A Rationale for the Market Maker Structure

Amir Rubin, Simon Fraser University, Burnaby, BC, Canada

ABSTRACT

We show that even in a symmetric information economy, a market maker can solve a free-rider problem that exists in the competitive limit order book market. Since individual investors assume that their own trade has no effect on market liquidity, they disregard it when maximizing their expected utility. A monopolist market maker that exerts search and promotion costs to increase trading volume can solve the free-rider problem. Under some circumstances, the benefits of solving the free-rider problem outweigh the costs of having a market maker who collects a fee. The theoretical results have both policy and empirical implications for financial markets.

Key Words: Market Maker, Liquidity, Volume, Free-rider, Risk Sharing

1 Introduction

Around the world exchanges have been converting their trading systems from the traditional call market to computer based limit order books. By doing so, these markets are allowing for continuous trade and are presumably improving trade by increasing the liquidity of the securities traded. Given that one aspect of liquidity is the time involved before an asset can be sold or bought, this progression towards continuous trading seems appropriate. However, continuous trading can also be accomplished by market makers (designated dealers) that serve as intermediaries. The fact that all recent changes in exchange trading mechanisms have been towards the computer based limit order book trading alternative and not the market maker trading alternative (e.g., France, Spain, Italy, Israel) raises questions concerning the usefulness of the market maker system. In other words, if the reason for choosing the computer based alternative is simply the cheap processing of trade that computers are capable of today, then why do market makers still exist in developed markets such as the New York Stock Exchange (NYSE)? Is there any value for the existence of market makers when continuous trading can be accomplished by other cheaper means? A common view among professionals and economists is that the NYSE is retaining its market maker system because it enjoys a significant advantage as an incumbent that earns rents and deters entry. This view has gained some momentum as the NYSE is reeling from recent scandals and calls are mounting for the world's largest stock exchange to revamp its trading system. Is the NYSE specialist system in need of reform? Critics' allegations of improper trading, complaints about the specialist system, as well as more recent questions about the exchange's exorbitant pay packages have left some investors and listed companies grumbling.

The objective of the study is to investigate the welfare effects of choosing a monopolist market maker trading structure with human intervention (similar to the specialist system) over a competitive structure such as a limit order market. The welfare comparison is done in a market with symmetric information to all market participants. We assume that the market maker serves only as an intermediary who buys shares from the seller and sells them immediately to the buyer. Thus, we model the economy in a setup which is only loosely connected to most of the microstructure literature (e.g., Kyle, 1985, Glosten and Milgrom, 1985). Most market microstructure literature focuses on informational issues (see Madhavan, 2000, and Biais, Glosten, and Spatt, 2002). These models assume different information structures and preferences for the different agents in the economy, i.e., the informed investors, the market makers, and the liquidity traders. In particular, research of the microstructure of security markets has concluded that informed trading is an important determinant of liquidity (e.g., Spatt, 1991) and one of the reasons why a monopolist market maker may have a positive role in financial markets (Glosten, 1989). However, Madhavan (2000) stresses that the ultimate decision on market structure is likely to be decided on the basis of factors that have less to do with information than many economists apparently believe. Following this thought, we abstract from informational differences between investors and we show that even under the homogenous information and preferences assumption, a monopolist market maker may still have a positive role in financial markets.

In this study we propose and develop a theory in which the relative advantage of having market makers depends to a large extent on the importance of providing more liquidity in the market. The main insight that is provided in our model is that a market maker can reduce what we call *liquidity risk* by solving a free-rider problem that occurs in incomplete markets that have a competitive limit order book market structure. Without a market maker, the investors in the economy do not take into account their own effect on liquidity when deciding on the amount of trade. Doing so is rational since each investor is "small" and assumes that his own trade has no effect on total market liquidity. Even though in our model greater volume increases the liquidity of the stock, each individual investor prefers to free-ride on the volume generated by the other investors and the result is that less volume is generated. The individual investors do not generate more trade even though if all the investors in the market had done so, they would have made the asset more liquid, which might have increased all of the investors' utility. The investors simply conjecture the aggregate volume and use their conjecture as an exogenous variable in their maximization problem. A monopolist market maker that exerts search and promotion costs in order to maximize profit can solve the free-rider problem. The market maker facilitates all trade in the economy and; therefore can contract with each individual investor and relate the investor's individual trade to his future liquidity risk. In return the market maker collects a fee. Effectively, this formulation makes investors consider their effect on liquidity, which in turn increases trading volume. Thus, similar to other public goods, an institutional arrangement might achieve a better equilibrium outcome.

Comparing the monopolist market maker and the competitive limit order book we find that Depending on the opportunity for improving risk sharing, a monopolist market maker structure can be efficient. By dividing the investors into two groups representing the ordinary shareholders who hold diversified portfolios and controlling shareholders who have a major stake in a company's equity (undiversified investors), we are able to derive an empirical hypothesis concerning the optimal market structure choice. We show that a market maker can increase welfare in economies where there is less opportunity for improving risk sharing. In these economies, where most of the equity is held in diversified portfolios, the ability to improve risk sharing is small, and liquidity may be scarce. This means that the market maker's role is important because it make investors consider their effect on volume. On the other hand, in economies where most of the equity is held by investors who hold undiversified portfolios, the ability to improve risk sharing is high. In these economies, the role of the market maker becomes unnecessary, and the payment of fees for its services is welfare reducing for the investors.

The contribution of this paper is to provide a welfare analysis of market structures in a symmetric information economy. This analysis is done by considering two important features of financial markets: their ability to provide liquidity and their ability to increase risk sharing between investors.

Our approach is related to several strands of the economics and finance literature. In the field of asset pricing, a growing body of research serves to demonstrate the importance of liquidity as a factor in determining expected returns for trading on securities. Theoretical works in this area include Constantinides (1986), Heaton and Lucas (1996), Vayanos (1998) and Vayanos and Vila (1999). Similar to what is done in those models, we model liquidity exogenously. However, we base our analyses differently by building on a relation between volume and transaction costs. Moreover, we do not concentrate on pricing issues, but rather analyze investors' welfare to obtain market structure implications.

There exist a few studies that deal with the liquidity externality. These include Admati and Pfleiderer (1988), Glosten (1989), Foster and Viswanathan (1990), Brusco and Jackson (1999), Dow (2004). In these models either the investors choose on their own to concentrate their trades on a single market at a single point in time or they do so with the help of the market makers. The idea is to benefit from the externalities generated by other traders. However, different from our study, all of the above studies build on heterogeneity in either preferences or private information. Thus, although their theories present insights to circumstances in which liquidity becomes an important factor, there results are dependent on the underlying assumptions about private information. Dealing with the liquidity externality without adverse selection are Pagano (1989) and Economides and Siow (1988). However different from what is done in this study, Pagano (1989) addresses the issue of concentration and fragmentation of trade across markets and not their structure, while Economides and Siow (1988) study the optimal number of markets for an asset.

Our free-rider problem occurs because of non-cooperative behavior between investors in large populations. This relates our paper to a subset of the economic governance literature that shows how such behaviors offer profit opportunities for individuals who can solve them (e.g., Dixit, 2003). In our study, a market maker, who is motivated by private profit rather than by social welfare, is able to improve welfare where investors fail to cooperate. Finally, our results bear some resemblance to the literature on welfare effects in incomplete markets. For example, similar to Elul (1995), we show that by introducing market makers we can achieve an equilibrium which may either make everyone better off or make everyone worse off. This is similar to the results in incomplete markets with more than one consumption good.

