The impact of asset repurchases and issues in an experimental market

Ernan Haruvy, Charles N. Noussair, and Owen Powell*

February 2010

Abstract

We create an experimental asset market in which we conduct share repurchases and share issues. Although the intrinsic value of the shares is independent of the quantity outstanding, the interventions result in changes in asset price. We find that: (1) A repurchase of shares increases the price of the asset, and a share issue decreases the price of the asset, compared to a benchmark of no intervention. These effects are consistent with the capital structure puzzle, a negative correlation that is typically observed between the price and the supply of shares of stock. (2) The empirical patterns observed are consistent with a model proposed by DeLong et al. (1990), which posits three trader types-- fundamental, speculator, and momentum-- interacting in the market. (3) The downward pressure on prices resulting from share issues drives prices down toward, but not beyond, fundamental values. We argue that this downward resistance at the fundamental value arises from the impact of an intervention on the proportion of the total stock of units and cash held by each trader type.

1. Introduction

There is considerable evidence that market interventions in the form of share issues or repurchases can affect asset prices. On average, the price of a stock falls after a firm announces a share issue (Grinblatt and Hwang, 1989; Ritter, 1991; Loughran and Ritter, 1995; Spiess and Affleck-Graves, 1995),[1] while repurchase announcements are typically followed by increases in share prices (Masulis, 1980; Vermaelen, 1981; Bartov, 1991; Grullon and Michaely, 2004; Lie, 2005).[2] This phenomenon is referred to as the capital

*Haruvy: School of Management, University of Texas-Dallas, 800 W. Campbell Rd., Richardson, TX 75083-0688, USA. E-mail: eharuvy@utdallas.edu. Noussair: Department of Economics, Faculty of Economics and Business Administration, Tilburg University, P.O.Box 90153, 5000 LE Tilburg, The Netherlands, e-mail: C.N.Noussair@uvt.nl. Powell: Department of Economics, University Carlos III Madrid, C./ Madrid, 126, 28903 Getafe (Madrid), e-mail: opowell@gmail.com. We thank seminar participants at the Universities of Pittsburgh, Innsbruck, Sydney, Melbourne, and New South Wales, as well as attendees at the 2008 Economic Science Association meetings in Lyon, France, for helpful comments.

[1] A particularly striking recent example of this phenomenon is the recent US government takeover of Fannie Mae and Freddie Mac in September 2008. The companies faced an urgent need for liquidity to meet short term debt obligations, and attempted to float a large number of new shares. However, the act of doing so had such a large negative effect on prices that the firms' market capitalization fell dramatically. This exacerbated their liquidity crisis and precipitated the nationalization of the two companies.

[2] Typically, there is a spike in share price immediately following the repurchase announcement (Masulis, 1980). However, Lie (2005) finds that firms that merely announce a repurchase program without actually repurchasing shares are less likely to experience a subsequent performance improvement, whereas firms

structure puzzle (Stigler, 1964; Myers, 1984). However, such interventions are typically not exogenous, and the resulting price changes can usually be explained by the claim that the interventions either affect the fundamental value of the stock, or influence investors' beliefs about fundamentals. This would be the case, for example, if the choice to intervene was indicative of capital structure optimization, signaling, insider knowledge or executive compensation schemes (Mintz, 1988; Lowenstein, 1991; Bagnoli et al., 1989; Dittmar, 2000; Brav et al., 2005; Bhattacharya, 1979; Miller and Rock, 1985; Vermaelen, 1981, 1984).

On the other hand, it has been proposed that changes in the supply of shares can affect stock prices solely because some traders value the shares more than others. Thus, the greater is the supply of shares; the lower is the valuation of the marginal shareholder. This would be the case even in settings, in which the quantity of shares does not affect their fundamental value. There is evidence consistent with this notion. Shleifer (1986) finds that stocks trade at higher prices in the first ten days after their inclusion in the *S&P500* than in the next ten days, suggesting that buyers with higher valuations purchase the stock first and others with lower valuations follow. Similar conclusions have been reached by other authors (Scholes (1972), Mikkelson and Partsch (1985), Kaul et al. (2000), Wurgler and Zhuravskaya (2002), Lynch and Mendenhall (1997)), who all interpret their results as consistent with the existence of a portion of investors who have higher marginal values than others. If this is the case, share repurchases would increase, and share issues would decrease, prices, even if they do not affect fundamentals or beliefs.

In the research reported here, we use experimental methods to investigate how this latter effect might operate[3]. To do so, we strip away all of the factors that might allow a share repurchase or issue to affect the fundamental value, and study the properties

---

that follow through on their announcements continue to experience large performance improvements within two quarters, persisting for at least two years thereafter. Grullon and Michaely (2004) find increases only in the year of the announcement and not in subsequent years.

[3] Experimentally, capital structure considerations have been investigated with a focus on investors' myopic attitudes to bond and stock payoff streams (e.g., Gneezy and Potters, 1997; Eriksen and Kvaloy, 2009), as well as to differential ability of equity and debt auctions (for venture capital funding) to result in efficient outcomes in the presence of asymmetric private information (Kogan and Morgan, 2009). The experiments reported here differ from these in a number of aspects. Among the differences are that we study two-sided market trading of one asset class, we make the information regarding fundamental values common, and we focus on relative demand and supply effects in asset trading.

of the market response to an exogenous intervention. We construct markets for assets whose fundamental value is independent of the total supply of shares. We then vary the supply of shares of the asset exogenously with share repurchases and share issues. While the repurchase or share issue has no effect on the intrinsic value of the asset[4], the intervention does affect the environment in ways that, coupled with boundedly rational trader behavior, may well change outcomes. A share issue or a repurchase changes the supply of shares relative to the cash available for purchases by traders.[5] In addition, it may change the allocation of shares among individuals, and thereby affect the weight or influence that traders of different types or using different strategies exert on market activity. These effects may lead the market to exhibit a price response to an intervention.

We consider three specific issues. The first is whether repurchases and share issues affect price level in a setting in which they can have no impact on an asset's intrinsic value. The second is whether either of the interventions leads to pricing of the asset closer to its intrinsic value. The third is whether the price patterns are consistent with a particular model of bubble formation, proposed by DeLong et al. (1990) and applied to experimental data by Haruvy and Noussair (2006, hereafter HN). In the model, each trader in the market is classified as belonging to one of three possible types. The three types are (1) fundamental value traders, who purchase and sell based on differences between price and fundamentals, (2) momentum traders, who trade as if they believe that previous price trends will continue, and (3) rational speculators, who anticipate and trade on future price movements.

Specifically, the fundamental value traders increase their holdings when prices are below fundamentals and decrease their holdings when prices are above fundamentals. Fundamental value traders thus behave like rational agents in classical models, who assume that the rationality of all traders is common knowledge. The momentum traders follow historical trends, increasing their holdings when prices have been increasing in the

[4] Another way to introduce shares to the market is with a share split. A share split simply replaces each share held by investors with a fixed number of shares greater than one. The idea behind such a conversion is to increase share liquidity when individual share units are deemed too expensive for some investors. At least in principle, this action could relax constraints on purchases by cash- strapped traders. We conducted some pilot experimental sessions, which are not reported here, and found that investors quickly made full adjustments for share splits.

