The effect of short selling bans on UK stocks in relation to market metrics of volatility, liquidity, and price discovery

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Abstract

In this study we look at the relationship between liquidity, volatility, and price discovery with short selling on UK stocks. We use the UK financial stocks short sale ban of the 2007-2009 financial crisis to explore the effects of short selling on liquidity, volatility and price discovery. We employ a control portfolio as well to see the effects of the short sale ban. We employ a GARCH model to explore the effects of short selling on volatility. Using this model, we find that volatility is not affected during the short sale ban, this in turn questions the significance of short sale bans. We employ a Bid-Ask Spread Model to explore the effects of short selling on liquidity. We find that the Bid-Ask Spread Model shows that liquidity deteriorates during the short sale ban period. Lastly, we employ a Wald-Wolfowitz Runs Test to see fat tails in its distribution, this shows the effects of price discovery on a short sale ban. We find that price discovery deteriorates during the short sale ban period.

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1. Introduction

The collapse of Lehman Brothers on 15 September 2008 was widely interpreted as an evidence about the lack of solvency of banking firms as well as, more broadly, financial institutions. This led to unprecedented sales of financial stocks listed on stock exchanges worldwide. Short sellers were pointed as being behind the freefall of financial stocks. In the hope of impeding the further decline of these stocks, on Wednesday the 17th September 2008, the US Securities and Exchange Commission (SEC) announced a ban against short sales of equities of financial firms (Autore et al, 2011; Beber and Pagano, 2013) taking effect on the following day (Securities and Exchange Commission, 2008). A similar decision made by the UK Financial Services Authority (FSA) on Thursday the 18th September 2008 to ban short sales of 29, later extend to 32, financial stocks (FT.com, 2008; Autore et al., 2011; Marsh and Payne, 2012). The ban in the US was set to be reviewed 30 days after it came into force, while the FSA in the UK announced that the ban would have expired on 16th January 2009. In both the statements, made by the US SEC and the UK FSA, there was a clear indication that short-selling activities and some of its extreme implementation like 'naked short selling', had been held responsible for the rapid decline of equities and therefore had to be stopped to protect stock market participants (Securities and Exchange Commission, 2008; Marsh and Payne, 2012).

The effects of an introduction of ban on short-selling activities are source of concerns for policy makers and investors alike. The formers are concerned whether restrictions introduced by regulatory agencies are effective in terms of bringing markets back to acceptable levels of stability. On the other hand, stock market participants are more concerned about the restrictions that short-selling bans might limit their activities. As pointed out by Bai and Qin (2014), bans on short-selling practices have fuelled the debate on whether the intervention of stock market regulators might obstacle the correct functioning of equity markets.

Volatility, liquidity, and price discovery are three central metrics informing decisions made by stock market investors. The extension to which the introduction of a short-selling ban could have modified the normal course of these metrics toward the direction aimed by stock markets regulators is the scope of this study. In particular we aim to answer three questions. First, was the ban imposed by the UK FSA successful in reducing the volatility of UK financial companies' stocks? Secondly, was the ban not to drain the liquidity of the mentioned stocks? Third, was the ban not an impediment to the price discovery activities conducted through the normal course of stocks' supply and demand interactions? To address these questions, we use the short sale ban of 2008 in UK financial equities as a period of investigation, as the only means of investing the effects of short selling are times during which short selling has been banned.

The rest of this paper is split into the following sections, Section 2 is the literature review, Section 3 is the data description, Section 4 is the estimation procedures, Section 5 is the empirical results and Section 6 is the conclusion.

2. Literature review

The empirical literature on short selling can be divided into four main strands focusing on the effects of short selling on stock volatility, price discovery and liquidity.

A first strand explored the relationship between short sales restrictions and stocks volatility. For instance, Ho (1996), looked at the Singapore stock exchange that had suspended trading for three days in 1985, once the exchange had opened contracts could only be done on a basis of immediate delivery (meaning settlement within 24 hours), this meant that short selling was severely restricted. Ho (1996) found that while this short selling was restricted, the volatility of stock returns increased. In a more recent study, Chang et al. (2007) explored the effect of short sale restrictions on stock market returns and their volatility by looking at the on the Hong Kong market and found that the restrictions lead to higher stock market volatility. Bohl et al. (2016) focused on the impact of short selling restrictions on stock return volatility. By focusing only on financial stocks, they applied two versions of the asymmetric Markov-switching GARCH model, over the period 2008-2010 by looking at the German stock market. They found that although the 2007-2009 global financial crisis led to periods of increased volatility for the stock markets in general, stocks with short selling restrictions experienced more volatility than the market as a whole. Therefore, Bohl et al. (2016) concluded that short selling restrictions were more destabilising than they were stabilising. Overall, the evidence from the empirical literature is that restricting short sales would have the effects of increasing the volatility of either stock markets as a whole or individual stocks specifically banned to being short saled by regulators.

A second strand of the empirical literature on short sale bans focuses on the effect of short selling restrictions on liquidity. For instance, Clifton and Snape (2008) explored this relationship following the short selling ban on financial and insurance stocks in 2008 in the UK stock market. Their findings shown that the average spread on banned stocks increases by 140% from 15 basis points to 36 basis points compared to a 56% increase for non-banned stocks from 14 basis points to 20 basis points. In addition, they reported that volume fell in banned stocks while it rose in unbanned stocks. In a more comprehensive study, Lobanova et al. (2010) look at the impact of short sale restrictions on volatility, liquidity and market efficiency using the 2008 US short sale ban as evidence. Their results suggest there were significant changes in liquidity, volume traded and return volatility following the introduction of the short sale ban took place. Their findings show that liquidity deteriorated substantially with spreads widening, returns of equity stocks decreased while their volatility increased, therefore suggesting that a significant drop in market efficiency has occurred as a consequence of the short sale ban. Marsh and Payne (2012) add further light to the short sale ban of financial and insurance stocks in the UK equity markets. They found that order flows were not affected and that banned stocks were sold off even more aggressively compared to their non-banned counterparts once the short sale ban took place. Order book liquidity was also seen to have weakened and price discovery was hampered; these effects are seen to be reversed once the short sale ban was reversed

A third strand of the literature on short sale ban focuses on the effect of short selling on price discovery. In a cross-country study, Bris et al. (2007) looked at 46 equity markets around the world and found that markets are much more efficient when short selling is allowed to take place. In other words, their findings show that restrictions on short sales prevent price discovery activities. Adding on, Brockman and Hao (2011) look at the relationship between short selling and price discovery. Some underlying shares representing their respective American Depositary Receipts (ADRs) can be sold short in their home market, while others cannot. Brockman

and Hao (2011) find that ADR short selling on American exchanges is more informative when those ADRs cannot be sold short in their home market. This suggests that short sellers make a good contribution to price discovery. In another study, Boehmer and Wu (2013) used shorting flows to see the impact short sellers have on price discovery. Firstly, as shorting flow increases, intraday informational efficiency of prices improves. Second, at monthly and annual time frames more shorting flow increases the addition of public information into prices faster. Thirdly, greater shorting flow leads to lower post earnings announcement drift for earnings misses. Overall, they find that stock prices are more accurate when short selling is allowed to take place, therefore short selling restrictions has a negative impact on price discovery in the market Boehmer and Wu (2013). In a more recently, Sochi and Swidler (2018) looked at the effects of price discovery using securities on the Dhaka Stock Exchange which have been in a constant short sale ban in comparison to securities on other stock the New York Stock Exchange in which short selling is allowed. By employing a Monte Carlo Simulation on both Dhaka Stock Exchange and New York Stock Exchange indexes in regards of consecutive positive or negative returns (runs), they found runs of longer duration on securities on the Dhaka Stock Exchange. In other words, fat tails in their run distribution where particularly evident in relation to the Dhaka Stock Exchange index returns then in the New York Stock index. Fat tails are indicative of a delay in information in pricing securities which can occur from the introduction of short sale ban. Therefore, Sochi and Swidler (2018) pointed out that market efficiency in the Dhaka Stock Exchange was negatively impacted due to the short sale bans.

