak, and Ritter (2005), most companies in our sample have a relatively small *Short Interest* percentage while some have an enormous *Short Interest* percentage causing the distribution to skew to the right. *Delay* and *Coefficient-based Delay* can take any value between zero and one, and zero and five respectively. Both variables have a mean that is around the middle of the distribution and similar to the median value, which means that both variables display no skewness. Similarly, *The R-squared* and *Market Correlation* both have means which are close to their median values.

4. Results

This section starts with my main analysis, in which I determine what drives short sales and try to answer my hypothesis based on the results. After that, I start my second analysis in which I determine the effect of contemporaneous short sales and try to confirm the results of my first analysis. After that I focus on the effect on the return distribution and reverse causality.

4.1 Core Analysis

In this analysis, I try to answer my research question by testing my baseline hypothesis, which proposes that short sales increase price efficiency, by either increasing the speed or the accuracy with which information is integrated into the stock price. I test this hypothesis in sections 4.1.2 to 4.1.4.

4.1.1 Short interest analysis

In this section, I try to determine what possibly drives short sales, besides I examine the relationship between Lagged and Contemporaneous *Short Interest.* To do so, I regress Contemporaneous *Short Interest* on Lagged *Short Interest* together with other possible drivers of short sales activity. In table 3 column (2), the regression where I include Lagged *Short Interest* as an independent variable, I find that this variable comes in significant with a coefficient of 0.1355. The size of the coefficient reveals that Lagged *Short Interest* is a good proxy for Contemporaneous *Short Interest*. Since I control for fixed effects, the average impact of *Short Interest* is already taken into account. Consequently, the result seems to be economically significant. Also, the explanatory power of the model increase with 1.8 percent to 3.6 percent after including the lagged dependent variable, so lagged *Short Interest* appears to be the best available predictor of contemporaneous *Short Interest*.

The effect of the *Book to Market* ratio is significant and positive, which indicates that firms with a higher *Book to Market* ratio experience increased short selling over the next month. Additionally, the effect of *Relative spread* is significant and negative, indicating that short sellers are more active in more liquid stocks. These findings are in line with the results of Dechow, Hutton, Meulbroek, and Sloan (2001) and Desai, Ramesh, Thiagarajan, and Balachandran (2002), who find that short sellers target highly liquid stocks with fundamentals indicating overpricing.

In line with the results reported by Busch and Obernberger (2017), I find that lagged negative returns drive short sales while lagged positive returns have no significant effect.

4.1.2 Short sales and price efficiency

In this section, I try to determine the impact of short sales on price efficiency. Therefore, I regress a price efficiency measure on a short sales proxy and control variables. As discussed in section 3.2, I will use both the level of *Short Interest* as well as the *Change in Short Interest* as research variables.

I find that short sales increase price efficiency regardless of the type of short sales proxy or delay measure used. Column (1) of table 4 shows that Lagged *Short Interest* is negatively correlated with *Delay*, a rise in the level of *Short Interest* is associated with a decrease in *Delay*. A within standard deviation increase in *Short Interest* (0.096) leads to a reduction in *Delay* of 0.0034 percentage points (= -0.0410 * 0.096, where -0.0410 is the coefficient from table 4), which equals 0.58 percent of median *Delay* (=0.0034 /0.578, where 0.578 is median *Delay*, retrieved from table 3). Busch and Obernberger (2017) report that a within standard deviation increase in repurchase activity (0.0081) leads to a reduction of 1.12 percent of median *Delay*. (=(0.6429*0.0081)/0.465, where 0.6429 is the coefficient of lagged repurchase activity, reported in table 4 and 0.465 is the median *Delay).* Boehmer and Wu (2013) document that a standard deviation increase in *Short Interest* (0.068), leads to a decrease in Delay of 2.49 percent (=(0.160*0.068/0.437), where 0.4374 is median *Delay* retrieved from table 1). For *Coefficient-based Delay* in column (3), I find a similar result concerning the economical and statistical significance.

For column (2), where I use *Change in Short Interest* as my research variable, I again find a negative correlation with *Delay*. Thus, an increase in short sales activity is associated with improved price efficiency. A within standard deviation increase (0.096) in *Short Interest* leads to a decrease in *Delay* of 0.0041 percentage points (-0.0424 *0.096, where -0.0424 is the coefficient from table 4), which corresponds to 0.70 percent of median *Delay* (0.0041 /0.578, where 0.753 is median *Delay* retrieved from table 3). For column (4), I find a similar effect of short sales on *Coefficient-based Delay.*

I find that short sales increase price efficiency and the information content of stock prices. This result supports my first hypothesis which states that short sales increase the price efficiency by increasing the speed or accuracy with which market information is incorporated into the stock price. I find no evidence for my alternative hypothesis that short sales decrease price efficiency, as I would obtain a positive correlation between short sales and *Delay*.

The effect of my control variables is in line with the previous literature. In every specification column (1-4) *Delay* increases in *Relative spread* and decreases in *Market Capitalisation*. These findings are in line with the current literature (cf. Hou and Moskowitz, 2005, Saffi and Sigurdsson, 2011). Hou and Moskowitz (2005) document that firms with high degrees of price *Delay* are mostly small firms neglected by investors. In line with the result of Busch and Obernberger (2017), I find that *Delay* decreases in *Volatility*. I observe that *Delay* decreases in *Trading Volume*, which is also documented by Boehmer and Wu (2013). Although *Number of Analysts* comes in with the right sign, this correlation lacks significance. In the next section, I focus on the effect of short sales on the relative amount of firm-specific and market information absorbed into the stock price.