The rest of the study proceeds as follows. In section 2 the model is developed and the differences between the limit order book structure and the monopolist market maker structure are formed. In section 3 we solve the model numerically and compare the two market structures. We show how risk sharing and liquidity risk play a role when deciding on the optimal market structure. In section 4 we discuss the empirical interpretation of our model and its implications for public policy. Finally, in section 5 we conclude.

2 The model

We consider a multi-period economy in which investors may experience a liquidity shock, which may force them to sell the risky asset in the market. However, in order to both illustrate and analyze the model, it is sufficient that we model only two dates ($t = 0$, $t = 1$) of the economy. Investors have concave utility functions and are allowed to trade in a riskless asset ("cash") and one risky asset ("stock"). There are two types of aggregate investors in the market distinguished by different endowments. For ease of illustration, the investors have the same CRRA utility function. The investors act as atomistic price takers maximizing the expected utility of terminal wealth. The riskless rate is exogenous, and there is unrestricted borrowing and lending at the riskless rate. For simplicity, we assume without loss of generality that the riskless rate is zero. There are no transaction costs or taxes, and asset shares are infinitely divisible. Figure 1 illustrates the possibility of transacted prices for the stock at $t = 1$. At $t = 1$ the fundamental value of the stock is known to be A. However, the distribution of values which an investor may expect to transact on if he wishes to buy or sell a share depends on the volume generated at $t = 0$. By this we capture the idea that there is uncertainty about the actual transaction price at $t = 1$ and that this uncertainty depends on the liquidity of the market. In other words, selling (or buying) stock at $t = 1$ involves transaction costs, which are volume dependent. We assume that the higher the volume of trade at $t = 0$, the more active is the stock, and therefore, the less uncertain the investors are about the $t = 1$ price of the stock. We postulate that a high volume affects the pool for potential investors trading in the future. Due to the law of large numbers, whether the investors of $t = 0$ are hit by a positive or negative liquidity shock at $t = 1$, their search related costs are small and they can transact at a price close to fundamental value. One can also think of volume as a measure that quantifies dollar value of trade per unit of time. This means that a high volume visible stock attracts new investors and will be subject to a more frequent updating of its bid-ask quotes. Under such circumstances, the distribution of the stock value would be narrower for a high volume stock compared to that of a low volume stock. The hypothesis is similar in nature to Arbel and Sterbel (1983), Arbel (1985), and Merton (1987) that argue that the arrival of additional analysts and traders reduces the estimation risk faced by traders.Note that the larger is the MPS around the intrinsic value of a stock; the lower is its $t = 0$ price because it is second degree stochastic dominance inferior to a same expected payoff stock with a smaller MPS. This price effect is consistent with Amihud and Mendelsen (1986, 1989, 1991), Kamara (1994), Brennan and Subrahmanyam (1996), Brennan, Chordia, and Subrahmanyam (1998), and Kalay, Wei, and Wohl (2002), who find a negative correlation between measures of liquidity and the expected return. In our model, the fact that liquidity is priced also leads to a positive volume-price contemporaneous relation. This type of contemporaneous relation has also been developed theoretically in Epps (1975), Copeland (1976), Tauchen and Pitts (1983), and Karpoff (1986). Empirically, the volume-pricing relationship has been documented in Shmirlock and Starks (1985), Harris (1986, 1987), Breen, Hodrick, and Korajczyk (1999), Coppejans, Domowitz, and Madhavan (2002), Gervais, Kaniel, and Mingelgrin (2001), Kalay, Wei and Wohl (2002).

2.1 The endowment economy

Since both representative investors are homogenous regarding both preferences and beliefs, the only difference between them is their endowments. The investors receive different endowments of cash and stock and then trade at $t = 0$. The two aggregate investors' endowment are made up of cash $(\overline{C}_1, \overline{C}_2\ )$ and stock $(\overline{X}_1, \overline{X}_2)$. The total supplies of cash and stock in

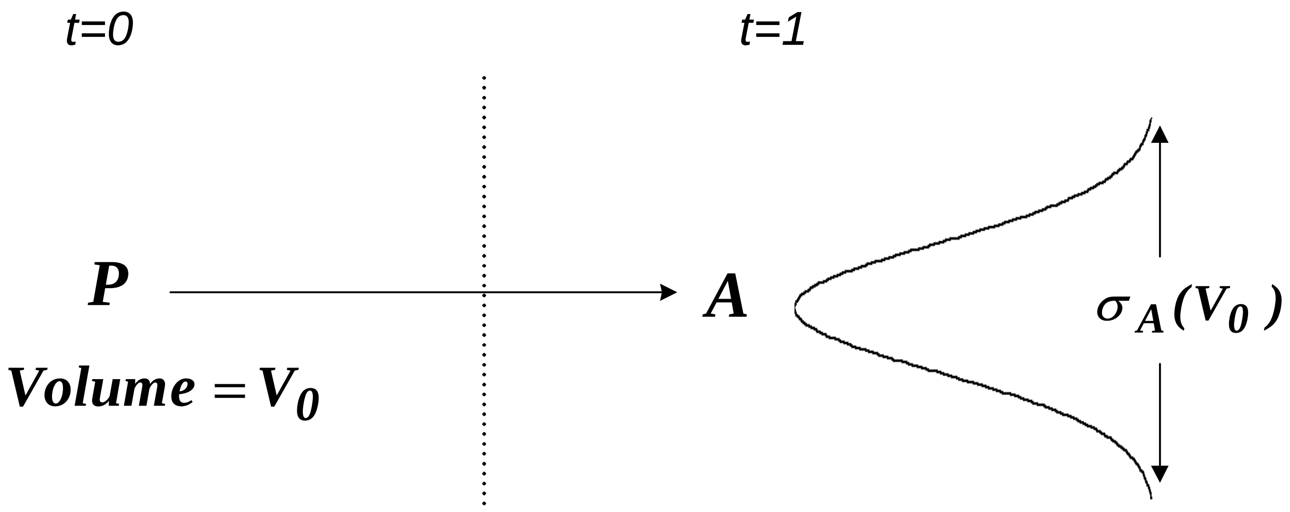

Figure 1: A schematic illustration of the feedback loop between volume and liquidity: V_0- volume at time $t = 0$; $A-$ time $t = 1$ expected price of the stock; $\sigma_{A,}$ variance of transaction prices at $t = 1$.

the economy are $\overline{C} = \overline{C}_1 + \overline{C}_2$ and $\overline{X} = \overline{X}_1 + \overline{X}_2$, respectively. Each aggregate investor is composed of n identical individual investors. The endowments of the individual investors are therefore, either $\left(\frac{\overline{C}_1}{n}, \frac{\overline{X}_1}{n}\right)$ for investors of type 1, and $\left(\frac{\overline{C}_2}{n}, \frac{\overline{X}_2}{n}\right)$ for investors of type 2. We consider the case of $n \to \infty$ as an approximation of the perfect competitive market.

