ESSAYS ON THE EFFECTS OF SHORT SALE CONSTRAINTS

by

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ABSTRACT

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ELENI GOUSGOUNIS

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This dissertation investigates the highly controversial topic of the pricing implications of short sale constraints. Many view short selling as a contributing factor to market efficiency, while others consider short sellers responsible for dramatic price declines. This dissertation examines whether short sale constraints are an obstacle to market efficiency and whether these constraints can ensure a lower probability of market crashes.

The first chapter models a market restricted from short selling. Investors have heterogeneous beliefs for the asset values, which causes overpricing as optimists drive prices upwards, while pessimists sit on the sidelines, unable to act on their market views. The main finding is that the magnitude of this overpricing depends not only on the investors' opinion dispersion on the value of the particular asset, but also on the correlation of the particular asset to other assets and the investors' opinion dispersion for the values of those other assets.

The second chapter adjusts the model of Chen, Hong and Stein (2002) to reflect a market with short sale restrictions that indiscriminately bind all investors and stocks. According to model predictions, opinion dispersion leads to overpricing. This hypothesis is empirically tested in the Indian equity market, which provides a natural testing environment, as short sales were banned across the equity market during 2001 - 2008. Various proxies of opinion dispersion are used, i.e., realized volatility, implied volatility, daily price range, and turnover. Overpricing is

measured as the difference between the discounted futures price and the price of the underlying equity index. The empirical results offer supportive evidence of a positive relationship between opinion dispersion and overpricing in a market with short sale constraints.

The third chapter tests empirically Hong and Stein's (2003) theoretical finding, that in an environment of short sale constraints, investor disagreement over future equity prices leads to negatively skewed return distributions. This study uses data from the Indian equity market to examine the third and fourth moments of the return distribution. The skewness of the return distribution is estimated both from realized returns and option prices. Empirical results provide partial supportive evidence for Hong and Stein's (2003) hypothesis.

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CHAPTER 1

What affects overpricing in a market with short sale constraints?

1. Introduction

The effect of short sale constraints on prices has been highly controversial. Many view short selling as a contributing factor to market efficiency, while others consider short sellers responsible for dramatic price declines and market crashes. The lack of a definitive assessment of the pricing implications of short sale constraints leads to the application of regulatory changes with often uncertain outcomes. One characteristic example is the short sale ban imposed on 799 financial stocks in September 2009, in an unsuccessul effort to stop asset prices from tumbling.

Miller (1977) was the first to model short sale constraints. In his one period model model with one representative investor and one asset, he shows that the application of short sale constraints will cause the asset's price to increase. Furthermore, he predicts that overpricing will be higher when opinion dispersion is higher, in which case , the asset price will be driven upwards by optimists, while pessimists will sit on the sidelines unable to act on their beliefs about the asset value. Harrison and Kreps (1978) model a market with short sale constraints and heterogeneous investors, in which investors are willing to buy the asset, even when its price exceeds the value which corresponds to the view of the most optimistic investor. Such an investment behaviour, according to their model, leads to overpricing. Figlewski (1981) shows overpricing will be higher for those short sale constrained assets with more adverse information. He argues that price inefficiencies will arise, even if investors correct their expectations at the market level. Diamond and Verrecchia (1987) model the effect of short sale constraints on market efficiency in a rational expectations framework; they predict that short sale constraints reduce the speed of price adjustment to private information leading to lower informational efficiency in the market. Jarrow (1980) extends Miller's (1977) model to include more than one asset, as well as investor opinion dispersion on both the expected values and the variance - covariance matrix of the assets. He shows that the pricing effect of short sale constraints can be complex, with assets being either overpriced or underpriced. However, according to Jarrow, assets will never be underpriced when investors have different beliefs about the mean future values but agree on the variance - covariance matrix of the asset returns. Chen, Hong and Stein (2002) extend Miller's (1977) model by assuming that opinions are uniformly distributed around the true value of the asset. They show that opinion dispersion will lead to overpricing if short sale constraints bind at least some investors and if opinion dispersion is above a certain minimum threshold.

This paper develops a model similar to Chen, Hong and Stein's (2002) to describe a market with short sale constraints and heterogeneous investors. The model differs from Chen, Hong and Stein (2002) in that there are *two* risky assets in the market and in that *all* investors are short - sale constrained. In particular, a special case of Jarrow's (1980) model is adopted, where investors have heterogeneous expectations about the value of the assets but agree on the variance - covariance matrix. Jarrow (1980) shows that in this case assets' pricing is not conclusive, i.e. assets will be priced either at fair value or they will be overpriced. This paper explores the determinants of this overpricing. It shows that when asset returns are uncorrelated, the magnitude of each asset's overpricing will be primarily driven by the opinion dispersion of the particular asset. However, when the assets are correlated to some degree, each asset's overpricing will not depend only on the investors' opinion dispersion for the value of the particular asset but also on the correlation of the asset to other assets, as well as the investors' opinion dispersion for the values of those other assets.

The rest of the paper is organized as follows: Section 2 presents the assumptions of the model and solves each investor's utility maximization problem when no short sale constraints are present. Section 3 analyses the results. Finally, Section 4 presents some policy implications of the main results and concludes the paper.

2. The Model

This model describes a market with two risky assets and one riskless asset. There are n short - sale constrained investors in the market, who have a constant absolute risk aversion utility function and heterogeneous expectations. At $t = 0$, investors form expectations for the value of the risky assets at the terminal period $t = 1$ and act on their views with the objective to maximize the utility of their terminal wealth. The returns of the risky assets follow a multivariate standard normal distribution. It is assumed that investors disagree on the expected terminal value of one of the two risky assets. The investor opinions of this asset value is assumed to be uniformly distributed between $(F_1 - H_1, F_1 + H_1)$, where F_1 is the "true" terminal value of the first risky asset and H_1 is a measure of the opinion dispersion for that asset. Therefore, if there were no short sale constraints, investors would be on average correct in their assessment and both assets would be priced correctly. The supply of the risky assets is fixed and therefore, asset prices at time $t = 0$ are driven by investor demand. The cumulative return of the risk free asset and the absolute risk aversion are equal to unity. In more detail, every investor i faces the following maximization problem:

$$Max\{E(-e^{-b\widetilde{W}_i})\} \tag{1}$$

$$s.t.\widetilde{W}_i = W_{0i}\tilde{R}_{pi}, \tag{2}$$

$$\tilde{R}_{pi} = R_f + w_{1i}(\tilde{R}_{1i} - R_f) + w_{2i}(\tilde{R}_{2i} - R_f) \tag{3}$$

where,

$$\tilde{R}_{1i} = \frac{(\tilde{V}_{1i} - P_1)}{P_1}, \quad \tilde{V}_{1i} = F_{1i} + \tilde{\varepsilon}_{1i}, \qquad \tilde{\varepsilon}_{1i} \sim N(0,1) \tag{4}$$

$$\tilde{R}_{2i} = \frac{(\tilde{V}_{2i} - P_2)}{P_2}, \quad \tilde{V}_{2i} = F_{2i} + \rho\tilde{\varepsilon}_{2i} + \sqrt{1-\rho^2}\tilde{\varepsilon}_{2i,} \qquad \tilde{\varepsilon}_{2i} \sim N(0,1) \tag{5}$$

$$F_{1i} \sim U(F_1 - H_1, F_2 + H_2), \tag{6}$$

$$F_{2i} = F_2, \tag{7}$$

$$R_f = 1, \tag{8}$$

$$b = 1, \tag{9}$$

and F_{ji}= View of investor i for the terminal value of risky asset j,

V_{ji}= Expected value of the terminal value of risky asset j for investor i,

$\tilde{R}_{\mathrm{ji}}$= Cumulative expected return of the risky asset j for investor i,

w_{ji}= Weight for asset j and investor i,

H_1= Opinion disagreement measure,

R_f= Cumulative expected return for riskless asset,

W_{0i}= Initial wealth for investor i,

$\widetilde{W}_i$= Expected terminal wealth for investor i,

b= Absolute risk aversion.

If there are no short sale constraints, the above problem can be solved to produce the following individual demand functions for every investor i:

$$Q_{1i} = \frac{P_1 - P_2\rho - F_{1i} + \rho F_{2i}}{\rho^2 - 1}, \tag{10}$$

$$Q_{2i} = \frac{P_2 - P_1\rho - F_{2i} + \rho F_{1i}}{\rho^2 - 1}. \tag{11}$$

The detailed solution can be found in Appendix 1. The derived demand function for each asset depends on the correlation between the two risky assets. Since everyone agrees on the terminal value of asset 2, we have F_{2i}=F_2. The views on the terminal value of asset 1 are uniformly distributed between $(F_1 - H_1, F_1 + H_1)$. We explore three cases:$\rho > 0$, $\rho = 0$, $\rho < 0$. In all three cases the aggregate demand function for every asset is constrained to be positive.

Case 1: $\rho > 0$

If $F_{1i} < P_1 + (F_2 - P_2)$, then investor i will want to short asset 1 and buy asset 2.

If $P_1 + (F_2 - P_2)\ \rho < F_{1i} < \frac{(F_2 - P_2)}{\rho} + P_1$, then investor i will want to buy both assets.

If $F_{1i} > \frac{(F_2 - P_2)}{\rho} + P_1$, then investor i will want to buy asset 1 and short asset 2.

Case 2: $\rho = 0$

If $P_2 < F_2$ and $F_1 < P_1$, then investor i will want to buy both assets.

If $P_2 < F_2$ and $F_1 > P_1$, then investor i will want to buy asset 2 and short asset 1.

Case 3: $\rho < 0$

If $F_{1i} > P_1 + \frac{(F_2 - P_2)}{\rho}$, then investor i will want to buy both assets.

If $\frac{(F_2 - P_2 + P_1 \rho)}{\rho} < F_{1i} < P_1 + F_2\rho - P_2\rho$, then investor i will want to buy asset 1 and short asset 2.

If $F_1 < \frac{F_2 - P_2 + P_1\rho}{\rho}$, then investor i will want to short both assets.

Figures 1-3 provide a graphical depiction of the above three cases. Noticeably, both when correlation is positive or negative, higher correlation will increase the effects of short sale constraints since the $Q_1 > 0$, $Q_2 > 0$ boundaries shrink. Similarly, higher opinion dispersion should also increase the effects of short sale constraints as it increases the number of investors that would short at least one of the two assets. Assuming that investors view the prices as fixed, the higher the correlation, the higher the probability that investors will want to short at least one of the two assets if no short sales apply. This means that the higher the correlation between the two assets, the higher the probability that the short sale constraints will bind and that the positive effect of short sale constraints on prices will be present. Additionally, the higher the opinion dispersion, the higher the probability that investors would want to short at least one of the two assets.

We estimate the constrained aggregate expected demand function which in equilibrium will be equal to the fixed supply. The level of overpricing at the equilibrium asset prices under short sale constraints is also estimated. Furthermore, we examine the effect of the first asset's opinion dispersion on the overpricing of both assets. Finally, we examine the effect of the correlation between the two assets on the overpricing of both assets. Jarrow (1980) shows that if short sale constraints exist, the assets may be overpriced (Appendix 2). However, he does not explore how opinion dispersion affects overpricing. The objective of this paper is to identify the main drivers of overpricing. It is proven that overpricing can be estimated by the following functions (Appendix 2):

$$Overpricing_1 = \frac{Q_{1c} - Q_{1u} + Q_{2c}\rho - Q_{2u}\rho}{n}, \tag{12}$$

$$Overpricing_2 = (Q_{2c} - Q_{2u} + Q_{1c}\rho - Q_{1u}\rho)/n. \tag{13}$$

The analysis below is organized in three parts. The first part examines the pricing implications of short sale constraints when the correlation between the two assets is positive. The second part examines the effect of short sale constraints on prices when the two assets are uncorrelated. The last part examines the effect of short sale constraints when the two assets are negatively correlated.

2.1. Positively correlated risky assets ($\rho > 0$)

If the returns of the two risky assets are positively correlated, there are four subcases to consider:

2.1.1. *Case 1.1:* $\boldsymbol{P_1 + (F_2 - P_2)\rho < F_1 - H_1 < F_1 + H_1 < (F_2 - P_2)\rho + P_1}$

In this case, none of the investors would choose to short any of the assets even if they were not constrained. Therefore, the constrained aggregate expected demand functions are equal to the unconstrained demand functions and there is no overpricing for any of the two risky assets:

$$\bar{Q}_{1c} = \frac{1}{2H_1}\int_{F_1-H_1}^{F_1+H} \frac{P_1-P_2\rho-F_{1i}+\rho F_2}{\rho^2-1}\, dF_{1i} = \frac{P_1-P_2\rho-F_{1i}+\rho F_2}{\rho^2-1} = \bar{Q}_{1u}, \tag{14}$$

$$\bar{Q}_{2c} = \frac{1}{2H_1}\int_{F_1-H_1}^{F_1+H} \frac{P_2-P_1\rho-F_2+\rho F_{1i}}{\rho^2-1}\, dF_{1i} = \frac{P_2-P_1\rho-F_2+\rho F_{1i}}{\rho^2-1} = \bar{Q}_{2u}, \tag{15}$$

$$Overpricing_1 = 0, \tag{16}$$

$$Overpricing_2 = 0. \tag{17}$$

2.1.2. *Case 1.2:* $\boldsymbol{F_1 - H_1 < P_1 + (F_2 - P_2)\rho < \frac{(F_2-P_2)}{\rho} + P_1 < F_1 + H_1}$

In this case, some investors would want to buy both assets but others would prefer to short one of the two assets depending on their different valuations of the first asset. Highly pessimist investors would want to short the first asset and long the second asset. However, since they cannot maintain a short position, they will not invest in the first asset, and they will reoptimize their portfolio to determine how much of the second asset to hold. Their demand function for the second asset now will be Q_{1i}=$(F_{1i} - P_1)$, as they have to allocate their assets between the second risky asset and the risk free asset (Pennachi, 2006, p.50). On the contrary, highly optimist investors would be willing to short the second asset and invest all of the proceeds in the first asset. The constrained aggregate expected demand functions are given below, and they are lower than the corresponding unrestricted demand functions:

$$\bar{Q_{1c}} = \frac{1}{2H_1}\int_{P_1+(F_2-P_2)\rho}^{P_1+\frac{(F_2-P_2)}{\rho}} \frac{P_1-P_2\rho-F_{1i}+\rho F_2}{\rho^2-1}\, dF_{1i} + \frac{1}{2H_1}\int_{P_1+\frac{(F_2-P_2)}{\rho}}^{F_1+H_1} (F_1-P_1)dF_{1i} \Rightarrow$$

$$\bar{Q_{1c}} = \frac{(F_1+F_2+H_1-P_1-P_2)(F_1-F_2+H_1-P_1+P_2)}{4H_1} > Q_{1u}, \tag{18}$$

$$\bar{Q_{2c}} = \frac{1}{2H_1}\int_{F_1-H_1}^{P_1+(F_2-P_2)\rho} (F_2-P_2)dF_{1i} + \frac{1}{2H_1}\int_{P_1+(F_2-P_2)\rho}^{P_1+\frac{(F_2-P_2)}{\rho}} \frac{P_2-P_1\rho-F_2+\rho F_{1i}}{\rho^2-1}\, dF_{1i} \Rightarrow$$

$$\bar{Q_{2c}} = \frac{(F_2-P_2)F_2-P_2+2(-F_1+H_1+P_1)\rho+(F_2-P_2)\rho^2}{4H_1\rho} > \bar{Q_{2u}}. \tag{19}$$

The pricing effects of correlation and opinion dispersion for every asset are estimated by the corresponding derivatives below:

$$\frac{\partial Overpricing_1}{\partial\rho} = \frac{(F_2-P_2)(-F_1+H_1+P_1+F_2\rho-P_2\rho)}{2H_1} > 0, \tag{20}$$

$$\frac{\partial Overpricing_2}{\partial\rho} = \frac{-(F_2-P_2)^2+(F_1+H_1-P_1)^2\rho}{4H_1\rho} > 0, \tag{21}$$

$$\frac{\partial Overpricing_1}{\partial H_1} = \frac{(-F_1+H_1+P_1+F_2\rho-P_2\rho)(F_1+H_1-P_1-F_2\rho+P_2\rho)}{4{H_1}^2} > 0, \quad (22)$$

$$\frac{\partial Overpricing_2}{\partial H_1}\frac{(-F_2+P_2+(F_1+H_1-P_1)\rho)(F_2-P_2+(-F_1+H_1+P_1)\rho)}{4{H_1}^2\rho} > 0. \quad (23)$$

2.1.3. *Case 1.3:* $\boldsymbol{F_1 - H_1 < P_1 + (F_2 - P_2)\rho < F_1 + H_1 < \frac{F_2-P_2}{\rho} + P_1}$

In this case, if there are not any short sale constraints in place, some of the investors would buy both assets, whereas the pessimist investors would want to short asset 1. Therefore the constrained expected aggregated demand functions can be given by:

$$\bar{Q}_{1c} = \frac{1}{2H_1}: \int_{P_1+(F_2-H_2)\rho}^{F_1+H_1} \frac{P_1-P_2\rho-F_{1i}+\rho F_2}{\rho^2-1} dF_{1i} \Rightarrow$$

$$\bar{Q}_{1c} = \frac{-(F_1+H_1-P_1-F_2\rho+P_2\rho)^2}{4H_1(-1+\rho^2)} > \bar{Q}_{1u}, \quad (24)$$

$$\bar{Q}_{2c} = \frac{1}{2H_1}\int_{F_1-H_1}^{P_1+(F_2-P_2)\rho} (F_2 - P_2)dF_{1i} + \frac{1}{2H_1}\int_{P_1+(F_2-P_2)\rho}^{F_1+H_1} \frac{P_2-P_1\rho-F_2+\rho F_{1i}}{\rho^2-1} dF_{1i} \Rightarrow$$

$$\bar{Q}_{2c} = \frac{\left(4H_1(-F_2+P_2)+(F_1+H_1-P_1)^2\rho+2(-F_1+H_1+P_1)(F_2-P_2)\rho^2+(F_2-P_2)^2\rho^3\right)}{4H_1(-1+\rho^2)} > \bar{Q}_{2u}. \quad (25)$$

In this case, asset 1 will appear to be overpriced, whereas the second asset will be priced at fair value.

