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The Impact of Investor Heterogeneity in Beliefs on Share Repurchase

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Abstract In this paper, we propose a new share repurchasing model to show the impact of the heterogeneity of investor beliefs on share repurchase. We first provide a comprehensive survey on the literature of share repurchases which has not been considered by previous studies, to the best of our knowledge. We review both the theoretical model structures and the major empirical results including various measures of divergence of opinion developed in the literature. Our new repurchasing model uses actual share repurchases to show that investors' divergence of opinion on the firm value matters in a manager's share repurchase decision. The long-term stock price performance is consistent with our model predictions.

Keywords: *actual share repurchases, heteroscedastic expectations, asset pricing, divergence of opinion*

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1. Introduction

Previous researchers studying share repurchases generally assume homogeneous expectations. Theoretical models have been built on signaling theory, agency theory, optimal capital structure theory, and so forth. However, the tender offer premium puzzle and the long-term stock price anomaly are left unexplained by existing models.[1] These unexplained surprises might indicate that the assumption of homogeneous expectations is too restrictive to reproduce investors' behaviors in share repurchases.

We have also realized that in this literature of repurchasing shares, the existing empirical hypothetical tests on the theoretical models exclusively use announcements of share repurchase. Given the fact that *actual* share repurchases can be largely different from the announced shares of repurchases, the disparity between the actual and announced repurchases is thus an idiosyncratic shock to investors. Apparently, this shock should be expected to impact on investors' expectations of the firm's future values.

In this paper, we first provide a comprehensive survey on the literature of share repurchases which has not been considered by previous studies, to the best of our knowledge. The paper reviews both the theoretical model structures and the major empirical results including various measures of divergence of opinion developed in the literature. It then follows a discussion of the divergence of investors' opinions on a stock's value. The divergence perspective allows us to study share repurchases from investors' heteroscedastic beliefs, compared to the homogeneous assumption. Of interest, we also propose a new repurchasing model to examine the impact of actual share repurchases on the long-term stock price performance under the assumption of investor heterogeneity in beliefs. The proposed model is illustrated in several numerical examples and shows that investors' divergence of opinion on the firm value matters in a manager's share repurchase decision. The larger the divergence of opinion, the more likely a manager announces share repurchases and the more shares he *actually* repurchases. The long-term stock price performance is consistent with the model predictions.

The rest of the paper is organized as follows. Section 2 comprehensively reviews the share repurchase literature including theoretical models, empirical results and the measures of heteroscedastic beliefs. Section 3 discusses investor heterogeneity and share repurchase. Section 4 proposes a new repurchasing model using actual share repurchases under divergence of opinion. Section 5 concludes this paper.

2. A Comprehensive Review in Share Repurchases

The implication of the marginal-investor-theory with divergence of opinion, and the use of investors' belief

[1] With the tender offer premium puzzle, managers offer a tender price that is higher than the equilibrium stock price, defined as the stock price five days after a tender offer announcement. The long-term price anomaly refers to the long-term stock price performance following repurchase announcement. Empirical studies show that stock prices drift upwards, associated with persistent long-term abnormal returns, for about three years after open market share repurchase announcements.

dispersion measures have been adopted by previous researchers examining share repurchases. Bagwell (1991a), Bagwell (1991b), and Bagwell (1992) examine a unique dataset from Dutch Auction share repurchase, and find that shareholders are willing to sell their shares at dramatically different prices, implying an upward-sloping supply curve for equities. Persons (1997) suggests managers use tender offer repurchases to transfer wealth from shareholders who do not tender, to those who do. This transfer realizes a direct loss of firm capital, and is used as the cost of managers' signal that the firm is undervalued.

Recently, the idea of divergence of opinion is introduced to explain open market share repurchases. Fried (2001) argues that the signaling theory in open market share repurchases is problematic, and managers announce open market repurchases because of opportunism. Managers take different actions after an announcement, depending on whether the stock is truly undervalued. Huang and Thakor (2010) build a simple model, where investors disagree with the managers about the firm's investment projects. Managers choose to repurchase shares in order to change the investor base when the divergence of opinion between investors and managers is high. Conlon, Fuller and Wang (2011) and Blau *et al.* (2011) propose a model where investors disagree with one another. Managers repurchase shares from pessimistic shareholders and transfer wealth from those shareholders to optimistic shareholders, who are willing to stay in the firm and continue to provide their capital. They provide an explanation of long-term abnormal returns, following open market share repurchases.

In this section, we comprehensively review the previous studies and findings in share repurchases. First, we discuss the definition of divergence of opinion and then compare repurchasing theories in homogeneity vs. heterogeneity, rational vs. irrational, and asset pricing model with heteroscedastic beliefs. We also provide the descriptions of various measures of divergent opinions of investors.

2.1. Definition of Divergence of Opinion

Ever since Keynes (1937) and Williams (1956), economists have recognized the differences in investors' preferences and proposed the marginal-investor theory which emphasizes the importance of divergence of opinion in the functioning of capital markets. Divergence of opinion is often defined as a type of investor heterogeneity in financial economics, in which, investors' valuation of a signal asset diverge from each other because they hold different prior beliefs, or have different information process models.

People often share common information yet disagree as to the meaning of this information, not only in the evaluation of risky assets but also in the evaluation of economic policies, political candidates, and the result of tossing a dice. Another example is the differences among financial analysts' forecasts in response to a firm's earnings announcement. Investor heterogeneity can come from tax preference, risk tolerance, liquidity requirement, and private information. This branch of the literature concerns rational expectations asset pricing models. In this article, we focus on the heterogeneity originated from two other sources: the investors' prior beliefs and the model (often the likelihood function) that investors choose to process the public information. The asset pricing models in this second branch of the literature are usually referred to as irrational expectations models.