The budget constraint for an individual investor

$$\left(\frac{C_i}{n} + Px_{ij}\right) = \left(\frac{\overline{C}_i}{n} + P\frac{\overline{X}_i}{n}\right) \tag{1}$$

where x_{ij} is the trade chosen by agent j of type i (where $i = 1, 2$). At time $t = 0$ the investors decide on the amounts of cash and stock in their portfolios. Since we have assumed that the riskless rate is zero, cash does not earn interest. Since all investors of the same type are identical, we can define the aggregate level of quantity chosen for aggregate investor 1 and 2 as

$$X_1 = \sum_{j=1}^{n} x_{1j} = nx_1 \tag{2}$$

$$X_2 = \sum_{j=1}^{n} x_{2j} = nx_2 \tag{3}$$

where x_1 and x_2 are the quantity chosen by individual of type 1 and 2 respectively. As was discussed, the price at $t = 1$ depends on the volume of trade. For simplification, without loss of generality, the uncertainty can be represented by the two extreme values of the distributions around A. Let R be distributed as following,

$$\widetilde{R} = \begin{cases} \frac{\alpha}{\beta+V} & \text{with probability } 0.5 \\ -\frac{\alpha}{\beta+V} & \text{with probability } 0.5 \end{cases} \tag{4}$$

then the actual transaction price for an individual investor is $A+\widetilde{R}$. The α and β parameters are positive and represent exogenous parameters of the economy. A lower α and a higher β may represent economies where there is more interaction in the market place between the investors. For example, if many investors in the economy are connected to the internet and can submit orders to the exchange on line, we would expect that search related costs be lower. Reflecting the effect of liquidity, dollar volume (V), quantified by price times quantity traded, plays the important role of reducing future spread. Note that the α and β parameters control the maximum possible spread, thus even a $V = 0$ will not result in an infinite spread. However, as $V \to \infty$, the spread goes to zero.

2.2 The limit order book structure

Since in this model investors differ only in their endowments, interactions between them on the competitive limit order book structure will produce the Walrasian equilibrium.

The individual investors' maximization problem involves maximizing expected utility assuming that volume is unaffected by the investor's own trade and equals their conjecture that $V = V_0$. Formally, we have

$$\max_{x_{ij}|V=V_o} E\left[U\left(\frac{\overline{C}_i}{n} + P\left(\frac{\overline{X}_i}{n}\right) + x_{ij}\left(A + \widetilde{R}(V_0) - P\right)\right)\right] \tag{5}$$

Although the volume V affects the utility and the equilibrium price, each individual investor is very small and takes the volume as an exogenous variable that equals V_0. In equilibrium markets must clear and the investors' conjecture on volume has to be confirmed, so we must have

$$\begin{aligned} \overline{X} &= nx_1 + nx_2 && (6) \\ P &= P(V_0, x_1, x_2) && (7) \\ V_0 &= P(V_0) \times \left|\overline{X}_i - X_i\right| && (8) \end{aligned}$$

Figure 2 illustrates the relation between volume and the price of the stock. A movement in the *Edgeworth trade box* represents a change in holdings due to trade. For example, point I_1 and I_2 represent two possible initial endowments of the aggregate investors, and the vector going from these two points represent a movement due to trade.

Remark *Since both aggregate investors have the same CRRA utility, they both wish to trade so that they move to the diagonal of the Edgeworth trade box.*

This can be understood by the fact that both types of investors invest the same proportion η of wealth in the stock

$$\eta = \frac{PX_1}{W_1} = \frac{PX_2}{W_2} \tag{9}$$

$$= \frac{PX_1}{C_1 + PX_1} = \frac{PX_2}{C_2 + PX_2} \tag{10}$$

This relation and the clearing conditions lead to

$$X_1(\overline{C} - C_1 + P(\overline{X} - X_1)) = (\overline{X} - X_1)(C_1 + PX_1) \tag{11}$$

Which can be simplified to

$$\frac{X_1}{C_1} = \frac{\overline{X}}{\overline{C}} = \frac{\overline{X}_1 + \overline{X}_2}{\overline{C}_1 + \overline{C}_2} \tag{12}$$

Thus, under homogenous beliefs and same CRRA utility, investors trade such that their portfolio holdings after trade lie on the diagonal of the Edgeworth trade box. Note that the total volume is simply the amount of cash that is transferred during trade between the two aggregate investors. In Figure 2, the vector that moves aggregate investors 1 portfolio from point I_1 (initial endowments $\overline{X}_1, \overline{C}_1$) to the diagonal (with after trade holdings X_1, C_1) determines the equilibrium price. Thus,

$$P = \tan(\theta) = \frac{V_0}{\left|\overline{X}_1 - X_1\right|} = \frac{\left|C_1 - \overline{C}_1\right|}{\left|\overline{X}_1 - X_1\right|} \tag{13}$$

Proposition 1 *There is a unique equilibrium.*

Proof. The proof follows from Figure 2.

During trade investors move to the diagonal and trade cash for stock. Thus, a positive amount of cash must be traded for a positive amount of stock. This means that in equilibrium θ must lie in the range of $0 \leq \theta \leq 90$ degrees. With an increase in θ from 0 to 90 we have:

(1) V increases monotonically and continuously from 0 to a.

(2) $\left|\overline{X}_1 - X_1\right|$depreciates monotonically and continuously from b to 0.

(3) The price increases monotonically and continuously from 0 to $\lim\limits_{\theta \to 90} \tan(\theta) \ = \infty$.

(4) By (1) – (3), each P corresponds to a unique set of V and $\left|\overline{X}_1 - X_1\right|$.

Thus, by point (3) above, there must exist a unique P that solves for the equilibrium price. By point (4) above, this unique P corresponds to a unique V_0. ■

An important issue that all investors are disregarding in this economy is their own volume effect on future uncertainty. Each individual investor's own trade is small. Investors act as