A fourth strand of the literature investigated the effect of short sale bans on all the main aspects such as volatility, liquidity, and price discovery. For instance, Lee and Wang (2015) investigate the daily short selling by foreign investors and the impact they have on stock price, liquidity, and volatility in the stock market of Korea. For the period of 2006 to 2010 they observed that most short sales were performed by foreign rather than domestic market participants. Lee and Wang (2015) observe that short selling by foreign market participants occurred when there was an increase in orders to buy a stock, however this does not help to improve stock liquidity. Volatility was not seen to increase by foreign short sellers, showing that foreign short sellers were not a destabilising presence in the Korean stock market. In a more recent study, Alves et al. (2016) measured the impact of the August 2011 financial stocks ban on covered short sells in the European countries of Belgium, France, Italy and Spain. The ban was put in place for 15 days. The short selling restriction did not reduce the volatility but that the volatility in those financial stocks increased instead, causing more problems for market regulators. Liquidity was also affected negatively in these stocks. The price discovery was affected as well as these stocks were shown to take longer to take in negative information that had entered the market.

The findings of the reviewed literature show short sale bans have negative effects on liquidity and tend to increase stock market volatility as well as affecting the price discovery process making the stock market less efficient. Our study locates itself within the fourth strand of the mentioned empirical literature. The main element of novelty is that our study is one of the few studies that focus on the effect of short sales restrictions on the UK stock market over the 2007-2009 global financial crisis period. In addition, to the best of our knowledge, methodologies used in this study they have not been used to investigate this topic for the UK stock market.

3. Data description

This study focuses on the period from 3rd January 2008 to 16th January 2009. We split the mentioned period into two sub-periods. The first period of 3rd January 2008 to 18th September 2008, in which no stocks have short sale bans implicated by the FCA. The second period of 19th September 2008 to 16th January 2009, where the FCA implicates ban on certain financial stocks to reduce downward pressure on these securities. We selected 24 companies listed on the UK stock market and collected data on trading volume, high price, low price, and percentage return on a daily basis from 3rd January 2008 to 16th January 2009 using Thomson Reuters DataStream. We also collect trading volume, high price, low price and percentage return for the FTSE 100 as a whole, which is used to represent our market return. The dataset we created consists of two sets of data for both banned and unbanned stocks. We take the largest 12 banned financial stocks[3] by market capitalisation and take the largest 12 unbanned stocks[4] by market capitalisation. The reason market capitalisation is used is to get the broadest exposure to the market possible, without having an infinite sample of stocks, of which smaller stocks can be missing data. All stocks were constituents of the FTSE 100 in 2008, and many are still. The FCA banned the short sale of these stocks between 19th September 2008 and 16th January 2009..In this paper we investigate the effect of short sales restrictions on two typologies of portfolios. The first made up of unbanned stock, and the other of banned stocks. Both portfolios were built by equal weighting daily returns across our study period, so that each stock in each portfolio carries an equal weight and no stock has more influence than the other. This in turn gives 12 stocks in each portfolio chosen by the highest market capitalisation available to us equally weighted. Table 1 present the descriptive for both the unbanned and banned portfolio across the entire period of analysis (column 1 of Table 1) as well as the two sub-periods (column 2 and 3, respectively) as identified through the decision of the FSA to impose a ban on the short sale of stocks on 19 September 2008. For the period before the short sale ban (i.e Period 1), the unbanned portfolio averages -0.05% return in a day (Table 1 – column 2 of Panel A), while during the short sale ban (i.e Period 2) the unbanned portfolio averages almost 0.044% (Table 1 – column 3 of Panel A) return in a day. On the other hand, the banned portfolio averages -0.133% return in a day for the period before the short sale ban (column 2 of Panel B), while during the short sale ban the banned portfolio averages -0.328% return in a day (column 3 of Panel B).

[3] The 12 largest banned stocks are the following: Admiral Group, Aviva, Barclays, HSBC Holdings, Lloyds Banking Group, Legal and General, Prudential, Standard Chartered, St James' Place, Standard Life Aberdeen, RSA Insurance Group, and the Royal Bank of Scotland Group.

[4] The 12 largest unbanned stocks are the following: AstraZeneca, BHP Billiton, BP, British American Tobacco, Diageo, GlaxoSmithKline, Shire, Reckitt Benckiser, Rio Tinto, Royal Dutch Shell, Vodafone Group, and Unilever.

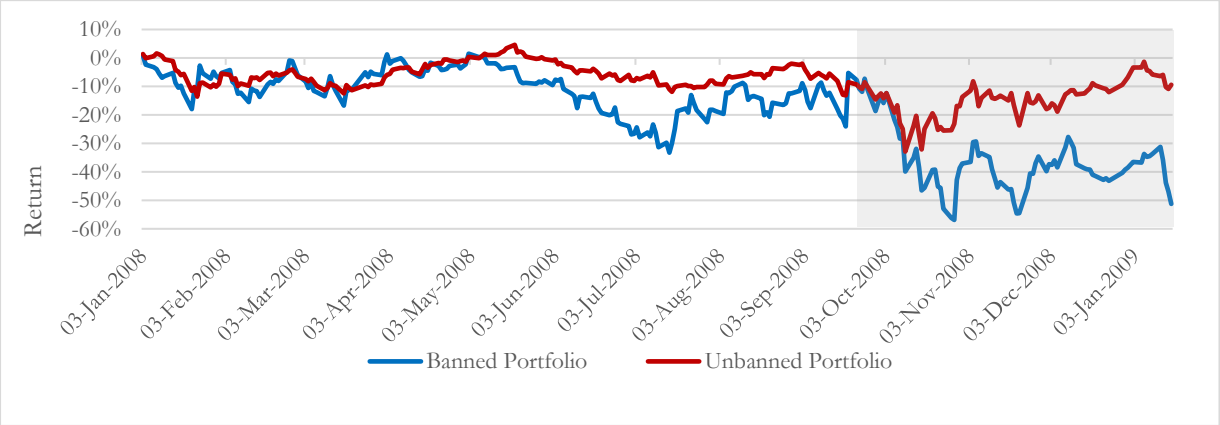
Table 1 – Descriptive Statistics

Panel A: Unbanned portfolio	(1) Overall period	(2) Period 1	(3) Period 2
Average daily returns	0.036%	-0.05%	0.044%
Standard Deviation daily returns	2.221%	1.318%	3.429%
Average daily volume	22,222,302	20,922,488	25,072,497
Standard Deviation daily volume	8,182,922	6,756,289	10,141,412
Panel B: Banned portfolio			
Average daily returns	-0.194%	-0.133%	-0.328%
Standard Deviation daily returns	3.436%	2.681%	4.697%
Average daily volume	27,061,317	29,261,751	22,236,268
Standard Deviation daily volume	13,207,678	12,817,105	12,833,350

Note. The overall period of analysis, as per column (1) in this table, spans from 3rd January 2008 to 16th January 2009. Period 1 (column 2) spans from 3rd January 2008 to 18 September 2008 inclusive, while Period 2 (column 3) spans from 19th September 2008 to 16th January 2009 inclusive.