2.2. Investor Homogeneity vs. Heterogeneity

Despite these differences and despite strong and persuasive arguments put forward for including heterogeneity in finance and economics, the homogeneous representative agent paradigm is still the leading structural approach to asset pricing. [2] Anderson, Ghysels and Juergens (2005) suggest that this happens for various reasons. First, in many contexts it is difficult to derive testable predictions in asset pricing models with heterogeneous agents. Second, even though some researchers have made progress recently (e.g. Constantinides and Duffie (1996), Heaton and Lucas (1996),Shefrin (2001), and Curcuru *et al.* (2004)), there is a lack of tangible data that represents heterogeneity. Third, and maybe most important, many of these formulations of heterogeneous agent models are observationally equivalent to representative agent models, as argued by Gorman (1953), Sharpe (1964), and Lintner (1965). Therefore, there is often no need to explicitly consider heterogeneous agents because there exists a representative agent, with a utility function of the same form as the agents. [3]

Some researchers disagree with Lintner (1965)'s conclusions. Mayshar (1983) points out that the divergence of opinion not only exists, but is essential in determining asset prices. It is essential because of its association with endogenous limitations on the number of active market participants. The traditional models fail to recognize the fact that investors choose not only the size of their holdings in each asset, but also in which asset to invest. However, the models do agree that when short sale constraints are present, an asset pricing model with divergent opinions may differ from a model without divergent opinions. However, Mayshar (1983) continues to argue that, even without short sale constraints, investors endogenously choose to hold or not to hold an asset, which in fact constructs an uncompleted sub-market as if the short sale constraints exist.

2.3. Rational vs Irrational Models

There are two major differences between the irrational asset pricing models and the rational ones. First, in the rational expectation models, trade is not generated by pubic information signals. Since all the investors share one utility function with the representative agent, all investors derive the same reservation value based on the public information. No trade is needed as the investors'

[2] The same argument is presented in Browning, Hansen and Heckman (1999) and Anderson, Ghysels and Juergens (2005).

[3] For example,Lintner (1969) states that "Any carryover of … Ricardian notations of 'marginal' buyers setting prices in purely competitive markets is utterly unjustified and misleading when dealing with security markets under uncertainty. Every investors is a marginal holder with respect to his last share … of each security he holds". Sharpe and Sharpe (1970) state that "in a somewhat superficial sense the equilibrium relationships derived for a world of complete agreement can be said to apply to a world in which there is disagreement, if certain values are considered to be averages".

portfolio is updated together with the market movements. In the irrational models of Kim and Verrecchia (1991) and Grundy and McNichols (1989), trades are generated by the public information because traders disagree on its interpretation due to prior private information. We argue that the divergence of opinion is generated from different prior beliefs.

Second, in the rational expectations models, disagreement is the result of private information. Investors who receive private information adjust their reservation value of an asset, and thus, adjust their portfolio holdings by buying or selling a certain amount of such assets. However, Milgrom and Stokey (1982) and Varian (1989) show that speculative trades based purely on differences in private information cannot occur among risk-averse traders in the absence of noise traders. No trade happens because uninformed traders observe the updated ask or bid price submitted by other traders and infer that the orders are submitted by informed traders, therefore, there is information risk to trade with them. With only risk averse investors present in the market, no one wants to trade with the other. Thus, rational expectation models usually rely on noise traders to generate the trades. When noise traders are present, uninformed traders are not able to distinguish whether the changes of asset price are due to private information, or noise orders.

2.4. Asset Pricing Models with Divergence of Opinion

Models with agents who have heterogeneous beliefs have been studied by Miller (1977),Harrison and Kreps (1978), Jarrow (1980), Mayshar (1983), Harris and Raviv (1993), Kandel and Pearson (1995), Van den Steen (2004), Anderson, Ghysels and Juergens (2005), Hong and Stein (2007), and Fama and French (2007). These models can be categorized into three groups: first, investors simply hold heterogeneous beliefs; second, investors generate heterogeneous beliefs on the same public information due to their different prior beliefs; and third, investors have different opinions about the same information because they interpret the information differently.

Early works, including Miller (1977), belong to the first category. Miller (1977) suggests a simple framework to analyze the asset prices with the investors' divergence of opinion. There are only two securities, one is the risk-free bond and the other is a risky stock. Miller (1977) shows that with the short sale constraints, asset prices tend to be higher than the average reservation value across all investors' expectation because pessimistic investors' opinions are not incorporated into security prices.

Jarrow (1980) and Mayshar (1983) extend Miller (1977)'s model from one risky security into portfolio rebalancing with multiple risky assets. Jarrow (1980) suggests that stock prices will be overvalued when a short sale is not allowed, and investors hold homogeneous beliefs on the asset returns, buthomogeneity of beliefs for the variance-covariance matrix of future asset returns. With the same assumption, Mayshar (1983) find the same results. Furthermore, Mayshar (1983) shows that investors endogenously choose to buy an asset and become active in a portion of the security market. With the heterogeneity of beliefs, the idiosyncratic risks are priced in equilibrium.

Harrison and Kreps (1978) and Van den Steen (2004) push this argument even further. Harrison and Kreps (1978) suggest that with the heterogeneity of beliefs, equilibrium asset prices could be even higher than the reservation value of the most optimistic investors. Speculative investors hold assets and expect to re-sell them to other investors in the future. Knowing that each investor may have a different reservation value, but not knowing the magnitude of the other investors' reservation value, speculative investors could offer to buy an asset at a price higher than their own reservation value. Van den Steen (2004) further shows that the over-optimism of those speculative investors is due to the biased self-attribution. Particularly, an agent tends to choose the action that she overestimates and then attributes the failure to exogenous factors.

Kandel and Pearson (1995)'s model belongs to the second category, where investors' heterogeneity comes from different prior beliefs. They argue that the predictions from their model are consistent with the empirical findings about the patterns of trading volume. As in the models of Kim and Verrecchia (1991) and Grundy and McNichols (1989), investors draw different conclusions from the same public information. More importantly, investors agree to disagree in equilibrium.

Harris and Raviv (1993) and Anderson, Ghysels and Juergens (2005) model the heterogeneity in the way that investors share common prior beliefs and receive common information but differ in the way in which they interpret this information. In Harris and Raviv (1993), each investor updates their beliefs about the future returns using her own model of the relationship between the news and the asset's returns. The Anderson, Ghysels and Juergens (2005) model assumes that investors have the correct beliefs about the expected consumption growth, but incorrect beliefs about the higher moments of consumption growth. Therefore, when the mean beliefs differ from the true beliefs, the heterogeneity/bias matters. These two papers find that their models with heterogeneity are better in explaining trading volume – asset price changes relationship and in predicting return – volatility relationship, respectively.