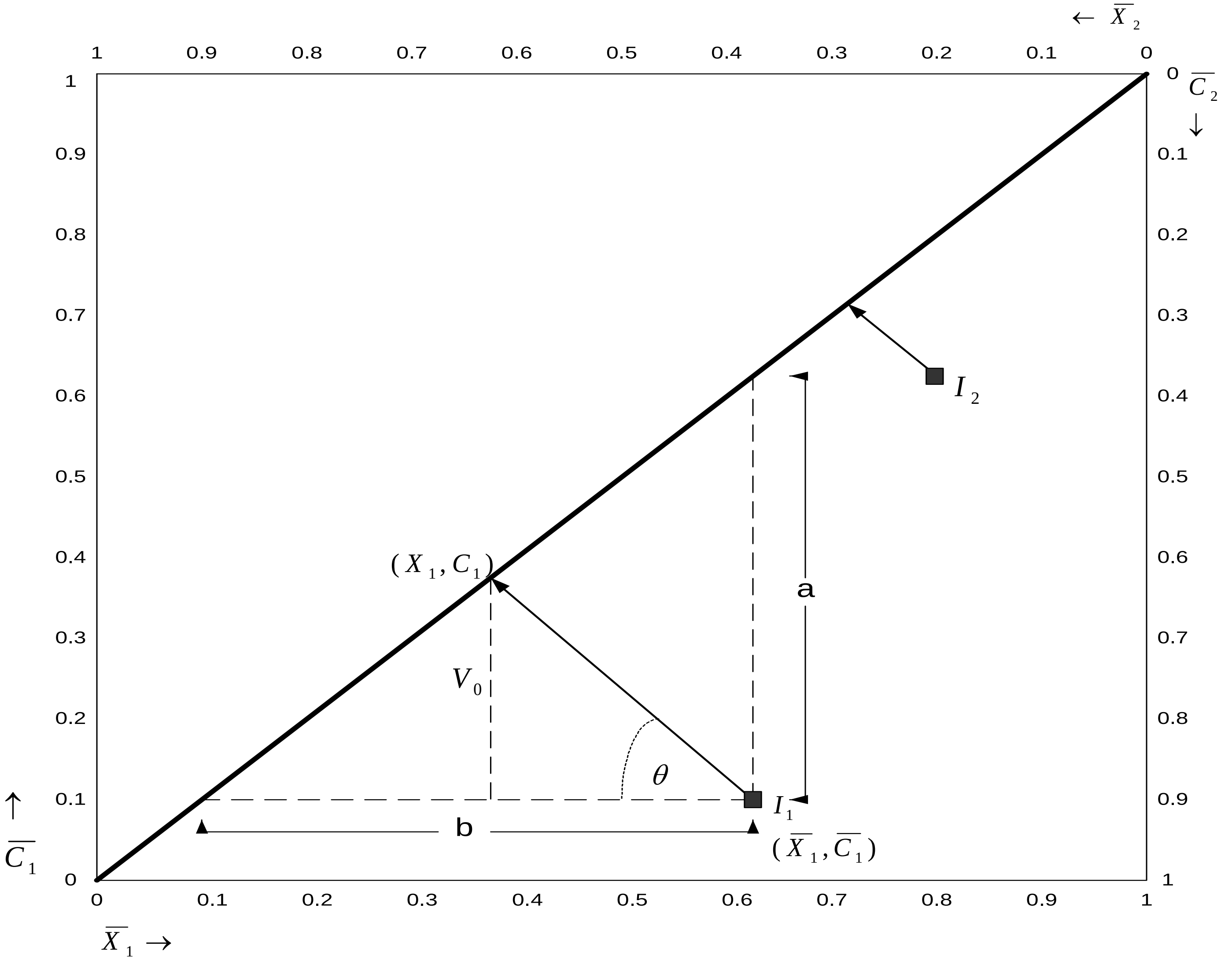

Figure 2: The Edgeworth Trade Box and the formulation of volume and price depending on the initial endowments of the investors.

though their own trade has no effect on total volume, therefore, has no effect on the spread at $t = 1$. This is a classic free-rider problem. It occurs because each of the two aggregate investors is made of many individual investors. Each individual investor prefers to free-ride on the volume generated by the other investors and the result is that there is no more volume than the amount needed for movement to the diagonal. Thus, no excess volume is generated. Volume is like a public good and because each investor's own volume is small, he does not consider his trade effect on total volume. In equilibrium the volume generated is the volume that would have been generated even if volume had no effect on the spread of $t = 1$. The individual investors will not generate more trade even though if all the investors in the market had done so, it would have reduced the spread at $t = 1$, and might have increased all investors' utility. The investors simply conjecture the future volume and use their conjecture as an exogenous variable in their maximization problem. In equilibrium, the conjecture must be proven right.

2.3 The market maker structure

2.3.1 The contract

We assume that all trades in the market are done with a risk neutral monopolist market maker, which takes the opposite side of every transaction, both at $t = 0$ and at $t = 1$. In order to make these transactions, the market maker has a proprietary search technology that is not available to other agents in the economy. The market maker contracts with each investor j of type i as follows:

1. For each share traded a fee ε_{ij} is charged.
2. The market maker records the individual volume generated, $v_{ij} = P\left|\frac{\overline{X}_i}{n} - x_{ij}\right|$, and commits to a future transaction spread. The transaction price is set to be at $A + \widetilde{R}_{ij}$, where $\widetilde{R}_{ij} = \begin{cases} \frac{\alpha/n}{\beta/n+v_{ij}} & \text{with probability } 0.5 \\ -\frac{\alpha/n}{\beta/n+v_{ij}} & \text{with probability } 0.5 \end{cases}$.

The market maker part is simply to interact with all the individual investors and commit to a certain future bid/ask spread depending on the individual investor's volume. Since the market maker is a monopolist he can enforce this policy at $t = 1$ and set a transaction price that is consistent with this formulation. Note that since the market maker will continue to interact with the investors in the future, he also has the incentive to keep his reputation and honer this agreement, i.e., this is a subgame perfect strategy. In fact, since all n investors of type i are identical, the market maker needs to set only two types of fees ε_i depending on whether the investor is a buyer or a seller. Due to the homogeneity of the investors, each type of investor chooses the same quantity x_i, $i = 1, 2$. In equilibrium the market maker's commitment to reduction in liquidity risk becomes a self fulfilling prophecy because all the investors trade more and that by itself reduces liquidity risk. Thus, the market maker does not bear any risk by contracting with the investors, because in equilibrium the volume generated in the market will be consistent with the spread that is stated in the policy of the market maker.

2.3.2 Market maker problem

For simplification of notation, we assume throughout the analysis that investors of type 1 are the sellers and that investors of type 2 are the buyers. Formally, we define the market maker profit function as

$$\pi(\varepsilon) = \left(\overline{X}_1 - X_1\right)\varepsilon_1 + \left(X_2 - \overline{X}_2\right)\varepsilon_2 - \gamma_1\left(\frac{\varepsilon_1}{P}\right)^2 - \gamma_2\left(\frac{\varepsilon_2}{P}\right)^2 \tag{14}$$

Where ε_i is the fee per share traded, and γ_i $(i = 1, 2)$ are constant parameters. The market maker's revenue is quantity traded times fee per traded share minus the convex effort cost, which is a function of search and promotion related costs. A high γ_i means that it is rather costly for the market maker to generate more trade (e.g., high communication costs, low technology), while a low γ_i corresponds to a rather developed market where search related costs are rather small. We assume that these costs will be higher when the fee is high. Moreover, since the fee should be compared to the actual price of a share, these costs are negatively related to stock price. In other words, it is easier to ask a \$1 fee for a stock that costs \$100 then it is to charge a \$1 fee for a \$2 stock. Since we have no reason to assume that these costs would be different on the buy or sell side, we assume that $\gamma = \gamma_1 = \gamma_2$. Differentiating the profit function with respect to ε_1 and ε_2 one can derive the market maker's first order condition,

$$\varepsilon_1 = \frac{P^2}{\gamma}\left(\overline{X}_1 - X_1\right) \tag{15}$$

$$\varepsilon_2 = \frac{P^2}{\gamma}\left(X_2 - \overline{X}_2\right) \tag{16}$$

2.3.3 Investor's problem

The individual investors act according to their agreement with the market maker. Under such circumstances, it is rational for them to consider their own individual volume generated in their maximization problem. Moreover, they know that the market maker contracts with each of the investor's in the market so that in equilibrium the market maker's guarantee is self-fulfilling.