4.1.3 Short sales and market synchrony

I use the *R-squared* and *Market Correlation* as proxies for the synchronicity between the stock and market return. If short sales are conducted to manipulate stock prices or to incorporate firm-specific information, the relative amount of idiosyncratic information will increase, subsequently the *R-squared* and *Market Correlation* will decrease. If short sales are conducted to improve the speed or accuracy with which market information is incorporated into the stock price, I expect the amount of firm-specific information or noise to decrease and thus the *R-squared* and *Market correlation* to increase.

Column (1) of table 5, shows that *Short Interest* has a positive impact on *R-squared*, implying that short sales decrease the relative level of firm-specific information or noise in the stock price. A within standard deviation increase (0.096) in *Short Interest* leads to a rise in *R-squared* of 0.0047 percentage points (0.0490*0.096, where 0.0490 is the coefficient from table 5), which corresponds to 2.60 percent of median *R-squared* (0.0047 /0.181 where 0.181 is median *R-squared*, retrieved from table 2). Busch and Obernberger (2017) find a comparable effect as lagged *Repurchase Intensity* the authors find an impact of 1.74 percent of median *R-squared*(=(0.0081*0.4569)/0.2217, where 0.4569 is the coefficient stated in table 5, and 0.2217 is median *R-squared* reported in table 2.

For the *Market Correlation* regression column (3), I find a similar result concerning coefficients, t-statistics and economic relevance. For *Change in Short Interest*, column (2), I again find a significant positive correlation with *R-squared*. Increased short sales activity is associated with improved market synchrony. A within standard deviation increase (0.096) in *Short Interest* corresponds with a 0.0041 percentage points increase in *R-squared* (0.0425*0.096 where 0.0425 is the coefficient collected from table 5), which equals 2.26 percent of median *R-squared* (0.0041/0.181 where 0.181 is median *R-squared*, retrieved from table 2). Again the results concerning the *Market Correlation* regression column (4), is similar regarding coefficients, t-statistics and economic relevance.

In conclusion, I find no evidence for the notion that short sales lead to more noisy prices. On the contrary, my results suggest that an increase in short sales activity increases the amount of market information incorporated into the stock price. This result confirms with the notion that short sales lead to more efficient prices as the information content of stock prices increases in short sales.

My control variables are in line with the current literature. *Market Capitalization* has a significant positive effect on *R-squared*, meaning that the level of noise reduces in firm size, which corresponds to the results of Saffi and Sigurdsson (2011). The literature is in disagreement about the effect of B*ook to Market* on *R-squared* (Busch and Obernberger, 2017*)*. In line with the authors, I find that *R-squared* decreases in *Book to Market,* which I find hard to justify. An increase in T*rading Volume* leads to higher *R-squared* and *Market Correlation*; this result is in line with the findings of Bris, Goetzmann, and Zhu (2007). Again, the variable *Number of Analyst* comes in with the right sign but lacks significance. In the next section, I will look at the different mechanisms through which short sales can improve market synchrony and price efficiency.

4.1.4 Short sales in up and down markets

In section 4.1.2, I found that *Short Interest* is negatively correlated with *Delay*. So, an increase in short sales activity leads to more efficient prices. As mentioned in the introduction, there are two ways to improve price efficiency through short sales. Short sales can either directly incorporate negative market information into the stock price, thereby increasing the speed of the price discovery process, or improve the accuracy of positive information integration by providing an upper bound at fundamental values. If short sales are conducted to incorporate negative market information, I should find that price efficiency increases in months of negative market news. Nevertheless, if short sales are undertaken to improve the accuracy of positive information integration, I should discover that price efficiency increases in months of positive market news.

Inspired by Busch and Obernberger (2017), I use the market return to indicate if positive or negative information comes to the market and split my short sales variable into up-market *Short Interest* and down market *Short Interest* accordingly. This approach seems reasonable since I find that short sales decrease *Delay* and reduce the relative amount of idiosyncratic information integrated into the stock price.

For the level of *Short Interest,* table 6A, I find that the effect is significant in both up and down markets. However, for down markets, I find coefficients that are twice as big as for up markets and 4 to 6 times as big as the original coefficients in table 3 and 4. In column (1), a down-market, I find that a within standard deviation increase (0.096) in *Short Interest* leads to a decrease in *Delay* of 0.0213 percentage points (0.096* -0.2217, where -0.2217 is the coefficient obtained from table), which corresponds with a decline of 3.68 percent of median *Delay* 0.0213/0.578, where 0.578 is median *Delay* obtained from table). Busch and Obernberger (2017) find a somewhat smaller effect for lagged repurchase intensity. Table 6 specification (2) of their paper, shows that in a down market a within standard deviation increase (0.0081) in repurchase intensity leads to a decrease in *Delay* of 1.84 percent of median *Delay* (=(0.081*-1.0563)/0.465, where -1.0563 is the coefficient retrieved from table 6 and 0.578 the median Delay acquired from table 2). For coefficient-based *Delay* column (2), I find a similar result for down market short sales.

Column (3) shows that down market short sales have a substantial positive effect on *R-squared.* A within standard deviation increase (0.096) in *Short Interest* leads to an increase in *R-squared* of 0.0170 percentage points(0.1775*0.096, where 0.1775 is the coefficient retrieved from table 6a), which corresponds with 9.44 percent of median *R-squared* (0.0170/0.181, where 0.181 is median *R-squared* acquired from table 2. For *Market Correlation*, column (4), I find similar results concerning coefficients, t-statistics, and economic relevance.