$$Overpricing_1 = \frac{(-F_1+H_1+P_1+F_2\rho-P_2\rho)^2}{4H_1 n} > 0, \quad (26)$$

$$Overpricing_2 = 0. \tag{27}$$

The pricing effects of correlation and opinion dispersion for the first asset are estimated by the corresponding derivatives below:

$$\frac{\partial Overpricing_1}{\partial \rho} = \frac{(F_2-P_2)(-F_1+H_1+P_1+F_2\rho-P_2\rho)}{2H_1} > 0, \tag{28}$$

$$\frac{\partial Overpricing_1}{\partial H_1} = \frac{(-F_1+H_1+P_1+F_2\rho-P_2\rho)(F_1+H_1-P_1-F_2\rho+P_2\rho)}{4{H_1}^2} > 0. \tag{29}$$

2.1.4. *Case 1.4:* $\boldsymbol{P_1 + (F_2 - P_2)\rho < F_1 - H_1 < \frac{(F_2-P_2)}{\rho} + P_1 < F_1 + H_1}$

In this case, if there were not any short sale constraints, some of the investors would buy both assets, whereas the optimist investors would want to short asset 2. Therefore the constrained expected aggregated demand functions can be given by:

$$\bar{Q}_{1c} = \frac{1}{2H_1}\int_{F_1-H_1}^{\frac{(F_2-P_2)}{\rho}+P_1} \frac{P_1-P_2\rho-F_{1i}+\rho F_2}{\rho^2-1} dF_{1i} + \frac{1}{2H_1}\int_{\frac{(F_2-P_2)}{\rho}+P_1}^{F_1+H_1} (F_1-P_1)dF_{1i} \Rightarrow$$

$$\bar{Q}_{1c} = \frac{\left({F_2}^2-4F_1H_1+4H_1P_1-2F_2P_2+{P_2}^2+2(-F_1+H_1+P_1)(F_2-P_2)\rho+(F_1+H_1-P_1)^2\rho^2\right)}{4H_1(-1+\rho^2)} > \bar{Q}_{1u}, \tag{30}$$

$$\bar{Q}_{2c} = \frac{1}{2H_1}\int_{F_1-H_1}^{\frac{(F_2-P_2)}{\rho}+P_1} \frac{P_2-P_1\rho-F_2+\rho F_{1i}}{\rho^2-1} dF_{1i} \Rightarrow$$

$$\bar{Q}_{2c} = -\frac{(F_2 - P_2 + (-F_1 + H_1 + P_1)\rho)^2}{4H_1\rho(-1+\rho^2)} > \bar{Q}_{2u}. \quad (31)$$

Therefore, the second asset will be overpriced, whereas the first asset will be priced at fair value.

$$Overpricing_1 = 0, \quad (32)$$

$$Overpricing_2 = \frac{(-F_2 + P_2 + (F_1 + H_1 - P_1)\rho)^2}{4H_1\rho} > 0. \quad (33)$$

The pricing effects of correlation and opinion dispersion for the second asset are estimated by the derivatives below:

$$\frac{\partial Overpricing_2}{\partial \rho} = \frac{-(F_2 - P_2)^2 + (F_1 + H_1 - P_1)^2\rho^2}{4H_1\rho^2} > 0, \quad (34)$$

$$\frac{\partial Overpricing_2}{\partial H_1} = \frac{-(F_2 - P_2 + (F_1 + H_1 - P_1)\rho)(F_2 - P_2 + (-F_1 + H_1 + P_1)\rho)}{4H_1\rho^2} > 0. \quad (35)$$

It appears that there is a "cross-asset spillover effect" as high opinion dispersion for the first asset increases the overpricing for asset 2.

2.2. Uncorrelated risky assets ($\rho = 0$)

In this scenario, there is no cross-asset spillover effect. We have the following two cases:

$$Q_{1i} = F_{1i} - P_1, \tag{36}$$

$$Q_{2i} = F_2 - P_2. \tag{37}$$

2.2.1. *Case 2.1:* $\boldsymbol{P2} < F2$ *and* $\boldsymbol{P_1} < \boldsymbol{F_1} - \boldsymbol{H_1} < \boldsymbol{F_1} + \boldsymbol{H_1}$

In this case, none of the investors would choose to short any of the assets even if they were not constrained. Therefore, the constrained aggregate expected demand functions are equal to the unconstrained demand functions and there is no overpricing for any of the two risky assets.

$$\bar{Q}_{1c} = \frac{1}{2H_1} \int_{F_1-H_1}^{F_1+H_1} (F_{1i} - P_1)\, dF_{1i} = F_1 - P_1 = \bar{Q}_{1u}, \tag{38}$$

$$\bar{Q}_{2c} = \frac{1}{2H_1} \int_{F_1-H_1}^{F_1+H_1} (F_2 - P_2)\, dF_{2i} = F_2 - P_2 = \bar{Q}_{2u}, \tag{39}$$

$$Overpricing_1 = 0, \tag{40}$$

$$Overpricing_2 = 0. \tag{41}$$

2.2.2. *Case 2.2:* $\boldsymbol{P2} < F2$ *and* $\boldsymbol{F_1} - \boldsymbol{H_1} < \boldsymbol{P_1} < \boldsymbol{F_1} + \boldsymbol{H_1}$

In this case, none of the investors would choose to short the second asset even if they were not constrained. However, some of the investors would choose to short the first asset if they were not constrained. The constrained expected aggregate demand functions are estimated below:

$$\bar{Q_{1c}} = \frac{1}{2H_1}\int_{P_1}^{F_1+H_1} (F_{1i} - P_1)dF_{1i} = \frac{P_1 - P_2\rho - F_1 + \rho F_2}{\rho^2 - 1} = \frac{(F_1+H_1-P_1)^2}{4H_1} > \bar{Q_{1u}}, \tag{42}$$

$$\bar{Q_{2c}} = \frac{1}{2H_1}\int_{F_1-P_1}^{F_1+H_1} (F_2 - P_2)dF_{2i} = F_2 - P_2 = \bar{Q_{2u}}. \tag{43}$$

Therefore, the first asset will be overpriced, whereas the second asset will be priced at fair value.

$$Overpricing_1 = \frac{(-F_1+H_1+P_1)^2}{4H_1} > 0, \tag{44}$$

$$Overpricing_2 = 0. \tag{45}$$

The pricing effect of opinion dispersion for the first asset is estimated by the following derivative:

$$\frac{\partial Overpricing_1}{\partial H_1} = \frac{(F_1+H_1-P_1)(-F_1+H_1+P_1)}{4{H_1}^2} > 0. \tag{46}$$

2.3. Negatively correlated risky assets $(\rho < 0)$

If the returns of the two risky assets are positively correlated, there are four subcases to consider:

2.3.1. *Case 3.1:* $\boldsymbol{P_1 + F_2\rho - P_2\,\rho < P_1 + \frac{(F_2 - P_2)}{\rho} < F_1 - H_1 < F_1 + H_1}$

In this case, none of the investors would choose to short any of the assets even if they were not constrained. Therefore, the constrained aggregate expected demand functions are equal to the unconstrained demand functions and there is no overpricing for any of the two risky assets:

$$\bar{Q}_{1c} = \frac{1}{2H_1}\int_{F_1-H_1}^{F_1+H_1} \frac{P_1 - P_2\rho - F_{1i} + \rho F_2}{\rho^2 - 1} dF_{1i} = \frac{P_1 - P_2\rho - F_1 + \rho F_2}{\rho^2 - 1} = \bar{Q}_{1u}, \tag{47}$$

$$\bar{Q}_{2c} = \frac{1}{2H_1}\int_{F_1-H_1}^{F_1+H_1} \frac{P_2 - P_1\rho - F_2 + \rho F_{1i}}{\rho^2 - 1} dF_{1i} = \frac{P_2 - P_1\rho - F_2 + \rho F_1}{\rho^2 - 1} = \bar{Q}_{2u}, \tag{48}$$

$$Overpricing_1 = 0, \tag{49}$$

$$Overpricing_2 = 0. \tag{50}$$

2.3.2. *Case 3.2:* $\boldsymbol{\frac{(F_2 - P_2 + P_1\rho)}{\rho} < F_1 - H_1 < P_1 + F_2\rho - P_2\rho < F_1 + H_1}$

In this case, if there were not any short sale constraints, some of the investors would buy both assets, whereas the pessimist investors would want to short asset 1. Therefore the constrained expected aggregated demand functions can be given by:

$$\bar{Q}_{1c} = \frac{1}{2H_1}\int_{P_1+(F_2-P_2)\rho}^{F_1+H_1} \frac{P_1 - P_2\rho - F_{1i} + \rho F_2}{\rho^2 - 1} dF_{1i} = -\frac{(F_1 + H_1 - P_1 - F_2\rho + P_2\rho)^2}{4H_1(-1 + \rho^2)} > \bar{Q}_{1u}, \tag{51}$$

$$\bar{Q}_{2c} = \frac{1}{2H_1}\int_{F_1-H_1}^{P_1+(F_2-P_2)\rho} (F_2 - P_2)\, dF_{1i} + \frac{1}{2H_1}\int_{P_1+(F_2-P_2)\rho}^{F_1+H_1} \frac{P_2-P_1\rho-F_2+\rho F_{1i}}{\rho^2-1}\, dF_{1i} \Rightarrow$$

$$\bar{Q}_{2c} = \frac{\left(4H_1(-F_2+P_2)+(F_1+H_1-P_1)^2\rho+2(-F_1+H_1+P_1)(F_2-P_2)\rho^2+(F_2-P_2)^2\rho^3\right)}{4H_1(-1+\rho^2)} > \bar{Q}_{2u}. \tag{52}$$

In this case, asset 1 will appear to be overpriced, whereas the second asset will be priced at fair value.

$$Overpricing_1 = \frac{(-F_1+H_1+P_1+F_2\rho-P_2\rho)^2}{4H_1} > 0, \tag{53}$$

$$Overpricing_2 = 0. \tag{54}$$

The pricing effects of correlation and opinion dispersion for the first asset are estimated by the corresponding derivatives below:

$$\frac{\partial Overpricing_1}{\partial \rho} = \frac{(F_2-P_2)(-F_1+H_1+P_1+F_2\rho-P_2\rho)}{2H_1} > 0, \tag{55}$$

$$\frac{\partial Overpricing_1}{\partial H_1} = \frac{(-F_1+H_1+P_1+F_2\rho-P_2\rho)(F_1+H_1-P_1-F_2\rho+P_2\rho)}{4{H_1}^2} > 0. \tag{56}$$

2.3.3. *Case 3.3:* $\boldsymbol{F_1 - H_1 < \frac{(F_2-P_2)}{\rho} + P_1 < P_1 + (F_2 - P_2)\rho < F_1 + P_1}$

When the returns of the two risky assets are very negatively correlated, some investors will want to hold a long position for both assets whereas many of the pessimists will want to either short the first asset and buy the second asset or short both assets. The investors that would like to short both assets will sit out of the market and those who would want to buy the second asset and short the first will reoptimize their portfolio. The constrained aggregate expected demand functions are given below and are lower than the corresponding unrestricted demand functions:

$$\bar{Q_{1c}} = \frac{1}{2H_1}\int_{P_1+(F_2-P_2)\rho}^{F_1+H_1} \frac{P_1-P_2\rho-F_{1i}+\rho F_2}{\rho^2-1}\, dF_{1i} = -\frac{(F_1+H_1-P_1-F_2\rho+P_2\rho)^2}{4H_1(-1+\rho^2)} > \bar{Q_{1u}}, \tag{57}$$

$$\bar{Q_{2c}} = \frac{1}{2H_1}\int_{\frac{(F_2-P_2)}{\rho}+P_1}^{P_1+(F_2-P_2)\rho} (F_2-P_2)dF_{1i} + \frac{1}{2H_1}\int_{P_1+(F_2-P_2)\rho}^{F_1+H_1} \frac{P_2-P_1\rho-F_2+\rho F_{1i}}{\rho^2-1} dF_{1i}, \tag{58}$$

$$\bar{Q_{2c}} = \frac{(F_1+H_1-P_1-F_2\rho+P_2\rho)\left(-2F_2+2P_2+(F_1+H_1-P_1)\rho+(F_2-P_2)\rho^2\right)}{4{H_1}^2(-1+\rho^2)}$$
$$+\frac{(F_2-P_2)\left(P_1+F_2\rho-P_2\rho-\frac{F_2-P_2+P_1\rho}{\rho}\right)}{2H_1} > \bar{Q_{2u}}. \tag{59}$$

Therefore both assets will be overpriced, as estimated below:

$$Overpricing_1 = \frac{(-F_1+H_1+P_1)^2+(F_2-P_2)^2(-2+\rho^2)}{4H_1 n} > 0, \tag{60}$$

$$Overpricing_2 = -\frac{(F_2-P_2)F_2-P_2+(-F_1+H_1+P_1)\rho}{2H_1\rho n} > 0. \tag{61}$$

The pricing effects of correlation and opinion dispersion for every asset are estimated by the corresponding derivatives below:

$$\frac{\partial Overpricing_1}{\partial \rho} = \frac{(F_2 - P_2)^2 \rho}{2H_1 n} < 0, \tag{62}$$

$$\frac{\partial Overpricing_2}{\partial \rho} = \frac{(F_2 - P_2)^2}{2H_1 \rho^2 n} > 0, \tag{63}$$

$$\frac{\partial Overpricing_1}{\partial H_1} = -\frac{-{H_1}^2 + (F_1 - P_1)^2 + (F_2 - P_2)^2(-2 + \rho^2)}{4{H_1}^2 n} > 0, \tag{64}$$

$$\frac{\partial Overpricing_2}{\partial H_1} = \frac{(F_2 - P_2)(F_2 - P_2 + (-F_1 + P_1)\rho)}{2{H_1}^2 \rho n} \lesseqgtr 0. \tag{65}$$

3. Results

Proposition 1: Short sale constraints may cause asset prices to soar above their fair value, even when there is no opinion dispersion for some of those assets. The model predicts that in an environment of short sale constraints none of the assets will be underpriced. On the contrary, one or both of the assets may be overpriced. For any overpricing to exist, there must be some opinion dispersion for at least one of the two assets. When there is no opinion dispersion for any one of the assets, they will both be priced at fair value. This result is consistent with Jarrow (1980) who predicts that short sale constraints may cause asset prices to be overpriced.

Contrary to Miller (1977) and Chen, Hong and Stein (2002) who only consider one risky asset and argue that some minimum level of opinion dispersion is required for overpricing to exist, this model shows that an asset can be overpriced even when everyone agrees on the value of the asset, as long as short sale constraints bind and investors disagree on the value of some other asset, whose returns are to some degreee correlated (positively or negatively) with the returns of the original asset. The correlation between the two risky assets may affect the allocation decision of some very optimist and/or very pessimist investors who would choose to take a short position of the asset with the certain expected cash flows, had the short sales been allowed. Short sale constraints will force those investors to stay out of the market, causing overpricing.

More specifically, when opinion dispersion for the first asset is low and the returns of the two assets are highly positively correlated, there may be some very optimist investors who will view the first asset as highly overpriced. They would want to buy the first asset and short the second asset, even though they believe that the value of the second asset is higher than its price. Short sale constraints will restrict this behavior causing overpricing for the second asset. Similarly, if the returns of the two assets are highly negatively correlated, short sale constraints will restrict the investing behavior of those very pessimist investors that would short both assets in the absense of these restrictions.

Proposition 2: High investor opinion dispersion for an asset bound by short sale constraints causes dramatic overpricing not just to this asset, but also to any other asset in the market that is correlated to some degree to it. Opinion dispersion for the value of an asset has a positive effect on its overpricing, when short sale constraints bind. This result is in agreement with the existing literature (Miller 1977, CHS 2002) and is explained by the pessimists' inability to act on their views on asset values. Furthermore, the level of opinion dispersion on the value of one asset will have a positive effect on the overpricing of any other asset positively correlated to the first asset. If the correlation between the two assets is negative, the second asset will be overpriced only if correlation is very negative and opinion dispersion is high. In this case, the effect of the first asset's opinion dispersion on the overpricing of the second asset will depend on the relative valuation of the two assets. The intuition behind this finding is that high disagreement for the value of one of the two assets translates in an increased number of very optimist and/or very pessimist investors who would be willing to short the second asset because of diversification benefits even though they do not consider it overpriced. Short sale constraints restrict this behavior causing overpricing. Interestingly, opinion dispersion on the value of one asset will have no effect on the value of any other asset if the two assets are uncorrelated.

Proposition 3: In a market, where short sale constraints bind, the correlation between the returns of the assets in the market will generally have a possitive effect on overpricing for all assets, as long as investors disagree on the value of one the assets. The intution behind this Proposition 3 lies in the fact that high correlation translates in lower diversification benefits, which alters investors' desired allocation. When correlation is low, investors will have a higher incentive to long both assets since the diversification benefit is high. However, if correlation is high the diversification benefit will be lower, which means that those investors with low valuations for one of the two assets will be more likely to short sell the asset with the low valuation. If correlation is positive, the two assets will be viewed more and more as substitutes when correlation is higher. As correlation increases, more investors would be willing to short one or both assets. Short sale constraints force these investors to stay out of the corresponding market causing overpricing. The only exception is the case when correlation is very negative and opinion dispersion is very high. Then, in the absense of short sale constraints some very pessimist investors will want to short both assets. The diversification benefits will, thus, be lower as correlation becomes more negative. Therefore, the level of correlation between the returns of the two assets will decrease overpricing. However, this effect will be uncommon, as most stock returns are not highly negatively correlated.

4. Conclusion

This paper models a market with heterogeneous investors and two risky assets. Consistent to previous literature, short sale constraints cause overpricing, which itself goes up as opinion dispersion increases. Additionally, we show that investors' disagreement over the value of one asset may cause overpricing for another asset, when the returns of these assets are correlated to some degree. Furthermore, the higher the opinion dispersion for one asset, the higher the overpricing of the other correlated asset.

Finally, the correlation between the asset returns in the market will generally have a positive effect on overpricing for all short sale constrained assets as long as there is some level of disagreement for the value of at least one of the assets. This finding is documented for the first time and can have crucial policy implications, especially when analyzing the effect of short sale constraints in international equity markets, which often have high concentration of their equities in a selected industries. The results of this paper suggest that markets with high concentration of their equity market in just a few industries, will tend to exhibit more pronounced overpricing if short sale constraints are applied.