Formally, the investor's problem is,

$$\max_{x_{ij}} E\left[U\left(\frac{\overline{C}_i}{n} + P\left(\frac{\overline{X}_i}{n}\right) + x_{ij}\left(A + \widetilde{R}(v_{ij}) - P - \varepsilon_i\right)\right)\right] \tag{17}$$

$$where,\ v_{ij} = P\left|\frac{\overline{X}_i}{n} - x_{ij}\right|$$

Under this scenario, investors choose a quantity x_{ij}, consider their own effect on liquidity, but also pay a fee ε_i per share traded. Effectively, the market maker influences the volume of trade in the market. As before, in equilibrium, due to the homogeneity of the investors, each type of investor chooses the same quantity x_i, $i = 1, 2$.

2.3.4 Equilibrium

Definition *A Nash equilibrium is a set of quantity, price, and fees* $(X_1^*, X_2^*, P^*, \varepsilon_1^*, \varepsilon_2^*)$ *if the following conditions hold:*

$$\varepsilon_1^* = \frac{(P^*)^2}{\gamma}\left(\overline{X}_1 - X_1^*\right) \tag{18}$$

$$\varepsilon_2^* = \frac{(P^*)^2}{\gamma}\left(X_2^* - \overline{X}_2\right) \tag{19}$$

$$X_i^*(P^*, \varepsilon_i^*) = n\hat{x}_{ij}(P^*, \varepsilon_i^*), \ \ i = 1, 2 \tag{20}$$

$$X_1^*(P^*, \varepsilon_1^*) + X_2^*(P^*, \varepsilon_2^*) = \overline{X} \tag{21}$$

where $\hat{x}_{ij}$ *represents the optimal demand of security from eq. (17).*

The above definition states that the market maker maximizes profits while investors maximize their utility. In equilibrium both the market maker and investors are able to satisfy the condition for maximization. The market maker decision on fees at a given equilibrium price P must correspond to a quantity demanded by the investors in order that the stock market clears.

3 Limit order book versus market maker

In this section the two market structures are compared numerically. Due to the complexity of the problem, we are not able to perform an analytical comparison. Even in the competitive equilibrium case with no market maker, the equilibrium requires that the two types of investors maximize their utility under the rational conjecture of knowing the volume in the market. This results in a system of non-linear equations, which we are not aware of ways to solve analytically. The market maker problem results in even a more complex system of non-linear equations. We believe that this does not reduce from the analysis because our objective is to see whether cases of market maker structure superiority exist. Under such circumstances, numerical simulations are sufficient to show that under some parameter values a market maker structure can achieve a second best and improve the welfare of all the investors. Without loss of generality we normalize the intrinsic value of the stock A, the amount of shares $\overline{X}$, and the amount of cash $\overline{C}$ to 1. The volume-liquidity variables α and β and the market maker cost parameter γ are chosen as to be $\alpha = 0.3$, $\beta = 0.6$, $\gamma = 50$.

We also assume that investors have a log utility function. After deriving the equilibrium variables (X_1, X_2, P) in the competitive limit book and the equilibrium variables (X_1, $X_2, P, \varepsilon_1, \varepsilon_2$) in the market maker structure, we compare the expected utilities of the two aggregate investors in the two market structures.

3.1 Equilibrium results

Figures 3, 4, and 4 show the numerical results. All of the tables are tabulated in the Edgeworth trade box format. This means that the numerical results in a specific box are the equilibrium results for initial endowments (before trade) that correspond to that specific box. Since the trade box is symmetric we provide only the numerical results for initial endowments beneath the diagonal. Figure 3 shows the equilibrium price in the limit order book structure and the market maker structure. One can see that in the limit order book structure the equilibrium price is an increasing function of the distance from the diagonal. The initial endowments distance from the diagonal affect on price is very significant. The difference in price between endowments on the diagonal (corresponding to $P = .875$) to endowments very far from the diagonal (corresponding to $P = .958$) is 9.5%. In the limit order book structure, volume is considered as exogenous and if there is much risk sharing between the investors, there is more trade which results in a higher equilibrium price for the stock. Contrary to this, in the market maker structure the price of the stock does not in general depend on the distance from the diagonal. What is important for the equilibrium price is the initial wealth distribution. One can observe that the price is higher when moving down and to the left. The wealthier are the buyers of the stock, and the poorer are the sellers of the stock, the higher is the equilibrium price of the stock. When the buyers are relatively poor (endowed with a small fraction of the risky asset and cash), they are not enthusiastic about increasing their trading activity to increase the liquidity in the market. Since they hold a small fraction of the risky asset, increased liquidity is not important to them. On the other hand, the sellers of the stock are relatively wealthy and value liquidity. In order to satisfy both parties the price of the risky asset must be low. Under some circumstances, the price in the market maker structure with the increased liquidity is lower than in the limit order book structure (see upper right corner of figure 3). Figure 4 shows the equilibrium volume in both market structures. One can see that in the limit order book structure volume depends solely on the distance from the diagonal. On the contrary, in the market maker structure, the market maker drives volume up if investors are initially close to the diagonal. The closer investors are to the diagonal, the more the excess volume the market maker generates compared to the limit order book structure. Figure 5 shows how the fee increases as we move away from the diagonal. The monopolist market maker knows that there is a high need for risk-sharing in the economy; and he uses that to his advantage by raising the fees. One can also see that in the lower right corner of the Edgeworth trade box, the market maker structure exhibits only a marginally higher volume compared to the limit order book structure.

The question of whether a market maker structure is efficient or not comes down to a comparison of utilities. The results of this comparison are shown in Figure 6. Note that

Price - Limit order book structure

← $\overline{X}_2$

$\overline{C}_2$ ↓

0.950																			0.875
0.900																		0.875	0.884
0.850																	0.875	0.884	0.893
0.800																0.875	0.884	0.893	0.900
0.750															0.875	0.884	0.893	0.900	0.907
0.700														0.875	0.884	0.893	0.900	0.907	0.913
0.650													0.875	0.884	0.893	0.900	0.907	0.913	0.919
0.600												0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924
0.550											0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928
0.500										0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933
0.450									0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937
0.400								0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937	0.940
0.350							0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937	0.940	0.943
0.300						0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937	0.940	0.943	0.946
0.250					0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937	0.940	0.943	0.946	0.949
0.200				0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937	0.940	0.943	0.946	0.949	0.952
0.150			0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937	0.940	0.943	0.946	0.949	0.952	0.954
0.100		0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937	0.940	0.943	0.946	0.949	0.952	0.954	0.956
0.050	0.875	0.884	0.893	0.900	0.907	0.913	0.919	0.924	0.928	0.933	0.937	0.940	0.943	0.946	0.949	0.952	0.954	0.956	0.958
	0.050	**0.100**	**0.150**	**0.200**	**0.250**	**0.300**	**0.350**	**0.400**	**0.450**	**0.500**	**0.550**	**0.600**	**0.650**	**0.700**	**0.750**	**0.800**	**0.850**	**0.900**	**0.950**