[5] See Caginalp et al. (1998) for a discussion of the effect of varying cash and asset endowments on bubble magnitudes.

recent past and reducing them when prices have been declining. The rational speculator accumulates holdings before prices increase and reduces holdings before prices decrease, while ignoring the difference between prices and fundamentals. These traders are rational, have correct short-term expectations about future prices, and recognize that prices will not necessarily follow fundamentals. Rational speculators are similar to the rational arbitrageurs of Abreu and Brunnermeier (2003, hereafter AB) in that they try to "ride" the bubble. However, the rational speculators have more accurate beliefs. Rational arbitrageurs in AB have dispersion of opinions (also see Morris, 1996) about the exact timing of the bubble and these differences result in lack of synchronization and the persistence of the bubble. In contrast, rational speculators in our model have identical and correct beliefs about future prices.[6]

Three empirical patterns emerging from simulations of the theoretical model serve as the hypotheses for our experiment. These patterns are the following (1) Repurchases increase prices, while share issues reduce prices. (2) Asset prices are closer to fundamentals after a share issue, and they are farther away from fundamentals after a repurchase than they would have been in the absence of an intervention. (3) A repurchase reduces the fundamental value traders' proportion of the market power, as measured by an index weighting the proportion of the total stock of shares and cash they hold. In contrast, fundamental value traders have a higher proportion of the market power after a new share issue. In the simulations, the greater market power of fundamental value traders after a share issue appears to be associated with prices tracking fundamentals more closely after a share issue.

The results of the experiment are presented in section 3. We find that the three patterns described above appear prominently in our data. (1) Prices are greater after a

[6] A similar model with three trader types was applied to experimental data by Caginalp and Ilieva (2008, hereafter CI). In the CI model, traders were classified into momentum traders, fundamental value traders, and neutral traders. The first two types correspond to the types of the same name discussed above. The neutral trader is essentially a catch-all category for those traders that could not be classified as the first two types. Rational speculators were not assigned a separate category. There are also two main implementation issues that differ between the HN and CI models. The first is that the HN classification looks at a trader's executed trades whereas CI classifies according to offers to buy and sell. The second is that HN classify a trader as belonging to the same type throughout the life of the asset, whereas CI allows a trader to switch type in each period. Each method comes with advantages and disadvantages but the HN classification permits simple simulations along the lines of DeLong et al. (1990), and this is an important component of our research strategy.

repurchase than after a share issue. (2) The absolute difference between prices and fundamentals is greater after a repurchase than after a share issue. (3) The interventions alter the weight that fundamental value traders have in the market. A repurchase reduces the market power of fundamental value types, while a share issue does the opposite. The greater weight that fundamental value traders have after a share issue appears to account for the strong tendency for prices to closely track fundamentals after the share issue. This conjecture is supported, in section 4.3, with additional simulations of interventions of different sizes.

2. Theory and Hypotheses

2.1. The General Setting

We construct a simple market where the effect of changing the supply of shares can be studied. The structure of the market is based on the paradigm created and studied in Smith et al. (1988).[7] The asset that is exchanged in the market has a finite lifespan of T periods. At the end of each period $t \in \{1,...,T\}$, the asset pays a dividend d_t that is independently drawn from a distribution that is identical for all periods and units of the asset. Thus, in any period t the expected dividend $E(d_t)$ on a unit of the asset is equal to the expected value of the dividend distribution. Because the dividends are drawn independently in each period, the expected future dividend stream at time t, $E[\sum_{t}^{T} d_t]$, equals the expected period dividend multiplied by the number of periods remaining in the life of the asset, so that $E[\sum_{t}^{T} d_t] = (T - t + 1)E(d_t)$. Since dividends are the only source of intrinsic value for the asset, the fundamental value f_t of the asset at time t equals the expected future dividend stream. In other words $f_t = (T - t + 1)E(d_t)$. In the present set of experiments, the life of the asset is $T = 15$. The dividend is $d_t \in \{0,8,28,60\}$, where each realization is equally likely, for all t, so that $E(d_t) = 24$. Therefore $f_t = 24(16 - t) = 384 - 24\,t$ at time t.

[7] The paradigm was first examined by Smith et al. (1988) has been used in much of the subsequent experimental literature on long-lived asset markets. See for example Porter and Smith (1995), Van Boening et al. (1993) Lei et al. (2001), Dufwenberg et al. (2005), Haruvy et al. (2007) or Hussam et al. (2008).

A market for the asset exists and is populated by a set of N traders. Each trader i begins each period t with inventories of shares s_{it} and cash c_{it}. These inventories are also equal to the shares and cash that player i holds at the end of period t-*1*, after the dividend for period t-1 has been paid. In each period any trader has the ability to exchange units of the asset for cash with any other trader in an open market provided that he always maintains non-negative cash and share balances.

The design, described in more detail in section three, consists of three treatments: the *Benchmark* treatment in which no external intervention takes place, the *Repurchase* treatment where a share repurchase occurs, and the *Share Issue* treatment where additional shares are sold into the market. In the Repurchase treatment, an intervention occurs at time t*,* in which $\frac{1}{2}\sum_i s_{it^*}$, one-half of the total stock of units that all traders hold, is purchased. In the Share Issue treatment, an intervention occurs at time t^* as well, when $\frac{1}{2}\sum_i s_{it^*}$ additional shares are sold to traders. Thus the Repurchase and the Share Issue represent interventions of equal size. In our experiment $t^* = 6$, so that the intervention takes place just after one third of the life of the asset has elapsed.[8]

2.2. The Model

Consider a non-exhaustive classification of traders into the following three types:

1) *Fundamental Value Traders* (FV): These traders increase (decrease) share holdings when median price is below (above) fundamental value.[9]
2) *Momentum Traders* (MM): These traders increase (decrease) share holdings in response to an upward (downward) price trend in the recent past.

[8] The subjects know that an intervention will occur in some future period but do not know the period t^* in which the intervention will happen. Prior knowledge of t^* would have, at least in principle, permitted coordination by subjects, thus fundamentally changing the nature of the market. For example, Abreu and Brunnermeier (2003) argue that news events at a defined future point make it possible for rational speculators to synchronize their exit strategies.

[9] DeLong et al. (1990) and Haruvy and Noussair (2006) referred to this type of trader as a Passive Trader. However, for clarity, we employ the term Fundamental Value trader in this paper.

3) *Rational Speculators* (RA): These traders correctly anticipate the next period's price movement. If the price move is upward (downward), they increase (decrease) holdings of shares.

The simulation model has the following features. The demand function of the *momentum traders* in period t is of the form $-\delta + \beta(p_{t-1} - p_{t-2})$, where p_{t-1} and p_{t-2} are the average transaction prices in periods t-1 and t-2, and δ and β are parameters. The demand function of the *fundamental value traders* is $-\alpha(p_t - f_t)$. Finally, the *rational speculator*, who has demand given by $\gamma(E(p_{t+1}) - p_t)$, trades based on the difference between the expected price in the next period and the current spot price. We set $E(p_{t+1}) = p_{t+1}$ and thus assume that speculators have correct expectations of the next period's price. The simulation has four demand parameters denoted by δ, β, α, and γ.

The simulations presented in figures 1 and 2, which are used as the basis for the null hypotheses for the experiment, assume the parameter values and proportions of trader types estimated in Haruvy and Noussair (2006). The parameter values were estimated by minimizing the distance between the simulated price patterns and actual data in their experiment.[10] The values are α=0.75, β=0.13, γ=0.55, and δ=0.48. The proportions of trader types are 0.33, 0.42, and 0.25, for fundamental value, momentum and rational speculators respectively.

Each set of market simulations includes 150 repetitions, or 150 groups of nine simulated traders. Traders are drawn at random from the three types with a probability corresponding to their assumed proportions. Each trader begins period 1 with the initial endowment of money and shares allocated to him in the current experiment. Next, there is a grid search on prices in each period. Prices are determined by setting net demand equal to zero (equating demand and supply). The price is adjusted until the net excess demand equals zero. We solve for period prices one by one, proceeding sequentially.