Figure 1 shows the trends over time of the cumulative returns[5] of banned and unbanned portfolios, respectively. The trend for each of the portfolios shows negative cumulative returns, which is to be expected since the period we are exploring is in the depth of the 2007-2009 global financial crisis. The banned portfolio underperforms the unbanned portfolio over the entire period, this is again to be expected as equities of UK financial companies were hit the most since the crisis stemmed from subprime lending and companies with exposure to this felt the worst effects. It is worthwhile to note that underperformance of banned stocks started before the short sale and once the short sale ban takes place on 19th September 2008, we see even more divergence in performance between portfolios. The sharp drop in September 2008 is clearly related to the collapse of the US investment bank Lehman Brothers.

Figure 1 – Returns comparison between banned and unbanned portfolio



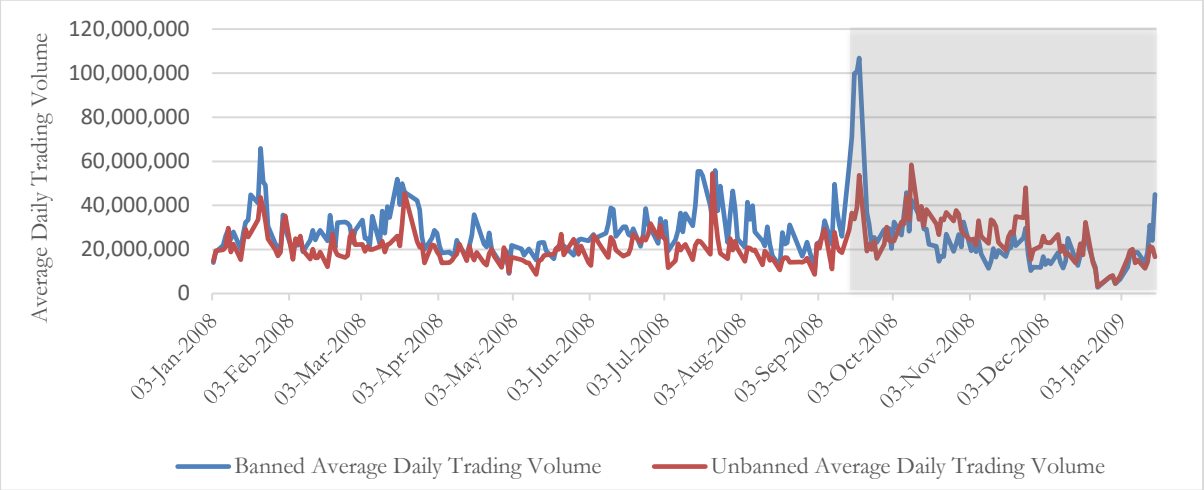
Notes. The area highlighted represent the short sale ban period from 19th September 2008 to 16th January 2009.

Another aspect we highlight in this study is the trading volume of both unbanned and banned stocks over the period of analysis. As we can see in Figure 2, the average daily trading volume between banned and unbanned portfolios, clearly indicate a big spike in banned trading stocks volume in September 2008, which, again, was due to the collapse of Lehmann Brothers. What is noticeable is the trading volume of unbanned portfolios is generally lower until the short sale trading ban is imposed on September 2008. Then we see a lowering of trading volume in the banned portfolios, showing the absence of short sellers. For the period before the short sale ban, the unbanned portfolio averages 20,980,652 shares traded in a day, during the short sale ban the

[5] Cumulative returns were calculated by taking the return at time $t+1$ and add it to the return at time t, and repeat for all t.

unbanned portfolio averages 25,072,496 shares traded in a day. On the other hand, for the period before the short sale ban, the banned portfolio averages 29,360,758 shares traded in a day, during the short sale ban the Banned Portfolio averages 22,236,268 shares traded in a day. Looking at this number, we can assume that short sale ban might have affected trading volumes of both banned and unbanned stocks

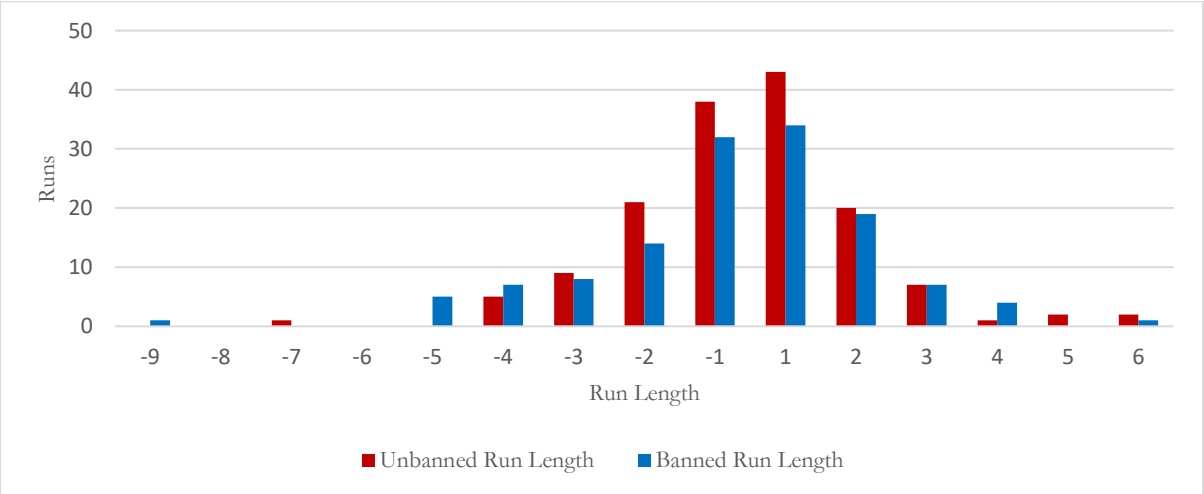
Figure 2 – Trading Volume comparison between banned and unbanned portfolios



Notes. The area highlighted represent the short sale ban period of 19th September 2008 to 16th January 2009.