↑ $\overline{C}_1$

$\overline{X}_1$ →

Price - Market maker structure

← $\overline{X}_2$

$\overline{C}_2$ ↓

0.950																			0.826
0.900																		0.851	0.851
0.850																	0.871	0.871	0.871
0.800																0.887	0.887	0.887	0.887
0.750															0.899	0.899	0.899	0.899	0.900
0.700														0.909	0.909	0.909	0.909	0.910	0.910
0.650													0.917	0.917	0.917	0.917	0.917	0.918	0.919
0.600												0.924	0.924	0.924	0.924	0.924	0.924	0.925	0.926
0.550											0.930	0.930	0.930	0.930	0.930	0.930	0.930	0.931	0.931
0.500										0.936	0.935	0.935	0.934	0.934	0.935	0.935	0.935	0.936	0.936
0.450									0.940	0.940	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.940	0.941
0.400								0.944	0.944	0.943	0.943	0.942	0.942	0.942	0.943	0.943	0.943	0.944	0.944
0.350							0.948	0.947	0.947	0.946	0.946	0.946	0.946	0.946	0.946	0.946	0.946	0.947	0.947
0.300						0.952	0.951	0.950	0.949	0.949	0.949	0.948	0.948	0.948	0.949	0.949	0.949	0.950	0.950
0.250					0.955	0.954	0.953	0.952	0.952	0.951	0.951	0.951	0.951	0.951	0.951	0.951	0.952	0.952	0.952
0.200				0.959	0.957	0.956	0.955	0.954	0.954	0.954	0.953	0.953	0.953	0.953	0.953	0.953	0.954	0.954	0.955
0.150			0.962	0.960	0.959	0.958	0.957	0.956	0.956	0.956	0.955	0.955	0.955	0.955	0.955	0.955	0.956	0.956	0.956
0.100		0.966	0.964	0.962	0.961	0.960	0.959	0.958	0.958	0.957	0.957	0.957	0.957	0.957	0.957	0.957	0.957	0.958	0.958
0.050	0.971	0.967	0.965	0.963	0.962	0.961	0.960	0.960	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.960
	0.050	**0.100**	**0.150**	**0.200**	**0.250**	**0.300**	**0.350**	**0.400**	**0.450**	**0.500**	**0.550**	**0.600**	**0.650**	**0.700**	**0.750**	**0.800**	**0.850**	**0.900**	**0.950**

↑ $\overline{C}_1$

$\overline{X}_1$ →

Figure 3: The equilibrium price of the risky asset in the limit order book structure and the market maker structure.

V_0 – **Volume - Limit order book structure**

$\leftarrow \bar{X}_2$

$\bar{C}_2 \downarrow$

0.950																			0.000
0.900																		0.000	0.023
0.850																	0.000	0.023	0.047
0.800																0.000	0.023	0.047	0.071
0.750															0.000	0.023	0.047	0.071	0.095
0.700														0.000	0.023	0.047	0.071	0.095	0.119
0.650													0.000	0.023	0.047	0.071	0.095	0.119	0.144
0.600												0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168
0.550											0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193
0.500										0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217
0.450									0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242
0.400								0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242	0.267
0.350							0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242	0.267	0.291
0.300						0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242	0.267	0.291	0.316
0.250					0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242	0.267	0.291	0.316	0.341
0.200				0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242	0.267	0.291	0.316	0.341	0.366
0.150			0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242	0.267	0.291	0.316	0.341	0.366	0.391
0.100		0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242	0.267	0.291	0.316	0.341	0.366	0.391	0.416
0.050	0.000	0.023	0.047	0.071	0.095	0.119	0.144	0.168	0.193	0.217	0.242	0.267	0.291	0.316	0.341	0.366	0.391	0.416	0.440
	0.050	**0.100**	**0.150**	**0.200**	**0.250**	**0.300**	**0.350**	**0.400**	**0.450**	**0.500**	**0.550**	**0.600**	**0.650**	**0.700**	**0.750**	**0.800**	**0.850**	**0.900**	**0.950**

$\uparrow \bar{C}_1$

$\bar{X}_1 \rightarrow$

Volume - Market maker structure

$\leftarrow \bar{X}_2$

$\bar{C}_2 \downarrow$

0.950																			0.030
0.900																		0.057	0.066
0.850																	0.079	0.090	0.101
0.800																0.098	0.110	0.121	0.133
0.750															0.114	0.126	0.138	0.150	0.163
0.700														0.126	0.139	0.152	0.165	0.178	0.191
0.650													0.136	0.149	0.163	0.176	0.190	0.203	0.217
0.600												0.142	0.157	0.171	0.185	0.199	0.213	0.227	0.242
0.550											0.147	0.162	0.177	0.192	0.207	0.221	0.236	0.250	0.265
0.500										0.149	0.165	0.181	0.196	0.212	0.227	0.242	0.257	0.272	0.287
0.450									0.148	0.165	0.182	0.199	0.215	0.231	0.246	0.262	0.277	0.292	0.308
0.400								0.145	0.164	0.182	0.199	0.216	0.233	0.249	0.265	0.281	0.297	0.312	0.328
0.350							0.140	0.160	0.179	0.198	0.216	0.233	0.250	0.267	0.283	0.299	0.315	0.331	0.347
0.300						0.132	0.154	0.174	0.194	0.213	0.232	0.250	0.267	0.284	0.301	0.317	0.333	0.349	0.365
0.250					0.121	0.145	0.167	0.189	0.209	0.229	0.248	0.266	0.284	0.301	0.318	0.334	0.351	0.367	0.383
0.200				0.106	0.133	0.157	0.181	0.203	0.224	0.244	0.263	0.282	0.300	0.318	0.335	0.351	0.368	0.384	0.400
0.150			0.088	0.117	0.144	0.170	0.194	0.217	0.239	0.259	0.279	0.298	0.316	0.334	0.351	0.368	0.384	0.401	0.417
0.100		0.065	0.097	0.128	0.156	0.182	0.207	0.231	0.253	0.274	0.294	0.314	0.332	0.350	0.368	0.384	0.401	0.417	0.433
0.050	0.036	0.073	0.107	0.138	0.168	0.195	0.221	0.245	0.268	0.289	0.310	0.330	0.348	0.366	0.384	0.401	0.417	0.434	0.450
	0.050	**0.100**	**0.150**	**0.200**	**0.250**	**0.300**	**0.350**	**0.400**	**0.450**	**0.500**	**0.550**	**0.600**	**0.650**	**0.700**	**0.750**	**0.800**	**0.850**	**0.900**	**0.950**

$\uparrow \bar{C}_1$

$\bar{X}_1 \rightarrow$

Figure 4: Volume in the limit order book structure and the market maker structure.

$\mathcal{E}$ — **Market maker fee**

← $\overline{X}_2$

$\overline{C}_2$ ↓

0.950																			0.001
0.900																		0.001	0.001
0.850																	0.001	0.002	0.002
0.800																0.002	0.002	0.002	0.002
0.750															0.002	0.002	0.002	0.003	0.003
0.700														0.002	0.003	0.003	0.003	0.003	0.003
0.650													0.002	0.003	0.003	0.003	0.003	0.004	0.004
0.600												0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004
0.550											0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005
0.500										0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.005
0.450									0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006
0.400								0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006
0.350							0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007
0.300						0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007
0.250					0.002	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007
0.200				0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008
0.150			0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008
0.100		0.001	0.002	0.002	0.003	0.004	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008
0.050	0.001	0.001	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.009
	0.050	**0.100**	**0.150**	**0.200**	**0.250**	**0.300**	**0.350**	**0.400**	**0.450**	**0.500**	**0.550**	**0.600**	**0.650**	**0.700**	**0.750**	**0.800**	**0.850**	**0.900**	**0.950**

↑ $\overline{C}_1$

$\overline{X}_1$ →

Figure 5: Fee in the market maker structure.

the trade box is symmetric from both sides of the diagonal. The figure shows that there is one region where a monopolist market maker structure Pareto Dominates the limit order book structure. The region is close to the diagonal where the volume generated in a market with a limit order book structure is small. Region 1 represents initial endowments in which investors of type 1 are better off with a market maker structure, while investors of type 2 are better off with a limit order book structure. Region 2 represents initial endowments in which investors of type 2 are better off with a market maker structure, while investors of type 1 are better off with a limit order book structure. Finally, the white region represents initial endowments in which the limit order book structure is the efficient trading structure. In this region, the investors would not have traded more with a monopolist market maker than without one. In this area there is much volume generated by the risk sharing criterion of simply moving to the diagonal and this reduces most of the future liquidity risk. The ability of the market maker to charge high fees for trade that was going to be generated anyway results in a utility loss for both investors in the market maker structure.