For up-markets in column (1-4), I find that short sales are negatively correlated with price efficiency and *R-squared*. The adverse effect of short sales in up-markets sales is about twice as small as the positive effect of down market short sales, for *Delay* and *Coefficient-based Delay*. For *R-squared* and *Market Correlation* this adverse effect of up market short sales is a third the size of the positive effect of down market short sales.

In Table 6B, I run the same analysis with *Change in Short Interest*. In line with my previous findings, I find that short sales increase price efficiency in down markets. Column (1) shows that a within standard deviation increase in *Short Interest* (0.096) leads to a decrease in Delay of 0.0063 percentage points (0.096*-0.066, where -0.066 is the coefficient retrieved from table 6b), which corresponds to a decrease of 1.10 percent (0.0063/0.578, where 0.578 is median Delay collected from table 2). For *Coefficient-based Delay*, column (2) I find a similar result.

Column (3) shows that a standard deviation increase in short sales lead to an increase of 3.06 percent of median *R-squared*(=(0.096*0.0576)/0.181, where 0.0576 is the coefficient retrieved from table 6b and 0.181 median *R-squared* from table 2). This effect is similar to the effect of 3.62 percent reported by Busch and Obernberger (2017) (=(0.0081*0.9909)/0.2217, where 0.9909 is the coefficient collected from table 6, and 0.2217 is median R-squared retrieved from table 2. column (4) shows that the results for *Market Correlation* are in line with the results concerning *R-squared*.

Nevertheless, the results concerning up market short sales in Table 6b show that compared to table 6a the effect of short sales in up and down markets becomes less significant. Also, the result for up market short sales show that *Change in Short Interest* has a positive effect on Price efficiency. Similarly, the effect of up market short sales on R-squared is now positive, however only significant for *R-squared*. For every specification, the impact of up market short sales is about half the size of the impact of down market short sales. Since short sellers can only incorporate negative information into the stock price, it appears that short sellers improve the accuracy of the integration of positive market information into the stock price.

Concluding, I find that short sales are used to directly incorporate negative market information into the stock price, thereby increasing the speed with which information is incorporated into the stock price and the information content of stock prices. This finding supports the notion that short sales provide short sellers with a direct way to incorporate market information into the stock price. For up market short sales, I find mixed results. For the level of Short Interest, I find that short sellers incorporate noise or firm-specific information into the stock price. However, for *Change in Short Interest*, I find that the effect on price efficiency and market synchrony is positive, which is in line with the notion that short sellers use share repurchases to bound the reaction to positive market information at fundamental values.

4.1.5 Conclusion

I find that short sales increase price efficiency and the information content of stock prices. This result supports my first hypothesis that short sales increase price efficiency, by either increasing the speed and/or the accuracy with which information is incorporated into the stock price. I find no evidence for the notion that short sales decrease price efficiency. In the subsequent analysis about the channels through which short sales improve price efficiency, I find evindence for the notion that short sales are used to incorporate negative market information. As I find that down market short sales increase price efficiency and the relative amount of market information incorporated into the stock price. The evidence on up market short sales is not conclusive. However, part of the results shows that short sales decrease the price efficiency and information content in stock price. Nevertheless, the results also hint that short sellers improve price efficiency, by improving the incorporation of positive information.

4.2 Short sales dummy Analysis:

In the previous analysis, I find evidence for the notion that short sellers increase price efficiency. In this analysis, I try to confirm the results of my baseline hypothesis. Also, I try to find out more about the channels through which short sales improve price efficiency, especially in up markets as I found mixed results in the first analysis.

4.2.1 Contemporaneous Short Interest

In this section, I focus on *Contemporaneous Short Interest*. In table 8a column (1), I find a negative correlation between *Short Interest* and *Delay*. However, this correlation is only significant at the ten percent level. Furthermore, the result for *Coefficient-based Delay*, column (2), is not significant. Column (3) shows that *R-squared* is positively correlated with contemporaneous *Short Interest.* This association demonstrates that an increase in *Short Interest* corresponds to a higher *R-squared.* In line with the results of table 5, short sales appear to increase the amount of market information in the stock price. This result is robust for *Market Correlation* column (4). As discussed in section 3.6 endogeneity and reverse causality problems can arise when I use Contemporaneous *Short Interest*. These problems might be the reason that I do not observe a significant relationship between Contemporaneous *Short Interest* and *Delay*.

4.2.2 Short Interest Dummy

In the previous section, I focussed on the effect of contemporaneous *Short Interest* on *Delay*. In this section, I use a dummy variable which indicates if a stock is on the eligible for short sales list. This variable represents the difference between short sales and non-short sales stocks and is determined beforehand; thereby I circumvent the reverse causality problem. This dummy variable enables me to observe the effect of short sales on price efficiency, even if short sales are conducted to improve price efficiency. Since I found a positive correlation between lagged *Short Interest* and price efficiency, I expect price efficiency to be higher for shares that allow for short sales.

Table 8B column (1) shows that stocks on the list display a smaller *Delay*. However, this result is only significant at the ten percent significance level. Column (2), presents a similar yet significant correlation with *Coefficient-based Delay*. Columns (2-3) reveal that stocks that allow for short sales display higher levels of market synchrony.