Figure 3 shows the runs distribution between banned and unbanned Portfolios. Runs are a technique that are often used to calculate the effects of short selling on price discovery (see, for instance, Sochi and Swidler 2018). A runs distribution allows to explore both positive and negative fat tails, which are often a cause of short selling impeding the price discovery process. From Figure 3, we observe that across the entire dataset, both portfolios of runs form a normal distribution, with more runs focused on the centre of run length 1 and -1, as opposed to runs focused on the extremes of length 6 and -9. This is to be expected as market movements often move either up or down in a zig zag fashion with retracements. This is shown with speculators in a market taking profit when they can either by selling a stock or closing a short position by buying the stock.

Figure 3 – Banned portfolio and unbanned portfolio Runs distribution



Notes. The area highlighted represent the short sale ban period of 19th September 2008 to 16th January 2009.

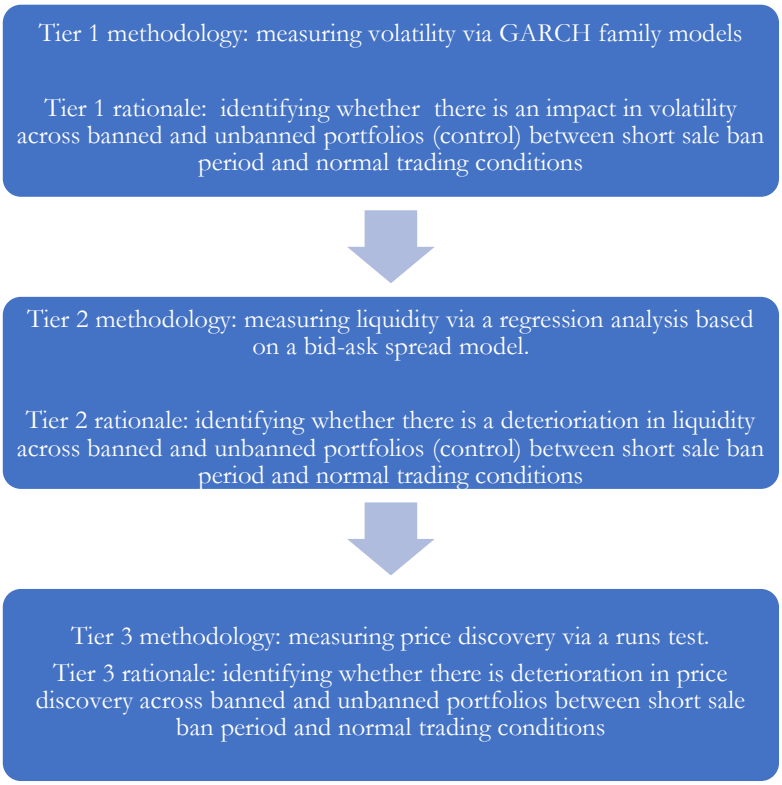
4. Estimation procedures

The aim of this section it to present the approach we used to investigate the effect of the short sale ban on selected portfolios of companies listed on the UK stock market by using different metrics and compare the results across two different periods (a pre-ban period and a ban-period) as identified in the previous section. Further, a detailed description of the relevant methodologies applied to measure the mentioned metrics is also presented.

4.1 An approach to measure the stability of the UK stock market over the ban short-sales period

To quantify the effect of short sales ban on the UK stock market, we propose a combined approach based on two alternative portfolios, banned and unbanned ones, as well as two periods we call as normal trading conditions and ban period respectively. Our approach is based on three sequential steps as presented in Diagram 1. In particular, the tier 1, by using GARCH family models, we investigate the changes in the volatility of the two mentioned portfolios across the two periods of interest. Furthermore, Tier 2 investigates whether a deterioration of liquidity might have been a consequence of the ban of the short selling of shares of financial companies. Finally, the Tier 3 aims to investigate whether the mentioned ban might have negatively affected price discovery. Therefore, our approach is to measure these three metrics (i.e. volatility, liquidity, and price discovery), over periods where short selling has been banned and compare it to periods where short selling has not been banned. Assuming that a deterioration of financial market stability comes with increased volatility, lower liquidity, and difficulties in price discover, the approach presented in Diagram 1 would enable us to shed further light on whether the 2008 ban lowered further the stability of the UK stock market.

Diagram 1 – An approach to control whether short sale bans further lower financial market stability



4.2 Measuring volatility

Volatility is the change in stock prices on a day to day basis created by the constant demand of buyers and constant supply of sellers. Volatility is known for clustering, where periods of high volatility occurs for a period only to be followed by periods of low volatility. The clustering nature means GARCH models are often a good fit to model volatility and can be amended to take note of changes in volatility for 2 or more sets of defined periods. What we find in our data is that we see periods of volatility clustering, which is normal for a financial time series. Picking the choice of model is based on data type and historical tendencies of the data in terms of movement, but GARCH models require fitting based on GARCH and ARCH lags. Fitting a model to the data is a main element of GARCH models as both ARCH and GARCH terms can take an infinite number of lags. The most common way an GARCH model can be fit is using either Akaike Information Criterion (AIC) or (Bayesian Information Criterion (BIC). A series of models is run such as GARCH (1,1), GARCH (1,2), ... , GARCH(p,q). From these models the AIC and BIC are evaluated to judge the fit of the model with respect to the dataset. GARCH (3,3) is usually taken as our last estimate, to make computation feasible, as Maximum Likelihood Estimation can be computationally challenging at larger lags. The lowest value of AIC or BIC is taken as the best fitting model. It is also worth noting since Maximum Likelihood Estimation is used, convergence is not guaranteed, so some models may not fit at all. We use both the AIC and BIC for both banned and unbanned portfolios. Table 1 shows the results for both banned and unbanned portfolios in regards to AIC and BIC. To remain consistent in our study, we decide to use the GARCH (1,1) model for both portfolios. This in turn makes comparisons between both portfolios easier and it also means emphasis of fit is put on the Banned Portfolio and the Unbanned Portfolio. We are indeed investigating the effects of a short sale ban on volatility, but we must also be aware of the fit we achieve with respect to our control variable. We use an GARCH (1,1) model to measure the volatility of 12 banned stocks and 12 unbanned stocks for the periods of the short sale ban and no short sale ban. The GARCH (1,1) model we use is built from the Capital Asset Pricing Model (CAPM), taking the risk-free rate equal to zero. The error term of the CAPM is the GARCH part of the model accounting for the volatility clustering. Therefore, our GARCH model is represented as follows:

$$R_t = c + \beta R_{mt} + \varepsilon_t \quad (1)$$

$$\varepsilon_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \sigma_{t-1}^2 + \delta D_{SSB} \quad (2)$$

Equation (1) is the mean equation and equation (2) is the variance equation of the GARCH(1,1) model. R_t is the daily average return of unbanned or banned stock portfolios. R_{mt} is the daily return of the FTSE 100, taken as the market return. ε_t^2 is the first ARCH value, ε_{t-1}^2 this is the past squared residual which represents the effect of recent news to future stock volatility. σ_{t-1}^2 is the GARCH component, which represents the lagged value of variance to capture the long-term effects of volatility. D_{SSB} is the dummy variable, which takes the value of 0 or 1 to represent the short sale ban and short sale no ban periods, respectively. The coefficient of D_{SSB} is used to determine whether there is a change in volatility and what direction that change in volatility is. If the coefficient is negative (positive) and there is statistical significance it can be seen that there is an increase (decrease) in volatility respectively for the portfolio of banned or unbanned stocks. However, if the estimated coefficient is 0, and holds statistical significance, we can say that there is no change in volatility. Therefore, the size of the

coefficient will determine the degree of change in volatility, this can be especially useful when comparing banned and unbanned portfolios with each other.