4 Discussion

Our analysis shows that a monopolist market maker can increase welfare and reduce the liquidity risk only in markets where there is not a high need for risk sharing. Only in these markets, the resulting equilibrium trade volume is not sufficient to reduce the liquidity risk. Thus, the need for market makers arises only in economies where risk sharing needs alone do not generate enough volume to reduce liquidity risk to a sufficient level. This result allows us to arrive at the following empirical hypothesis: A monopolist market maker structure is efficient for shares that are mostly held by ordinary shareholders, while the limit order book structure is justified for shares that have a higher percentage holding by the controlling shareholders. In other words, if controlling shareholders hold a high percentage of the equity in an economy, there is high opportunity for risk sharing. Therefore, a market maker structure is not efficient. This implies that shares traded on the NYSE should be mostly held by ordinary investors who invest in shares either directly or through institutional investors for diversification reasons. Conversely, in the limit order book structure, we would expect to see shares with a high percentage of holding by the controlling shareholders. One can also think about this interpretation in terms of a life-cycle of a public firm. We would expect more cases of initial public offering in a competitive limit order book structure market. With time, as the controlling shareholders hold less of the total amount of shares, excess volume generating becomes more important, so when the company becomes mature and widely held, the monopolist market maker structure becomes desirable which can lead companies to move to exchanges such as the NYSE.

4.1 Policy implications

The policy implication for the regulators is that there are benefits to a monopolist structure compared to the competitive structure. In broad terms, if one agrees that liquidity has

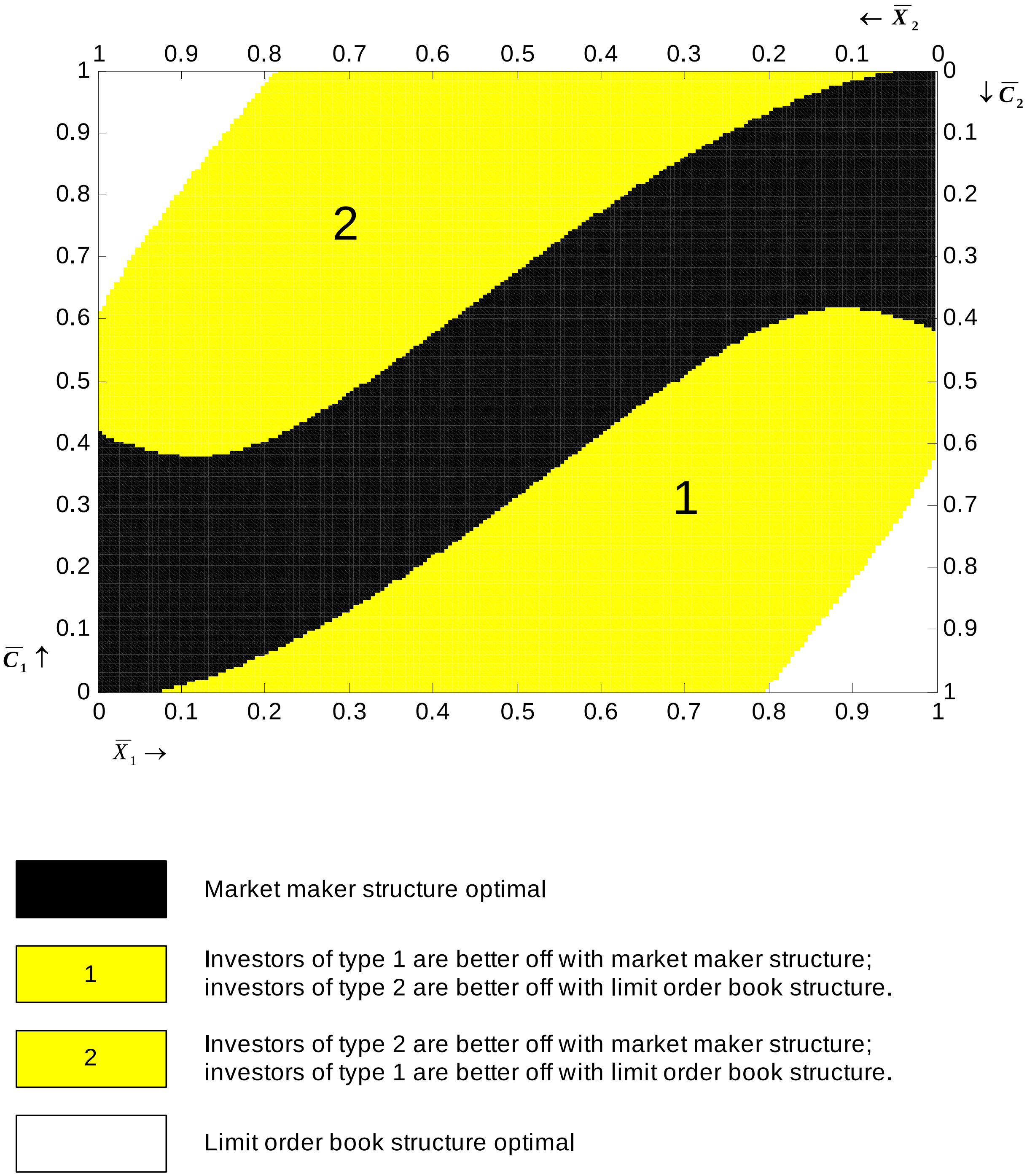

Figure 6: Welfare comparison between the limit order book trade structure and the market maker trade structure.

the property of a public good, then a non-competitive trading environment can reduce this negative externality. This means that the NYSE specialist structure might be efficient if liquidity is an important issue.

As for more competitive environments of market makers such as Nasdaq, it is important to realize, that even though it is commonly stressed that a competitive environment is good for investors, it may also reduce the liquidity in the market. In a speech in June 2003 before the Securities Industry Association Market Structure Conference, entitled "Market Structure and the Future of Competition," Nasdaq President and Chief Executive Officer Robert Greifeld said, "I suggest we should be doing more to take advantage of the ways an electronic system can improve execution. In today's environment, with competitive markets, we should not let the slower market centers hold up the entire market or limit choice." We do not wish to argue against the promotion of an environment of competition, however, the increased competition agenda should be considered in light of the negative externalities that are discussed in this essay. It is important to realize that looking at the fee charged in financial market is only one half of the picture. The other half should consider what is given for that fee. The empirical fact that market makers are only present in developed economies (Unites States, United Kingdom, Canada) is consistent with the idea that investors in these countries are more diversified than the investors in most other countries, where the majority of shares are still held by few undiversified investors.