[10] Haruvy and Noussair (2006) assume that their markets are characterized by the interaction of the three types postulated by DeLong et al. (1990). They find that the model can explain the price patterns emerging from the relaxation of short selling constraints, as well as price patterns following the infusion of cash into the market. Specifically, they study conditions where traders could sell stocks short under different short-sale and cash reserve constraints. They also study conditions where cash in the system is multiplied by 10 over baseline levels. In general, loosening of short selling constraints lowers prices and increasing cash balances raises prices.

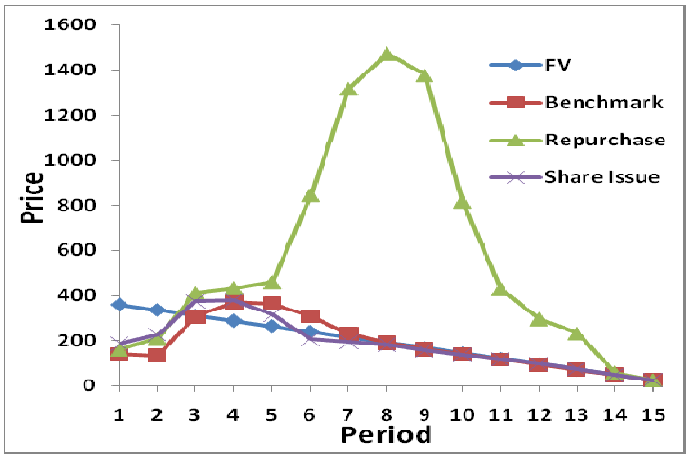
There are two iterations through the 15 periods to solve for prices. The first iteration determines the beliefs of the speculators; the second iteration solves for the actual prices. Figures 1 and 2 show the average value of some key variables over the 150 simulated markets.[11]

2.3. Hypotheses

Figure 1 shows the results of simulations of the market price patterns for the three treatments. The vertical axis indicates the price level and the horizontal axis the market period. The Benchmark treatment produces a bubble lasting from period 4 until period 7. The Share Issue treatment shows a decrease in price at the time of the intervention in period 6 to below fundamental values, but tracks fundamentals closely afterwards. The Repurchase treatment exhibits an acceleration of the bubble at the time of the intervention, and a market crash beginning in period 10. The figure shows that the model produces the price patterns associated with the Capital Structure Puzzle. A share issue lowers prices whereas a repurchase increases prices, compared to the levels at which they would have been in the absence of the intervention.

[11] Periods 1 and 2 are fixed at empirical values (the actual average values observed in the experimental treatment that is simulated). The price in period 15 is assumed to be 24, the period 15 fundamental value. These restrictions are necessary because the momentum types take prices in the two prior periods as exogenous and the rational speculator type takes the price one period ahead as exogenous.

Figure 1: Prices in Simulated Markets Corresponding to the Three Treatments



To measure overall price level, we employ a metric called *Total Bias*. We define *Total Bias* as

$$Total\ Bias = \sum_{t=1}^{T} (p_t - f_t) \qquad (1)$$

where p_t and f_t, respectively, indicate the median transaction price and the fundamental value in period t. A positive Total Bias corresponds to prices that exceed fundamental values on average over the life of the asset, and a negative Total Bias indicates that prices are lower than fundamentals on average. Greater bias in one market than another indicates a higher price level relative to fundamental value in the first market. The Total Bias measure is used to test our first hypothesis, that share repurchases increase prices and share issues lower prices, relative to the Benchmark treatment.

Hypothesis 1: Repurchases lead to higher prices, and share issues lead to lower prices, than would have existed in the absence of the intervention. That is, *Total Bias (Repurchase treatment) > Total Bias (Benchmark treatment) > Total Bias (Share Issue treatment).*

Another pattern that appears in figure 1 is that the treatments differ in how far prices diverge from fundamentals. The figure suggests that pricing is on average closer to fundamental values in the Share Issue treatment than in the Benchmark treatment, which is in turn closer than in the Repurchase treatment. To test the hypothesis that different

treatments differ in this type of mispricing, we employ a measure of proximity to fundamental values. The measure is called the *Total Dispersion* of prices in a market and it is defined as:

$$Total\ Dispersion = \sum_{t=1}^{T} \left| p_t - f_t \right|. \qquad (2)$$

Hypothesis 2: The share issue moves prices closer to fundamental value, while the repurchase moves prices farther away from fundamentals, than they would be in the absence of an intervention. ***Total Dispersion (Repurchase treatment) > Total Dispersion (Benchmark treatment) > Total Dispersion (Share Issue treatment)***

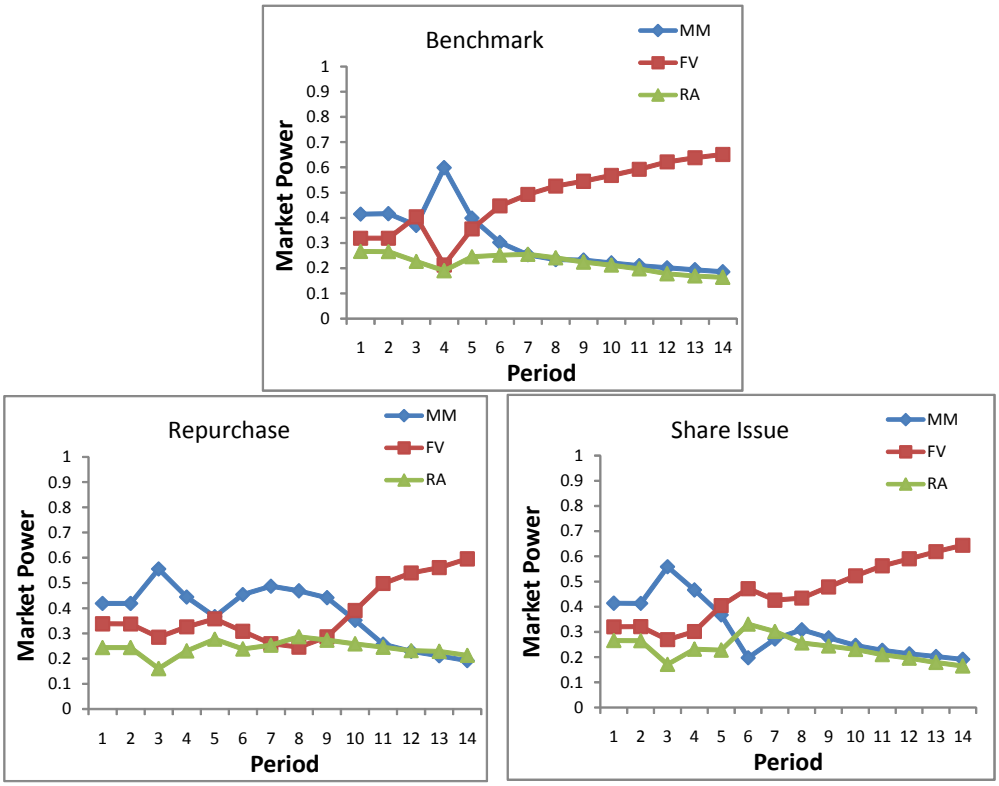
The simulations suggest that in the Share Issue treatment, prices tend to track fundamental values fairly closely. Closer inspection of the allocation of cash and share inventories held by individuals of each type suggests that this pattern appears to be related to the fact that an intervention exerts an effect on the relative market influence of the three trader types. If a share issue shifts influence away from momentum traders and toward fundamental value traders, this provides a plausible account for the ability of the share issue to reduce mispricing. If the opposite effects occur after a share repurchase, that momentum traders gain influence and fundamental value traders lose influence, this would provide an account of how the share repurchase could exacerbate the bubble.

Consider the following measure of the market power of subject *i* in period *t*:

$$Power_{i,t} = 0.5(s_{it} / s_t) + 0.5(c_{it} / c_t) \qquad (3)$$

where s_t and c_t indicate total shares and cash in period *t*, respectively. The measure is a convex combination of subject *i*'s relative share of the total cash and stock available in the period, with equal weight on each dimension. We use this measure to study whether differences in price paths between treatments can be explained by a reallocation of market influence among trader types as a consequence of an intervention.