Concluding, in line with my previous results, short sales decrease the noise in the stock price and increase the market synchrony measures; *R-squared* and *Market Correlation.* Also, I find weak evidence for the notion that stocks in which short sales are allowed display a smaller degree of *Delay*.

4.2.3 Short Interest dummy in up and down markets.

The previous section was concentrated around the effect of the short sales dummy on price efficiency. In this section, in line with my earlier analysis, I interact the short sales dummy with a dummy variable for up and down markets to see through which channel short sales increase the price efficiency and market synchrony. In line with section 4.1.4, I expect short sales to decrease *Delay* by increasing the speed with which negative market information gets incorporated into the stock price.

Table 8C column (1- 2), displays the effect of the short sales dummy on price efficiency, in up and in down markets. I find that the down market short sales dummy significantly increases price efficiency. I observe that the coefficient of the short sales dummy in down markets is approximately three times as big as the original coefficient in table 8b, while the size of the dummy in up markets is unchanged. In line with the result from the first analysis, short sales appear to increase the speed with which negative market information is incorporated into the stock price. For up markets in column (1-2), I find that allowing for short sales significantly increases *Delay*.

Column (3-4) display the effect of the ability to sell short on market synchrony in up and down markets. I observe that down market short sales significantly increase *R-squared* and *Market Correlation*, with a coefficient approximately three times larger than the original coefficient in table 8b. However, for up markets, I find that allowing for short sales does not affect the market synchrony measures.

Concluding, I find evidence for the notion that short sales increase price efficiency and the information content of stock prices, by incorporating negative market information into the stock price. I find that up market short sales have no effect on the relative amount of firm-specific information or noise into the stock price. This is direct evidence against the notion that short sales are used to improve the incorporation of positive information by bounding the reaction of positive news at fundamental values, as the noise in the stock price would decrease. I find weak evidence for the notion that up market short sales decrease price efficiency.

4.2.4 Conclusion

The results show that contemporaneous short sales do not affect price efficiency. For the short sales dummy, which is less affected by reverse causality or possible endogeneity, I find that this correlation becomes more significant. I obtain weak evidence that short sales increase price efficiency and substantial evidence that short sales increase the relative amount of market information incorporated into the stock price. In the subsequent analysis of the possible channels through which short sales affect price efficiency, I find evidence for the notion that short sales are used to incorporate negative market information. Also, I find direct evidence against the second channel, that short sales increase the accuracy of positive market information.

4.3 Price Stability

In the previous sections, I focused on the effect of short sales on price efficiency. Although I find that the overall impact of short sales on price efficiency is positive, it can still be that short sales increase the frequency of extreme returns. From a regulatory point of view it is interesting to know if short sellers can worsen or cause extreme returns. Consequently, this section focusses on the effect of short sales on the return distribution.

In the previous section, I found that short sales help to make prices more efficient by improving the price discovery process, thereby keeping prices closer to their fundamental values. Accordingly, I would expect less frequent extreme returns so a decrease in *Skewness* and *Kurtosis*. Since short sales provide short sellers with a way to directly include negative market information into the stock price, I expect short sales to decrease *Skewness*.

Table 7A displays that *Short Interest* decreases *Skewness* and *Volatility,* but has no significant correlation with *Kurtosis*. In table 7B, I replace Short Interest with a dummy indicating if short sales are allowed, to compare the difference in return distribution between short sales and non-short sales companies. As can be seen from the table stocks that allow short sales display lower Skewness Kurtosis and Volatility.

Concluding, I find no evidence that Short sales adversely affect the return distribution. Adversely, I find that increased Short sales lead to lower Skewness and Kurtosis. Also, stocks that allow for short sales display lower Skewness, Kurtosis, and Volatility.

4.4 Causality

As discussed in section 3.6, I have to be cautious with the interpretation of my results due to reverse causality. Although I already try to minimize the possibility of reverse causality by including fixed effects, time fixed effects and the lagged dependent variable, as discussed in section 3.6 In this section, I try to rule out the possibility that reverse causality drives the results of section 4.1.2 to 4.1.4. Intuitively if two variables are correlated variable x has an impact on y and vice versa, that is if both variables happen at the same time. In section 4.1.2 and 4.1.3, I regress *Delay* or *R-squared* on lagged *Short Interest* and find a Significant correlation. In this section, my dependent variable is either *Short Interest* or *Change in Short Interest*. I regress *Short Interest* on my lagged efficiency and synchrony measures. If these lagged variables have no significant correlation with *Short Interest*, I can rule out reverse causality.

For the efficiency measures, column (1-2), (5-6) only column (1) displays a correlation which is significant at the 5 percent level. There appears to be a significant relationship between lagged *Delay* and *Short Interest*. However, for the same regression with Coefficient-based Delay in column (2) or with *Change In Short Interest* in column (5), I find no significant correlation. Therefore, I find it unlikely that reverse causality drives my results.

For my synchrony measures column (3-4) and (7-8), I obtain mixed results. For Short Interest column (3-4), I find that lagged *R-squared* and lagged *Market Correlation* display a significant positive correlation with *Short Interest*. It appears that stocks with relatively more market information incorporated into the stock price display higher levels of short Interest in the next period. However, as column (7-8) shows Lagged market synchrony measures are not correlated with the actual short sales activity, *Change in Short Interest*. Also in my additional analysis in section 4.2.2 I find that the short sales dummy, a variable which is predetermined and therefore not subject to reverse causality has a significant effect on *R-squared* and *Delay*. Consequently, I conclude that reverse causality does not cause my results.