Recently, Hong and Stein (2007) and Fama and French (2007) review the literature of investor heterogeneity in the way of divergence of opinion. Both studies emphasized the importance of the divergence of opinion in improve the traditional asset pricing models built on the assumption of investor homogeneity. Hong and Stein (2007) extend the short sale constraints into the 'limits of arbitrage' and make the heterogeneous models a broader usage. They also argue that the limits of attention could also be a source of divergence of opinion. Fama and French (2007) argue that the assumptions for traditional asset pricing models, (i) there is complete agreement among investors about probability distributions of future payoffs on assets, and (ii) investors choose asset holdings based solely on anticipated payoffs, are unrealistic. Fama and French (2007) point out that the investors could disagree with each other due to their different tastes for assets as for consumption goods. They also suggest that with divergence of opinion, the uninformed investors hold the sub-optimal portfolio due the 'limits of arbitrage' suggested by Shleifer and Vishny (1997), in which the

arbitrage is risky and risk averse informed investors do not fully offset the price effects of the misinformed.

Overall, the theoretical works suggest that (i) the market equilibrium version of the divergence of opinion exists; (ii) the equilibrium asset prices in the market with heterogeneous investors differ from the ones in the market where investors are homogeneous; (iii) the predictions from asset pricing models with investor heterogeneity fit the pattern of trading volume, price changes, and return volatility better.

2.5. Empirical Findings around Divergence of Opinion

In addition to the theoretical work, empirical evidences also support the existence of divergence of opinion and its impact on asset prices. The evidence comes from 1) event studies, such as corporate public announcements, analyst earnings forecasts, stock Initial Public Offerings (IPOs), and share repurchases; 2) cross-sectional studies on equilibrium asset returns; and 3) the relationship among trading volume, price changes, and return volatilities.

Researchers have long noticed that investors respond differently to corporate public announcements, and that disagreement exists in analysts' earnings forecasts. [4] Abarbanell, Lanen and Verrecchia (1995) suggest a relationship between analyst earnings forecast dispersions and the divergence of opinion among investors. They find that as a proxy of divergence of opinion, the dispersion of analyst forecasts can explain the volume reactions to earnings surprises. Anderson, Ghysels and Juergens (2005) confirm this relationship between the divergence of opinion and the dispersion of analyst forecasts by examining the cross-sectional stock returns. They find that the dispersion of analyst forecasts is a priced factor in asset pricing models and has prediction power on the return volatility.

Diether, Malloy and Scherbina (2002) test whether the dispersion of analyst forecasts is a proxy for divergence of opinion or risk. They find that their result is consistent with the argument that dispersion is a proxy for divergence of opinion rather than risk. Boehme, Danielsen and Sorescu (2006)use this proxy to test the Miller (1977)'s hypothesis and find that with the presence of short sale constraints and divergence of opinion, stocks tend to be overvalued.

Ekholm (2006) examines how different types of investors react to new earnings information. With extremely detailed data from Finland market, he finds that large investors' trading behaviors differ from the majority of investors and tend to be the other side of trades in response to an earnings surprise. They argue that differences in trading behaviors are due to investors' overconfidence. Coval and Thakor (2005) suggest that the financial intermediaries work as a 'beliefs-bridge' between optimists and pessimists.

The empirical evidence of the existence of short sale constraints and the effects of divergence of opinion on asset equilibrium price has been documented. D'avolio (2002), Duffie, Garleanu and Pedersen (2002), and Geczy, Musto and Reed (2002) study the security borrowing market and estimate the direct costs of borrowing securities for short sales. Margrabe (1978), Figlewski and Webb (1993), Ofek, Richardson and Whitelaw (2004), Evans *et al.* (2008), and Danielsen and Sorescu (2009) suggest that option market can be an substitution for mitigating short sale constraints in completing a market. Jones and Lamont (2002), Chen and Singal (2003), Hong and Stein (2003), Nagel (2005), Haruvy and Noussair (2006), Danielsen and Sorescu (2009) examine the effects of divergence of opinion on asset prices with the presents of short sale constraints. Specifically, Boehme, Danielsen and Sorescu (2006) directly test Miller (1977)'s predictions and find that with present of short sale constraints and divergence of opinion simultaneously, the stock tend to be overvalued, as the price reflects the beliefs from the optimistic investors only.

Recently, heterogeneous beliefs are also been adopt to explain the abnormal returns following the IPOs and the share repurchases. The studies include Chemmanur, Krishnan and Nandy (2009), Huang and Thakor (2010), and Blau *et al.* (2011). The authors argue that in the events of IPOs and share repurchases, the underwriters and managers try to attract the capital from the optimistic investors and therefore result in a higher price of firms' stocks. The direct evidence of investors' heterogeneity in their reservation value of an asset is also found by Bagwell (1992) from Dutch auction share repurchases.

2.6. Measurement of Divergence of Opinion

A direct measure of investors' beliefs is usually un-observable and the estimates are often difficult. Researchers in finance, accounting, and economics have to rely on certain observable proxies. The theoretical framework and the empirical implications in finding proper proxies for investors' beliefs have been developed from various research lines, including methodologies based on abnormal stock trading volume, analyst earnings forecast dispersion, stock bid-ask spreads, and rating agency splits. We survey the methodology and the rationale of each of the measure in this section.

2.6.1. Unexplained Volume Based Proxies

Prior research suggests that a component of trading volume may be attributed to opinion divergence. The rationale is that investors trade with each other when they interpret the public information differently, either because they have different prior beliefs or because they use different models to interpret the public information.

Harrison and Kreps (1978) suggest that abnormal trading volume around corporate public announcements could be explained by the divergence of opinion among traders. Varian (1985) and Varian (1989) focus on the differences in prior beliefs as opposed to differences in models. Harris and Raviv (1993) show similar results when investors share the common public information and prior beliefs, but differ from each other in their information process models.

Kandel and Pearson (1995) predict that volume will be increasing in the diversity of investor opinions around earnings events. They document that volume is higher

[4]For example, the works include Ajinkya, Atiase and Gift (1991), Abarbanell, Lanen and Verrecchia (1995), Diether, Malloy and Scherbina (2002), Doukas, Kim and Pantzalis (2006), Zhang (2006b), Zhang (2006a), Lerman, Livnat and Mendenhall (2007), Alexandridis, Antoniou and Petmezas (2007), Sadka and Scherbina (2007), and Barron, Stanford and Yu (2009).

around earnings events than during control periods with similar returns and no earnings news. They propose a theory to explain this finding, even in those cases in which earnings events elicit little or no price reaction. Their theory assumes that investors possess different likelihood functions and this causes them to interpret earnings news differently, consistent with Harris and Raviv (1993)'s predictions.