Figures 2a – 2c: Market Power in Simulations Corresponding to the Three Treatments



Figures 2a – 2c illustrate the evolution of market power of the three types of trader in each of the three sets of simulations. The vertical axis indicates the total market power of all agents of each type, and the horizontal axis is the market period. To understand the patterns in figures 2a-c, recall the dynamics of the typical bubble price pattern as displayed in figure 1. Also bear in mind that purchases at low prices and sales at high prices increase a trader's relative market power.

In the early periods of each treatment, momentum traders tend to increase their market power as they purchase shares aggressively at low prices. In the Benchmark treatment, however, after a bubble forms, the MM traders make purchases from fundamental value traders at high prices, reducing their power, while increasing the power of FV traders. As prices fall and the market operates near fundamentals for the remainder of the life of the asset, FV traders steadily accumulate market power, since they only make trades that are profitable on average.

In the Repurchase treatment, the intervention increases the market power of MM traders and decreases that of FV traders as a large bubble forms. At the time of the

intervention, the fundamental value traders quickly run out of shares and prices continue to rise in response to the demand generated by the repurchase. The momentum traders, however, hold out for higher prices and thus sell to the experimenter near the top of the bubble, increasing their market power. However, after the intervention is completed, the MM traders return to making unprofitable purchases at high prices, leading to a reduction in their market power.

Under a Share Issue, the intervention causes an increase in the market power of FV traders and a decrease in that of MMs. The intervention supplies new shares to the market, lowering the market price to a level below fundamentals. The FV traders purchase the bulk of these units, and do so at favorable prices. RA traders also purchase some of the units as they anticipate the subsequent increase in price to fundamentals, but MM traders miss out on the bargain. These shares generate cash dividends, so the fundamental value traders have large and increasing quantities of both cash and shares to keep the market from deviating too far from fundamentals for the remainder of the life of the asset. As the market operates close to fundamentals, FV traders steadily accumulate market power by receiving dividends and by taking advantage of small price fluctuations. Hypothesis 3 posits that in the experiment, the share of the market power of fundamental value traders will exhibit similar differences between treatments as in the simulations.

Hypothesis 3. Over the life of the asset, the average market power of Fundamental Value traders is lowest under the Repurchase treatment. The Market Power of Fundamental Value traders is greatest under the Share Issue treatment.

3. Experimental Design

Our dataset consists of six sessions conducted under each treatment, for a total of 18 sessions[12]. Four sessions of each treatment were conducted at Tilburg University, and two at the University of Texas at Dallas. Subjects were recruited via an online system and through posters and announcements. No subject participated in more than one session of this experiment. On average, the sessions lasted 2 hours. Table 1 provides a summary of

[12] Two sessions only included 8 subjects. Nevertheless, on average the number of initial shares and cash per subject were the same in all sessions.

the parameter choices for the experiment.[13] The market was computerized and used continuous double auction trading rules implemented with the z-Tree computer program (Fischbacher, 2007) developed at the University of Zurich.

Upon arrival in a session, subjects were trained in making purchases and sales in the z-Tree program. The training phase did not count toward final earnings. Subjects were then assigned one of three possible initial portfolios of cash and shares and the market for the asset was conducted. Subjects received a participation fee in addition to any earnings they had received in the asset market (converted to Euros or US dollars at predetermined exchange rates).

The implementation of the interventions operated as follows. In period 6, an intervention occurred in the Share Issue and Repurchase treatments, but not in the Benchmark treatment. In the *Share Issue* (*Repurchase*) intervention, the computerized firm received a trading requirement that involved selling (buying) a certain number, equal to 50% of the total stock of units, of shares to (from) the market. The computerized firm then participated in the market until its target had been achieved. To achieve its target, the computerized firm periodically (every 5 seconds) checked whether the bid-ask spread was above or below a certain threshold. If the bid-ask spread was above the threshold, the firm placed a new offer to sell (buy) for one unit that was lower (higher) than the current best standing offer to sell (buy) by the amount of the threshold (set to 10 francs, units of experimental currency). Otherwise the firm accepted the best standing offer to buy (sell). The parametric structure of the markets and interventions is summarized in table 1.

[13] These were identical to those used in Smith et al. (1988) for their "design 4" parameterization, but with initial endowments of shares of each individual doubled, and units denominated in terms of "francs", an experimental currency, rather than in terms of cents.

Table 1. Experimental Parameters

Period length	240 seconds
Dividend distribution	A four-point distribution of 0, 8, 28 and 60 francs, with equal probability.
Expected period dividend	24 francs
Fundamental value at time *t*	24*(16 – *t*) francs
Initial portfolios	Portfolio 1: 6 shares and 450 francs. Portfolio 2: 4 shares and 1170 francs. Portfolio 3: 2 shares and 1890 francs.
Exchange rate	170 francs = 1 Euro or 150 francs = 1 US dollar.
Number of periods, *T*	15
Number of traders, *N*	9
Length of time between firm actions	5 seconds
Bid-ask spread threshold	10 francs
Time of intervention start, *t**	Beginning of Period 6

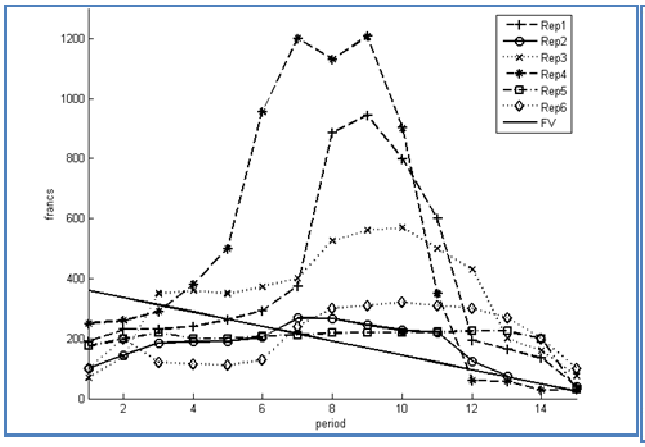
4. Results

4.1. Price patterns

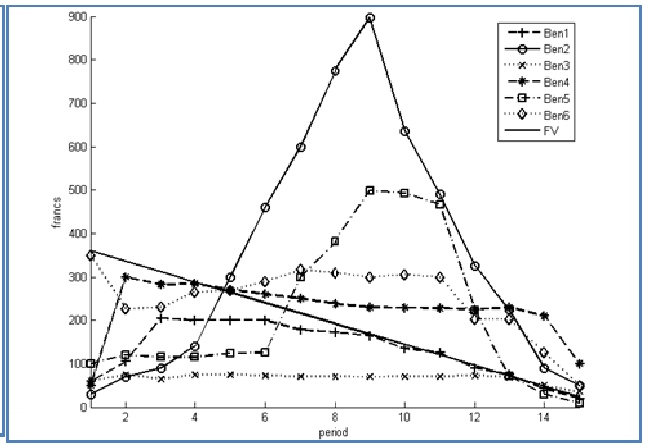
Figure 3 illustrates the median transaction price by period in each session, along with the fundamental value. Each of panels (a)-(c) corresponds to one of the treatments. Within each panel, one time series represents the fundamental value and the others each represent prices in one session. Panel (d) presents the averages over the six sessions of each treatment.