Appendix

Appendix 1

Every investor solves the following utility maximization problem:

$$Max\{E(-e^{-b\widetilde{W}_i})\} \tag{1.1}$$

$$s.t. \quad \widetilde{W}_i = W_{0i}\tilde{R}_{pi}, \tag{1.2}$$

$$\tilde{R}_{pi} = R_f + w_{1i}(\tilde{R}_{1i} - R_f) + w_{2i}(\tilde{R}_{2i} - R_f), \tag{1.3}$$

where,

$$\tilde{R}_{1i} = \frac{(\tilde{V}_{1i} - P_1)}{P_1}, \quad \tilde{V}_{1i} = F_{1i} + \tilde{\varepsilon}_{1i}, \qquad \tilde{\varepsilon}_{1i} \sim N(0,1) \tag{1.4}$$

$$\tilde{R}_{2i} = \frac{(\tilde{V}_{2i} - P_2)}{P_2}, \quad \tilde{V}_{2i} = F_{2i} + \rho\tilde{\varepsilon}_{2i} + \sqrt{1-\rho^2}\tilde{\varepsilon}_{2i,} \qquad \tilde{\varepsilon}_{2i} \sim N(0,1) \tag{1.5}$$

$$F_{1i} \sim U(F_1 - H_1, F_2 + H_2), \tag{1.6}$$

$$F_{2i} = F_2, \tag{1.7}$$

$$R_f = 1, \tag{1.8}$$

$$b = 1, \tag{1.9}$$

and F_{ji} = View of investor i for the terminal value of risky asset j,

$\tilde{V}_{\text{ji}}$ =Expected value of the terminal value of risky asset j for investor i,

$\tilde{R}_{\text{ji}}$= Cumulative expected return of the risky asset j for investor i,

w_{ji}= Weight for asset j and investor i,

H_1 = Opinion disagreement measure,

R_f= Cumulative expected return for riskless asset,

W_{0i}=Initial wealth for investor i,

$\widetilde{W}_i$ = Expected terminal wealth for investor i

b = Absolute risk aversion.

So, $\tilde{R}_1, \tilde{R}_2$ follow a bivariate normal distribution with the following means and variances:

$$\tilde{E}R_1 = \frac{F_{1i}}{P_1}, \tag{1.10}$$

$$\tilde{E}R_2 = \frac{F_2}{P_2}, \tag{1.11}$$

$$\sigma_1{}^2 = Var(\tilde{R}_{1i}) = Var\,\frac{(\tilde{V}_{1i}-P_1)}{P_1} = \frac{1}{P_1{}^2}, \tag{1.12}$$

$$\sigma_2{}^2 = Var(\tilde{R}_{2i}) = Var\,\frac{(\tilde{V}_{2i}-P_2)}{P_2} = \frac{1}{P_2{}^2}, \tag{1.13}$$

Therefore, $\tilde{R}_p \sim N(\mu_p, \sigma_p)$and the maximization problem can be written as follows:

$$Max\{-e^{-bW_{0i}(R_f+w_{1i}(\tilde{R}_{1i}-R_f)+w_{2i}(\tilde{R}_{2i}-R_f))+\frac{1}{2}W_{0i}b^2\sigma_p{}^2}\} \tag{1.14}$$

$$FOC_1: \tilde{R}_{1i} - R_f - \frac{1}{2}W_{0i}(2\sigma_1{}^2 w_{1i} + 2\rho\sigma_1\sigma_2 w_{2i}) = 0, \tag{1.15}$$

.

$$\tilde{R}_{2i} - R_f - \frac{1}{2}W_{0i}(2\sigma_2{}^2 w_{2i} + 2\rho\sigma_1\sigma_2 w_{1i}) = 0. \tag{1.16}$$

Solving for the weights and substituting for $\widetilde{R}_{1i}, \tilde{R}_{2i}, \sigma_1, \sigma_2, R_f = 1, b = 1$:

$$w_{1i} = \frac{P_1(-\widetilde{V}_{1i}+P_1+(\widetilde{V}_{2i}-P_2)\rho)}{(-1+\rho^2)W_{0i}}, \tag{1.17}$$

$$w_{2i} = \frac{P_2(-\widetilde{V}_{2i}+P_2+(\widetilde{V}_{1i}-P_1)\rho)}{(-1+\rho^2)W_{0i}}. \tag{1.18}$$

Therefore, if there are no short sale constraints investor i's demand function for each one of the assets will be:

$$Q_{1i} = \frac{w_{1i}W_{0i}}{P_1} = \frac{P_1-P_2\rho-F_{1i}+\rho F_{2i}}{\rho^2-1}, \tag{1.19}$$

$$Q_{2i} = \frac{w_{2i}W_{0i}}{P_2} = \frac{P_2-P_1\rho-F_2+\rho F_{1i}}{\rho^2-1}. \tag{1.20}$$

Since every one agrees on the terminal value of asset 2, $F_{2i} = F_2$.

Appendix 2

The above two asset maximization problem under short sale constraints is solved in Jarrow (1980) with the use of the Langrangian function and the application of the Kuhn - Tucker conditions, used to account for the short sale constraints: $Q_1 > 0$, $Q_2 > 0$. Jarrow (1980) shows that each investor i will have the following demand functions for the two assets:

$$Q_{1i}{}^{c} = \frac{F_{1i}-P_1-\rho(F_{2i}-P_2)}{b(1-\rho^2)} + \frac{\lambda_{1i}-\rho\lambda_{2i}}{b(1-\rho^2)} = Q_{1i}{}^{u}(P_{1,}P_2) + \frac{\lambda_{1i}-\rho\lambda_{2i}}{b(1-\rho^2)}, \tag{2.1}$$

$$Q_{2i}{}^{c} = \frac{F_{2i}-P_2-\rho(F_{1i}-P_1)}{b(1-\rho^2)} + \frac{\lambda_{2i}-\rho\lambda_{1i}}{b(1-\rho^2)} = Q_{2i}{}^{u}(P_{1,}P_2) + \frac{\lambda_{2i}-\rho\lambda_{1i}}{b(1-\rho^2)}, \tag{2.2}$$

where $\lambda_{1i} > 0$ if $Q_{1i} < 0$ and $\lambda_{1i} = 0$ if $Q_{1i} > 0$,

and $\lambda_{2i} > 0$ if $Q_{2i} < 0$ and $\lambda_{2i} = 0$ if $Q_{2i} > 0$.

Aggregating the demand functions across all n investors:

$$Q_1{}^{c}(P_1, P_2) = Q_{1i}{}^{u}\left(P_{1,}P_2\right) + \frac{\sum_{i=1}^{n}\lambda_{1i}+\sum_{i=1}^{n}\lambda_{2i}\rho}{1-\rho^2}, \tag{2.3}$$

$$Q_2{}^{c}(P_1, P_2) = Q_{2i}{}^{u}\left(P_{1,}P_2\right) + \frac{\sum_{i=1}^{n}\lambda_{2i}+\sum_{i=1}^{n}\lambda_{1i}\rho}{1-\rho^2}. \tag{2.4}$$

Jarrow (1980) shows that:

$$Overpricing_1 = P_1{}^{c} - P_1{}^{u} = \frac{\sum_{i=1}^{n}\lambda_1}{n}, \tag{2.5}$$

and

$$Overpricing_2 = {P_1}^c - {P_1}^u = \frac{\sum_{i=1}^{n} \lambda_1}{n}. \qquad (2.6)$$

where (${P_1}^c$, ${P_2}^c$) describes the set of equilibrium prices under short sale constraints. (${P_1}^c$, ${P_2}^c$) are estimated by solving the following system of equations:

$${Q_1}^c(P_1, P_2) = {Q_1}^S, \qquad (2.7)$$

$${Q_2}^c(P_1, P_2) = {Q_2}^S, \qquad (2.8)$$

${Q_1}^S$= fixed supply for asset 1,

${Q_2}^S$ = fixed supply for asset 2,

(${P_1}^u$, ${P_2}^u$) describes the set of equilibrium prices when short sales are allowed. They are estimated by solving the followign system of equations:

$${Q_1}^u(P_1, P_2) = {Q_1}^S, \qquad (2.9)$$

$${Q_2}^u(P_1, P_2) = {Q_2}^S. \qquad (2.10)$$

${Q_1}^S$= fixed supply for asset 1

${Q_2}^S$= fixed supply for asset 2

Solving the above system under the short sale constraints for the sum of λs, we estimate another specification for overpricing:

$$Q_1{}^c(P_1, P_2) = Q_{1i}{}^u\big(P_{1,}P_2\big) + \frac{\sum_{i=1}^{n} \lambda_{1i} + \sum_{i=1}^{n} \lambda_{2i}\rho}{1-\rho^2} = Q_1{}^S, \quad (2.11)$$

$$Q_2{}^c(P_1, P_2) = Q_{2i}{}^u\big(P_{1,}P_2\big) + \frac{\sum_{i=1}^{n} \lambda_{2i} + \sum_{i=1}^{n} \lambda_{1i}\rho}{1-\rho^2} = Q_2{}^S \Leftrightarrow \quad (2.12)$$

$$\sum_{i=1}^{n} \lambda_{1i} = Q_1{}^c(P_1{}^c, P_2{}^c) - Q_{1i}{}^u(P_1{}^c, P_2{}^c) + \rho(Q_2{}^c(P_1{}^c, P_2{}^c) - Q_2{}^u(P_1{}^c, P_2{}^c)), \quad (2.13)$$

$$\sum_{i=1}^{n} \lambda_{2i} = Q_2{}^c(P_1{}^c, P_2{}^c) - Q_{2i}{}^u(P_1{}^c, P_2{}^c) + \rho(Q_1{}^c(P_1{}^c, P_2{}^c) - Q_1{}^u(P_1{}^c, P_2{}^c)), \quad (2.14)$$

where

$$Q_1{}^c(P_1{}^c, P_2{}^c) = Q_1{}^S, \quad (2.15)$$

and

$$Q_2{}^c(P_1{}^c, P_2{}^c) = Q_2{}^S. \quad (2.16)$$

Therefore,

$$Overpricing_1 = \frac{\sum_{i=1}^{n} \lambda_1}{n} = \frac{Q_1{}^c(P_1{}^c,P_2{}^c) - Q_{1i}{}^u(P_1{}^c,P_2{}^c) + \rho\Big(Q_2{}^c(P_1{}^c,P_2{}^c) - Q_2{}^u(P_1{}^c,P_2{}^c)\Big)}{n}, \quad (2.17)$$

$$Overpricing_2 = \frac{\sum_{i=1}^{n} \lambda_2}{n} = \frac{Q_2{}^c(P_1{}^c,P_2{}^c) - Q_{2i}{}^u(P_1{}^c,P_2{}^c) + \rho\Big(Q_1{}^c(P_1{}^c,P_2{}^c) - Q_1{}^u(P_1{}^c,P_2{}^c)\Big)}{n}. \quad (2.18)$$

Figure 1: Positively correlated risky assets.

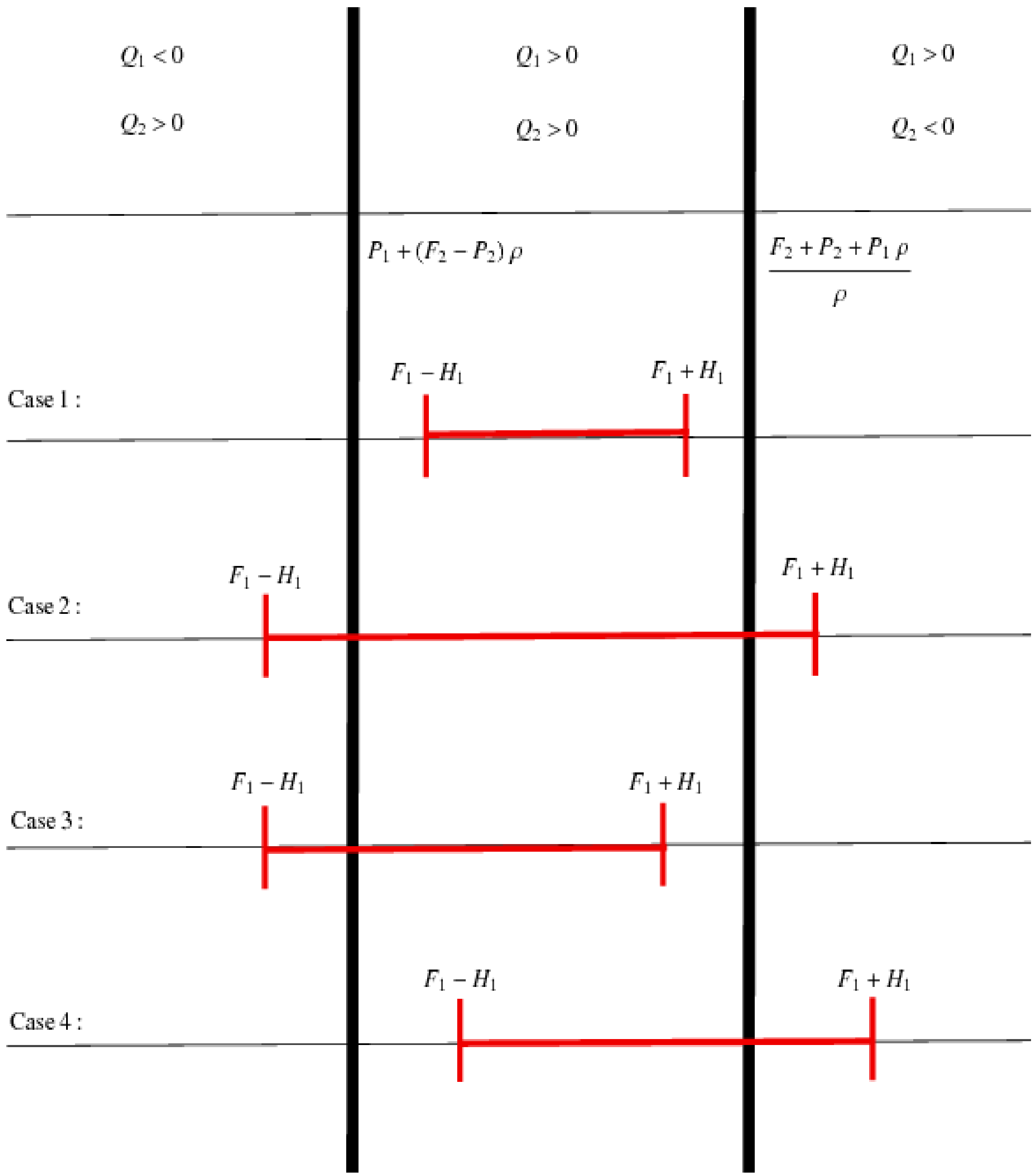


Figure 2: Uncorrelated risky assets.