Similar to Kandel and Pearson (1995), Kim and Verrecchia (1991) construct a model in which earnings announcements may increase information asymmetries because some market participants process the announcement into private or informed judgments. In the context of their model, the authors show that greater diversity of opinions, caused by the differential processing of the information, leads to an increase in trading volume.

These models differ in the way that the origins of the divergence of opinion, either from the different prior beliefs, or from different information process models, or both. Nevertheless, the conclusions are comparable—greater opinion divergence across investors is associated with more trading volume.

Empirically, there is also support for using volume to proxy for differential opinions by traders. Studies analyzing total trading volume around earnings announcements include those of Bamber (1987), De Long et al. (1990), Ajinkya, Atiase and Gift (1991), and Ajinkya et al. (2004). Generally, these studies find that volume is higher around earnings events that are more likely associated with more divergent investor opinions. Garfinkel and Sokobin (2006) look at the relationship between the divergence of opinion and trading volume after earnings announcement. They argue that the post-earnings announcement drift could be explained by the divergence of opinion among investors and the correlated price changes.

Consistent evidence is also found from investors who trade on macroeconomic information releases. Fleming and Remolona (1999) find that trading volume increases significantly, while price volatility and spreads remain wide, as investors in Treasury securities trade to reconcile differential interpretations of macroeconomic information releases.

Direct evidence is also recorded in the experimental literature, Smith, Suchanek and Williams (1988) show that even when traders observe identical probabilistic dividend distributions, then trade occurs, sometimes in large volume. They conclude that there is diversity in opinions.

The large trading volume could also be due to the different private information access across different types of investors. In the homogeneous expectation models, with the presence of noise traders, uninformed traders are unable to distinguish the trades from informed traders. Therefore, private information can also cause large trading volume. However, Brockman and Chung (2001) find that volume is increasing in the heterogeneity parameter on information event days, after controlling for the information effects of the announcements.

Finally, we recommend a measure suggested by Hong and Stein (2007) and Garfinkel (2009). We measure the divergence of opinion among investors with the abnormal market adjusted turnover, $Abto_{i,t}$. To avoid the less-trading-frequency problem, we improve their method byusing weekly cumulative trading volume rather than daily trading volume. [5] The weekly market adjusted turnover, $Abto_{i,t}$, is the firm's weekly trading volume divided by its shares outstanding minus the ratio of market total trading volume, $Vol_{m,t}$, scaled by market total shares outstanding, $Shrs_{m,t}$, as in equation 3.1, where subscription i and m stands for the identification for each stock and the whole market.. We then measure the degree of divergence of opinion with the mean and median value of the weekly market adjusted turnover for each firm year.

$$Abto_{i,t} = \frac{Vol_{i,t}}{Shrs_{i,t}} - \frac{Vol_{m,t}}{Shrs_{m,t}}, where$$
$$Vol_{m,t} = \sum_{i=1}^{m} Vol_{i,t} \text{ and } Shrs_{m,t} = \sum_{i=1}^{m} Shrs_{i,t} \quad (1)$$

A large proportion of this literature is focus on the relationship between trading volume and the absolute price changes, such as Harrison and Kreps (1978), Varian (1985), Varian (1989), De Long et al. (1990), and Kandel and Pearson (1995) among others. The results suggest that absolute price changes and volume are positively correlated, consecutive price changes exhibit negative serial correlation, and volume is positively auto-correlated.

We thus recommend the standardized unexplained stock trading volume, $SUV_{i,t}$ (Garfinkel and Sokobin (2006) and Garfinkel (2009)) as an alternative measure of divergence of opinion. Standardized unexplained stock trading volume measures the unexpected trading volume from the effect of both liquidity and information. Unexpected trading volume is the residual volume ($\varepsilon_{i,t}$) from a regression of the firm's weekly trading volume on weekly signed absolutely returns:

$$Volume_{i,t} = \alpha_i + \beta_i \left| Ret_{i,t} \right|^{+} + \gamma_i \left| Ret_{i,t} \right|^{-} + \varepsilon_{i,t} \quad (2)$$

The plus and minus superscripts on the absolute valued returns indicate the sign of weekly returns. The standardized unexplained trading volume is the yearly average of such residuals scaled by the standard deviation of residual, as:

$$SUV_{i,t} = \frac{\sum_{1}^{52} \varepsilon_{i,t} \Big/ 52}{\sigma_{\varepsilon_{i,t}}} \quad (3)$$

2.6.2. Analyst Forecast Based Proxies

Unlike trading volume proxy for divergence of opinion, which is initiated by theoretical works and then supported by empirical evidences, analyst earnings forecasts dispersion proxy is concluded from empirical findings. The dispersion among analyst earnings forecasts can be looked as a natural experiment of the test on investor heterogeneity. Analysts respond to the same corporate earnings announcement and make forecasts on the future earnings by each of them. Analysts often make different forecasts on future earnings.

Another difference between analyst forecasts dispersion proxy and trading volume proxy is that researchers usually

[5] Some very illiquid stocks could have very small trading volume during some days in a year. The estimation from those extreme values can cause bias on our estimates of divergence of opinion.

do not distinguish whether the divergence of opinion among analysts is due to the different prior beliefs or different information process models. Lack of theoretical framework and testable data, it is difficult to distinguish the original sources of the divergence of opinion.

Supportive evidence from empirical findings is numerous. Ajinkya, Atiase and Gift (1991) formally test the link between the dispersion in financial analysts' earnings forecasts and the abnormal trading volume as a proxy of divergence of opinion, predicted by Varian (1985) and Karpoff (1986). Ajinkya, Atiase and Gift (1991) show that the dispersion in analysts' earnings forecasts is positively related with the abnormal trading volume following the annual earnings announcements and is a proper proxy for agents' differing beliefs about the firm's prospects.

Abarbanell, Lanen and Verrecchia (1995) improve Ajinkya, Atiase and Gift (1991)'s measures by showing that, in a model of rational trade that incorporated earnings forecasts, forecast dispersion along is insufficient to proxy for investor uncertainty. Other forecast properties, including the number of forecasts, the periods of the forecasts, and so forth also affect forecast dispersion. They describe an empirical methodology and show that with their method the dispersion-volume response coefficient is monotonically increasing after controlling for other effect, e.g. price changes.