Figure 3: Median period prices, all sessions of each treatment

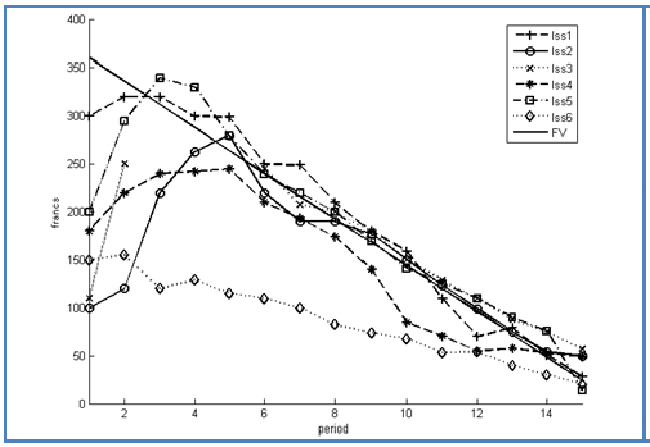
Repurchase



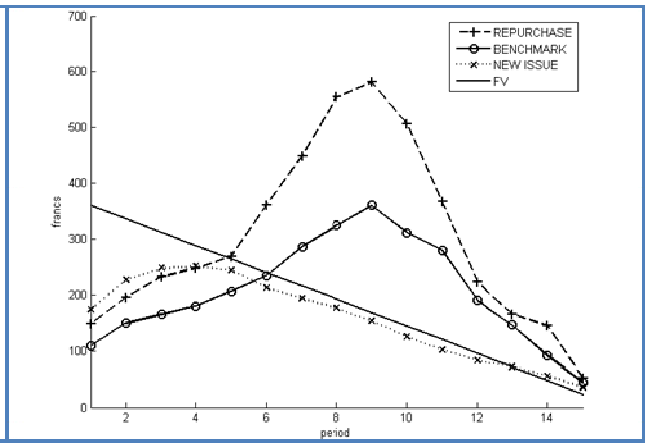
Benchmark



Share Issue



Treatment averages



We first consider whether Hypotheses 1 and 2 are supported. The figures above show that prices are higher in the Repurchase treatment than in the Benchmark treatment. In turn, they are higher in the Benchmark treatment than under Share Issue. Furthermore, in the Repurchase and Benchmark treatments, prices are substantially greater than fundamentals for most of the trading horizon. Table 2 below indicates the Total Bias averaged over all sessions of each treatment, as well as in periods 6 – 15, after the intervention has taken place.

Table 2. Measures of Mispricing, Treatment Averages

Measure of Mispricing	Repurchase Treatment	Benchmark Treatment	Share Issue Treatment
Total Bias	1596	196	-519
Total Dispersion	2795	2032	698
Total Bias: Per. 6 to 15	3102	1421	-165
Total Dispersion: Per. 6 to 15	3228	1897	363

The *p*-values resulting from rank-sum tests of our hypotheses (taking each session in its entirety as an observation) are shown in table 3. We find that Total Bias is significantly different at the 5% level between the Repurchase and the Share Issue treatments (*p*-value=0.015), while neither of the two treatments is significantly different from the Benchmark treatment. The significance of the difference between prices under the two different interventions, coupled with the fact that, as shown in table 2, all pair-wise treatment differences we observe are in the direction predicted by our hypothesis, lead us to conclude that the hypothesis is supported.

Table 3. Hypothesis results: P-values

Hypothesis	Variable	Repurchase differs from Benchmark	Benchmark differs from Share Issue	Repurchase differs from Share Issue
H 1	**Total Bias**	0.485	0.310	0.015**
H 2	**Total Dispersion**	0.394	0.015**	0.009**
H 3	**Market Power of FV Traders**	0.643	0.114	0.049**

A similar pattern is observed in Table 3 with respect to Total Dispersion, our measure of aggregate mispricing. The ranking of treatment averages follows the same pattern as it did for Total Bias. Specifically, Repurchase sessions have the highest magnitude of mispricing relative to fundamentals, followed by Benchmark, and then Share Issue. Table 3 reports that two of the three differences between treatments are highly significant ($p < 0.015$), providing strong support for Hypothesis 2.

4.2 Market Power

We now consider how the interventions affect the market power that each type holds. In order to classify subjects, we first assign a period score that measures how well a subject's behavior in each period coincides with how each of the three theoretical trader types would have behaved (see table 4 below)[14]. Then we sum the period scores to get an aggregate measure of how well a subject's behavior coincides with each of the three types over the span of the entire market. He is then classified as belonging to the type for which he has the highest score, provided that he satisfies the condition corresponding to the type in at least 50% of all periods in the session. Those individuals not fitting any of the three types are classified as "other".

[14] When a trader's actions in period *t* corresponds to any particular type, his score for that type increases by the absolute change in his share holding between period *t-1* and *t*. When a trader's share holding remains unchanged from one period to the next, the trader's score is incremented by 1 for each of the three types.

Table 4: Criteria for classification of traders to types

Trader type	**Condition**
Fundamental Value	*If* $(p_t > f_t)$, *then* $(s_{it} < s_{i,t-1})$.
	If $(p_t < f_t)$, *then* $(s_{it} > s_{i,t-1})$.
Momentum	*If* $(p_{t-1} < p_{t-2})$, *then* $(s_{it} < s_{i,t-1})$.
	If $(p_{t-1} > p_{t-2})$, *then* $(s_{it} > s_{i,t-1})$.
Rational Speculator	*If* $(p_t > p_{t+1})$, *then* $(s_{it} < s_{i,t-1})$.
	If $(p_t < p_{t+1})$, *then* $(s_{it} > s_{i,t-1})$.

The first row of *Figure 4* presents the average market power over time of an individual of each of the three different trader types, while the second shows market power for an individual of each trader type averaged over all sessions of a treatment. Turning first to the effect of an intervention in period 6, we find that the average FV type has more market power after a share issue than after a repurchase, and vice-versa for RA types. MMs also acquire considerably more market power in the latter periods of the Repurchase sessions. Thus, it appears that the interventions have the effect of transferring market power to or away from FV types.

Figure 4 – Market Power per Subject of Each Type (*Vertical bars indicate beginning of interventions.*)