4.3 Measuring liquidity

Liquidity is the ability to buy and sell a security in ease in which to not affect the bid or ask price of a security too dramatically. As pointed out by Chai et al (2010), liquidity is a requirements stock should have to be traded in the quantities required by market participants without any price discount. Alternative indicators of liquidity have been used in the empirical literature (see, for instance, Lee and Swaminathan, 2000; Amihud, 2002; Chai et al, 2010). A very popular measure of liquidity, given its simplicity of computation, is the bid-ask spread, where the wider the bid-ask spread the more illiquid a security is seen to be and vice versa. By using the mentioned measure of liquidity, we investigate the determinant of the bid-ask spread for both banned and unbanned portfolios for no short sale ban and short sale ban periods by using a model as proposed by Lebanova (2010). In this model stock characteristics are used as determinants of liquidity. However, we extend that model by including a dummy variable, to check whether the introduction of short sale ban in the UK stock markets over the 2007-2009 global financial crisis, had any effects on stock liquidity. The extended model we use is then as follows:

$$S_t = c + \beta_0 avg\_r_t^2 + \beta_1 avg\_v_{it} + \beta_2 ex\_avg\_v_{it} + \beta_3 D_{SSB} + \varepsilon_t \quad (3)$$

where S_t is the average spread for unbanned or banned portfolio at time t, $avg\_r_t^2$ is the daily average return of the unbanned or banned Portfolio squared at time t, avg_v_{it} is the daily average volume for the unbanned or banned portfolio at time t, $ex\_avg\_v_{it}$ is the excess daily average volume of the unbanned or banned portfolios at time t. The excess daily trading volume $ex\_avg\_v_{it}$ is calculated by subtracting the daily trading volume at time t from the average daily trading volume from the duration of January 2008 to January 2009. D_{SSB} is the dummy variable which takes the value of 0 or 1 for short sale ban or no short sale ban period being compared. If the coefficient of D_{SSB} has a negative value and is significant it can be proved there is a decline in liquidity from the first no short sale ban period to the second short sale ban period. Conversely, if that coefficient has a positive value and is significant it can be proved there is an increase in liquidity from the first no short sale ban period to the second short sale ban period. The bid-ask spread S_t can be difficult to obtain for securities even in advanced stock market like the UK. Therefore, following similar studies (see, for instance, Li et al, 2018) we used an estimator as a proxy S_t, as proposed by Corwin and Schultz (2012), who proposed the following bid-ask spread estimator based on daily high and low prices for securities, that is:

$$S = \frac{2(e^{\alpha}-1)}{(1+e^{\alpha})} \quad (4)$$

where:

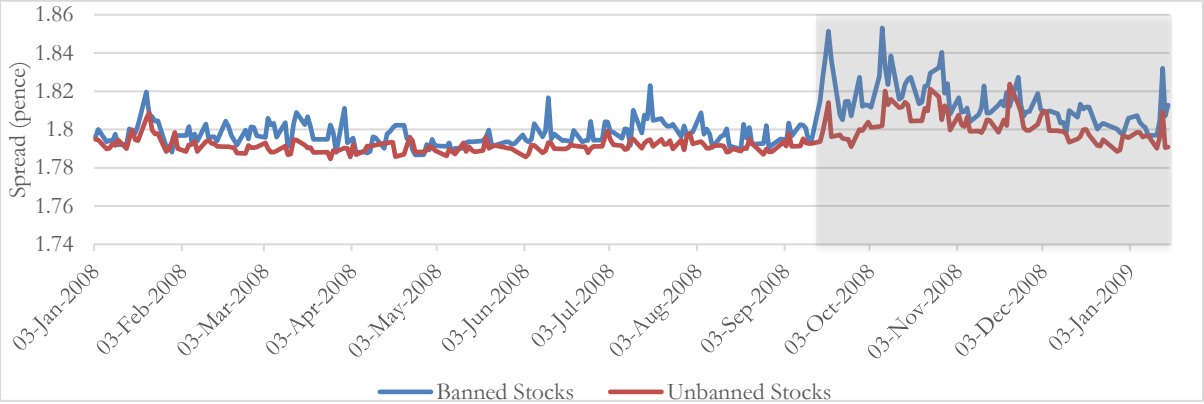
$$\alpha = \frac{\sqrt{2\beta}-\sqrt{\beta}}{3-2\sqrt{2}} - \sqrt{\frac{\gamma}{3-2\sqrt{2}}} \quad (5)$$

$$\beta = E\left\{\sum_{j=0}^{1}(ln\frac{H_{t+j}^0}{L_{t+j}^0})^2\right\} \quad (6)$$

$$\gamma = E\left\{\sum_{j=0}^{1}(ln\frac{H_{t,t+1}^0}{L_{t,t+1}^0})^2\right\} \quad (7)$$

From equations (4), (5), (6) and (7), α is the high-low price estimator, β is the summation of the squared high-low price spread. γ is the squared high-low price spread. S is the stock's high-low bid-ask spread estimator. H_t is stock's high price on day t, L_t is the stock's low price on day t. $H_{t,t+1}$ is the stock's highest price over the two-day period of t and t+1. $L_{t,t+1}$ is the stock's lowest price over the two-day period of t and t+1. Corwin and Schultz (2012) bid ask spread estimator only requires high and low prices for a security over a two-day rolling period, which is much easier to obtain than actual bid-ask prices. Corwin and Schultz (2012) spread estimator has been seen to be 10% within the true spread according to Corwin and Schultz (2012). We calculate the spread estimator as presented in equation (4), by using high and low prices to work out a good approximation to spreads for our 24 stocks. Figure 4 illustrates the trend over time of the spread estimator as we calculated in accordance to equation (4). We see that in general the Unbanned Portfolio has held the lower spread of the two portfolios. We also see that once the short sale ban takes place, both portfolios experience increases in spread but the Banned Portfolio experiences the much larger increase in spread. The short sale ban period is indicated with the grey area shown in Figure 4. This large increase in spread for the Banned Portfolio is attributed to the lack of short sellers in the market. It is clear from Figure 4 that the short sell ban has affected spreads for the both the Banned and the Unbanned Portfolios.

Figure 4 – Bid Ask Spread using Corwin and Schultz (2012) Estimator



Notes. Spreads are quoted in pence sterling and represent the difference between the bid and the ask price on average for each portfolio on a given day.

4.4 Measuring price discovery

Price discovery is the ability of a market to determine the fair price of a security efficiently and without delay. If price discovery is hampered, over and under-pricing of securities may occur for longer than in efficient markets. This is an advantage to stock market participants in the market, as they can take advantage of this if they can identify it. Generally, markets have better price discovery when less restrictions are imposed as seen in Brockman and Hao (2011) and Sochi and Swidler (2018), so that supply and demand can fully incorporate all known information. By restricting the natural supply of stocks, natural demand of stocks and the availability of information on stocks, price discovery can be impacted negatively. A deterioration in price discovery hampers market efficiency. Less efficient markets overall hurt buyers and sellers and can decline confidence in a market. Market confidence declines can lead to general economic declines, as negative sentiment can lead firms to slow down investment and consumers to stop spending. Overall, we can see having good price discovery in a market stretches beyond market participants, it can affect the general economy as a whole through a chain of effects.