Several researchers have adopted the dispersion in analyst earnings forecasts as a proxy for investors' divergence of opinion. For example, Diether, Malloy and Scherbina (2002) and Doukas, Kim and Pantzalis (2006) use dispersion in analyst earnings forecasts as a proxy to test Miller (1977)'s hypothesis;Zhang (2006a) and Zhang (2006b) examine how dispersion in analyst forecasts represents the information uncertainty and the cross-sectional relationship between forecast dispersion and the asset returns.

Lerman, Livnat and Mendenhall (2007) and Alexandridis, Antoniou and Petmezas (2007) also adopt this methodology to examine the asset pricing anomalies. While Lerman, Livnat and Mendenhall (2007) focus on post-earnings announcement drift and Alexandridis, Antoniou and Petmezas (2007) highlight the importance of divergence of opinion in explaining the post-acquisition performance, both studies suggest dispersion in analyst forecasts is a good proxy for investors' divergence of opinion. Recently, Sadka and Scherbina (2007) and Barron, Stanford and Yu (2009) also choose this proxy to test the relationship between divergence of opinion, asset liquidity, and asset prices.

We recommend the two measures suggested by Diether, Malloy and Scherbina (2002). The first proxy is the standard deviation of analyst earnings forecasts divided by the mean of the analysts' forecasts, $Disp\_mean_{i,t}$, (see Diether, Malloy and Scherbina (2002)). For each month, we compute the monthly divergence of opinion for a firm by using the annual fiscal year earnings estimate for that month. We then estimate the average yearly divergence of opinion ($Disp\_mean_{i,t}$) as the mean of the monthly divergence of opinion in any given year.

$$Disp\_mean_{i,t} = \frac{Std(forecast)_{i,t}}{Mean(forecast)_{i,t}}; \quad (4)$$

Since the mean of analyst earnings forecast could be zero, and infinite analyst dispersion could be problematic, we choose an alternative measure $Disp\_price_{i,t}$, which we define as the standard deviation of analyst earnings forecasts scaled by stock price. Our model suggests that it is the difference in valuations between optimistic and pessimistic investors that matter. Thus, our second proxy for the divergence of opinion is the difference between the highest earnings forecast and the lowest one, scaled by the absolute value of the mean earnings forecast.

$$Disp\_price_{i,t} = \frac{Std(forecast)_{i,t}}{Stock\_Price_{i,t}}; \quad (5)$$

2.6.3. Bid-ask Spreads

In the literature of market microstructure, bid-ask spread has been suggested as a proxy for divergence of opinion. For example, Houge et al. (2001) use the opening bid-ask spread as a proxy of divergence of opinion of investors to test Miller (1977)'s hypothesis on IPOs. The authors argue that the bid-ask spread can be decomposed into three components, the order processing, adverse selection, and inventory costs. Among them, adverse selection components reflect the dispersion between investors' opinions. The same methodology has also been adopted by Handa, Schwartz and Tiwari (2003).

However, the adverse selection component proposed by Amihud and Mendelson (1980) and Ho and Stoll (1983) represent the different evaluation caused by different private information. Uninformed market makers face adverse selection costs when they trade with informed traders. This type of divergence of opinion is not belongs to the scope of our definition of divergence of opinion. We therefore do not recommend use the adverse selection components of bid-ask spread as a proxy for divergence of opinion.

2.6.4. Agency Rating Splits

Morgan (2002) use the splits among agency ratings as a measure of dispersion of valuations among rating agencies. However, he does not model and test whether the splits among agencies are due to the different private information or due to the divergence of opinion defined in this paper. The purpose of his study is to test whether the splits of agency ratings represent the difficulty level for outside investors to understand and predict the firm's prospects. Flannery, Kwan and Nimalendran (2004) re-examine this issue with a more widely accepted proxy of divergence of opinion, the dispersion in analyst earnings forecasts, and find the contradict result. Furthermore, the agency rating data is often not publicly available. Morgan (2002) collects the data by hand. We do not use this measure in our study due to the contradictory results obtained by previous researches and the difficulty of collecting the data.

3. Investor Heterogeneity and Share Repurchase

Bagwell (1991a)first initiates the argument of the implementation of investor heterogeneity in the context of tender offer share repurchase. However, Bagwell (1991a)

shows that managers can use share repurchase as a takeover deterrent when the supply curve for shares is upward-sloping. The upward-sloping supply curve represents the divergence of opinion among shareholders in evaluation the firm's value. Managers can push up stock price with share repurchases, because shareholders willing to tender in the repurchases are systematically those with the lowest valuations. The repurchases skew the distribution of remaining shareholders toward a more expensive pool. The result holds even the capital gains taxation is considered.

Bagwell (1991b) and Bagwell (1992) provide supportive evidence of investor's heterogeneity in stock valuation to his upward-sloping supply curve argument. By examining Dutch auction share repurchases, Bagwell documents that the supply curves of shares are clearly upward-sloping. The shareholders' valuations on the firm differ dramatically. He argues that the "the hypothesis of common valuations indeed is not always a good approximation".[6]

Although Bagwell does not examine why shareholders are heterogeneous in their valuations, his evidence does support the hypothesis that shareholders respond differently to a single corporate announcement.

Persons (1997) builds a model with investor heterogeneity to explain the tender offer premium puzzle. He also argues that managers transfer wealth from shareholders who do NOT tender to who do. Such wealth transferring is costly for the managers, and therefore, prevents the low-performance firms from mimicking their signals.However, in his model, the investor heterogeneity comes from information asymmetry, rather than different prior beliefs or information process models as defined in this paper.

Huang and Thakor (2010) inherent the idea from Dittmar and Thakor (2007) but use it inversely in share repurchase rather than issuance. Huang and Thakor (2010) look at the open market repurchases. They argue that managers could have different evaluations on their firm's value from outside investors. More importantly, they point out that such differences could come from divergence of opinion rather than information asymmetry. The divergence of opinion could due to the fact that different generations have heterogeneous prior beliefs about the probability of the firm's future investment opportunities. Although they do not specifically model the differences in prior beliefs, they provide empirical evidence suggesting that divergence of opinion, proxied by dispersion in analyst forecasts and the structure of institutional holdings is an important factor which affects the managers' share repurchasing decisions.