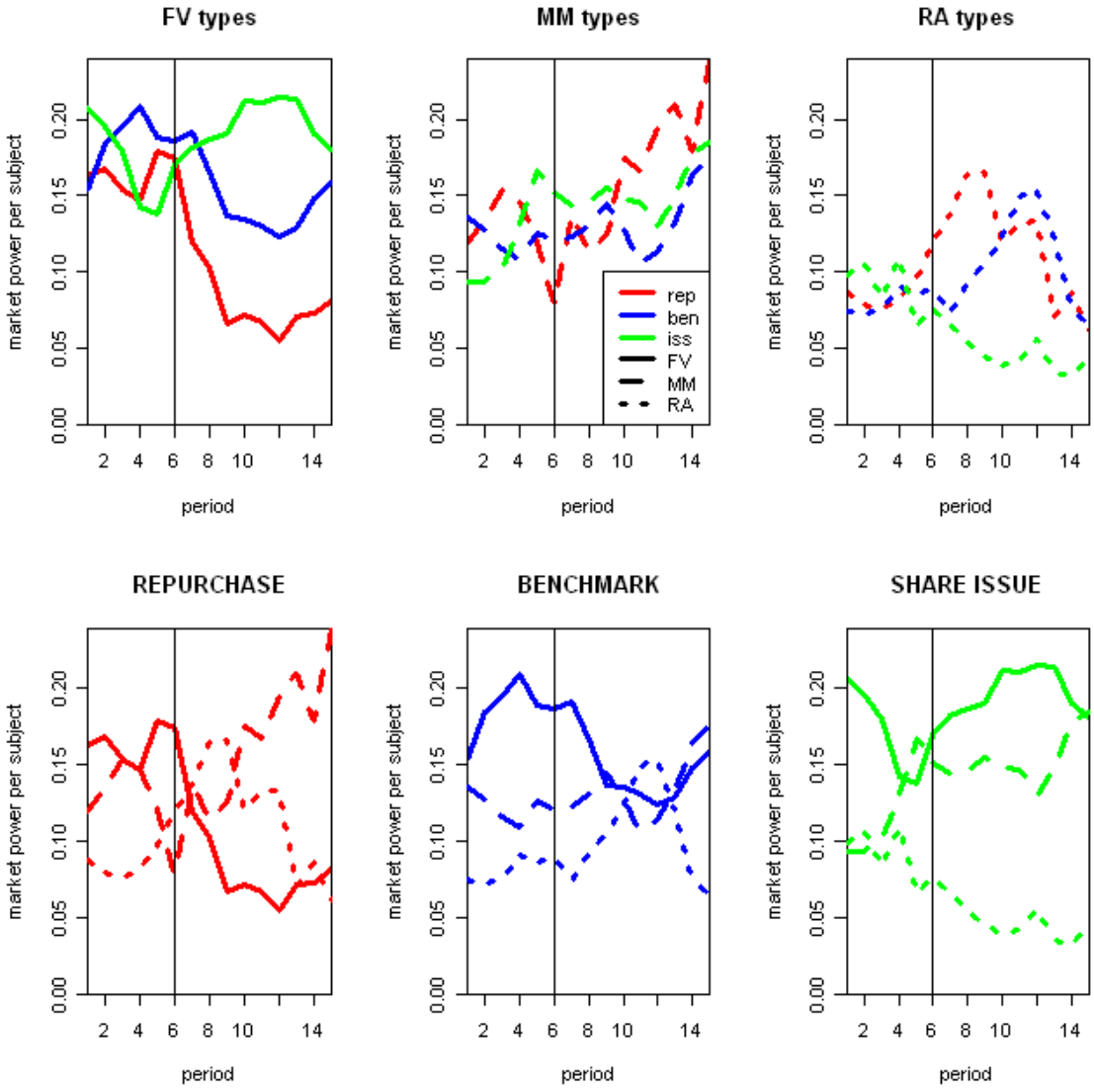


Table 5 shows the average number of individuals in a market that are classified as belonging to each of the three types, by treatment. It shows that in the Repurchase treatment, more individuals are MM traders than in the other treatments. On the other hand, there are fewer FV traders in the Repurchase than in the other treatments. There are also more individuals classified as FV traders in the Share Issue than in the other treatments. Thus hypothesis 3 receives strong support. More individuals are classified as FV traders in Share Issue than in Benchmark, and fewer act as FV traders in Repurchase

than in Benchmark. Furthermore, as shown in Table 3, the average FV trader has significantly more market power in the Share Issue than in the Repurchase treatment.

Table 5 – Average Number of Traders of Each Type, by Treatment

	Repurchase	Benchmark	Share Issue
Rational	2.28	1.94	2.03
Momentum	3.86	2.94	2.53
Fundamental	2.53	3.28	4.11

4.3 The effect of repurchases and issues of different sizes

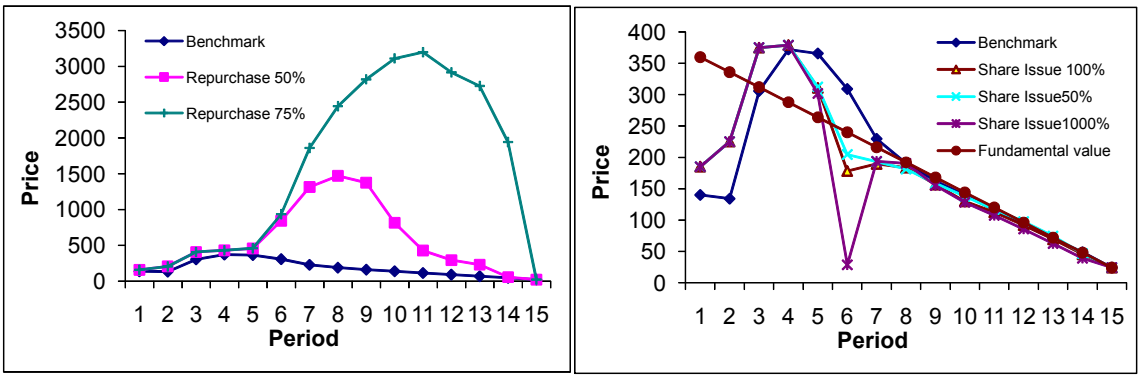
We now consider the potential effect of interventions of different sizes, with a focus on how robust the downward resistance of prices at fundamentals is to larger share issues. The results of simulations of several scenarios are given in figure 5. In addition to simulations of the interventions we actually conducted in our experiment, the figure contains average price paths resulting from a repurchase of 75% of the total stock of units, as well as from share issues of 100% and 1000% of the initial stock of units.[15]

The figure shows that a larger repurchase creates a larger bubble, both in magnitude and duration. Comparison of the 75% and the 50% repurchases reveal a similar pattern in period 6 but higher prices thereafter under a larger repurchase. The larger share issues of 100% and 1000% flood the market initially, but the market tracks fundamental value closely afterward. The price decreases in period 6, rebounds in period 7, and then tracks fundamentals closely from period 8 onward. The quick recovery to fundamental values occurs as FV traders purchase the bulk of the large quantities on offer when the large increase in supply from the intervention reduces prices in period 6. The

[15] In the simulations of share issues the entire supply of units can be and is sold in period 6, because there is a sufficient amount of disposable cash held by agents to purchase many units at very low prices. In the simulations of repurchases, it may take multiple periods for the intervention to be completed. A cash constraint for the repurchasing firm at 10,000 currency units per period is imposed in the simulations and the constraint is typically binding in periods 6 and 7. In the experiment, because of the 5-second interval between the submission of one of the firm's bids and the next, a constraint limiting the speed of completion of the intervention exists. The time available in period 6 sometimes expires before the experimenter has completed his intervention.

price pattern suggests that the downward resistance of prices at fundamental values following a share issue would be strong, even in the face of very large issues.

Figure 5: Simulated prices for repurchases of 50% and 75% of the outstanding shares and for share issues of 100% and 1000% of outstanding shares (*interventions occur in period 6.*)



5. Conclusion

In our experimental markets, we observe that share repurchases and issues can have an impact on price levels, quite apart from any informational content they may provide to the market. Modeling traders as following particular momentum, rational speculative, and fundamental trading strategies can largely explain the effect of the interventions on prices. The model we specify has the features that repurchases tend to remove power from traders who use fundamental values as a limit price, whereas share issues tend to concentrate power in the hands of fundamental value traders. This reallocation of weight to fundamental value traders that accompanies a share issue appears to move market prices closer to fundamentals. The simulation results reported in figure 5 show a strong asymmetry between the two types of interventions.

Our findings are consistent with the evidence from empirical finance that asset demand is downward-sloping. During the dot com bubble of the late 1990s, there were stocks trading at what appeared to be extreme price-to-earnings multiples and investors lamented their inability to capitalize on these sure opportunities due to the constraints inherent in short selling (Ofek and Richardson, 2003). Furthermore, the effects of demand and supply of assets are apparent in other asset classes, including real estate (Lin

and Yung, 2006), junk bonds (Kaplan and Stein, 1993), and emerging economies' debt (Krugman, 1995). It is clear how such markets might form bubbles as a result of demand-and-supply imbalances. It should thus not be surprising then that these factors play a role in stocks as well.

Of course, experiments do not contain many important features of stock markets, and the generality of our results hinges on how generic our environment is. As other work in the literature points out, the consequences on the firm's debt-equity balance, information signals, and tax positions of shareholders, are non-negligible. For example, knowing that issuing new shares lowers prices of all shares, firms would not pursue such a strategy unless they needed a new cash infusion to pursue a promising new investment or pay off debt that the company deems too expensive. This insight would in turn make new share issues non-neutral with respect to investor expectations of future payoff streams. A similar argument could be made regarding share repurchases. The research presented here clarifies our understanding of interventions by showing that they can still have a profound effect on relative demand and supply in the market, even controlling for the other consequences they might have on intrinsic values or on the beliefs of traders.