5 Conclusion

There are a few empirical studies that are consistent with the notion that the regulators decision on the type of exchange structure matters. These studies show that the choice of exchange structure can influence both the pricing and the volume of the securities traded. The NYSE points to the "specialist system" as a superior form of market organization, citing the "increased liquidity" in its promotional literature. On the other hand, it is rather hard to find an exchange with a limit order book trading structure promoting its services due to its increased liquidity. Compatible with this notion, the theory developed in this study suggests that since volume affects the visibility of a stock, a monopolist market maker structure can increase liquidity of a stock compared to a competitive limit order book market structure. A monopolist market maker can solve a free-rider problem that occurs when individual investors do not take into account their own trade effect on market liquidity.

When comparing the monopolist market maker structure and the limit order book structure it is found that the initial endowments of the investors play an important role. Depending on the opportunity for risk sharing that is present in the economy; a monopolist market maker structure can be efficient. By dividing the economy into two group of investors representing the ordinary shareholders and the controlling shareholders, we are able derive some empirical implications concerning the optimality of the market structure.

Bibliography

Admati, A., Pfleiderer, P., “A Theory of Intraday Patterns: Volume and Price Variability”, *Review of Financial Studies* 1, 1988, 3-40.

Amihud, Y., Mendelson, H., “Asset Pricing and the Bid-Ask Spread”, *Journal of Financial Economics 17*, 1986, 223-249.

Amihud, Y., Mendelson, H., “The Effects of Beta, Bid-Ask Spread, Residual Risk and Size on Stock Returns”, *Journal of Finance* 44, 1989, 479-486.

Amihud, Y., Mendelson, H., “Liquidity, Maturity and the Yields on U.S. Treasury Securities”, *Journal of Finance* 46, 1991, 1411-1425.

Arbel, A., “Generic Stocks: An Old Product in a New Package”, *Journal of Portfolio Management* 11, 1985, 4-13.

Arbel, A., Sterbel, P., “The Neglected and Small Firm Effects”, *Financial Review* 17, 1983, 201-218.

Biais, B., Glosten, L., Spatt, C., “The Microstructure of Stock Markets”, Unpublished working paper, 2002, Université de Toulouse.

Breen, W., Hodrick, L., Korajczyk, R., “The Determinants of Equity Illiquidity”, Unpublished working paper, 1999, Northwestern University.

Brennan, M., Chordia, T., Subrahmanyam, A., ”Alternative Factor Specifications, Security Characteristics, and the Cross-Section of Expected Stock Returns”, *Journal of Financial Economics* 49, 1998, 345-373.

Brennan, M., Subrahmanyam, A., “Market Microstructure and Asset Pricing: On the Compensation for Illiquidity in Stock Returns”, *Journal of Financial Economics* 41, 1996, 441-464.

Brusco, S., Jackson, M., “The Optimal Design of a Market”, *Journal of Economic Theory* 99, 1999, 1-39.

Constantinides, G., “Capital Market Equilibrium with Transaction Costs”, *Journal of Political Economy* 94, 1986, 842-862.

Copeland, T., “A Model of Asset Trading Under the Assumption of Sequential Information Arrival”, *Journal of Finance* 31, 1976, 1149-1168.

Coppejans, M., Domowitz, I., Madhavan, A., “Liquidity in an Automated Auction”, Unpublished working paper, 2002, SSRN FEN.

Dixit, A., “On Modes of Economic Governance”, *Econometrica* 71, 2003, 449-481.

Dow, J., “Is Liquidity Self-Fulfilling?, *Journal of Business* 77, 2004, 895-908.

Economides, N., Siow, A., “The Division of Markets is Limited by the Extent of Liquidity (Spatial Competition with Externalities)”, *American Economic Review* 78, 1988, 108-121.

Elul, R., “Welfare Effects of Financial Innovation in Incomplete Markets Economies with Several Consumption Goods”, *Journal of Economic Theory* 65, 1995, 43-78.

Epps, T., “Security Price Changes and Transaction Volumes: Theory and Evidence”, *American Economic Review* 65, 1975, 586-597.

Foster, D., Vishwanathan, S., “A Theory of Interday Variations in Volume, Variance, and

Trading Costs in Securities Markets", *Review of Financial Studies* 3, 1990, 593-624.

Harris, L., "Cross-Security Tests of the Mixture of Distribution Hypothesis", *Journal of Financial and Quantitative Analysis* 21, 1986, 39-46.

Harris, L., "Transactions Data Tests of the Mixture of Distributions Hypothesis", *Journal of Financial and Quantitative Analysis* 22, 1987, 127-142.

Gervais, S., Kaniel, R., Mingelgrin, D., "The High-Volume Return Premium", *Journal of Finance* 56, 2001, 877-919.

Glosten, L., "Insider Trading, Liquidity, and the Role of the Monopolist Specialist", *Journal of Business* 62, 1989, 211-235.

Glosten, L., Milgrom, P., "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders", *Journal of Financial Economics* 14, 1985, 71-100.

Heaton, J., Lucas, D., "Evaluating the Effects of Incomplete Markets on Risk Sharing and Asset Pricing", *Journal of Political Economy* 104, 1996, 443-487.

Kalay, A., Wei, L., Wohl, A., "Continuous Trading or Call Auctions: Revealed Preferences of Investors at the Tel Aviv Stock Exchange", *Journal of Finance* 57, 2002, 523-542.

Kamara, A., "Liquidity, Taxes, and Short-Term Treasury Yields", *Journal of Financial and Quantitative Analysis* 29, 1994, 403-416.

Karpoff, J., "A Theory of Trading Volume", *Journal of Finance* 41, 1986, 1069-1087.

Kyle, A., "Continuous Auctions and Insider Trading", *Econometrica* 53, 1985, 1315-1336.

Madhavan, A., "Market Microstructure: A Survey", *Journal of Financial Markets* 3, 2000, 205-258.

Merton, R., "A Simple Model of Capital Market Equilibrium with Incomplete Information", *Journal of Finance* 42, 1987, 483-510.

Pagano, M., "Trading Volume and Asset Liquidity", *Quarterly Journal of Economics*, 1989, 255-274.

Shmirlock, M., Starks, L., "A Further Examination of Stock Price Changes and Transactions Volume", *Journal of Financial Research* 7, 1985, 217-225.

Spatt, C., "Introduction to the Market Microstructure Symposium", *Review of Financial Studies* 4, 1991, 385-388.

Tauchen, G., Pitts, M., "The Price Variability-Volume Relationship on Speculative Markets", *Econometrica* 51, 485-505.

Vayanos, D., "Transaction Costs and Asset Prices: A Dynamic Equilibrium Model", *Review of Financial Studies* 11, 1998, 1-58.

Vayanos, D., Vila, J., "Equilibrium Interest Rate and Liquidity Premium with Transaction Costs", *Economic Theory* 13, 1999, 509-539.

Author profile:
Amir Rubin
Ph.D: University of British Columbia, Vancouver, 2003.
Assitant Professor of Finance, Simon Fraser University, Burnaby, Canada.