For price discovery we can use a non-parametric test known as a Wald Wolfowitz Runs Test (more commonly known just as a Runs Test) to explore randomness in stock returns. This test was used in Molik and Bepari (2009) and Sochi and Swidler (2018) to measure price discovery. For this test we use the daily returns of the banned and unbanned portfolios. A run constitutes a consecutive succession of returns that are of the same sign. A zero return in a day continues the run and a run only ends when the sign of the return changes, therefore the smallest run can be of length 1 in absolute terms and the longest run can be of infinite length in absolute terms. Runs are limited to integer intervals, so it is not possible to have half a run or a quarter of a run. A zero run is also not defined, as zero is not positive or negative.

To understand the link between the run tests and short selling effect on price discovery we look at the tails of the run distribution. If the tails of the run distribution are larger than expected by the unbanned stock portfolio, it would indicate the short selling ban impacting price discovery. If a short selling ban inhibits price discovery given bad news, then the returns would be more negatively skewed than we would find in an efficient market. This means more runs would be found in the left tail of the distribution. Also, if good news causes markets to overreact, a short selling ban might stop a correction, this means the right tail of the distribution would have more runs. Therefore, fatter left and right tails of the run distribution are indicative of a short sale ban affecting price discovery.

It is very much evident when exploring a short-sale ban period with a control portfolio (the unbanned Portfolio), that these changes in runs are caused by the short sale ban and no other outside factors. Islam and Khaled (2005) note that emerging markets in particular are characterised by lower volumes, ability of manipulation of stock prices by a few large traders, less stringent accounting requirements, delays in settlement and the weaker transmission of public financial information. Thus, in emerging markets, price discovery issues may also arise from these problems, therefore exploring a market with a control portfolio is essential to mitigate outside factors. We in turn do this in a developed stock market like the one in the United Kingdom, thus making our results less prone to outside factors affecting price discovery even more.

In our study, we look at the distribution of *n* day runs by dividing the 4 samples into runs of 5 days or longer and runs between 1 and 4 days. we use a percentile on the distribution to show why 5 length runs are considered long and why 4 length runs are considered normal. Achieving more runs than expected that are 5 days or longer indicates fat tails, and implies a short selling ban restricts price discovery. This means there are extended periods for markets to understand new information. If that result is obtained, it necessarily follows that shorter run periods (1–4 days) will have fewer runs than expected in an efficient market. In our case the Unbanned Portfolio is used as a control for market efficiency. A comparison between the independent variable (Banned Portfolio) and control variable (Unbanned Portfolio) is sufficient to show the effect of the short sale ban on price discovery.

5. Results

We report in separate sections the empirical results for volatility changes based on GARCH models, then the results for liquidity changes using a Bid-Ask Spread model and the main results for the price discovery changes using the runs test.

5.1 Volatility results

The volatility results are reported in Table 2. Both the estimated GARCH models for the unbanned portfolio (Table 2 - column 1) and banned portfolio (Table 2 – column 2), The constant term of the conditional equation holds significance at the 5% level for both unbanned and banned portfolios. The FTSE 100 returns have a positive and statistically significant effects on both unbanned and banned portfolio returns. This effect is larger on the latter (1.182) than the former (0.73). The size of the estimated coefficients for the GARCH term is larger for unbanned portfolio (0.877) if compared to the unbanned portfolio (0.776). This result confirm that equities of financial companies were however characterised by slightly larger volatility if compared to equities of companies included in the unbanned portfolio. The dummy variable DSB indicating the short sales ban period is not statistically significant. Therefore, the short sale ban was not effective in terms of reducing volatility of those stocks that were targeted by short-sellers. In particular, this result is consistent with other studies (see, for instance, Ho, 1996; Chang et al., 2007; Lobanova et al., 2010) that question the significance of governments implementing short sale bans . It is worth looking at why there was not a statistical change in volatility, because of the introduction of the short sale bans decided by the UK Financial Services Authority. Since the UK stock market was going through a period of crisis which deepened once the short sale ban was in place, further volatility may have resulted from this crisis to offset the downward selling pressure of short sellers. Since short sale bans usually take place during crises periods, this behaviour is likely to persist. If a short sale ban were to be implemented in say a non-crisis period, volatility effects may be present, however, to the best of our knowledge, there has not been a case where a short sale ban has been put in place without negative downward pressure already present in the market. The relationship of volatility with short sale bans in crisis and non-crisis periods is however of note and in worthwhile for research.

Table 2– Unbanned Portfolio and Banned Portfolio GARCH (1,1) Model with Dummy Variable

	(1) Unbanned Portfolio (Control)	(2) Banned Portfolio
Mean equation		
c	0.000	0.000
	(0.522)	(0.921)
R_{mt}	**0.730*** **	**1.182*** **
	(0.000)	**(0.000)**
Conditional equation		
c	**0.000** **	0.000
	(0.014)	(0.226)
ε_{t-1}^2	**0.237*** **	**0.092*** **
	(0.000)	**(0.005)**
σ_{t-1}^2	**0.776*** **	**0.877*** **
	(0.000)	**(0.000)**
D_{SSB}	0.002	-0.001
	(0.180)	(0.737)

Notes. This table shows the results of the GARCH (1,1) model as specified in equations (1) and (2) for both unbanned and banned Portfolios. *P-values* are given in brackets. ***/**/* indicate statistical significance at 1%, 5%, and 10% level, respectively.

5.2 Liquidity results

Table 3 reports the results based on the equation (3) which was estimated for both unbanned and banned portfolios in regard to the bid-ask spread.

Results related to the unbanned portfolio (column 2) show that both *Daily Average Return Squared* as well as *Daily Average Trading Volume* had positive and statistically significant effect on the dependent variable,

therefore contributing to increase the bid-ask spread of securities in the unbanned portfolio. Further, the effect of the dummy variable D_{SSB} is positive and statistically significant, indicating a reduction on the liquidity of the mentioned portfolio when the ban took place.

On the other hand, for the banned portfolio (column 3) just only *Daily Average Trading Volume* shows a positive and statistically significant effect on the spread of the banned equities of financial companies, whereas no effect of the dummy variable D_{SSB} is found on the banned portfolio. This latter finding is not consistent with such other studies as Zhisheng et al. (2018) and Alves et al. (2016), where it is shown that liquidity usually deteriorate when short sale bans are imposed. These studies found that as market participants are removed from the market, because of the introduction of short-sales bans, bid-ask spreads widen, and this leads to a loss in liquidity.