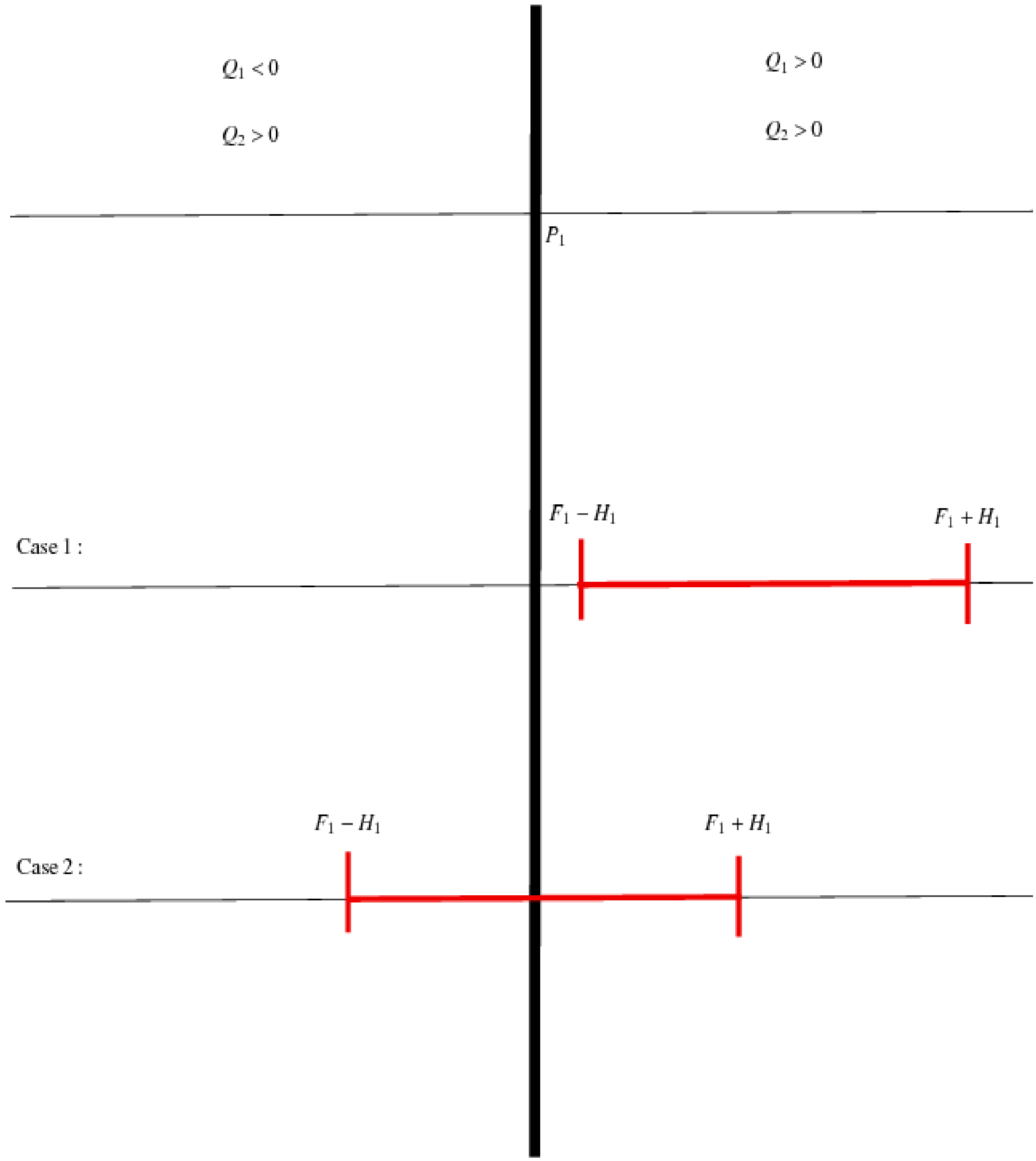
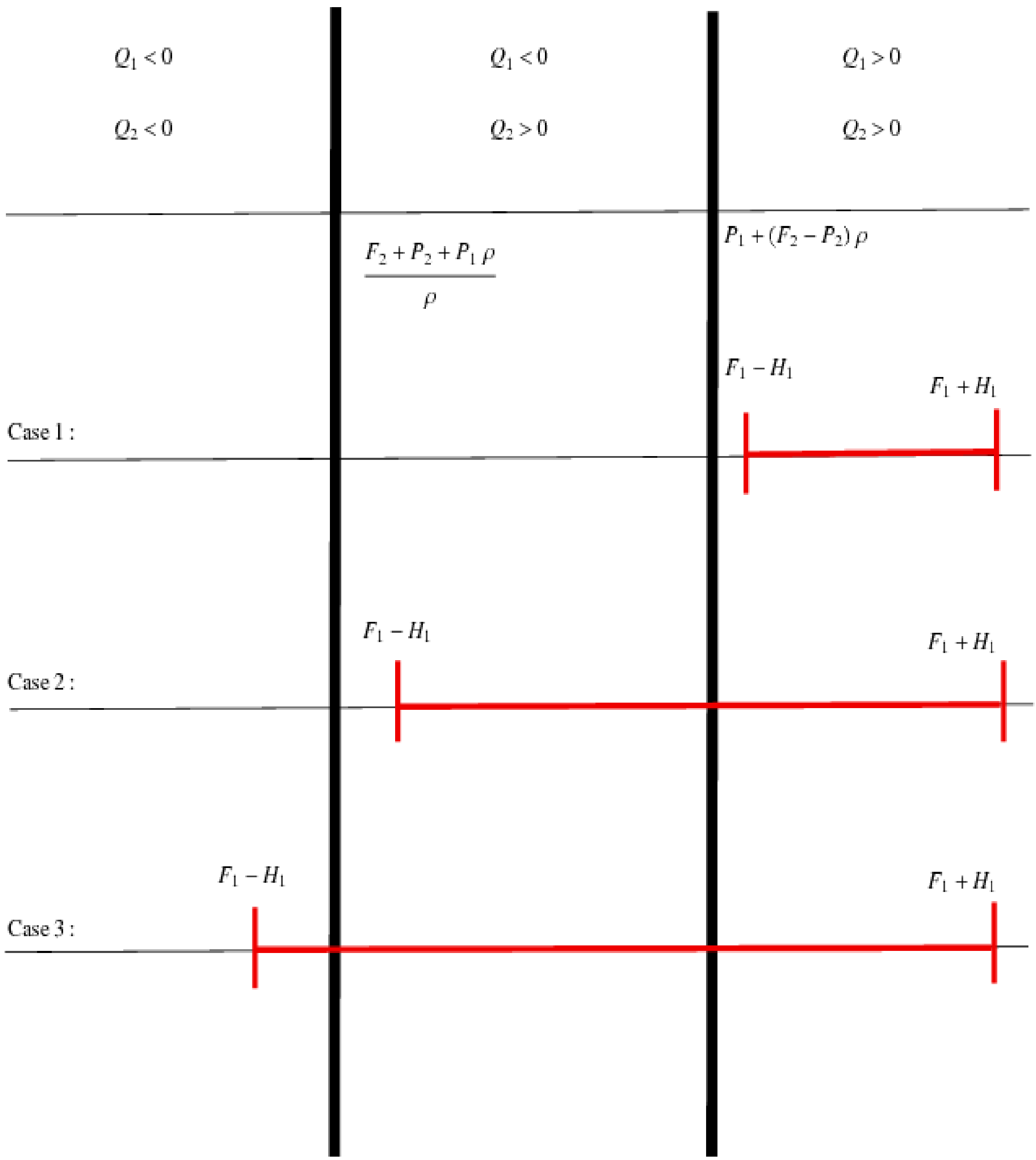


Figure 3: Negatively correlated risky assets.



CHAPTER 2

Short Sale Constraints and Opinion Dispersion: Evidence from the Indian Equity Market

1. Introduction

As SEC's recent short sales ban of 799 financial stocks in September 2008 highlights, short sales constraints still generate significant controversy and the constraints' effects remain far from straightforward. The September 2008 ban was meant to avert the downward spiral of equity prices. Nevertheless, its effectiveness has been questionable, with Christopher Cox, SEC chairman, recently admitting that the ban may have been a mistake,[1] as it did not succeed in preventing the prices from tumbling; to the contrary it led to a liquidity squeeze. The controversy highlights the general regulatory uncertainty on short sales, also evidenced by the elimination of the decades old uptick rule[2] in 2007, only to be potentially reinstated in the near future.[3]

The pricing implications of short sales have been a subject of debate long before the current economic crisis. The finance community appears split in two camps, each one with

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[1] Amit R. Paley and David S. Hilzenrath, "SEC Chief Defends His Restraint: Cox Rebuffs Criticism of Leadership During Crisis," *The Washington Post*, Wednesday, December 24, 2008; Page A01

[2] "The Commission originally adopted Rule 10a-1 in 1938 to restrict short selling in a declining market. Rule 10a-1(a)(1) provided that, subject to certain exceptions, a listed security may be sold short (A) at a price above the price at which the immediately preceding sale was effected (plus tick), or (B) at the last sale price if it is higher than the last different price (zero-plus tick)," "Amendments to Exchange Act Rule 10a-1 and Rules 201 and 200(g) of Regulations SHO," SEC. Retrieved on 2009-04-10.

[3] SEC is currently seeking public comment on restoring the rule in some modified version: Securities Exchange Commission, "SEC Seeks Comments on Short Sale Price Test and Circuit Breaker Restrictions", Press Release, 2009-76

strong opinions on the appropriate regulation of short sales. Opponents of short sale constraints argue that short sales allow the views of all investors, both optimists and pessimists, to be reflected on the market, facilitating, therefore, the efficient price discovery. For them, short sale restrictions are viewed as obstacles to market efficiency, potentially leading to overpricing. On the other hand, supporters of short sale constraints argue that short sellers can place downward pressure in the market and exacerbate a possible market panic. In their view, there should be such restrictions in place to avoid such precipitous psychological reactions. One of the most notorious examples cited by the supporters of short sale constraints is the case of black Wednesday in 1992, when George Soros sold short 10 billion British pounds, breaking the Bank of England.

The goal of this paper is to shed some light on the controversy over short sale constraints. Building on Chen et al. (2002), this paper models the pricing implications in a market where short sale constraints indiscriminately bind all investors and stocks. According to model predictions, opinion dispersion has a positive effect on overpricing. The model is empirically tested in the Indian equity market, which provides a natural testing environment as short sales were banned across the equity market during the period between 2001 and 2008.

Overpricing is measured as the difference between the discounted futures price and the price of the underlying equity index. Various proxies of opinion dispersion are used, such as realized volatility, implied volatility, daily price range, and turnover. The empirical results offer supportive evidence of the relationship between opinion dispersion and overpricing in a market with short sale constraints.

The rest of the paper is organized as follows: Section 2 offers a review of the empirical literature on opinion dispersion's effects on overpricing in markets with short sale constraints.

Section 3 sets the model and presents the model predictions. Section 4 provides some background information on the most prevalent Indian equity index, S&P CNX Nifty and describes the structure of the Indian equity derivatives market. Section 5 describes the dataset used for this study. Section 6 describes how overpricing is measured and presents a univariate analysis. It, also, describes the proxies of opinion dispersion and presents some univariate results. Section 7 describes the empirical multivariate results of the model. Section 8 describes future robustness tests and theoretical extensions of this paper. Finally, Section 9 concludes the paper.

2. Literature Review

Miller (1977) was the first to study the pricing implications of short sale constraints. He argued that short sale constraints can inflate market prices as bearish investors cannot act on their market views. According to Miller (1977), when opinion dispersion is high, the prohibition of short sales leads to overpricing, as pessimistic investors cannot take short positions and remain out of the market. He assumes one risky asset in his model, which could represent the whole market, i.e., an index, or an individual stock. Jarrow (1980) builds on Miller's model and shows that universal short sale constraints lead to overpricing of the entire market. The overpricing hypothesis has recently been revisited by a series of papers that develop theoretical models (Chen et al., 2002; Hong and Stein, 2003) and a series of empirical papers.

Most of these papers test the effect of opinion dispersion on pricing under short sale constraints using data on individual U.S. stocks. In markets, like the U.S. one, where short sales are generally not prohibited, these studies use different proxies for the binding strength of short sale constraints. Short interest is one of the proxies widely used and it is estimated as the number of shares that are short over the total number of shares outstanding (Figlewski, 1981). When short interest is high, short sale constraints are not particularly binding. Another proxy is the cost of borrowing (Jones and Lamont, 2002), i.e., the rebate rate, which represents the interest rate that the short seller needs to pay to borrow the stock. The higher this rate the more short sale constrained the equity (Boehme and Danielsen, 2006). An alternative measure for short sale constraints is the presence of an exchange traded option on the stock, since that offers a different way for pessimists to express their views (Boehme et al, 2006; Figlewski and Webb, 1993). One final way to approximate for short sale constraints is to look at the level of institutional holdings, such as mutual funds that typically do not have short positions (Nagel, 2005; Asquith, Pathak and Ritter, 2005). There are also a few studies that look at foreign markets where there is a list of firms, whose stocks are under regulatory short sale ban. The list is often revised offering an ideal dataset for an event study. Hu (2008) provides evidence from the Taiwan market and Chang, Cheng and Yu (2008) look at individual short sale constrained stocks in Hong Kong.

In order to test the effect of opinion dispersion on the pricing of short sale constrained assets, it is essential to measure disagreement in the market. A variety of proxies are used for such measurement. Miller (1977) proposes turnover as a proxy for opinion dispersion.[4] A series of papers have further used this measure of opinion dispersion (i.e., Boehme et al., 2006; Nagel, 2005; Goetzmann and Massa, 2005). Other popular proxies include dispersion in analysts' forecasts (Bohme et al., 2006; Diether and Scherbina, 2002), historical stock return volatility (Boehme et al., (2006); Goetzmann and Massa, 2005; Nagel, 2005, heterogeneity of trade among investor classes (Goetzmann and Massa, 2005).

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[4] "Since much stock trading consists of investors who are pessimistic about a stock selling to those who are optimistic, turnover provides one measure of diversity of opinion (strictly speaking of changes in relative opinion)" Miller 1977.

Most papers in the literature measure overpricing based on lower future returns. These papers assume that following the overpricing, the market price corrects itself. The size of the correction, evidenced by lower future returns, is a proxy of the previous overpricing. The timeframe employed varies from paper to paper. Goetzmann and Massa (2005) find a negative effect of opinion dispersion on overnight returns. Boehme et al. (2006) find a negative effect of opinion dispersion on monthly and annual subsequent returns. Chen et al. (2002) and Nagel (2005) find a negative effect of opinion dispersion on quarterly subsequent returns, while Desai, Thiagarajan, Balachandran (2002) find annual negative subsequent returns. Asquith et al. (2005) examine monthly subsequent returns and they find that the constrained stocks underperform during the period 1988-1992 only when the portfolio is estimated on an equally weighted basis, but not when it is estimated on a value weighted basis.

3. The Model

A two-period model is developed describing an equity market with short sale constraints, binding all stocks and investors. The model follows Chen et al. (2002), but it differs in that *all* investors are short sale constrained. The model assumes one risky asset in the market. Investors choose how much to invest in that asset, considering that their only alternative is to invest in the riskless asset that has zero return. Time 0 is the valuation date for all investors. At time 1, the risky asset provides a terminal dividend F plus an error term ε, which is normally distributed with zero mean and standard deviation equal to unity. Investors have a constant absolute risk aversion utility function, which is mathematically described by a negative exponential function. Investors have diverse opinions of the risky asset's terminal value F. In fact, their views of the terminal value F are uniformly distributed between $(F-H, F+H)$. Investors maximize their utility function in order to decide how much to invest in the risky asset.

In order to determine whether overpricing is driven by opinion dispersion, the price of assets needs to be estimated. Assuming investors face a constant supply of shares Q, the equilibrium price depends on investors' aggregate demand function. We will derive the aggregate demand by aggregating *individual* demands. In particular, every investor i faces the following optimization problem:

$$Max\{E(-e^{-b\widetilde{W}_i})\} \tag{1}$$

$$s.t. \widetilde{W}_i = W_{0i}\tilde{R}_{pi}, \tag{2}$$

$$\tilde{R}_{pi} = R_f + w_i(\tilde{R}_i - R_f), \tag{3}$$

where b= absolute risk aversion,

W_{0i}= initial wealth,

$\widetilde{W}_i$= expected wealth,

$\tilde{R}_{pi}$ = expected cumulative portfolio return,

R_f = cumulative risk free rate, which in this model is assumed to be equal to 1,

$\tilde{R}_i$= cumulative return for the risky asset,

w_i = proportion invested in the risky asset.

Therefore, the demand curve for every unconstrained investor would be:

$$Q_i^{DU} = \frac{1}{b}(F_i - P). \tag{4}$$

But since we have assumed that short sale constraints bind every investor, the demanded quantity cannot be negative. Therefore, the demand for every short sale constrained investor is:

$$Q_i^{DC} = Max\{\frac{1}{b}(F_i - P),0\}. \tag{5}$$

The derivation of the demand function for every investor is reported in Appendix 1. Since investors opinions are uniformly distributed between $(F - H, F + H)$ the aggregate demand should be the sum of the individual demands.

If the price is below the worst view of the risky asset's terminal value $(F - H)$, then the expected quantity will be equal to:

$$Q^{DC1} = \frac{1}{2H}\int_{F-H}^{F+H} \frac{1}{b}(F_i - P^{C1})dF_i = Q^{DU} \Rightarrow P = F - Q^{DU}b = P^C = P^U. \tag{6}$$

which coincides with the total demand, if there were no short sale constraints. However, if the price is above the level of the most pessimistic view of the risky asset's terminal value, the expected total demand will be equal to:

$$Q^{DC2} = \frac{1}{2H}\int_{P}^{F+H} \frac{1}{b}(F_i - P)dF_i \Rightarrow P = F + H - 2\sqrt{HQ^{DC2}b} = P^C > P^U. \tag{7}$$

Solving the integrals and rearranging leads to some interesting pricing implications. More specifically:

If $H < \frac{Q}{\gamma_b}$: $$P^C = F - \frac{Q}{\gamma_b} = P^U. \quad (8)$$

If $H \geq \frac{Q}{\gamma_b}$: $$P^C = F + H - 2 * \sqrt{\frac{H * Q}{\gamma_b}} \geq P^U. \quad (9)$$

where $\gamma_b = \frac{1}{b}$ measures the risk tolerance.

Therefore, the model predicts that below a certain level of opinion dispersion, the price of the risky asset will be identical to the prevailing price under no short sale constraints. At those levels, the price is independent of the level of opinion dispersion. However, when the level of opinion dispersion is above a certain level, the price of the risky asset, influenced by opinion dispersion, will be higher than the prevailing price under no short sale constraints. Thus, beyond that level of opinion dispersion, the model predicts that there will be overpricing and higher opinion dispersion will lead to higher overpricing. Finally, the expected return will be equal to $F - P$ and it will be negatively affected by opinion dispersion when there is considerable disagreement in the market. The intermediate steps and the derivative calculations are reported in Appendix 2.

According to the model, when there is agreement on the price of the asset at time 1, i.e., minimal opinion dispersion, all investors will invest an amount at time 0 that will be less than the amount expected in the future. Therefore, investors will not need to short the asset, and, thus, the existence of short sale constraints will make no difference. Because of the general agreement, no overpricing will be observed. However, when there is *disagreement* as to the future price of the asset, short sale constraints make a difference. The pessimists, who would otherwise short the asset in a no-constraint environment, can no longer express their views by shorting the asset, and they will, thus, simply stay out of the market. The price will inevitably only reflect the opinion of the optimists who are willing to buy the asset because they believe that the future price will increase. This price will be higher than the price that would prevail if the pessimists were allowed to express their views in the market through short selling. When the opinion dispersion is highest, the overpricing in the market will also be the highest. Finally, higher overpricing will translate in lower future returns as the market corrects itself in the final period. Therefore, high opinion dispersion would lead to lower future returns.

We summarize, the hypothesis derived from the model, which is tested in the empirical section that follows. ***Hypothesis: In a market with short sale constraints, high opinion dispersion leads to positive deviations from the efficient price (overpricing) as long as opinion dispersion exceeds a certain minimum threshold.***

4. The Indian Markets: Background Information

The Indian equity market provides a natural testing environment for the prediction of the proposed model, as short sales were banned across the equity market from 2001 to 2008. This section provides an overview of the main characteristics of the S&P CNX Nifty index, the most prevalent Indian equity index and the Nifty Benchmark Exchange – Traded Scheme (Nifty BeES), India's first Exchange Traded Fund (ETF). It also describes the operations of the Indian equity derivatives market.

S&P CNX Nifty Index: The Standard & Poor's CNX Nifty commenced trading in April 1996 and today it is the leading index on the National Stock Exchange of India, often used as a benchmark for the Indian market portfolio. It includes 50 of the approximately 935 companies listed on the NSE, many of which are blue chip companies. It accounts for 22 sectors of the

Indian economy and it represents about 60% of the total market capitalization of the National Stock Exchange. It is highly liquid, as it only includes stocks with low impact cost. It includes only the capital gains and losses due to price movements; not dividends. The daily movements of the total returns index, which includes both price movements and the dividend yield, are shown in Figure 1. Noticeably, the S&P CNX Nify Index has experienced a remarkable boom during 2004-2008, followed by a price decline, consistent to the 2008 worldwide financial crises.