5. Conclusion

In this paper, I study the impact of short sales on price efficiency and the amount of market information incorporated into the stock price. The evidence is in line with the notion that short sales increase price efficiency and the information content of stock prices. The results show that short sales are used to directly incorporate negative market information into the stock price, thereby increasing the speed of the price discovery process. I find no evidence for the notion that short sales are used to improve the accuracy of positive information incorporation. I find no evidence for the notion that short sales decrease overall price efficiency, the results concerning the effect of short sales on the return distribution support this view.

References:

Asquith, P., Pathak, P. A., & Ritter, J. R. (2005). Short interest, institutional ownership, and stock returns. *Journal of Financial Economics*, *78*(2), 243-276.

Boehmer, E., Jones, C. M., & Zhang, X. (2008). Which shorts are informed?. *The Journal of Finance*, *63*(2), 491-527.

Boehmer, E., & Wu, J. (2013). Short selling and the price discovery process. *The Review of Financial Studies*, *26*(2), 287-322.

Brennan, M. J., & Subrahmanyam, A. (1995). Investment analysis and price formation in securities markets. *Journal of Financial Economics*, *38*(3), 361-381.

Bris, A., Goetzmann, W. N., & Zhu, N. (2007). Efficiency and the bear: Short sales and markets around the world. *The Journal of Finance*, *62*(3), 1029-1079.

Brunnermeier, M. K., & Pedersen, L. H. (2005). Predatory trading. *The Journal of Finance*, *60*(4), 1825-1863.

Busch, P., & Obernberger, S. (2017). Actual share repurchases, price efficiency, and the information content of stock prices. *The review of financial studies*, *30*(1), 324-362.

Chang, E. C., Cheng, J. W., & Yu, Y. (2007). Short‐sales constraints and price discovery: Evidence from the Hong Kong market. *The Journal of Finance*, *62*(5), 2097-2121.

Dechow, P. M., Hutton, A. P., Meulbroek, L., & Sloan, R. G. (2001). Short-sellers, fundamental analysis, and stock returns. *Journal of Financial Economics*, *61*(1), 77-106.

Desai, H., Ramesh, K., Thiagarajan, S. R., & Balachandran, B. V. (2002). An investigation of the informational role of short interest in the Nasdaq market. *The Journal of Finance*, *57*(5), 2263-2287.

Diamond, D. W., & Verrecchia, R. E. (1987). Constraints on short-selling and asset price adjustment to private information. *Journal of Financial Economics*, *18*(2), 277-311.

Diether, K. B., Lee, K. H., & Werner, I. M. (2008). Short-sale strategies and return predictability. *The Review of Financial Studies*, *22*(2), 575-607.
Goldstein, I., & Guembel, A. (2008). Manipulation and the allocational role of prices. *The Review of Economic Studies*, *75*(1), 133-164.

Hou, K., & Moskowitz, T. J. (2005). Market frictions, price delay, and the cross-section of expected returns. *The Review of Financial Studies*, *18*(3), 981-1020.

Miller, E. M. (1977). Risk, uncertainty, and divergence of opinion. *The Journal of Finance*, *32*(4), 1151-1168.

Mitchell, M., Pulvino, T., & Stafford, E. (2004). Price pressure around mergers. *The Journal of Finance*, *59*(1), 31-63.

Morck, R., Yeung, B., & Yu, W. (2000). The information content of stock markets: why do emerging markets have synchronous stock price movements?. *Journal of Financial Economics*, *58*(1-2), 215-260.

Roll, R. (1988). R2. The Journal of Finance, *43*, 541-566

Saffi, P. A., & Sigurdsson, K. (2010). Price efficiency and short selling. *The Review of Financial Studies*, *24*(3), 821-852.

Shkilko, A., Van Ness, B. F., & Van Ness, R. A. (2008). Aggressive short selling and price reversals. Financial Management. 41, 345-370

Table 1: Variable Discription. This table displays the name, definition, source and unit for all dependent and control variables. (ln) reflects that the natural logarithm of the variable is used in the analysis.

Name	Definition	Source	Unit
Analyst	The number of analyst(s) keeping track of a particular stock.	TAQ	unit
Book to Market	The monthly average of daily Book to Market ratio.	DS	ratio
Book Value Equity	The investment of common shareholders in a particular company.	WS	unit
Cash	The money available for use in the normal operations of a specific company.	WS	unit
Delay	The efficiency measure generated by taking the ratio of the R-squared measure of the extended and the base model.	DS	ratio
Coefficient-based Delay	The weighted sum of coefficients of the lagged market returns, divided by the sum of all coefficients. (extended model)	DS	ratio
Dividends	The monthly average of dividends per share time the number of shares outstanding.	WS	unit
EBITDA	The earnings of a company before interest expenses, income taxes and depreciation.	WC	unit
Leverage	Total assets - book value of equity)/ (Total assets- book value equity + Marketcap)	DS	unit
Market Cap	The average stock price per month times the average number of shares outstanding.	DS	unit
Market Correlation	The Correlation between the stock return and the simultaneous market return.	DS	ratio
Relative Spread	The absolute difference between the prevailing bid and ask quote divided by the quote midpoint.	DS	unit
Return	The daily end of the month price divided bt the prevailing end of the month price minus one.	DS	unit
Return >0	The monthly stock return constructed from daily data if positive, otherwise zero.	DS	unit
Return <0	The monthly stock return constructed from data if positive, otherwise zero.	DS	unit
R-squared	The explanatory power of the simple marketmodel regression.	DS	ratio
Shares Outstanding	The monthly avarage of the daily number of shares outstanding.	DS	000
Total Assets	The sum of total current assets, long term receivables, investment in unconsolidated subsidiaries,other investments, net property plant and equipment and other assets.	DS	unit
Trading Volume	The per month sum of daily dollar trading volume.	DS	$000
Turnover	The number of shares traded for a stock on a particular day.	DS	$000
Volatilty	The monthly standard deviation calculated using daily stock returns. (ln)	DS	unit