Table 3– Unbanned Portfolio and Banned Portfolio Bid-Ask Spread Model with Dummy Variable

	(1) Unbanned Portfolio (Control)	(2) Banned Portfolio
c	**1.784***** **(0.000)**	**1.782***** **(0.000)**
$avg\_r_t^2 + \beta_1$	**0.815***** **(0.001)**	0.093 (0.580)
avg_v_{it}	**0.000***** **(0.000)**	**0.000***** **(0.000)**
$ex\_avg\_v_{it} +$	0.000 (0.912)	0.00 (0.21)
D_{SSB}	**0.008***** **(0.00**)	0.019 (0.00)
R-squared	0.664	0.665
Adj R-squared	0.659	0.66
Observations	264	264

Notes. This table shows the results of the Bid-Ask Spread model, as per equation (3), for both Unbanned and Banned Portfolios. *P-values* are given in brackets. ***/**/* indicate statistical significance at 1%, 5%, and 10% level, respectively.

5.3 Price discovery results

We first report for the runs in each portfolio across our study period of 3rd January 2008 to 16th January 2009. Table 4 shows the main results of the Unbanned Portfolio (control) and Banned Portfolio run length in the non-ban period and short sale ban period. We initially see that the distribution of runs across the time period is wide with the maximum negative run length recorded at -9 and the maximum positive run length recorded at 6. Looking at Columns (9) and (10), our results show most of the runs for both portfolios in the non-ban period are of run length 1 and -1. We consider runs of length 1 to 4 to be normal and runs of length 5 and above to be in the tail of the distribution, i.e. a fluctuation that is big and not considered normal, this is confirmed with a percentile on the distribution shown in Table 5. This table shows the percentile distribution of runs for each run length, taking this on a cumulative percentage, we can identify for the tails of the distribution. We consider anything less than 2.5% of the bottom cumulative percentile as the tail of the distribution at the lower end. We also consider anything more than 2% of the top cumulative percentile as the tail of the distribution at the upper end. Using these definitions, runs of length 1-4 are considered normal and runs of length 5 and above are considered to be in the tail. If we look at the Unbanned Portfolio during the non-ban period (Panel A of table 4), we see that there are 4 runs in the tail of the distribution. Similarly, if we look at the Banned Portfolio during the non-ban period, we see that there are again 4 runs in the tail of the distribution. Both portfolios show similar characteristics in regard to the tails of their distributions. If we move onto the short sale ban period (Panel B of table 4, we immediately notice that the number of runs in each portfolio is smaller, this is not an effect of the short sale ban but because the relatively short time period of the short sale ban as opposed to the non-ban period.

The short sale ban was effective for a period of approximately 3 months, while this is smaller than the approximately 9-month length of the non-ban period. Again, we form a normal distribution in run returns for the short sale ban period for both portfolios. Looking at the tails of the distributions in the short sale ban period (Panel A of Table 5) we see that the Unbanned Portfolio has 1 run in the tail of the distribution, while the Banned Portfolio has 3 runs in the tail of the distribution. This means that the Banned Portfolio is exhibiting fatter tails compared to the Unbanned Portfolio, one of the indications that a short sale ban may be inhibiting the price discovery process. We see that the banned portfolio generally has larger runs than the unbanned portfolio, showing that the banned portfolio is much more volatile intraday compared to the unbanned portfolio. This however does not account for intraday volatility, as a run will only show whether there is zero return, a positive return or a negative return, We take into account that runs are measured over days and volatility is daily, so we can't say that longer run lengths indicate more volatility (as volatility is usually measured on a daily basis). The distribution of runs in the unbanned portfolio is very much even, with very little difference in distribution between the non-ban period and short sale ban period. However, for the banned portfolio, there is a slight widening in distribution during the short sale ban period over the non-ban period.

For Table 5, if we focus on the tails of the distribution, runs of length -5 or lower and runs of length 5 or higher, we can see a statistical difference in run lengths over the non-ban period and short sale ban period. For the banned portfolio, runs of -5 and lower constitute 2.21% of the distribution in the non-ban period (Panel A of Table 5) and 2.41% of the distribution in the short sale ban period (Panel B of Table 5). For the unbanned portfolio, runs of -5 and lower constitute 0.552% in the non-ban period (Panel A of Table 5) and 0% in the short sale ban period (Panel B of Table 5). For the banned portfolio, runs of 5 and higher constitute 0% in the non-ban period (Panel A of Table 5) and 1.205% in the short sale ban period (Panel B of Table 5). For the unbanned portfolio, runs of 5 and higher constitute 1.657% in the non-ban period and 1.205% in the short sale ban period. In total for the banned portfolio, runs of -5 and lower and 5 and higher make up 2.21% of the distribution in the non-ban period and 3.615% of the distribution in the short sale ban period. In total for the unbanned portfolio, runs of -5 and lower and 5 and higher make up 2.209% in the non-ban period and 1.205% in the short sale ban period. Therefore, we see an increase in the runs distribution percentages for the banned portfolio over the unbanned portfolio.

Table 4 –Run Length in Non-Ban Period and Short Sale Ban Period

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6
Panel A - Period 1															
Unbanned Portfolio	0	0	1	0	0	3	6	12	32	34	13	4	0	2	1
Banned Portfolio	0	0	0	0	4	5	6	11	21	23	16	4	3	0	0
Panel B - Period 2															
Unbanned Portfolio	0	0	0	0	0	2	3	9	6	9	7	3	1	0	1
Banned Portfolio	1	0	0	0	1	2	2	3	11	11	3	3	1	0	1

Notes. This table shows the runs for the Unbanned Portfolio and Banned Portfolio for both Non-Ban Period (i.e. Period 1) and Ban Period (i.e. Period 2) for the 2008 Financial Crisis Short Sale Ban in the UK. Non-ban period includes daily returns from 2nd January 2008 to 18th September 2008 and the short sale ban period includes daily returns from 19th September 2008 to 16th January 2009. A run constitutes a consecutive sequence of either positive or negative daily returns for each portfolio. A zero-percentage daily return constitutes the run carrying on until there is a sign change.

Table 5 - Unbanned Portfolio and Banned Portfolio Percentage Run Length in Non-Ban Period and Short Sale Ban Period

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6
Period 1															
Unbanned Portfolio	0	0	0.552	0	0	1.657	3.315	6.63	17.68	18.785	7.182	2.210	0	1.105	0.552
Banned Portfolio	0	0	0	0	2.21	2.762	3.315	6.077	11.602	12,707	8.84	2.21	1.65	0	0
Period 2															
Unbanned Portfolio	0	0	0	0	0	2.41	3.614	10.843	7.229	10.843	8.434	3.614	1.205	0	1.205
Banned Portfolio	1.205	0	0	0	1.205	2.410	2.420	3.614	13.253	13.253	3.614	3.614	1.205	0	1.205

Notes. This table shows the percentage run length for the Unbanned Portfolio and Banned Portfolio for both Non-Ban Period and Ban Period for the 2008 Financial Crisis Short Sale Ban in the United Kingdom. Non-ban period includes daily returns from 2nd January 2008 to 18th September 2008 and the short sale ban period includes daily returns from 19th September 2008 to 16th January 2009. A run constitutes a consecutive sequence of either positive or negative daily returns for each portfolio. A zero-percentage daily return constitutes the run carrying on until there is a sign change. The percentage run length shows the percentage of runs of each length in each time.period.