Nifty BeES: The Nifty Benchmark Exchange – Traded Scheme (Nifty BeES) is the first Exchange Traded Fund, which tracks the total returns of the S&P CNX Nifty Index. In more detail, one unit of Nifty BeES corresponds to $1/10^{th}$ of the S&P CNX Nifty Index. Nifty BeES was initiated by the Benchmark Mutual Fund in December 2001 and it is listed on the capital market segment of the National stock exchange. Like other ETFs, it can be bought and sold through brokers just like stocks, facilitating investors' efforts to obtain exposure to a diversified portfolio approximating the S&P CNX Nifty Index. Nifty BeES has received numerous awards during the last decade, including the Golden Peacock Award for the Most Innovative Financial Product (2002-03) and the Best Performing Mutual Fund of the Year in the Index Fund Category at CNBC (2007-08)[5,6].

Equity Derivatives in India: Derivatives trading was initially introduced in India in June 2000, when trading in index futures commenced. Trading in index options commenced a year later in June 2001. Although the Indian options market in organized exchanges is relatively young, its size has been growing at an increasing pace. Table 1 describes the growth of NSE's derivatives market. NSE's derivatives market has achieved an average annual growth of more

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[5] Value Research, 2001, December 14. *Nifty BeES: India's first ETF Launched*. Retrieved January 27, 2010, from Value Research website: http://new.valueresearchonline.com/story/h2_storyView.asp?str=1505

[6] Benchmark, n.d. Retrieved on January 27, 2010 from Benchmark Funds website: http://www.benchmarkfunds.com/static/Nifty/overview.cgi.

than hundred percent during the period 2001-2008, with the total derivatives settlement growing from 860.1 Rs.Cr. ($18.44 millions) in 2001 to 1,565,192.30 Rs. Cr. ($39,222 millions) in 2008. The Indian options are traded on the National Stock Exchange (NSE) and the Bombay Stock Exchange (BSE), whereas futures are traded on the National Stock Exchange, the Bombay Stock Exchange and the Singapore Stock Exchange. Both NSE and BSE have moved to an electronic platform, eliminating arbitrage opportunities from price differentials in the two exchanges. NSE has been accounting for the bulk of the total turnover in derivatives trading since 2002, rendering it the leading exchange for derivatives trading in India.[7]

At any point in time, there are only three contracts available for trading with one month, two months and three months to expiration. Also, there are long term option contracts for three quarterly months of the cycle March/June/September/December and five months following semi-annual months of the cycle June/December. These contracts expire on the last Thursday of the expiry month. If the last Thursday is a holiday, the derivative contracts expire the previous day. All derivatives are cash settled. The number of strikes provided on S&P CNX Nifty depends on the previous day's closing price of the index.

In the period 2002-2008, most of the investors in the derivatives market were retail investors, since institutional investors are prohibited from investing in the derivatives market - except for those involved in hedging activities. In fact, during the year 2007-2008, 63% of the investors were retail investors whereas institutional investors accounted for only 12% of the NSE turnover on futures and options. Most of the institutional investors were foreign institutional investors.[8]

Jogani & Fernandes (2003) and Shah (2003) examine the efficiency of the derivatives

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[7] National Stock Exchange, 2008 Annual Report

[8] National Stock Exchange, 2008 Annual Report

market and show that in the period 2001-2002 there were many arbitrage opportunities involving derivatives. In fact, they observe that during 2001-2002 the futures on S&P CNX Nifty index were selling at a discount to the actual index price level as opposed to the premium that one would expect. The restrictions in short selling were effectively lifted in 2008. Also, many call-put parity violations are persistently observed. Cited reasons for the persistence of those arbitrage opportunities are the restrictions on institutional investors, the lack of knowledge and expertise of the retail investors, and the high bid-ask spread of options. Evidence of call - put parity violations are also reported in Varma (2003).

5. Data

Since this paper examines the investors' behavior in a market with only one risky asset, we will assume that this one risky asset is represented by the S&P CNX NSE NIFTY index. The dataset employed includes daily closing prices for the S&P CNX NSE NIFTY and for all futures and options on the S&P CNX NSE NIFTY index. It also includes hourly intra-day snapshots of the trading book for all derivatives on S&P CNX NSE NIFTY, all trades throughout the day on the underlying index and the corresponding derivatives. The data extends from 2002 to 2008 and it was obtained from the National Stock Exchange, the leading Indian exchange in trading derivatives. The highly liquid nature of these instruments guarantees a high level of market efficiency.

The derivatives chosen are the ones nearest to expiration, unless the time to expiration is a week or less. In that case, the derivatives of the following month are considered, so that the derivatives in the sample are always the most liquid possible. Dividend yield and interest rate data are required in order to estimate the deviations from the equilibrium prices and the arbitrage gaps. The dividend yield for the index is provided by India's National Stock Exchange (NSE). The one month interbank borrowing and lending rates (MIBOR, MIBID) are used whenever an interest rate is required. Both datasets are provided by NSE.

6. Methodology: Variable Construction

In this section, we describe the construction of our proxies for mispricing and opinion dispersion.

6.1. Mispricing

Existing literature has used subsequent returns to measure mispricing. The rationale behind this measure is that if equity assets are overpriced, the prices will at some point correct, i.e., exhibiting negative subsequent returns. The size of the correction is a measure of mispricing. The length of the period considered for the estimation of subsequent returns varies from study to study. However, it is difficult to determine which would be the appropriate timeframe to consider, and most of the studies do not provide a theoretical justification for their preferred timeframe.

Moreover, overpricing does not necessarily translate into lower future returns in the short run. In the proposed theoretical model, if opinion dispersion is high, there will always be a price correction since the true fair value of the risky asset is revealed during the second period in a two period model. However, when applying the model in an actual market, it is difficult to determine how long it would take for the fair price to be revealed. At the same time, a price correction would be more likely to happen if short sale restrictions are eliminated, which does not apply to the case of the Indian equity market during the period 2002-2008.

In order to avoid these shortfalls, the alternative proxy used in this paper is a futures-based measure. Overpricing is estimated as the logarithmic difference between the index price and the discounted futures price. Since there are no short sale constraints in the *derivatives* market, taking both a long and a short position in the futures market is feasible, even when there are short sale constraints in the *equity* market. An arbitrage argument could be used to justify the proposed proxy. In perfect markets with no short sale constraints the relationship between the futures price and the underlying price will be described by:

$$F_{0,t} = S_0 e^{(r-\delta)T}, \qquad (10)$$

where $F_{0,t}$= today's price of the futures contract expiring at time t,

S_0= the price of the underlying today,

r= interest rate,

δ= dividend yield,

T= time to expiration.

In perfect markets, if the futures price is *below* the price of the underlying with the accumulated net interest, $(r-\delta)$, arbitrageurs will engage in cash and carry arbitrage.[9] The arbitrage will bring the price back to equilibrium so that the equality will still hold. If the futures price increases *above* the price of the underlying with the accumulated net interest, arbitrageurs will engage in reverse cash and carry,[10] which will bring the price back to equilibrium, so that the equality will still hold.

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[9] Cash and carry involves the following steps: T=0 : borrow funds, buy the underlying, short a futures contract, T=1: repay loan with interest, deliver asset

[10] Reverse cash and carry involves the following steps: T=0: short underlying, lend proceeds, buy a futures contract T=1: collect proceeds from loan, accept delivery, repay short sale with the underlying from the futures contract

In imperfect markets, with short sale constraints, however, if the futures price deviates from the futures price determined by the above equality, arbitrageurs might not be able to reverse the deviation. More specifically, cash and carry will still be feasible, since it involves buying a futures contract and buying the underlying. However, if the futures price moves towards the opposite direction, arbitrageurs will not be able to engage in *reverse* cash and carry since they will not be able to short the underlying. Therefore, in an equity market with short sale constraints the following inequality will hold:

$$F_{0,t} < S_0 e^{(r-\delta)T}, \tag{11}$$

which can also be expressed as:

$$S_0 - F_{0,t} e^{-(r-\delta)T} \geq 0. \tag{12}$$

This positive difference is a measure of overpricing. The higher the deviation of the underlying to the discounted futures price, the higher the overpricing will be. Therefore, the percentage difference of the underlying from the discounted futures price can be a measure of overpricing.

In order to apply this measure of overpricing, we use all intra-day data and we match every futures trade with the value of the underlying index at the exact time of the trade and we estimate overpricing as defined by the equation above. Then, we estimate daily overpricing as the average overpricing across all trades throughout the day. When there are many trades at exactly the same second, we average the trade quotes. We choose the futures with the nearest expiration date, unless the expiration is less than a week away. If it is less than a week long, the following month is chosen as an expiration month. Therefore, at all times the most liquid futures contract is used.

6.2. Opinion Dispersion

A series of proxies for opinion dispersion are used in this study: standard deviation of daily returns, historical, intra-day volatility, implied volatility, daily price range and market turnover. Each proxy is first described, and then applied to the data.

Historical volatility: Historical volatility is estimated as standard deviation of daily index returns over the previous month.

Intra-day volatility: Another proxy is the intra-day volatility, which is estimated using the Andersen and Bollerslev (1998) intra-day measure. The intra-day variance is estimated as the sum of the squared five minute returns. The intra-day volatility is the square root of the intra-day variance. The same measure has been estimated excluding the first and the last half an hour of trading.

The *daily price range* is measured by the logarithmic (percentage) difference between the highest and the lowest index price throughout the day. This measure is the closest to our theoretical definition of heterogeneity of opinions for the terminal value in the market as measured by parameter H. In our theoretical model, opinions are uniformly distributed between $(F - H, F + H)$ and the price range is therefore $2H$.

The *market turnover* is often used as a measure of opinion dispersion and refers to the ratio of the volume over the number of outstanding shares in the market. There are two turnover measures used in this paper, both based on the definitions of the World Federation of Exchanges. For the first measure, *de-trended turnover,* turnover is equal to the value of trades, and the average daily turnover over the past month is de-trended by dividing by the average daily turnover over the year before the beginning of the previous month. Turnover is de-trended to ensure stationarity. The second measure, *turnover velocity*, follows the definition of the non-annualized turnover velocity and it is estimated by dividing the monthly turnover (value of shares) with the month-end market capitalization.

Table 2 presents the cross-correlations of the numerous proxies of opinion dispersion. Historical volatility, Intra-day volatility and Price range have a relatively higher cross-correlation. The turnover measures have lower correlation with the previous three proxies.

7. Empirical Results

The model predicts that in an equity market with short sale constraints there will be overpricing when there is considerable disagreement. That is because, as noted earlier, the pessimist investors will be forced to stay out of the market and the price of the risky asset will be primarily driven by the optimists.

Figure 2 describes the average daily overpricing during the period 2002-2008. We observe that the futures-based overpricing is mostly positive. During the period May 2004 - October 2008, which coincides with the time the Indian equity index was booming, overpricing is consistently positive. Moreover, overpricing was positive for 1422 days out of the 1583 days under the short sale ban included in our sample.

In order to test the predictions of the model, we test the effect of opinion dispersion on overpricing. The summary statistics of the various opinion dispersion proxies used in this study are reported in Table 3. The mean historical daily standard deviation is 1.4%, the mean intra-day volatility is 1.3% and the mean price range is 2%, all positive and statistically significant. The turnover proxies are also positive and statistically significant, with turnover velocity equal to 10.7% and de-trended Turnover equal to 1.2.

Table 4 presents the results of a series of regressions, testing the effect of various opinion dispersion proxies on overpricing. We include the daily past returns as a control variable. The rationale is that overpricing should be higher when the market drops because of negative news, as short sellers can only enter the futures market widening the gap between the futures price and the underlying price. Furthermore, the lagged mispricing is included in our specifications since mispricing is likely to be persistent. Historical standard deviation, intra-day volatility and price range appear to have a positive and significant effect on mispricing. The coefficient of historical standard deviation is 3.763 (2.783), the coefficient of intra-day volatility is 3.325 (2.415) and the coefficient of price range is 1.869 (2.220). Turnover estimates – detrended turnover and turnover velocity – do not appear to have any significant effect. Daily past returns have a consistent, negative and significant effect on mispricing, as expected. Lagged mispricing has a positive and highly significant coefficient, indicating that mispricing persists. The t-statistics reported are Newey-West t-statistics, correcting for heteroskedasticity and autocorrelation. Furthermore, all variables are stationary.

The specifications described in Table 4 are repeated in Table 5 under a GARCH(1,1). The volatility coefficients – historical standard deviation, intra-day volatility and price range – , although slightly lower, have a positive sign and are statistically significant, indicating that higher opinion dispersion leads to higher mispricing. The turnover proxies are insignificant, as before. Also, daily past returns have a negative and significant effect on mispricing and lagged mispricing has a positive and significant effect across all specifications.

A Quandt-Andrews (Andrews 1993) stability test for the coefficients of the specifications described in Table 4 is performed. The maximum likelihood F-statistics and the Hansen (1997) p- values for every specification are reported in Table 4 (Panel B). A breakpoint is identified in all specifications either on 8/26/2003 or 9/16/2003. In the first half of the sample, mispricing alternates sign frequently, but remains on average positive. On the contrary, in the second half of the sample, mispricing is mostly positive. Our understanding is that this difference is the reason for the structural break.

In an effort to isolate the effect of opinion dispersion on overpricing we include in our specifications an interactive term of the opinion dispersion measures and a dummy that takes the value of unity when overpricing is positive. Past daily returns and lagged mispricing are also included as control variables. The results are presented presented in Table 6. The coefficients of the interactive terms of all opinion dispersion proxies – both volatility and turnover estimates - with the dummy are positive and statistical significant. In more detail, the coefficient of the interactive term of historical standard deviation with the dummy is 7.744 (5.817), the coefficient of the interactive term of intra day volatility with the dummy is 7.464 (5.072) and the coefficient of the interactive term of price range with the dummy is 4.519 (6.143). Also, the coefficient of the interactive term of turnover velocity with the dummy is 0.125 (2.335) and the coefficient of the intercactive term of detrended turnover and the dummy is 0.029 (3.304). When we include the interactive term of both historical standard deviation and turnover in our specification, we find that they both have a positive and statistical effect onoverpricing (last column of Table 6). As before, lagged mispricing has a positive and statically significant effect on overpricing and daily past returns have a negative and statistically significant effect on overpricing.

Table 7 repeats the specifications described in Table 6 using GARCH (1, 1). The coefficients of the interactive terms of all opinion dispersion proxies with the dummy are positive and statistical significant, consistent to the OLS estimates. However, the economic significance of the opinion dispersion proxies and the explanatory power of the specification have improved. Also, lagged mispricing has a positive and statistically significant effect on overpricing indicating mispricing persistence and the daily past returns have a negative and significant effect on overpricing, consistent with all our previous results.

8. Robustness tests and Future Research

Existing literature has used subsequent returns as a measure of overpricing. Subsequent returns are naturally expected to be lower, when overpricing is corrected. In other words, when overpricing is corrected, opinion dispersion should have a negative and significant effect on subsequent returns. The appropriate timeframe for this correction is indeterminate. In this paper, a daily and monthly timeframe is employed. Table 8 presents the regression results of the effect of opinion dispersion on subsequent abnormal returns[11],[12]. The results in Table 8 indicate that opinion dispersion does not have a significant effect on subsequent returns. One explanation for this finding is that subsequent returns are not a good measure of mispricing because their use assumes that either short sale constraints are lifted, which is not the case in the Indian market, or opinion dispersion is greatly reduced, for which we have no evidence.

An empirical extension would be to test the predictions of the model in the context of an event study employing data after April 21st, 2008, when the ban was lifted. Figure 1 shows that the index value drops during that period. Without further testing, it would be arbitrary to assume that this price decline is due to the elimination of short sale constraints, especially since this

[11]Daily abnormal returns are estimated as the residuals of the regression of Nifty index daily returns on MSCI World index returns. Monthly abnormal returns are estimated as the sum of the residuals over a period of a month.

[12]Even when raw subsequent returns were used, there was no significant effect of opinion dispersion on subsequent returns. We report only the results for the subsequent abnormal returns.

period coincides with the beginning of the current economic crisis. Therefore, in the potential extension, amongst other macroeconomic variables, a control variable for the current global economic crisis should be included. The post 2008 data necessary for this endeavor have not been released at the time of this study.

9. Conclusion

Short sale constraints have generated great controversy after the recent US regulatory developments: the elimination of the uptick rule, the consideration of reinstatement of a modified uptick rule and the three week short sale ban of the stocks of 799 financial institutions. The effectiveness of these specific restrictions and other short sale constraints has long been debated, but they have not been settled. Their supporters argue that unrestricted short sales can exacerbate market panic and drive prices below fair value, whereas those with the opposing view counterargue that short sale constraints impede the efficient price discover by prohibiting pessimists from participating actively in the market.

This paper examines the pricing implications of short sale constraints. It presents a model that describes an equity market under short sale restrictions. It predicts that if the opinion dispersion is above some minimum level, there will be overpricing in the market, as the pessimists will not be able to actively express their opinions in the market and thus the price will be driven by the optimists' long positions. In that case, there will be a positive relationship between opinion dispersion and overpricing.

The model is empirically tested in the Indian equity market, where short sales were prohibited during the period 2001-2008[13]. The Indian equity market serves as a natural testing environment for the predictions of the proposed model. Overpricing is measured by the percentage difference between the index value and the discounted futures price on the index. Opinion dispersion is approximated by a series of measures such as historical volatility, intra-day volatility, implied volatility, price range, turnover, average turnover. Results indicate that opinion dispersion is a contributing factor to overpricing.

[13] Our sample starts on 1/1/2002.

Appendix

Appendix 1

Every investor i faces the following optimization problem:

$$Max\{E(-e^{-b\widetilde{W}_i})\} \tag{1.1}$$

$$s.t. \widetilde{W}_i = W_{0i}\tilde{R}_{pi}, \tag{1.2}$$

$$\tilde{R}_{pi} = R_f + w_i(\widetilde{\mathrm{R}}_{\mathrm{i}} - R_f), \tag{1.3}$$

where b= absolute risk aversion,

W_{0i}= initial wealth,

$\widetilde{W}_i$= expected wealth,

$\tilde{R}_{pi}$ = expected cumulative portfolio return,

R_f = cumulative risk free rate, which in this model is assumed to be equal to 1,

$\tilde{R}_i$= cumulative return for the risky asset,

w_i = proportion invested in the risky asset.