4. Divergence of Opinion and Actual Share Repurchase

We introduce share repurchases when investors have divergent opinions by considering a simple model. The purpose of the model is to show that stock price will increase following managers' actual share repurchases.

[6]Bagwell (1991b), "Shareholder Heterogeneity: Evidence and Implications," *American Economic Review*, Vol 81, pp218.

The model is built on the framework of Miller (1977). Figure 1 shows the demand curves of shares when investors have divergent opinions on the firm's value. The curve AO, BO, and CO are three different demand curves (similar to the upward sloping 'supply' curve in Bagwell (1991b)). The curve AO represents a demand curve of shares in a firm with the highest investor divergence of opinion on the firm value and CO represents a demand curve without the investor divergence of opinion. N is the number of shares outstanding. It also represents the supply curve of shares. The model includes short sale constraints.

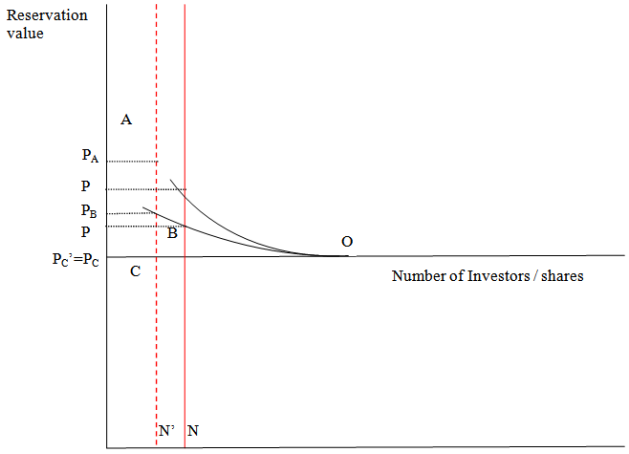

Figure 1. Divergence of opinion and share repurchase

In equilibrium, the stock prices will be at P_A, P_B, and P_C, for each demand curve, respectively. Consistent with Miller (1977), $P_A > P_B > P_C$ suggests that firms with high divergence of opinion among investors are likely to be overvalued.

When managers repurchase shares, the supply curve shifts to the left from N to N'. One can see that the equilibrium prices move up to P_A', P_B', and P_C', respectively. From the graph, one can directly observe that, $P_A'-P_A > P_B'-P_B > P_C'-P_C=0$. We conclude that: (i) without divergence of opinion, the stock price will not change when managers repurchase shares; and (ii) the larger the divergence of opinion, the more the stock price will increase when managers repurchase the same amount of shares.

4.1. Key Assumptions of the Model

Assumption 1: *Investors are heterogeneous either in their prior beliefs, or in their information processing models (the likelihood models).*

This assumption allows investors to respond differently to a public announcement made by the firm's managers. However, the assumption does not require that investors hold different private information. Investors know that they are heterogeneous in their opinions about the firm's value, but they agree to disagree with each other. The objective function for each investor is to maximize the payoff. They make decisions on their own beliefs.

Assumption 2: *Short sales are allowed but constraints exist.*

This assumption suggests that shareholders, who tender their shares, as a whole, are not able to short sale all their previous portfolios after tendering. The short sale constraints could be the result of the high stock-borrowing costs, the trading policy constraints, or the 'limits-of-

arbitrage' due to risks in arbitraging for risk-averse investors. Similar to the divergence of opinion, short sale constraints are also the common knowledge for all investors and the manager.

Assumption 3: *The share repurchases do not distort the firm's investment portfolio.*

With this assumption, the *true* future value of the firm does not change due to share repurchases. This assumption also implies that share repurchases do not contain information about future earnings.

4.2. A Simple Numerical Example with 'Stupid-investors'

We first provide a simple model where investors have different beliefs on a firm's value, but they do NOT update their beliefs even they observe the manager's repurchase announcement and the changes in price after the announcement.

For simplicity, we assume there are three shareholders and one manager in the firm. Each of them holds one share. Let the 'true' value of the firm at liquidation be \$48. If all shareholders keep their shares to the last period of liquidation, each of them will equally acquire one-fourth of the firm's wealth, \$12.

With the divergent opinions, each of investor (including shareholders and the manager) has his own expectation on the firm's future value. Shareholder 1 (SH1) believes each share will be worth \$10, \$11 for shareholder 2 (SH2), and \$13 for shareholder 3 (SH3). The manager, by chance, holds the belief of \$12 each share.

With short sale constraints, the stock is traded at \$10 per share, which is determined by the most pessimistic shareholder's opinion, according to the marginal-investor-theory. From the point of the manager's view, the stock is undervalued, since the manager believes that the stock is worth \$12. If all shareholders and the manager choose to hold the shares until the last period, the expected payoffs for each of them are: SH1:10, SH2:11, M:12, and SH3:13.

We will show that the manager can increase his payoff by repurchasing shares. The manager will continue to repurchase shares until the stock price equals his valuation. Shareholders choose to accept or reject the manager's repurchasing offers by comparing the offering prices and the belief of each of them.

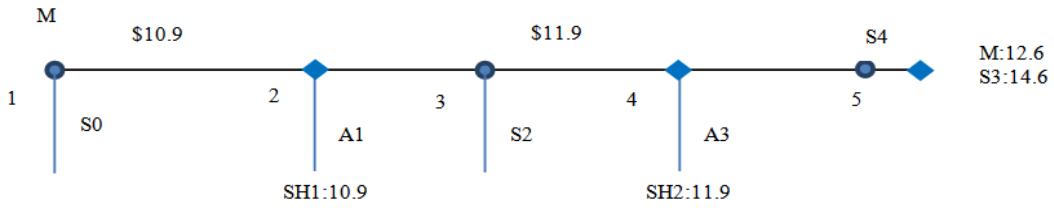

Figure 2. 'Stupid' investors' strategies in share repurchase

The game tree is presented in Figure 2. There are 5 nodes in the game. At each node, the round circle represents the manager's decision, while the square circle represents the shareholders' choice. M, SH1, SH2, and SH3 stand for the manager, and other three shareholders. The final payoffs for each of them are also labeled in the game for each investor. The manager's strategy set is {stop, offer}. S0, S2, and S4 are the manager's strategy at node 0, 2, and 4 to stop repurchase shares. \$10.9 and \$11.9 are the tendering prices if the manager chooses the offer strategy at node 0 and node 2. Shareholders' strategy set is {accept, reject}. A1 and A2 represent that the shareholder accept the manager's offer at node 1 and node 3, respectively.[7]

At node 1, the initial point, the manager has two strategies: (1) to repurchase at least one share or (2) not to repurchase any share. If the manager chooses not to repurchase any share, the game is over and the expected payoffs for each of investors do not change. If the manager chooses to repurchase at least one share, he offers a tender price, \$10.9, which is slightly higher than current stock price, to buy shares from other shareholders.