A graphical representation of the results in Tables 5 and 6 are presented in Figure 5 and Figure 6. Starting with Figure 5 we present a graphical representation of the Banned Portfolio and Unbanned Portfolio runs distribution for the non-ban period as presented in Table 6. Further. Figure 6 shows a graphical representation of the Banned Portfolio and Unbanned Portfolio runs distribution for the short sale ban period. Looking at the tails of the distributions in the short sale ban period, we observe that the Unbanned Portfolio has 1 run in the tail of the distribution, while the Banned Portfolio has 3 runs in the tail of the distribution. This means that the Banned Portfolio is exhibiting fatter tails compared to the Unbanned Portfolio, one of the indications that a short sale ban is inhibiting the price discovery process. The greater frequency of longer runs in the Banned Portfolio compared to the Unbanned Portfolio in the short sale ban period is indicative of a market needing longer to process information, whether that is positive or negative news. This in turn is a negative for the market and means new information cannot be incorporated into prices as efficiently as we would like.

Figure 5 – Banned Portfolio and Unbanned Portfolio Runs Distribution During Non-Ban Period

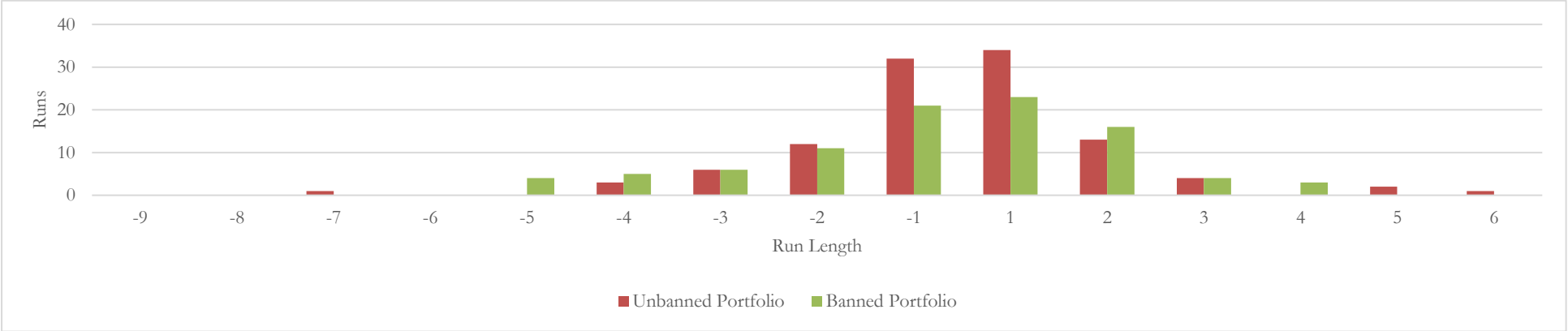
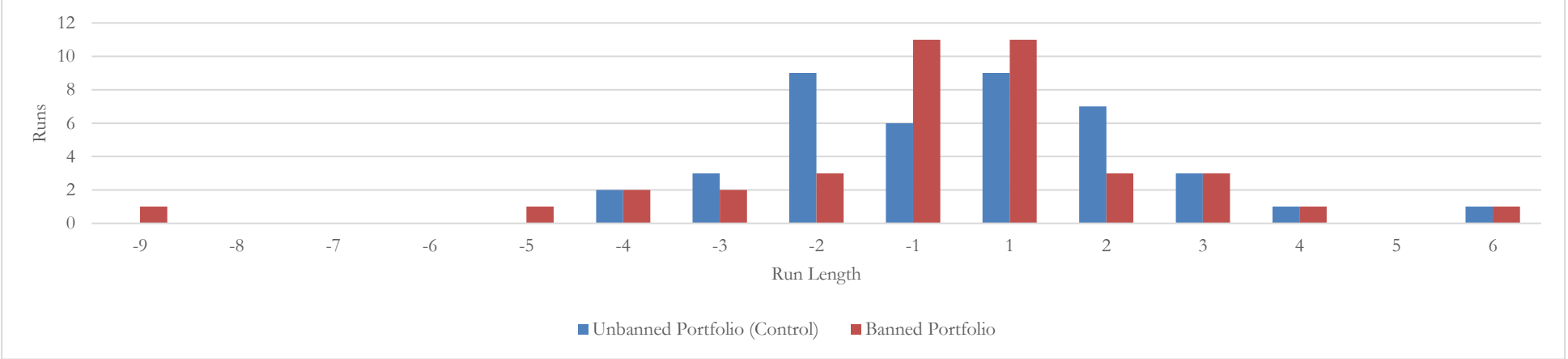


Figure 6- Banned Portfolios and Unbanned Portfolios Runs Distribution During Short Sale Ban Period



6. Conclusions

In this study we looked to investigate the relationship between short selling in the UK and the effect it has on the liquidity, volatility, and price discovery of stocks. Short selling is implemented in a large number of stock exchanges to allow efficient markets and better price discovery, it means overvalued stocks are brought down and undervalued stocks are brought up from shorts closing their position. The extra volume adds to efficiency in the market and efficient markets are ideal for both investors, financial regulatory authorities and central banks.

We used a GARCH (1,1) model with a dummy variable to see how volatility changes between no short sale ban and short sale ban periods. We found no change in volatility between the two periods being investigated, further showing whether a short sale ban is effective at all.

Bid-ask spreads are often used as a gauge of the liquidity in a security. The wider the bid-ask spread, the more illiquid a stock is said to be. To investigate liquidity in UK stocks, we again used the 2008 short sale ban as a proxy. We found that liquidity deteriorated in both banned and unbanned portfolios when the short sale ban took place, however the deterioration in liquidity was much more evident in the banned portfolio, and this can also be seen with the wider bid-ask spread in the banned portfolio. Overall, we show that the short sale ban caused a loss of liquidity in securities and thus impacted market efficiency.

To investigate price discovery in UK stocks, we used the Wald-Wolfowitz Runs Test to gauge for fat tails in the run distributions of both banned and unbanned stock samples. Fat tails are indicative of short selling bans affecting price discovery. We found longer runs in the banned portfolio compared to the unbanned portfolio, showing fatter tails. This clearly indicated that a deterioration in price discovery most likely took place, because of the short sale ban. This outcome is consistent with the existing literature, where short sale bans are seen to affect price discovery in a negative fashion.

A policy implication of our results is that a trading halt may be more worthwhile over an extended period over a short sale ban. It may be worthwhile in the future looking at the effects of trading halts on stabilising markets compared to outright short sale bans. The deterioration in liquidity is always a concern for market participants, as it leads to inconsistencies in pricing, which has been further highlighted by our price discovery findings. Long term investors might not be opposed to a period of closure in the market, which hampers short-term speculators. In a broader sense it may be of interest of regulators to promote investment over speculation, where most of the shorting activity takes place. This could be done by increasing taxes on financial transactions in such a way that short term speculation is not profitable or in turn, giving tax breaks for capital gains in investments held over a longer period. These are considerations worth taking note of regarding short sale bans in the market. Of course, these considerations can be implemented during volatile times in a market or for a longer duration. It is a fine balance between maintaining the liquidity from speculators and driving a market towards long term investment over short term speculation.

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