The above optimization problem can be re-written as:

$$Max\{E(-e^{-b\widetilde{W}_i})\} = Max\{-e^{-b*W_0*(R_f+w_i*(R_f+w_i(\bar{\mathrm{R}}_{\mathrm{i}}-R_f))+\frac{1}{2}b^2\sigma^2W_0^2w_i^2)}\}. \tag{1.4}$$

Since $U(w)$ is monotonic the investor's optimization problem can be expressed as follows:

$$Max\{w_i(\bar{R_i} - R_f) - \frac{1}{2}bW_0^2 w_i \sigma^2\} \quad (1.5)$$

$$FOC: \bar{R_i} - R_f - bW_0 w_i \sigma^2 = 0 \Rightarrow w_i = \frac{\bar{R_i} - R_f}{b\sigma^2}, \quad (1.6)$$

and if $R_f = 1$:

$$w_i = \frac{\bar{R_i} - 1}{b\sigma^2 W_0}. \quad (1.7)$$

Therefore, the dollar demand for the risky asset will be determined by the following equation:

$$\$D = W_0 w_i = \frac{\bar{R_i}}{b\sigma^2}. \quad (1.8)$$

Now let's estimate $\bar{R}_i$ and σ^2. The return for every investor i will be:

$$\tilde{R}_i = \frac{(F_i + \varepsilon) - P}{P} + 1, \varepsilon \sim N(0,1). \quad (1.9)$$

Then,

$$\bar{R_i} = \frac{F_i - P}{P} + 1, \quad (1.10)$$

and

$$\sigma^2 = Var(R_i) = \frac{1}{P^2} Var(F_i + \varepsilon) = \frac{1}{P^2} * 1 \Rightarrow \sigma^2 = \frac{1}{P^2}. \quad (1.11)$$

$(1.8), (1.10), (1.11) \Rightarrow$

$$Q^D = \frac{w_i W_0}{P} = \frac{1}{b}(F_i - P) \Rightarrow Q_i^D = \frac{w_i W_0}{P} = \frac{1}{b}(F_i - P). \quad (1.12)$$

Therefore the demand function for every unconstrained investor would be:

$$Q_i^{DU} = \frac{1}{b}(F_i - P). \tag{1.13}$$

But since we have assumed that short sale constraints bind every investor the demanded quantity cannot be negative. Therefore, the demand for every short sale constrained investor is:

$$Q_i^{DC} = Max\{\frac{1}{b}\ (F_i - P),0\}. \tag{1.14}$$

Appendix 2

Since investors opinions are uniformly distributed between $(F-H, F+H)$ the aggregate demand should be the sum of the individual demands. Therefore there are two cases:

CASE 1: $\mathrm{P} < F-H$

$$Q^{DC1} = \frac{1}{2H}\int_{F-H}^{F+H}\frac{1}{b}(F_i - P^{C1})dF_i = Q^{DU} \Rightarrow P = F - Q^{DU}b = P^C = P^U.$$

(2.1)

CASE 2: $\mathrm{P} > F-H$

$$Q^{DC2} = \frac{1}{2H}\int_{P}^{F+H}\frac{1}{b}(F_i - P)dF_i \Rightarrow P = F + H - 2\sqrt{HQ^{DC2}b} = P^C > P^U. \qquad (2.2)$$

Substituting P in the conditions and solving for P leads to some interesting pricing implications:

CASE 1: $H < \frac{Q^D}{\gamma_b}$,

$$P^C = F - \frac{Q^D}{\gamma_b} = P^U, \qquad (2.3)$$

and

CASE 2: $H \geq \frac{Q^D}{\gamma_b}$,

$$P^C = F + H - 2 * \sqrt{\frac{H * Q^D}{\gamma_b}} \geq P^U. \qquad (2.4)$$

where $\gamma_b = \dfrac{1}{b}$ called risk tolerance,

$P^c - P^U =$ overpricing,

$F - P^c =$ the return.

Overpricing will be equal to zero in the first case and positive in the second case. The return will be positive in the first case. In the second case,

If $\frac{Q^D}{\gamma_b} < H < \frac{2Q^D}{\gamma_b}$,

$$F - P^c > 0, \tag{2.5}$$

and if $H > \frac{2Q^D}{\gamma_b}$,

$$F - P^c < 0. \tag{2.6}$$

In order to determine the predicted effect of dispersion of opinion on prices, overpricing and future returns we need to take the first derivative of each one towards the opinion dispersion parameter H. In Case 1, the constrained price is not a function of opinion dispersion. Therefore, in Case 1:

$$\frac{\partial P^c}{\partial H} = 0, \tag{2.7}$$

$$\frac{\partial (P^c - P^U)}{\partial H} = 0, \tag{2.8}$$

$$\frac{\partial (F - P^c)}{\partial H} = 0. \tag{2.9}$$

In Case 2, where $H \geq \frac{Q^D}{\gamma_b}$:

$$\frac{\partial P^c}{\partial H} = 1 - 2\sqrt{\frac{Q^D}{\gamma_B}}\frac{1}{2\sqrt{H}} \geq 0,$$

$$\frac{\partial(P^C - P^U)}{\partial H} = 1 - \sqrt{\frac{Q^D}{\gamma_B}} \frac{1}{\sqrt{H}} \geq 0, \tag{2.11}$$

$$\frac{\partial(F - P^C)}{\partial H} = -1 + \sqrt{\frac{Q^D}{\gamma_B}} \frac{1}{\sqrt{H}} < 0. \tag{2.12}$$

Table 1: The Indian derivatives market.
The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. This table presents the development of the derivatives market of the National Stock Exchange of India. The table is taken from the 2008 annual report of the National Stock Exchange of India.

National Stock Exchange of India		
	Total Settlement for Index/Stock Derivatives	
Years	**(Rs.cr)**	**(US $mn)**
2000-2001	860.1	18.44
2001-2002	7858.8	161.04
2002-2003	23107.6	486.47
2003-2004	122,959.80	2833.3
2004-2005	146,486.20	3348.25
2005-2006	285,218.00	6393.59
2006-2007	664,944.70	15254.52
2007-2008	1,565,192.30	39,227.88

Table 2: Correlation of opinion dispersion proxies

The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index. Historical volatility is estimated as standard deviation of daily index returns over the previous month. Intra-day volatility is the Andersen – Bollerslev intra-day volatility estimate. Price range is the logarithmic difference of the highest and lowest price every day. Turnover velocity is estimated as the monthly value of traded shares over the month-end market capitalization. De-trended turnover is the monthly value of traded shares over the previous month's monthly value of traded shares.

	Historical standard deviation	Intra-day volatility	Price range	De-trended turnover	Turnover velocity
Historical standard deviation	1.000	0.517	0.520	0.207	0.021
Intra-day volatility		1.000	0.881	0.075	-0.051
Price range			1.000	0.072	-0.052
De-trended turnover				1.000	0.846
Turnover velocity					1.000

Table 3: Summary statistics

The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index. Mispricing is measured by the percentage difference between the index value and the discounted futures price on the index. Historical volatility is estimated as standard deviation of daily index returns over the previous month. Intra-day volatility is the Andersen – Bollerslev intra-day volatility estimate. Price range is the logarithmic difference of the highest and lowest price every day. Turnover velocity is estimated as the monthly value of traded shares over the month-end market capitalization. De-trended turnover is the monthly value of traded shares over the previous month's monthly value of traded shares.

	Mean	Median	Standard Deviation	Obs
Overpricing	0.527	0.446	0.528	1582
Historical Standard Deviation	0.014	0.011	0.043	1582
Intra-day volatility	0.013	0.011	0.009	1582
Price range	0.020	0.016	0.014	1582
Turnover Velocity	0.107	0.045	0.147	1582
De-trended turnover	1.209	1.007	1.022	1582

Table 4: The effect of opinion dispersion on mispricing

The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index. The dependent variable is mispricing, the percentage difference between the index value and the discounted futures price on the index. Historical volatility is estimated as standard deviation of daily index returns over the previous month. Intra-day volatility is the Andersen – Bollerslev intra-day volatility estimate. Price range is the logarithmic difference of the highest and lowest price every day. Turnover velocity is estimated as the monthly value of traded shares over the month-end market capitalization. De-trended turnover is the monthly value of traded shares over the previous month's monthly value of traded shares. Daily past returns are the logarithmic lagged returns; t-statistics are in parentheses and are adjusted for autocorrelation and heteroskedasticity using Newey-West. *, **, *** signify 10%, 5% and 1% statistical significance.

Panel A: Effect of opinion dispersion on mispricing

Dependent variable: Mispricing	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Lagged Mispricing	0.825***	0.884***	0.885***	0.893***	0.892***	0.881***
	(57.168)	(89.637)	(90.411)	(85.487)	(85.894)	(73.909)
Historical Standard deviation	3.763***					2.972***
	(2.783)					(3.228)
Intra-day volatility		3.325***				
		(2.415)				
Price range			1.869***			
			(2.220)			
Turnover velocity				-0.015		
				(-0.372)		
De-trended turnover					0.003	-0.018
					(0.608)	(-0.450)
Daily Past Returns	-2.756***	-1.197*	-1.267**	-1.759***	-1.754***	-1.681***
	(-4.015)	(-1.743)	(-1.918)	(-2.436)	(-2.431)	(-4.257)
R-squared	0.760	0.790	0.790	0.790	0.790	0.790
No. Obs	1581	1581	1581	1581	1581	1581

Table 4(cont'd): The effect of opinion dispersion on mispricing

The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index. Panel B reports the F-statistic and the p-values for the Quandt-Andrews stability tests, performed on the specifications of Panel A.

Panel B: Quandt - Andrews stability test						
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Maximum LR F-statistic	18.198	35.978	37.523	37.624	38.407	29.649
Prob	0.024	0.000	0.000	0.000	0.000	0.001
Breakpoint	8/26/2003	9/16/2003	9/16/2003	9/17/2003	8/26/2003	9/16/2003

Table 5: The effect of opinion dispersion on mispricing using an autoregressive conditional heteroskedastic process.

The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index. The dependent variable is mispricing, the percentage difference between the index value and the discounted futures price on the index. Historical volatility is estimated as standard deviation of daily index returns over the previous month. Intra-day volatility is the Andersen – Bollerslev intra-day volatility estimate. Price range is the logarithmic difference of the highest and lowest price every day. Turnover velocity is estimated as the monthly value of traded shares over the month-end market capitalization. De-trended turnover is the monthly value of traded shares over the previous month's monthly value of traded shares. Daily past returns are the logarithmic lagged returns. An autoregressive conditional heteroskedastic process is used; z-statistics are in parentheses. *, **, *** signify 10%, 5% and 1% statistical significance.

Dependent variable: Mispricing	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Lagged Mispricing	0.885***	0.889***	0.890***	0.892***	0.892***	0.885***
	(71.699)	(77.921)	(77.165)	(76.916)	(76.602)	(71.697)
Historical standard deviation	2.426***					2.419***
	(3.480)					(3.397)
Intra-day volatility		2.828***				
		(5.780)				
Price range			1.284***			
			(4.014)			
Turnover velocity				-0.028		-0.025
				(-0.763)		(-0.700)
De-trended turnover					0.004	
					(0.753)	
Daily Past Returns	-1.195***	-0.628***	-0.811***	-1.276***	-1.263***	-1.200***
	(-5.128)	(-2.058)	(-2.532)	(-5.668)	(-5.554)	(-5.155)
No. Obs	1581	1581	1581	1581	1581	1581

Table 6: The effect of opinion dispersion on overpricing.

The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index. The dependent variable is mispricing, the percentage difference between the index value and the discounted futures price on the index. Historical volatility is estimated as standard deviation of daily index returns over the previous month. Intra-day volatility is the Andersen – Bollerslev intra-day volatility estimate. Price range is the logarithmic difference of the highest and lowest price every day. Turnover velocity is estimated as the monthly value of traded shares over the month-end market capitalization. De-trended turnover is the monthly value of traded shares over the previous month's monthly value of traded shares. Dummy is equal to unity if mispricing is positive and zero otherwise. Daily past returns are the logarithmic lagged returns; t-statistics are in parentheses and are adjusted for autocorrelation and heteroskedasticity using Newey-West. *, **, *** signify 10%, 5% and 1% statistical significance.

Dependent variable: Mispricing	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Lagged Mispricing	0.834***	0.845***	0.847***	0.888***	0.877***	0.832***
	(51.343)	(58.967)	(66.980)	(82.748)	(71.278)	(64.868)
Historical standard deviation * Dummy	7.744***					7.555***
	(5.817)					(8.974)
Intra-day volatility * Dummy		7.464***				
		(5.062)				
Price range * Dummy			4.519***			
			(6.143)			
Turnover velocity * Dummy				0.125***		0.083***
				(2.335)		(1.999)
De-trended turnover * Dummy					0.029***	
					(3.304)	
Daily Past Returns	-1.694***	-0.703***	-0.815***	-1.784***	-1.769***	-1.713***
	(-2.498)	(-1.037)	(-1.219)	(-2.480)	(-2.489)	(-4.449)
R-squared	1581	1581	1581	1581	1581	1581
No. Obs	0.806	0.809	0.809	0.797	0.799	0.807

Table 7: The effect of opinion dispersion on overpricing using an autoregressive conditional heteroskedastic process.
The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks. All measures are estimated on the S&P CNX Nifty index. The dependent variable is mispricing, the percentage difference between the index value and the discounted futures price on the index. Historical volatility is estimated as standard deviation of daily index returns over the previous month. Intra-day volatility is the Andersen – Bollerslev intra-day volatility estimate. Price range is the logarithmic difference of the highest and lowest price every day. Turnover velocity is estimated as the monthly value of traded shares over the month-end market capitalization. De-trended turnover is the monthly value of traded shares over the previous month's monthly value of traded shares. Dummy is equal to unity if mispricing is positive and zero otherwise. Daily past returns are the logarithmic lagged returns; t-statistics are in parentheses and are adjusted for autocorrelation and heteroskedasticity using Newey-West. An autoregressive conditional heteroskedastic process is used; z-statistics are in parentheses. *, **, *** signify 10%, 5% and 1% statistical significance.

Dependent variable: Mispricing	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Lagged Mispricing	0.826***	0.839***	0.845***	0.889***	0.876***	0.824***
	(60.714)	(74.019)	(69.292)	(74.618)	(71.411)	(60.176)
Historical standard volatility * Dummy	8.977***					8.822***
	(11.150)					(10.939)
Intra-day volatility * Dummy		8.302***				
		(22.660)				
Price range * Dummy			4.630***			
			(15.786)			
Turnover velocity * Dummy				0.120***		0.087**
				(3.261)		(1.960)
De-trended turnover * Dummy					0.032***	
					(6.180)	
Daily Past Returns	-0.987***	-0.081***	-0.241***	-1.276***	-1.254***	-1.002***
	(-4.680)	(-0.289)	(-0.888)	(-5.605)	(-5.507)	(-4.713)
No. Obs	1581	1581	1581	1581	1581	1581

Table 8: The effect of opinion dispersion on subsequent returns

The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index. The dependent variable is mispricing, the percentage difference between the index value and the discounted futures price on the index. Historical volatility is estimated as standard deviation of daily index returns over the previous month. Intra-day volatility is the Andersen – Bollerslev intra-day volatility estimate. Price range is the logarithmic difference of the highest and lowest price every day. Turnover velocity is estimated as the monthly value of traded shares over the month-end market capitalization. De-trended turnover is the monthly value of traded shares over the previous month's monthly value of traded shares. Daily past returns are the logarithmic lagged returns; t-statistics are in parentheses and are adjusted for autocorrelation and heteroskedasticity using Newey-West. *, **, *** signify 10%, 5% and 1% statistical significance.

Panel A: Daily future abnormal returns					
	(i)	(ii)	(iii)	(iv)	(v)
Historical standard deviation	-0.059181				
	-1.049447				
Intra-day volatility		0.038516			
		0.485223			
Price range			-0.002487		
			-0.058161		
Turnover velocity				0.000137	
				0.071269	
De-trended turnover					-0.000214
					-0.750742
Daily past returns	0.000468	0.008793	0.001306	0.001983	0.001745
	0.013354	0.242201	0.036479	0.056763	0.05
R-squared	0.000796	0.00049	0.000009	0.000006	0.000239
Obs	1466	1466	1466	1466	1466

Table 8(cont'd): The effect of opinion dispersion on subsequent returns

Panel B: Monthly future abnormal returns					
	(i)	(ii)	(iii)	(iv)	(v)
Historical standard deviation	-1.1672				
	-1.7615*				
Intra-day volatility		-0.4017			
		-1.1843			
Price range			-0.2570		
			-1.1369		
Turnover velocity				0.0187	
				0.8133	
De-trended volatility					-0.0011
					-0.7147
Monthly past returns	-0.0812	-0.0293	-0.0298	-0.0101	-0.0150
	-1.1101	-0.4485	-0.4543	-0.1622	-0.5751
R-squared	0.0120	0.0030	0.0030	0.0022	0.0005
Obs	1445	1445	1445	1445	1445

Figure 1: S&P CNX NIFTY INDEX
The sample period is from June 1999 to December 2009. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index.