At node 2, all shareholders observe the tender price and choose their own strategy, to accept the offer or reject the offer, by comparing the expected payoff from each of these two strategies. With a \$10.9 offering price, only shareholder 1 is willing to tender his share, since his payoff from tendering, 10.9, is higher than his expected payoff, 10, from holding his share. Other shareholders choose to reject the offer, since tendering shares will reduce their payoffs.

After shareholder 1 tendering his share, the manager re-calculates the value (his expected payoffs) for each of the remaining shares, (12*4-10.9)/3=12.37. The shareholder 2 and 3 re-calculate the expected payoffs too, based on their own evaluation on the firm value. After shareholder 1 tendering, the expected payoffs for each of the investors are: S1:10.9, S2:11.03, M:12.37, and S3:13.7. The stock price is updated to \$10.9-11.03, determined by the manager's repurchasing price (bid price) and the opinion of shareholder 2 (ask price), who is not the most pessimistic shareholder.

At node 3, the manager again has two strategies: to repurchase more shares or to stop repurchase. He compares the current stock price with his own evaluation, and concludes that the stock is still undervalued. The manager thus chooses to repurchase more shares and offer \$11.9, a price slightly higher than current stock price.

At node 4, remaining shareholders observe the manager's second offer, and choose to reject this offer or to accept it. Only shareholder 2 chooses to accept this offer and tender his share, since his expected payoff from tendering 11.9 is higher than 11 from holding his share. Shareholder 3 chooses to reject this offer. Aft shareholder 2 tenders his share, the manager re-calculates his expected payoff again, and the value is 12.6.

At node 5, the manager still has two strategies to choose: to repurchase or to stop. Since the stock price is now \$11.9, which (almost) equals to the opinion of the manager himself. The manager will not repurchase any more shares and choose to stop. Without any more

[7] We do not label the shareholders' reject strategy in the game. If a shareholder does not accept the manager's offer, he automatically chooses the reject strategy.

repurchases, the payoff for the manager and the shareholder 3's payoff are: M:12.6 and S3:14.6. The game is over.

The equilibrium of this game is: the manager will offer twice and repurchase two shares from shareholder 1 and shareholder 2, respectively. The manager first offers $10.9, and shareholder 1 accepts the offer. The manager then offers $11.9 and shareholder 2 accepts the offer. The manager then chooses to stop and the game is over. The payoffs for each of them are: S1:10.9, S2:11.9, M:12.6, and S3:14.6.

At each period of this game, trade occurs as it increases the payoff for each player. Stock price goes up following the investors' expectation schedule, when the manager repurchases shares. The manager stops repurchase, when the stock price equals to his belief and he cannot increase his payoff through repurchases.

4.3. A 'smart' Investor with Complete Information

In the above 'stupid-investors' model, investors do not respond to the information in the manager's repurchasing announcement. They choose their strategy, at each step, based upon only the *current* repurchasing information (offering price) and their own evaluation.

We now analyze a model where investors choose their strategy based upon the information from the whole game. We further assume that all investors share the full information of the game. Both shareholders and the manager know the whole structure of the game, namely the prices that the manager will offer at each step and the step where the manager will stop offer further repurchases.

To simplify the discussion, we consider the game where only one shareholder and the manager hold one share of the firm asset for each of them. The shareholder believes the firm is worth $10 per share and the manager's belief is $12 per share. The game is played as below in Figure 3.

This game tree has 5 nodes. At each node, the round circle represents the manager's decision and the square circle represents the shareholders' choice. M stands for the manager, while SH stands for the shareholder. $10.9 and $11.9 are the manager's offering prices. S1, S3, and S5 represent that the manager choose to stop repurchase at each node, respectively. A2, A4, R2, and R4 represent the shareholder's strategy at each node, to accept the offer or to reject the offer. The payoffs for the shareholder and the manager at each step are labeled in the figure.

We solve this game with backward induction. At the last period, node 5, the manager has two strategies to choose: (1) continue to offering at a price higher than 12, or (2) stop the offering. If the manager choose to offer at a higher price, for example 12.1, his pay off will be 11.9. This payoff is lower than 12, the one he can get from stopping the offering. Therefore, the best strategy for the manager is to stop the offering and accept the expected payoff 12. With this 'stop' strategy, the expected pay offs for the shareholder and the manager are (10, 12).

At the node 4, the shareholder's strategy set is (1) to accept the manager's offer at $11.9, or (2) to reject this offer. With the complete information, the shareholder knows that if he rejects this offer, his expected payoff will be 10, since he knows that the manager will stop offer at next step. Therefore, the shareholder will choose to accept the manager's offer, 11.9, at this step.

At the node 3, the manager knows that if the manager extends the offer at $11.9, the shareholder will choose to accept the offer at his turn rather than reject it. The manager also knows that when the shareholder accepts the offer, his expected payoff will be 12.1. At the node 3, the other strategy that the manager can choose is to stop offering. If the manager choose to stop offering, he know that his expected payoff will be 12, which is less than the payoff he can get if he offer to repurchase at $11.9. Therefore, manager will choose to offer at the price $11.9 at node 3.

Back to node 2, the shareholder has choices between reject the offer at $10.9 or accept this offer. Since the shareholder knows the whole structure of the game, he knows that manager will offer at $11.9, if he rejects this offer of $10.9. He also knows that he can accept the offer at next step with a payoff 11.9, which is higher than the payoff 10.9 from accept the current offer. He thus chooses to reject the offer at $10.9 and expects the manager to offer at $11.9.

Back to the node 1, the original node, the manager knows the shareholder will reject his offer at $10.9 and wait for the offer at $11.9. However, if the manager chooses not to offer at very beginning, his expected payoff is only 12. Comparing the payoff he can get from offering to the last step, 12.1, the manager will choose to offer to repurchase shares. The game is solved.