Other evidence for downward-sloping demand has been offered by Haruvy and Noussair (2006) with regard to short selling. In that work, short selling constraints are shown to be an important factor in bubble magnitude (also see Allen et al., 1993). Introducing a sufficient number of additional shares to the market through looser short selling restrictions created pricing below fundamentals. The short sellers tended to be the momentum traders and the rational speculators. In contrast, the increase in shares implemented here through the share issues results in the allocation of those shares primarily to the fundamental value traders. This helps to reduce mispricing rather than to increase it, as in the case of short selling.

Because of the change in the allocation of shares among types resulting from the two types of intervention, it appears that a larger repurchase would serve to persistently increase prices even more than in our experiments. Demand from momentum traders and rational speculators would be further encouraged, even as fundamental value traders, who would wish to sell, would run out of their units more quickly. On the other hand, a larger issue would not lower prices beyond fundamentals, at least not for longer than a period or

two. The units the experimenter sells would be purchased primarily by the fundamental value traders. This means that fundamental value traders would have a greater percentage of the shares after the issue and receive the dividends on these shares, which adds to their cash balances. This encourages prices to track fundamentals even more closely, because fundamental value traders would have a greater ability to exploit any deviations from fundamentals in a manner that would push prices back toward intrinsic values.

References

Abreu, D. and Brunnermeier, M. K. (2003), Bubbles and Crashes, *Econometrica* 71 (1), 173-204.

Allen, F., Morris S. and Postlewaite A. (1993), Finite Bubbles with Short Sale Constraints and Asymmetric Information, *Journal of Economic Theory*, 61 (2) 206-229

Bagnoli, M., Gordon, R. and Lipman, BL (1989) Stock repurchase as a takeover defense, *Review of Financial Studies*, 2(3) 423-443.

Bartov, E., (1991). Open-market stock repurchases as signals for earnings changes, *Journal of Accounting and Economics* 14, 275-294.

Bhattacharya, S. (1979) Imperfect Information, Dividend Policy, and "the Bird in the Hand" Fallacy, *Bell Journal of Economics* 10, 259–270.

Brav, A., Graham, J.R., Harvey, C.R., and Michaely, R. (2005), Payout policy in the 21st century, *Journal of Financial Economics* 77, 483-527.

Caginalp, G. and Ilieva, V. (2008) The dynamics of trader motivations in asset bubbles, *Journal of Economic Behavior and Organization*, 66, 3-4, 641-656.

Caginalp, G., Porter, D. and Smith, V. (1998) Initial Cash/Asset Ratio and Asset Prices: An Experimental Study, *Proc Natl. Acad. Sci.* 95, 756-761.

DeLong, J. B., A. Shleifer, Summers, L. H. and Waldmann, R. J. (1990) Positive Feedback Investment Strategies and Destabilizing Rational Speculation, *Journal of Finance*, 45(2), 379-395.

Dittmar, A. K. (2000) Why Do Firms Repurchase Stock, *Journal of Business*, 73(3), 331-355.

Dufwenberg, M., Lindqvist, T. and Moore, E. (2005), Bubbles & Experience: An Experiment, *American Economic Review* 95, 1731-37.

Eriksen, K. and Kvaloy, O. (2009), Myopic Investment Management, *Review of Finance*, forthcoming.

Fischbacher, U. (2007) z-Tree: Zurich toolbox for ready-made economic experiments, *Experimental Economics*, Springer, vol. 10(2), pages 171-178.

Gneezy, U. and Potters, J. (1997) An Experiment on Risk Taking and Evaluation Rounds, *Quarterly Journal of Economics* 102, 631-645.

Grinblatt, M. and Hwang, C. Y. (1989) Signaling and the Pricing of New Issues, *Journal of Finance*, 44(2) 393-42.

Grullon, G., and Michaely, R. (2004), The information content of share repurchase programs, *Journal of Finance*, 59(2) 651-680.

Haruvy, E. and C. Noussair (2006), The Effect of Short Selling on Bubbles and Crashes in Experimental Spot Asset Markets, *Journal of Finance* 61, 1119-1157.

Haruvy, E., Lahav, Y. and Noussair, C. (2007) Traders' Expectations in Asset Markets: Experimental Evidence, *American Economic Review*, 97(5), 1901-1920.

Hussam, R. N., Porter, D. and Smith, V. L. (2008), Thar She Blows: Can Bubbles Be Rekindled with Experienced Subjects?, *American Economic Review*, 98:3, 924-937.

Kaplan, S. N. and Stein, J. C. (1993) The Evolution of Buyout Pricing and Financial Structure in the 1980s, *The Quarterly Journal of Economics*, 108(2), 313-357.

Kaul, A., Mehrotra, V. and Morck, R. (2000), Demand Curves for Stocks Do Slope down: New Evidence from an Index Weights Adjustment, *The Journal of Finance*, 55(2), 893-912.

Kogan, S. and Morgan, R. (2009) Securities Auctions Under Moral Hazard: An Experimental Study, *Review of Finance*, fothcoming.

Krugman, P. (1995) Dutch Tulips and Emerging Markets, *Foreign Affairs*, 74(4) 28-44.

Lei, V., Noussair, C. and Plott, C. (2001) Non-Speculative Bubbles in Experimental Asset Markets: Lack of Common Knowledge of Rationality or Actual Irrationality, *Econometrica*, 69, 830-859.

Lie, E. (2005) Operating Performance Following Open Market Share Repurchase Announcements, *Journal of Accounting & Economics* 39(3), 411-436.

Lin, C. Y. and Yung, K. (2006) Equity Capital Flows and Demand for REITs, *Journal of Real Estate Finance and Economics, 33(3)* 275-291.

Lowenstein, L. (1991). *Sense and Nonsense in Corporate Finance* (Addison-Wesley: New York).

Loughran, T. and Ritter, J. R. (1995) The New Issues Puzzle, *The Journal of Finance*, Vol. 50, No. 1. (Mar., 1995), pp. 23-51.

Lynch, A. and Mendenhall, R. (1997) New Evidence on Stock Price Effects Associated with Changes in the S&P 500, *Journal of Business* 70, 351-384.

Masulis, R. W. (1980) Stock Repurchase by Tender Offer: An Analysis of the Causes of Common Stock Price Changes. *The Journal of Finance*, 35(2), 305-319.

Mikkelson, W. H., and Partch, M. M. (1985) Stock price effects and costs of secondary distributions, *Journal of Financial Economics* 14, 165-194.

Miller, Merton H., and Kevin Rock, (1985) Dividend policy under asymmetric information, *Journal of Finance* 40, 1031–1051.

Mintz, S. L. (1988) 'Pssst, Ford Motor – and Many Others – Have Found Something Better Than Dividends', *Corporate Finance*, 54–58.

Morris, S. (1996) Speculative Investor Behavior and Learning, *Quarterly Journal of Economics* 111, 1111-1133.

Myers, S. C. (1984) The Capital Structure Puzzle, *The Journal of Finance*, Vol. 39, No. 3, 575-592.

Ofek, E. and M. Richardson (2003). DotCom Mania: the Rise and Fall of Internet Stock Prices. Journal of Finance, 58, 1113-1137.

Porter, D., and Smith, V. (1995) Futures Contracting and Dividend Uncertainty in Experimental Asset Markets, *The Journal of Business*, Vol. 68(4), 509-541.