Table 2: Descriptive Statistics. This table provides descriptive statistics of firms listed on the Hong Kong stock exchange between 2004 and 2016, for short sale and non short sale companies. For each firm this table reports the Arithmetic mean, the median, the standard deviaton, the within standard deviation, the 1_{st} percentile, and the 99_{th} percentile. The variables are catagorized by dependent variables, short sale measures and control variables (SS sample) reflects the short sale subsample. The within standard deviation is calculated by a firm fixed effects regression of the particular variable. No variables are displayed in natural logarithms. Variables denoted with (winsorized) are winsorized at the 1% confidence level. All amounts are in Hong Kong dollar.

	Mean	Median	S.D	S.D (within)	1_{st} Perc.	99_{th} perc.	N
Dependent Variables							
Delay	0.681	0.753	0.279	0.258	0.061	1.000	154,585
Coefficient-based Delay	2.234	2.256	0.614	0.585	0.801	3.585	154,460
R-squared	14.66%	7.39%	17.69%	15.26%	0.00%	73.65%	154,585
|Market Correlation|	0.250	0.247	0.290	0.257	-0.403	0.854	154,585
Dependent Variables (SS Sample)							
Delay	0.573	0.578	0.296	0.268	0.041	1	52,554
Coefficient-based Delay	2.045	2.039	0.649	0.610	0.656	3.529	52,554
R-squared	23.83%	18.06%	21.53 %	18.84%	0.01%	80.76%	52,554
|Market Correlation|	0.406	0.429	0.271	0.237	-0.272	0.893	52,554
Short Sale Measure							
Short Sale Volume	0.087	0.048	0.104	0.096	0.003	0.471	52,554
Control variables							
Number of Analyst	8.601	6	7.847	3.888	1	31	68,205
Book to Market (winsorized)	0.924	0.744	0.778	0.477	-0.233	2.878	133,873
Marketcap (mil.) (winsorized)	17,000	1,510	55,300	39,200	18.7	422,000	154,585
Relative Spread (winsorized)	3.64%	1.70%	5.5 8%	4.31%	0.17%	34.31%	154,191
Return	0.012	-0.007	0.185	0.185	-0.416	0.891	154,094
Volatility	0.034	0.027	0.024	0.022	0.006	0.138	154,585
Controls Variables (SS Sample)							
Cash to Assets (winsorized)	13.77%	8.45%	15.92%	12.43%	0.03%	80.88%	43,801
Dividends to Assets (winsorized)	2.74%	0.60%	6.47%	4.90%	0%	44.64%	49,302
EBITDA to Assets (winsorized)	0.102	0.077	0.086	0.067	0.004	0.433	42,465
Leverage	0.578	0.611	0.273	0.126	0.020	0.985	40,433
Total Assets (mill.) (winsorized)	198,000	21,200	830,000	237,000	141	686,0000	49,749

Table 3: Short sales explained. This table presents OLS regressions of Short Interest on control variables. In specification (2), the lagged dependent variable is added to the regression. All variables except for Short Interest, Leverage, and return dummies are winsorized at the 1% level. Standard errors are clustered at the firm level. T-statistics are provided within parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent variable	Short Interest	
	(1)	(2)
$\text{Short Interest}_{t-1}$		0.1355***
		(17.0)
$\text{Return}_{t-1} > 0$	0.0022	0.0024
	(0.5)	(0.6)
$\text{Return}_{t-1} < 0$	0.0102**	0.0090**
	(2.5)	(2.2)
$\text{Book to Market}_{t-1}$	0.0102***	0.0086***
	(4.2)	(4.1)
$\text{Total Assets}_{t-1}$	2.98E14***	2.59E14***
	(8.3)	(8.3)
$\text{Relative Spread}_{t-1}$ (ln)	-0.6667***	-0.6347***
	(-2.8)	(-2.9)
$\text{EBITDA to Assets}_{t-1}$	-0.0632	-0.0590*
	(-1.9)	(-2.0)
Leverage_{t-1}	-0.1012***	-0.0895***
	(-8.8)	(-8.9)
$\text{Dividends to Assets}_{t-1}$	0.0729	0.0628
	(1.4)	(1.4)
$\text{Cash to Assets}_{t-1}$	-0.0157	-0.0129
	(1.1)	(-1.0)
Constant	0.1307***	0.1146***
	(14.6)	(14.1)
R-squared	0.018	0.036
Observations	30,754	30,754
Firm FE	Y	Y
Month FE	Y	Y