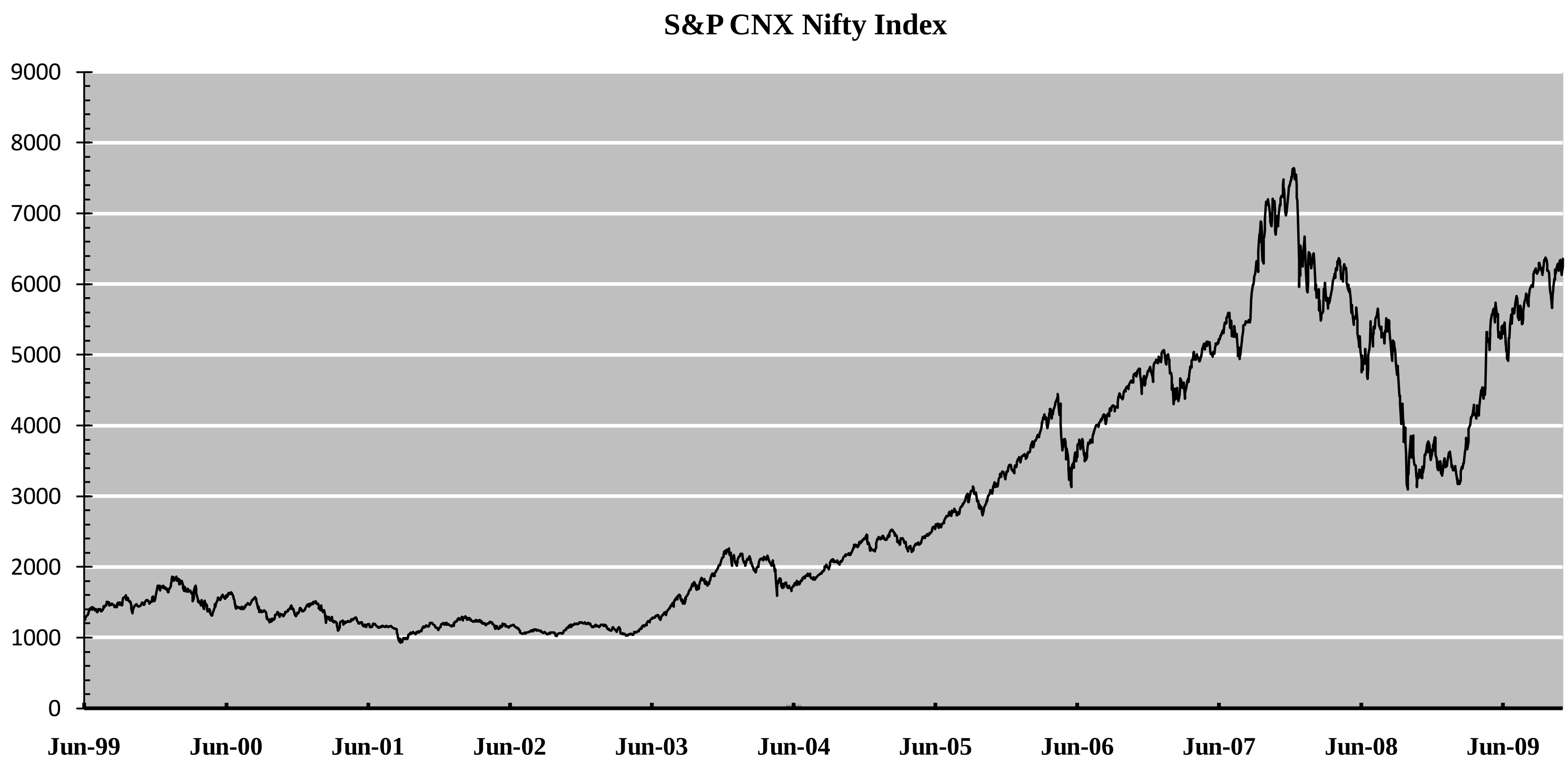
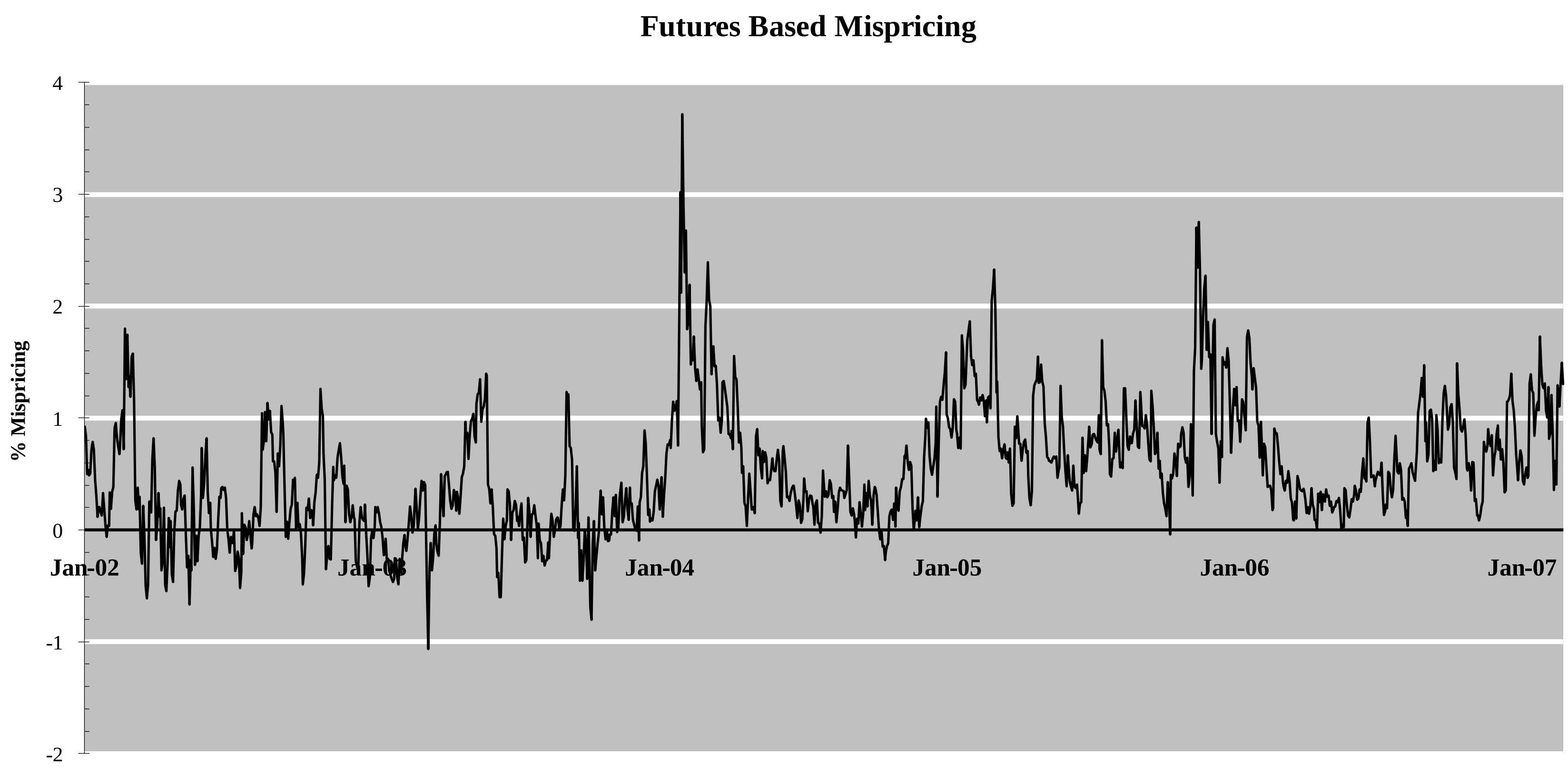


Figure 2: Futures Based Mispricing

The sample period is from January 1st 2002 to April 17th 2008. During this period there was a short sales ban applied to all stocks in India. All measures are estimated on the S&P CNX Nifty index. Mispricing is measured by the percentage difference between the index value and the discounted futures price on the index.



CHAPTER 3

Short Sale Constraints:

The Impact on the Return Distribution

1. Introduction

The academic literature on the skewness of the return distribution in a market with short sale constraints is relatively recent and unclear as to the relationship between skewness and such constraints. Bris, Goetzmann and Zhu (2007) suggest that although short sale reduce market efficiency, they also reduce market crashes, which translates in higher observed skewness in the market. Hong and Stein (2003), however, in their a model predict that although markets with short sale constraints may generally exhibit less negatively skewed expected return distributions, these distributions can become more negatively skewed when prices start to decline, especially if opinion dispersion in the market is high. According to their reasoning, as prices decline, the reservation prices of some pessimists may be revealed because they become support buyers, leading to a further price decline. In this scenario, short sale constraints have a negative effect on stabilizing market prices. Hong and Stein (2003) also suggest that high turnover which is commonly used as a proxy for opinion dispersion causes return distributions to become more negative.

Empirical testing of the pricing implications of short sale constraints has been a challenging task due to the different types of short sale restrictions that vary both in binding strength and time horizon. These variations render cross sectional comparisons difficult. Moreover, most countries have not had a complete short sales ban, which leads to the need for developing different proxies for such complete restrictions. For instance, the US market has not had a complete ban and, when applied, it was only of limited scope and lifetime, i.e., the ban on the 799 financial stocks that lasted for less than a month. Similar problems arise when many other markets are considered, e.g, in the U.K, Europe and Australia. Bris et al. (2007) present a cross sectional study, which examines the pricing implications of short sale constraints in 59 countries. Moreover, Bris et al. (2003) show that, although about 93% of the international markets are shortable, non-shortable securities worldwide have major pricing implications for the global equity index. In the empirical study that accompanies Hong and Stein (2003), Chen, Hong and Stein (2001) proxy opinion dispersion with turnover and find that high turnover leads to more negatively skewed returns. Marsh and Niemer (2008) study the impact of the recent ban in the US and the UK on the return distribution of the restricted stocks but they fail to find a significant effect of the imposition of short sale restrictions. Hueng (2006) uses data from the Shanghai and Shenzhen composite indexes to test Hong and Stein's (2003) theory, since short sale constraints were not practiced in China during his sample period. His results show that higher trading volume predicts a more negatively skewed distribution, which is consistent with Hong and Stein's (2003) hypothesis.

This paper uses data from the Indian equity market, where short sales were strictly prohibited during 2001-2008, to test whether short sale constraints reduce the severity of market panics and determine the relation between skewness and opinion dispersion. In particular, the paper examines whether expected equity returns are less negatively skewed, when short sales are prohibited. Higher skewness would indicate that short sale constraints protect market prices from a downward spiral. Examining the skewness of the return distribution of assets subject to short restrictions tests the regulators' position that short sale constraints can prevent market crashes. The paper tests this hypothesis by estimating the expected distribution of equity index returns. The expected return distribution is estimated both from realized daily returns, as well as from options. Option prices allow the estimation of the risk neutral skewness and kurtosis, whose major advantage is their forward looking nature. The risk neutral third and fourth moments are estimated following Bakshi, Kapadia and Madan (2003) methodology.

This paper proceeds as follows. Section II describes the data used in this study. Section III discusses the construction of the main variables. Section IV presents the empirical results. Section V concludes the paper.

2. Data

This paper uses data from the Indian equity market, where short sales were strictly prohibited from March 7th 2001 to April 20th 2008, to test whether short sale constraints reduce the severity of market panics. More specifically, the paper tests whether turnover has a positive effect on the skewness of CNX S&P Nifty's return distribution. Our dataset includes daily closing prices for the S&P CNX NSE NIFTY index and for all futures and options on the index. The dataset has been obtained from the National Stock Exchange, the leader Indian exchange in trading derivative. The sample for the underlying extends from 1999 to 2009, and includes closing prices, dividend yield rates on S&P CNX NSE Nifty and data on the volume and market capitalization of the index. The derivatives sample extends from 2002 to 2008.

To address liquidity concerns, we use closing prices for options on the S&P CNX Nifty with more than 7 but less than 45 days until expiration. Options with open interest less than 100 have been excluded. Finally, the option prices used, are tested so that they do not violate the following lower upper boundaries conditions for calls and puts respectively:

$$Se^{(-q(T-t))} \geq C \geq Se^{-q(T-t)} - Ke^{(-r(T-t))}, \quad (1)$$

$$Ke^{(-r(T-t))} \leq P \leq Ke^{(-r(T-t))} - S^{(-q(T-t))}. \quad (2)$$

For the estimation of the risk neutral densities we keep the days for which there are options for at least 8 strikes. In order to estimate the implied volatilities from options, the average of the one month Mibor and Mibid is used as the annual interest rate. If for any day, there is a missing observation, we use the previous day's interest rate. This should not be a concern as interbank interest rates are not highly volatile. Mibid and Mibor are taken from NSE. At the same time, the MSCI world index is used in order to estimate a skewness measure based on abnormal returns. Daily data from MSCI extend from 2002 to 2009.

3. Methodology: Variable Construction

In this section, we describe how skewness, kurtosis, and turnover – a proxy for opinion dispersion – are estimated.

3.1. Skewness and Kurtosis

We follow a few different ways to the skewness and kurtosis of the Nifty's return distribution. First, we use realized daily returns. Second, we use abnormal returns based on MSCI World index. Finally, we use the estimated third and fourth moment from options.

3.1.1. *Moments from realized returns*

For every day in the sample, we estimate skewness and kurtosis using future daily logarithmic returns for the next calendar month and the next six calendar months. We, therefore, obtain a skewness and a kurtosis estimate over one month and a skewness and a kurtosis measure over six months. Chen et al. (2001) test Hong and Stein's (2003) hypothesis in the US market by estimating skewness over a future six month period. In more detail, we use the following corresponding formulas to estimate skewness and kurtosis:

$$Skew_{it} = (n(n-1)^{3/2} \sum R_{it}^3)/((n-1)(n-2)(\sum R_{it}^2)^{3/2}), \tag{3}$$

and

$$Kurt_{it} = (\frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum (\frac{R_{it}}{s})^4) - \frac{3(n-1)^2}{(n-2)(n-3)}. \tag{4}$$

where, R_{it}= de-meaned future daily logarithmic returns. We use the daily data based on the rolling window in our summary statistics. However, in our regression analysis we use non-overlapping monthly data in order to avoid autocorrelation problems.

3.1.2. *Moments from abnormal returns*

In order to account for general worldwide economic conditions we re-estimate skewness and kurtosis using the above formulas, but instead of using raw logarithmic returns, we now estimate abnormal returns on the MSCI world index. These future abnormal returns are estimated as the residuals from the following regression:

$$R_{ijt} = \alpha_{ij} + \beta_i^W r_t^W + \varepsilon_{ijt}. \tag{5}$$

3.1.3. Skewness from options' implied volatility

Our first measure of skewness from options follows the methodology of Xing, Zhang and Zhao (2010), who estimate skewness as the difference between the implied volatility of out-of-the-money put options and the implied volatility of at-the-money call options:

$$Skew_{it} = IV_{it}^{OTM_P} + IV_{it}^{ATM_C}, \tag{6}$$

where,

$IV_{it}^{OTM_P}$ = implied volatility of out-of-the money put option,

$IV_{it}^{ATM_C}$ =implied volatility of at-the-money call option.

The out-of-the money put option used is the one with moneyness closest to 0.95 on a given day and the closest expiration, with the condition that the time to expiration is between 7 and 45 days. Furthermore, open interest for these options is over 100. These conditions are enforced to ensure liquidity of the options used. Since options written on the S&P CNX NSE NIFTY index are European options and S&P CNX NSE NIFTY is not adjusted for dividends, we estimate implied volatilities following the Black & Scholes model adjusted for dividends:

$$C = Se^{-q(T-t)}N(d_1) - Ke^{(-r(T-t))}N(d_2), \tag{7}$$

$$P = Ke^{(-r(T-t))}N(-d_2) - S^{(-q(T-t))}N(-d_1). \tag{8}$$

where,

$$d_1 = \frac{\ln(S/K)+(r-q+\sigma^2/2)(T-t)}{\sigma\sqrt{(T-t)}}, \quad (9)$$

$$d_2 = d_1 - \sigma\sqrt{(T-t)}, \quad (10)$$

and q=diviend yield,

$N(X)$ = cumulative probability distribution function.

The Indian index options exhibit a volatility smile. Kannan, Misra and Misra (2006) note that the volatility smile, observed in the NSE Nifty options during 2004, resembles the US options market prior to 1987. We estimate the daily implied volatility of options on S&P CNX Nifty from calls and puts for those strikes, for which both a call and a put closing price are available. The average implied volatility from calls is 20% and the average implied volatility from puts is 26%. The median implied volatility from calls is 19% and the median implied volatility from puts is about 24%. On average there are 468 daily trades per call option and 390 daily trades per put option. However, there are a few options with less than 10 trades on a given day.

3.1.4. Skewness from options' implied volatility

We estimate risk neutral skewness and kurtosis from options. The benefit of using risk neutral skewness and kurtosis from options is that they are forward looking measures that account for the probability of crashes and therefore they do not suffer from the "peso problem" of the realized returns. Risk neutral skewness is positively related to the physical measure of skewness and negatively related to the physical measure of kurtosis. We estimate these higher moments using the derivations of Bakshi et al. (2003):

$$Skew(t,\tau) = \frac{e^{r\tau}W(t,\tau) - 3\mu(t,\tau)e^{r\tau}V(t,\tau) + 2(\mu(t,\tau))^3}{(e^{r\tau}V(t,\tau) - (\mu(t,\tau))^2)^{\frac{3}{2}}}, \quad (11)$$

and

$$Kurt(t,\tau) = \frac{e^{r\tau}X(t,\tau) - 4\mu(t,\tau)e^{r\tau}W(t,\tau) + 6e^{r\tau}\mu(t,\tau)^2V(t,\tau) - 4\mu(t,\tau)^4}{(e^{r\tau}V(t,\tau) - \mu(t,\tau)^2)^2}. \quad (12)$$

$\mu(t,\tau)$, $W(t,\tau)$, $V(t,\tau)$, $X(t,\tau)$ are reported in the Appendix 1.

In order to estimate the risk neutral skewness and kurtosis given by Bakshi's formulas, we need to make them discrete. To do that, we use out-of-the money put and call options. In total we have 28,000 observations. Since the number of strikes on a given day are not enough to get an accurate estimate of skewness and kurtosis, we need to curve-fit the data. Therefore, we follow the methodology used in papers in the risk neutral density literature - initiated by Jackwerth and Rubinstein (1996). Instead of curve-fitting option quotes, we smooth Black-Scholes implied volatilities, in order to avoid overweighting in-the-money options -since out-of-the money options have zero intrinsic value. After curve-fitting the implied volatilities, we translate them back into a smooth, equally spaced option series and we estimate the risk neutral probabilities as described above.

We curve-fit implied volatilities on a series of strike prices that range from the minimum strike price to the maximum strike price of my combined options sample on a given day using a spacing of 1Rs between strike prices. For the curve-fitting, I use a polynomial of a 4th degree, which gives me a consistent goodness of fit of at least 97% on any given day. Alternatively, we could have used a smoothing spline, following Jackwerth and Rubinstein (1996) and Jackwerth (2000). However, that would require determining the optimal smoothing parameter which offers a high goodness of fit without overfitting the data and resulting in negative probabilities. The polynomial of a 4th degree does not have any subjectivity in selecting specific parameters, it offers a satisfactory goodness of fit and on average it results in smooth and positive risk neutral density functions.

Finally, we convert the fitted implied volatilities back in option prices and we approximate the skewness and kurtosis using the discretized Bakshi et al. (2003) formulas.