Ritter, J. R. (1991), The Long-Run Performance of Initial Public Offerings, *Journal of Finance*, Vol. 46, No. 1, 3-27.

Scholes, M. S, 1972. The Market for Securities: Substitution versus Price Pressure and the Effects of Information on Share Prices, *Journal of Business*, 45(2), 179-211.

Shleifer, A. (1986). Do Demand Curves for Stocks Slope Down? *Journal of Finance*, 41(3), 579-590.

Smith, V., G. Suchanek, and Williams, A. (1988) Bubbles, Crashes, and Endogenous Expectations in Experimental Spot Asset Markets, *Econometrica*, 56, 1119-1151.

Spiess, D. K. and Affleck-Graves, J. (1995) Underperformance in Long-run Stock Returns Following Seasoned Equity Offerings, *Journal of Financial Economics,* 38, 243-267.

Stigler, G. J., (1964). Public Regulation of the Securities Markets, *Journal of Business* 37, 117-142.

Van Boening, M., Williams, A. and LaMaster, S. (1993) Price Bubbles and Crashes in Experimental Call Markers, Economic Letters 41, 179-185.

Vermaelen, T. (1981) Common stock repurchases and market signaling: An empirical study, *Journal of Financial Economics* 9, 139-183.

Vermaelen, T. (1984) Repurchase Tender Offers, Signaling and Managerial Incentives, *Journal of Financial and Quantitative Analysis* 19, 163–181.

Wurgler, J., and Zhuravskaya, K. (2002) Does Arbitrage Flatten Demand Curves for Stocks? *Journal of Business* 75, 583–608.

Appendix: Experimental Instructions

Instructions for experiment

1. General Instructions

This is an experiment on decision making in a market. The instructions are simple and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash at the end of the experiment. The experiment consists of a sequence of trading Periods in which you will have the opportunity to buy and sell in a market. The currency used in the market is francs. All trading will be done in terms of francs. The cash payment to you at the end of the experiment will be in euros. The conversion rate is: **170 francs to 1 euro**.

2. How to use the computerized market

In the top right hand corner of the screen you see how much time is left in the current trading Period. The goods that can be bought and sold in the market are called Shares. In the center of your screen you see the number of Shares you currently have and the amount of Money (francs) you have available to buy Shares.

If you would like to offer to sell a share, use the text area entitled "Enter offer to sell" in the first column. In that text area you can enter the price at which you are offering to sell a share, and then select "Submit Offer To Sell". Please do so now. Type a number in the appropriate space, and then click on the field labeled "Submit Offer To Sell". You will notice that nine numbers, one submitted by each participant, now appear in the second column from the left, entitled "Offers To Sell". Your offer is listed in blue. Submitting a second offer will replace your previous offer.

The lowest offer-to-sell price will always be on the bottom of that list. You can select an offer by clicking on it. It will then be highlighted. If you select "Buy", the button at the bottom of this column, you will buy one share for the currently selected sell price. Please purchase a share now by selecting an offer and clicking the "Buy" button. Since each of you had offered to sell a share and attempted to buy a share, if all were successful, you all have the same number of shares you started out with. This is because you bought one share and sold one share. Please note that if you have an offer selected and the offer gets changed, it will become deselected if the offer became worse for you. If the offer gets better, it will remain selected.

When you buy a share, your Money decreases by the price of the purchase. When you sell a share your Money increases by the price of the sale. You may make an offer to buy a unit by selecting "Submit Offer To Buy." Please do so now. Type a number in the text area "Enter offer to buy", then press the red button labeled "Submit Offer To Buy". You can replace your offer-to-buy by submitting a new offer. You can accept any of the offers-to-buy by selecting the offer and then clicking on the "Sell" button. Please do so now.

In the middle column, labeled "Transaction Prices", you can see the prices at which Shares have been bought and sold in this period. You will now have about 10 minutes to buy and sell shares. This is a practice period. Your actions in the practice period do not count toward your earnings and do not influence your position later in the experiment. The only goal of the practice period is

to master the use of the interface. Please be sure that you have successfully submitted offers to buy and offers to sell. Also be sure that you have accepted buy and sell offers. If you have any questions, please raise your hand and the experimenter will come by and assist you.

3. Specific Instructions for this experiment

The experiment will consist of 15 trading periods. In each period, there will be a market open for 4 minutes, in which you may buy and sell shares. Shares are assets with a life of 15 periods, and your inventory of shares carries over from one trading period to the next. You may receive dividends for each share in your inventory at the end of each of the 15 trading periods.

At the end of each trading period, including period 15, the computer will randomly determine the dividend value for all shares in that period. Each period, each share you hold at the end of the period:

earns you a dividend of 0 francs with probability 1/4
earns you a dividend of 8 francs with probability 1/4
earns you a dividend of 28 francs with probability 1/4
earns you a dividend of 60 francs with probability 1/4

Each of the four dividend values is equally likely, thus the average dividend in each period is 24. Dividends are added to your cash balance automatically. After the dividend is paid at the end of period 15, there will be no further earnings possible from shares.

---------- Insert only for Repurchase Treatment ----------

4. Share Buyback

Over the course of the 15 periods, the computer will buy back half of the shares from the market. It will do so by submitting offers to buy shares. These offers will look and work exactly the same as offers created by other subjects. They will be listed under the "Offers to Buy" column and they can be accepted by using the "Sell" button. Once the computer has purchased back half of the shares, it will no longer participate in the market.

----------Insert only for Share issue Treatment ----------

4. Share Sale

Over the course of the 15 periods, the computer will sell a number of shares on the market. The number of shares will equal half of the existing shares in the market. It will do so by submitting offers to sell shares. These offers will look and work exactly the same as offers created by other subjects. They will be listed under the "Offers to Sell" column and they can be accepted by using the "Buy" button. Once the computer has sold all of its shares, it will no longer participate in the market.

---------- End of Insert ----------

5. Average Holding Value Table

You can use your **AVERAGE HOLDING VALUE TABLE** to help you make decisions. There are 5 columns in the table. The first column, labeled Ending Period, indicates the last trading period of the experiment. The second column, labeled Current Period, indicates the period during which the average holding value is being calculated. The third column gives the number of holding periods from the period in the second column until the end of the experiment. The fourth column, labeled Average Dividend per Period, gives the average amount that the dividend will be in each period for each unit held in your inventory. The fifth column, labeled Average Holding Value Per Unit of Inventory, gives the average value for each unit held in your inventory from now until the end of the experiment. That is, for each share you hold for the remainder of the experiment, you will earn on average the amount listed in column 5.

Suppose for example that there are 7 periods remaining. Since the dividend on a Share has a 25% chance of being 0, a 25% chance of being 8, a 25% chance of being 28 and a 25% chance of being 60 in any period, the dividend is on average 24 per period for each Share. If you hold a Share for the remaining 7 periods, the total dividend for the Share over the 7 periods is on average 7*24 = 168. Therefore, the total value of holding a Share over the 7 periods is on average 168.

AVERAGE HOLDING VALUE TABLE

Ending Period	Current Period	Number of Holding Periods	x	Average Dividend Per Period	=	Average Holding Value Per Share in Inventory
15	1	15		24		360
15	2	14		24		336
15	3	13		24		312
15	4	12		24		288
15	5	11		24		264
15	6	10		24		240
15	7	9		24		216
15	8	8		24		192
15	9	7		24		168
15	10	6		24		144

15	11	5	24	120
15	12	4	24	96
15	13	3	24	72
15	14	2	24	48
15	15	1	24	24

6. Your Earnings

Your earnings for the entire experiment will equal the amount of cash that you have at the end of period 15, after the last dividend has been paid. The amount of cash you will have is equal to:

The cash (called "Money" on your screen) you have at the beginning of the experiment

+ dividends you receive

+ money received from sales of shares

- money spent on purchases of shares