Table 4: The effect of short sales on Delay. This table presents OLS regressions of Delay and Coefficient-based Delay on Short Interest and Change in Short Interest. In specification (1) and (2) Delay is used as the dependent variable, Coefficient-based Delay is used in specification (3) and (4). Column (1) and (3) use Short Interest as research variable, column (2) and (4) use Change in Short Interest. Standard errors are clustered at the firm level. Volume is the trading volume scaled by Market capitalisation. Book to Market, Market Cap, Relative Spread, and Volume are winsorized at the 1% level. T-statistics are provided within parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent Variable	Delay		Coefficient-based Delay	
	(1)	(2)	(3)	(4)
Short Interest$_{t-1}$	-0.0410***		-0.0946***	
	(-2.8)		(-3.0)	
Δ Short Interest$_{t-1}$		-0.0424***		-0.0928***
		(-4.2)		(-4.0)
Delay$_{t-1}$	0.0916***	0.0917***		
	(27.4)	(27.5)		
Coefficient-based Delay$_{t-1}$			0.0414***	0.0415***
			(13.3)	(13.3)
Return$_{t-1}$ >0	0.0044	0.0044	0.0009	0.0009
	(1.2)	(1.2)	(0.1)	(0.1)
Return$_{t-1}$ <0	-0.0213***	-0.0214***	-0.0437***	-0.0439***
	(-5.8)	(-5.9)	(-4.8)	(-4.9)
Market Cap$_{t-1}$ (ln)	-2.05E^{13}***	-2.06E^{13}***	-3.12^{13}***	-3.15E^{13}***
	(-6.8)	(-6.8)	(-5.8)	(-5.8)
Book to Market$_{t-1}$	0.0173***	0.0172***	0.0269***	0.0266***
	(9.2)	(9.2)	(6.8)	(6.7)
Volatility$_{t-1}$ (ln)	-0.0430***	-0.0430***	-0.0793***	-0.0793***
	(-25.1)	(-25.1)	(-20.4)	(-20.4)
Analyst$_{t-1}$(ln)	-0.0034	-0.0041	-0.0034	-0.0052
	(-1.3)	(1.5)	(-0.6)	(-0.9)
Relative spread$_{t-1}$ (ln)	0.3144***	0.3150***	0.5547***	0.5562***
	(16.3)	(16.3)	(13.0)	(13.1)
Volume$_{t-1}$	-0.0064***	-0.0064***	-0.0108***	-0.0107***
	(-8.1)	(8.0)	(-6.6)	(-6.5)
Constant	0.4047***	0.4045***	1.7620***	1.7615***
	(43.9)	(43.9)	(85.1)	(85.2)
R-squared (within firm)	0.028	0.028	0.012	0.012
Observations	130,015	130,015	129,903	129,903
Firm FE	Y	Y	Y	Y
Month FE	Y	Y	Y	Y

Table 5: The effect of short sales on the informational content of stock prices. This table presents OLS regressions of R-squared and Market Correlation on Short Interest and Change in Short Interest. In specification (1) and (2) R-squared is used as dependent variable, in specification (3) and (4) the dependent variable is Market Correlation. In specification (1) and (3) Short Interest is used as research variable, in specification (2) and (4) the research variable is Change in Short Interest. Volume is the trading volume scaled by Market Cap. Book to Market, Market Cap, Relative Spread, and Volume are winsorized at the 1% level. Standard errors are clustered at the firm level. T-statistics are provided within parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent Variable	R-squared		|Market Correlation|	
	(1)	(2)	(3)	(4)
$\text{Short Interest}_{t-1}$	0.0490***		0.0345***	
	(4.6)		(2.8)	
Δ $\text{Short Interest}_{t-1}$		0.0425***		0.0349***
		(5.9)		(4.1)
R-squared_{t-1}	0.1781***	0.1784***		
	(45.5)	(45.6)		
$\|\text{Market Correlation}\|_{t-1}$			0.1645***	0.1646***
			(47.3)	(47.3)
Market Cap_{t-1} (ln)	$1.83E^{13}$***	$1.84E^{13}$***	$2.66E^{13}$***	$2.67E^{13}$***
	(8.5)	(8.6)	(8.9)	(8.9)
$\text{Book to Market}_{t-1}$	-0.0167***	-0.0166***	-0.0280***	-0.0279***
	(-14.9)	(-14.8)	(-14.5)	(-14.5)
Analyst_{t-1} (ln)	0.0035**	0.0044**	0.0045*	-0.0279*
	(2.0)	(2.6)	(1.7)	(1.9)
$\text{Relative spread}_{t-1}$ (ln)	-0.1022***	-0.1029***	-0.3290***	-0.3295***
	(-12.1)	(-12.1)	(-16.2)	(-16.3)
Volume_{t-1}	0.0080***	0.0080***	0.0124***	0.0124***
	(17.5)	(17.5)	(14.6)	(14.6)
Constant	0.1938***	0.1939***	0.3331***	0.3332***
	(49.7)	(50.0)	(47.3)	(47.4)
R-squared (within firm)	0.042	0.043	0.041	0.041
Observations	130,020	130,020	130,020	130,020
Firm FE	Y	Y	Y	Y
Month FE	Y	Y	Y	Y

Table 6A: The effect of Short sales on Delay and Market synchrony in up and down markets. This table represents the regression of Delay, R-squared, and Market Correlation on Short Interest. The dependent variable is Delay in specification (1), Coefficient-based Delay in specification (2), R-squared in specification (3) and Market Correlation in specification (4). Standard errors are clustered at the firm level. T-statistics are provided wthin parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent variable	Delay	Coeff.-based Delay	R-squared	Market Correlation
	(1)	(2)	(3)	(4)
Short Interest Up_{t-1}	0.1090***	0.1697***	-0.0713***	-0.0882***
	(6.5)	(4.6)	(-6.5)	(-6.5)
Short Interest Down_{t-1}	-0.2217***	-0.4151***	0.1775***	0.1545***
	(-12.0)	(-10.0)	(12.8)	(9.9)
Observations	127,197	127,197	127,197	127,195
R-squared	0.024	0.010	0.052	0.054
Firm Fixed Effects	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y