3.2. Opinion Dispersion

Turnover is often used as a measure of opinion dispersion and refers to the ratio of the volume over the number of outstanding shares in the market. The turnover measure used in this paper follows the World Federation's of Exchanges definition of the non-annualized *turnover velocity*, and it is estimated by dividing the monthly turnover (value of shares) with the month-end market capitalization.

4. Empirical Results

According to Bris et al. (2007), short sale constraints should inhibit market panics and, therefore, increase the skewness of the return distribution. Hong and Stein (2003) argue that the application of a short sale ban may have the exact opposite effect, since as the price starts to drop, the inactive short sellers reveal their negative views as they become support buyers. Morever, Hong and Stein (2003) predict that returns will become even more negatively skewed when opinion dispersion and, thus, turnover is high.

The Indian Equity Market is a natural testing environment as a short sale ban was in effect from March 7^{th} 2001 to April 20^{th}. Tables 1 and 2 present the descriptive statistics of the skewness measures in our sample. All skewness measures cover the period January 2002 - April

2008, which coincides with the period of the ban. They also cover a timeframe before the ban and a timeframe after the ban. However, the extent of coverage beyond the ban period depends on the given measure because of the more limited derivatives sample, the loss of observations in the calculation of returns and the loss of observations in the process of excluding non-liquid options. Table 1 reports the statistics for the skewness measures relying on realized returns, whereas Table 2 reports the summary statistics for the skewness measures derived from options.

The mean of the historical skewness estimated from the past daily returns over a period of a month (Realized Monthly Raw Skewness) is negative during the period of the ban, but is positive both before the ban became in effect and after it was lifted. The median, the minimum and the maximum historical skewness are also lower during the ban period compared to the period after the ban. Both a test of equality of means and a test of equality of medians indicate that the differences in the samples are statistically significant. The mean and the median of the historical skew estimated from the past daily returns over the period of six months are also lower during the ban period and the differences are statistically significant. Although the summary statistics provide supportive evidence for the theory of Hong and Stein (2003), they are by no means conclusive, as short sale constraints are not the sole factor explaining a negatively skewed distribution. Ideally, we would want to either identify all the contributing factors, or to be able to compare the skewness to a benchmark measure, that reflects the level of skewness in the absence of short sale constraints if all other factors remained the same. Identifying all the contributing factors with accuracy is not feasible. In an effort to use a benchmark, we examine the skewness of the S&P Nifty's abnormal returns based on the MSCI world index. We are, therefore, effectively using the world index as a benchmark. The mean and the median of the beta-adjusted skewness are significantly lower during the ban period when a one month timeframe is considered. On the contrary, when the six-month period is considered the mean is not significantly different after the ban is lifted compared to the ban period.

Table 2 presents the summary statistics for the skewness estimated from option prices. Our tests indicate that there are no significant differences in the Risk Neutral Skewness between the two periods. The skewness measure estimated from the difference in the implied volatility of the out-of-the money puts and the at-the-money calls appears to be higher during the ban period. However, these results are not very reliable as our options data on the post ban period are limited to only a couple of months. Moreover, the skewness measures derived from options differ from the previous measure in that they represent the skewness of the risk neutral return distribution. Bakshi et al. (2003) show that the risk neutral skewness is positively related to the physical skewness measure and negatively related to the kurtosis of the underlying physical distribution of returns.

Table 3 presents the summary statistics for the kurtosis of the returns. While there is no formal theory predicting the effect of short sale constraints on the fourth moment, it is often suggested that short sale restrictions should decrease kurtosis. This will happen assuming that short sale restrictions reduce the probability of market panics. Panel A of Table 3 reports the kurtosis measures from realized returns. The mean and the median kurtosis of the daily realized returns over a monthly timeframe (Realized Monthly Raw Skewness) are reduced after the ban is lifted. However, results are not consistent when the semi-annual period is considered. The mean kurtosis from daily raw returns over a semiannual timeframe is higher after the ban is lifted, whereas the median is lower after short sales are allowed. When the abnormal returns on the world index returns are considered, results are sensitive to the employed timeframe. The mean kurtosis of abnormal returns over a monthly timeframe (beta-adjusted Realized Monthly

Kurtosis) is positive during the ban and lower after the ban is lifted. The difference of means during the two periods is statistically significant. The median is also lower after the ban is lifted, but the difference is not significant. Both the mean and the median kurtosis of abnormal returns over a semiannual timeframe (beta-adjusted Realized Semiannual Kurtosis) are lower during the ban. The difference of medians is significant.

Panel B of Table 3 presents the kurtosis of the risk neutral density during and after ban. There is no significant difference in the risk neutral kurtosis during the ban and the post-ban period. Finally, we report the frequency of extreme negative returns. Extreme negative daily returns are two standard deviations below the mean returns in the sample. Interestingly, the frequency of extreme negative returns is lower after the ban is lifted. Our summary statistics offer some supportive evidence for the Hong and Stein's (2003) hypothesis about the ineffectiveness of short sale constraints to reduce market panics.

Hong and Stein's hypothesis also suggests that returns will become more negatively skewed when turnover, which proxies for opinion dispersion, will be high. To test for this we regress turnover on the various measures of skewness. A positive and significant effect of turnover on skewness will offer supportive evidence for Hong and Stein's hypothesis. We also control for the standard deviation of the past month. We expect the sign to be negative, since the third moment is scaled by the standard deviation. Also, similarly to Chen et al. (2001), who tested Hong and Stein's (2003) hypothesis in the US market, we control for past returns. Consistent to Chen et al (2001), we expect past returns to have a negative effect on skewness. The results of the regressions involving the measures of the skewness of the physical distribution are presented in Table 4. They include non-overlapping observation in order to avoid autocorrelation problems. In the monthly historical timeframe none of the variables has a statistically significant effect on skewness. Further, turnover does not have a significant effect when the abnormal returns are considered. Table 4 also reports the effects of turnover on option derived skewness measures. Consistent to the results from the physical returns, turnover does not seem to have a highly significant effect on risk neutral skewness, regardless of which measure is considered – risk neurtral skewness or implied volatility skewness.

5. Conclusion

According to Bris et al. (2007), short sale constraints should inhibit market panics and, therefore, increase the skewness of the return distribution. Hong and Stein (2003) argue that the application of a short sale ban may have the exact opposite effect, because as prices start to drop, the inactive short sellers reveal their negative views as they become support buyers. Moreover, Hong and Stein predict that returns will become even more negatively skewed when opinion dispersion and, thus, turnover is high.

This paper tests the above hypotheses empirically in the Indian Equity Market, short sale were strictly prohibited from March 7th 2001 to April 20th 2008. More specifically, this paper estimates the skewness of CNX S& P Nifty index based on daily future returns during a one month time and a six month timeframe and compares the third and fourth moment of the return distribution during the period of the ban and the post-ban period. Our results seem to partially favor the Hong and Stein (2003) hypothesis, since skewness appears to be lower during period of the ban, even when we control for the returns of the world market index. Additionally, kurtosis appears to be higher during the period of the ban. Risk neutral skewness is also used as a robustness measure, since it has the benefit of not being affected by the "peso problem" of realized returns. However, since the period after the ban is still relatively short, our data limitations don’t allow us to reach conclusive results based on the risk neutral density.

We also test the effect of turnover on skewness, which according to the Hong and Stein (2003) hypothesis, high opinion dispersion leads to more negatively expected returns. This would mean that short sale constraints have exactly the opposite effect than the one regulatory authorities hope to achieve with a ban. Turnover, similar to other studies, is used as a proxy for opinion dispersion. Contrary to Chen et al (2001), we apply similar tests in the US market, we do not find evidence that turnover affects skewness during the period of the short sale ban in India. However, our results, based on the physical measures of skewness, are sensitive to the sample size. Moreover, we use a monthly period to estimate historical skewness, whereas Chen et al. (2001) use a six month period. The chosen period might also influence the results.

In conclusion, our tests on the Indian equity market offer partial support of the Hong and Stein’s (2003) hypothesis: although market skewness is lower during the period that short sales were prohibited compared to the period after the ban, turnover does not appear to have a significant effect on market skewness.

Appendix

Appendix 1: Risk – Neutral Skewness and Kurtosis

The risk neutral skewness and kurtosis are given by the following:

$$Skew(t,\tau) = \frac{e^{r\tau}W(t,\tau) - 3\mu(t,\tau)e^{r\tau}V(t,\tau) + 2(\mu(t,\tau))^3}{(e^{r\tau}V(t,\tau) - (\mu(t,\tau))^2)^{\frac{3}{2}}}, \quad (1.1)$$

and

$$Kurt(t,\tau) = \frac{e^{r\tau}X(t,\tau) - 4\mu(t,\tau)e^{r\tau}W(t,\tau) + 6e^{r\tau}\mu(t,\tau)^2V(t,\tau) - 4\mu(t,\tau)^4}{(e^{r\tau}V(t,\tau) - \mu(t,\tau)^2)^2}, \quad (1.2)$$

where,

$$\mu(t,\tau) = e^{r\tau} - 1 - \frac{e^{r\tau}}{2}V(t,\tau) - \frac{e^{r\tau}}{6}W(t,\tau) - \frac{e^{r\tau}}{24}X(t,\tau), \quad (1.3)$$

$$V(t,\tau) = \int_{S(t)}^{\infty} \frac{2(1-\ln(\frac{K}{S(t)}))}{K^2}C(t,\tau;K)dK + \int_{0}^{S(t)} \frac{2(1+\ln(\frac{S(t)}{K}))}{K^2}P(t,\tau;K)dK, \quad (1.4)$$

$$W(t,\tau) = \int_{S(t)}^{\infty} \frac{6\ln(\frac{K}{S(t)}) - 3(\ln(\frac{K}{S(t)}))^2}{K^2}C(t,\tau;K)dK - \int_{0}^{S(t)} \frac{6\ln(\frac{S(t)}{K}) + 3(\ln(\frac{S(t)}{K}))^2}{K^2}P(t,\tau;K)dK, \quad (1.5)$$

and

$$X(t,\tau) = \int_{S(t)}^{\infty} \frac{12(\ln(\frac{K}{S(t)})^2) - 4(\ln(\frac{K}{S(t)}))^3}{K^2}C(t,\tau;K)dK + \int_{0}^{S(t)} \frac{12(\ln(\frac{S(t)}{K})^2) + 4(\ln(\frac{S(t)}{K}))^3}{K^2}P(t,\tau;K)dK. \quad (1.6)$$

Table 1: Summary statistics: skewness measures from realized returns.

The sample period is from February 1st 1999 to November 20th 2009. Realized Raw Skewness is the skewness of the logarithmic returns over a month or six months. Realized, beta adjusted skewness is the skewness of abnormal daily returns over the corresponding timeframe. All measures are estimated on a rolling window. The last two columns report the critical values for the difference of means and medians, respectively. The test of means is an F-test, whereas the test of medians is a Kruskal-Wallis test.

	Mean	Median	Max	Min	Std. Dev.	Obs.	Test of means (F-test)	Test of medians
Realized Monthly Raw Skewness								
Before short sales ban	0.025	0.085	1.752	-1.752	0.606	530		
During short sales ban	-0.192	-0.150	1.976	-2.565	0.639	1817		
After short sales ban	0.121	0.046	3.245	-1.173	0.748	391		
All	-0.106	-0.090	3.245	-2.565	0.661	2738	50.499***	77.727***
Realized Semiannual Raw Skewness								
Before short sales ban	-0.137	-0.177	0.801	-0.802	0.376	424		
During short sales ban	-0.506	-0.442	0.838	-2.461	0.508	1817		
After short sales ban	0.459	-0.021	2.719	-0.694	1.036	391		
All	-0.303	-0.364	2.719	-2.461	0.692	2632	434.587***	453.667***
Realized Monthly Skewness (beta adjusted)								
During short sales ban	-0.240	-0.210	1.314	-2.317	0.565	1475		
After short sales ban	-0.041	-0.023	0.809	-1.284	0.500	130		
All	-0.223	-0.199	1.314	-2.317	0.562	1605	14.620***	17.109***
Realized Semiannual Skewness (beta adjusted)								
During short sales ban	-0.507	-0.407	0.823	-2.410	0.510	1475		
After short sales ban	-0.493	-0.540	0.096	-1.171	0.180	130		
All	-0.506	-0.415	0.823	-2.410	0.492	1605	0.108	6.274***

Table 2: Summary statistics: skewness measures from options

The sample period is from January 1st 2002 to June 30th 2008. A short sale ban was in place from March 7th 2001 – April 21st 2008. Risk neutral skewness is estimated using the methodology of BKM (2003). Implied Volatility Skewness is the difference between the implied volatility of out of the money put options and the implied volatility of at the money call options. Options with expiration time of 45 days or less were used for both measures. The last two columns report the critical values for the difference of means and medians, respectively. The test of means is an F-test, whereas the test of medians is a Kruskal-Wallis test; *, **, *** signify 10%, 5% and 1% statistical significance.

	Mean	Median	Max	Min	Std. Dev.	Obs.	Test of means (F-test)	Test of medians
Risk Neutral Skewness								
During short sales ban	-0.896	-0.974	18.121	-4.408	1.191	1505		
After short sales ban	-0.758	-0.904	0.773	-1.864	0.614	49		
All	-0.892	-0.963	18.121	-4.408	1.178	1554	-1.712	2.131
Implied Volatility Skewness								
During short sales ban	-0.073	-0.073	0.426	-0.383	0.054	1261		
After short sales ban	-0.096	-0.081	0.002	-0.221	0.047	82		
All	-0.074	-0.074	0.426	-0.383	0.054	1343	7.701***	11.828***

Table 3: Summary statistics: kurtosis

The sample period is from February 1st 1999 to November 20th 2009. Realized Raw Kurtosis is the kurtosis of the logarithmic returns over a month or six months. Realized, beta - adjusted kurtosis is the kurtosis of abnormal daily returns over the corresponding timeframe. All measures are estimated on a rolling window. The last two columns report the critical values for the difference of means and medians, respectively. The test of means is an F-test, whereas the test of medians is a Kruskal-Wallis test; *, **, *** signify 10%, 5% and 1% statistical significance.

Panel A: Kurtosis from realized returns

	Mean	Median	Max	Min	Std. Dev.	Obs.	Test of means (F-test)	Test of medians
Realized Monthly Raw Kurtosis								
Before short sales ban	0.558	0.209	5.240	-1.402	1.298	530		
During short sales ban	0.428	0.025	8.881	-1.550	1.453	1817		
After short sales ban	0.328	-0.276	13.047	-1.511	2.455	391		
All	0.439	0.008	13.047	-1.550	1.609	2738	2.406*	54.533***
Realized Semiannual Raw Kurtosis								
Before short sales ban	1.350	1.311	3.074	0.127	0.564	424		
During short sales ban	2.038	1.354	22.250	-0.598	3.033	1814		
After short sales ban	4.494	1.290	20.514	-0.386	5.834	390		
All	2.292	1.325	22.250	-0.598	3.515	2628	104.559***	7.511***
Realized Monthly Kurtosis (beta-adjusted)								
During short sales ban	0.235	-0.110	7.653	-1.733	1.353	1475		
After short sales ban	-0.053	-0.121	2.206	-1.627	0.908	130		
All	0.212	-0.111	7.653	-1.733	1.325	1605	5.656***	2.065
Realized Semiannual Kurtosis (beta-adjusted)								
During short sales ban	1.859	0.977	21.263	-0.504	3.193	1475		
After short sales ban	2.257	2.453	3.632	-1.627	0.903	130		
All	1.891	1.092	21.263	-1.627	3.073	1605	1.913	123.711***

Table 3 (cont'd): Summary statistics: kurtosis

The sample period is from January 1^{st} 2002 to June 30^{th} 2008. A short sale ban was in place from March 7^{th} 2001 – April 21^{st} 2008. Risk neutral kurtosis is estimated using the methodology of BKM (2003). A day is counted as a crash if the daily returns are lower than two standard deviation from the mean daily return during the corresponding period. The last two columns report the critical values for the difference of means and medians, respectively. The test of means is an F-test, whereas the test of medians is a Kruskal-Wallis test; *, **, *** signify 10%, 5% and 1% statistical significance.

	Mean	Median	Max	Min	Std. Dev.	Obs.	Test of means (F-test)	Test of medians
Risk Neutral Kurtosis								
During short sales ban	4.442	3.365	223.028	0.689	6.611	1505		
After short sales ban	3.831	3.143	9.193	1.539	1.734	49		
All	4.423	3.361	223.028	0.689	6.514	1554	0.912	0.117
Frequency of extreme negative returns	Crashes	Trading days	Ratio					
Before short sales ban	17	548	0.031					
During short sales ban	62	1786	0.035					
After short sales ban	9	412	0.022					
All	88	2746	0.032					

Table 4: The effect of turnover on market skewness

The sample period is from March 2001 to April 2008, when a short sale ban was in place. Realized Raw Skewness is the skewness of the logarithmic returns over a month. Realized, beta adjusted skewness is the skewness of abnormal daily returns over the corresponding timeframe. All measures are estimated monthly and non-overlapping. Risk neutral skewness is estimated using the methodology of BKM (2003). Implied Volatility Skewness is the difference between the implied volatility of out of the money put options and the implied volatility of at the money call options. Options with expiration time of 45 days or less were used for both measures. Turnover is estimated as the monthly value of traded shares over the month-end market capitalization; t-statistics are in parentheses; t-statistics are in parentheses and are adjusted for autocorrelation and heteroskedasticity using Newey-West. *, **, *** signify 10%, 5% and 1% statistical significance.

	Realized monthly raw skewness$_{t+1}$	Realized monthly skewness (beta-adjusted) $_{t+1}$	Risk Neutral Skewness	Implied Volatility Skewness
Turnover$_t$	0.04	-0.353	0.260*	0.011
	(0.122)	(-1.545)	(1.947)	(1.077)
Skew$_t$			0.483***	0.551***
			(3.464)	(7.827)
Sigma$_t$	10.316	31.660***	-7.433	-0.040
	(1.128)	(3.058)	(-1.373)	(-0.156)
Ret$_t$	0.852	2.975***	-5.423***	0.0972***
	(0.991)	(3.126)	(-3.894)	(2.450)
No. of obs	85	69	1477	1155
R-squared	0.013	0.128	0.665	0.340

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Chapter 3

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