Table 6B: The effect of Short sales on Delay and Market synchrony in up and down markets. This table represents the OLS regression of Delay, Coefficient-based Delay, R-squared, and Market Correlation on Change in Short Interest. The dependent variable is Delay in specification (1), Coefficient-based Delay in specification (2), R-squared in specification (3), and Market Correlation in specification (4). T-statistics are provided within parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent variable	Delay	Coeff.-based Delay	R-squared	Market Correlation
	(1)	(2)	(3)	(4)
Δ Short Interest Up_{t-1}	-0.0270**	-0.0625**	0.0286***	0.0101
	(-2.1)	(-2.1)	(3.3)	(0.4)
Δ Short Interest Down_{t-1}	-0.0660***	-0.1388***	0.0576***	0.0611***
	(-4.3)	(-3.9)	(5.2)	(4.9)
Observations	130,020	129,908	130,020	130,015
R-squared	0.021	0.008	0.046	0.052
Firm Fixed Effects	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y

Table 7A: The effect of short sales on the Return Distribution. In this table Short Interest is regressed on Skewness, Kurtosis, and Volatility. Standard errors are clustered at the firm level. T-statistics are provided within parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent Variable:	Skewness (1)	Kurtosis (2)	Volatility (3)
Short Interest$_{t-1}$	-0.0984** (-2.5)	0.0145 (0.1)	-0.0867*** (-4.1)
R-squared (within firm)	0.004	0.020	0.1548
Observations	130,158	130,158	130,148
Firm FE	Y	Y	Y
Month FE	Y	Y	Y
Controls	Y	Y	Y

Table 7B: The effect of Short Sales dummy on the Return Distribution. In this table Short Interest is regressed on Skewness, Kurtosis, and Volatility. Standard errors are clustered at the firm level. T-statistics are provided within parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent Variable:	Skewness (1)	Kurtosis (2)	Volatility (3)
Short dummy	-0.078*** (-4.5)	-0.1679*** (-3.5)	-0.0273** (-2.4)
R-squared (within firm)	0.004	0.021	0.1548
Observations	130,158	130,158	130,148
Firm FE	Y	Y	Y
Month FE	Y	Y	Y
Controls	Y	Y	Y

Table 8A: The effect of Short sales on Delay and Market synchrony in up and down markets. This table represents the OLS regression of Delay, Coefficient-based Delay, R-squared, and Market Correlation on contemporaneous Short Interest. The dependent variable is Delay in specification (1), Coefficient-based Delay in specification (2), R-squared in specification (3), and Market Correlation in speficiaton (4). Standard errors are clustered at the firm level. T-statistics are provided within parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent Variable:	Delay	Coeff.-based Delay$_t$	R-squared$_t$	|Market Correlation|
	(1)	(2)	(3)	(4)
Short Interest$_t$	-0.0238*	-0.0434	0.0352***	0.0337***
	(-1.7)	(-1.4)	(3.6)	(2.7)
R-squared (within firm)	0.028	0.012	0.055	0.052
Observations	130,015	129,903	130,015	130,015
Firm FE	Y	Y	Y	Y
Month FE	Y	Y	Y	Y
Controls	Y	Y	Y	Y

Table 8B: The effect of a Short Sales dummy on efficieny and market synchrony measures. This table presents the regression of Delay, Coefficienct-based Delay, R-squared, and Market correlation on a Short Sales dummy. The dependent variable is Delay in specification (1), Coefficient-based delay in specification (2), R-squared in specification (3), and Market Correlation in speficiaton (4). Standard errors are clustered at the firm level. T-statistics are provided in parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent Variable:	Delay	Coeff.-based Delay	R-squared	|Market Correlation|
	(1)	(2)	(3)	(4)
Short Interest dum$_t$	-0.0107*	-0.0261**	0.0292***	0.0405***
	(-1.8)	(-2.1)	(8.1)	(6.9)
R-squared (within firm)	0.028	0.012	0.055	0.052
Observations	130,020	129,908	130,020	130,020
Firm Fixed Effects	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y

Table 8C: The effect of a Short Sale Dummy of a short sale dummy in up down market. This table presents the regression of Delay, R-squared, and Market Correlation on an Up market short sales dummy and a down market short sales dummy. The dependent variable is Delay in specification (1), Coefficient-based Delay in specification (2), R-squared in specification (3), and Market Correlation in speficiaton (4). Standard errors are clustered at the firm level. T-statistics are provided in parentheses. *,**,*** represents the 1%, 5% and 10% significance level respectively.

Dependent Variable:	Delay	Coeff.-based Delay	R-squared	|Market Correlation|
	(1)	(2)	(3)	(4)
Short Interest dum Up_t	0.0284***	0.0415***	-0.0029	-0.0018
	(4.9)	(3.3)	(-0.8)	(-0.3)
Short Interest dum $Down_t$	-0.0613***	-0.1135***	0.0709***	0.0955***
	(-10.2)	(-9.0)	(18.9)	(16.0)
R-squared (within firm)	0.032	0.014	0.067	0.057
Observations	130,020	129,908	130,020	130,020
Firm Fixed Effects	Y	Y	Y	Y
Time Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y