There exists an equilibrium, in which the payoffs for the shareholder and the manager are (11.9, 12.1). The shareholder will reject all the manager's offers but the last one. The manager will choose to repurchase shares with a higher offering price until the last step, where the offering price (almost) equals to the manager's evaluation.

In this 'smart-investor', complete information game, shareholders will choose to hold their shares right before the manager stop offering, regardless of their own expectation. The trade will not occur until the manager's last offer. All shareholders, whose evaluations are lower than the manager's, will accept the manager's last offer. Other shareholders, whose evaluations are higher than (or equal to) the manager's, will reject all the manager's offerings. The payoffs for all shareholders and the manager increase when trade occurs.

4.5. A Pessimistic 'smart' Investor with in-Complete Information

At the initial state of the nature, a manager and a shareholder hold each share of a company. There are two states in the game, where the nature decides which state applies. In the state with good economy, the shareholder and the manager hold beliefs, $10 and $12, for value of each share. In the state with bad economy, the shareholder and the manager hold beliefs, $10 and $11, for value of each share. The possibility of the good economy is 0.2, and 0.8 for the bad economy.

Both the manager and the shareholder do not have the knowledge that which state of nature applies. The shareholder neither has the knowledge of the manager's belief, but he can observe the current offering price. The game tree is presented in Figure 4 and all symbols are same as the ones in Figure 3.

At node 1, if the manager does not offer to repurchase, the game is over. However, whatever the nature is, the manager has potential gain from the trade, as 11.1>11 in the bad economy, and 13.1>12 in the good economy. The manager is thus willing to offer a repurchase. His first offer is \$10.9.

At node 2, observing the manager's offer price \$10.9, the shareholder makes the choice between accept the offer or reject it.

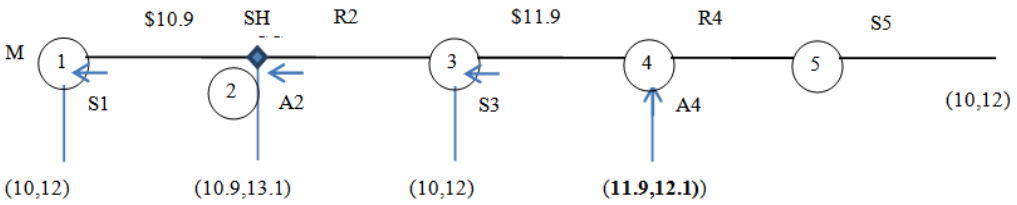

Figure 3. Smart Investor with completed information

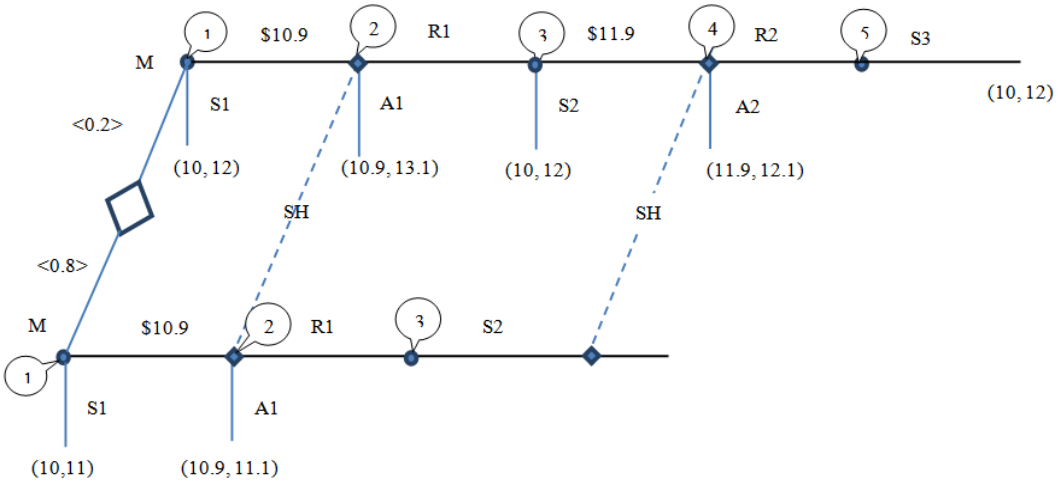

Figure 4. Smart pessimistic investors with incomplete information

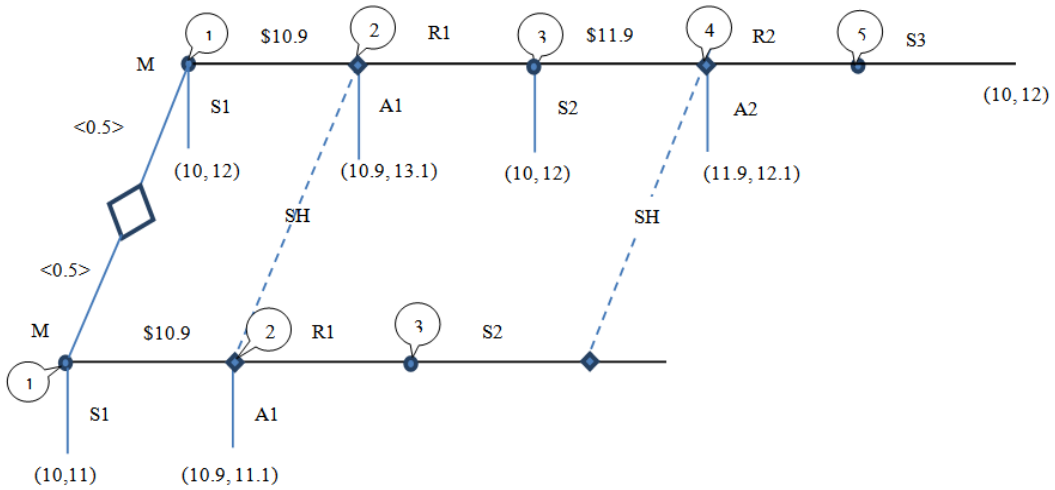

Figure 5. Smart optimistic investors with incomplete information

If the shareholder believes that the current state is in the good economy and the manager's reservation value is \$12, he will choose to reject the offer at node 2, since the payoff from the next offer, 11.9, will be higher than the one from the current offer 10.9. After the shareholder rejects the manager's first offer at node 2, he expects the manager's second offer.

At node 3, the manager chooses to continue to offer repurchase, since the payoff from repurchase 12.1 is higher than 12 from stop repurchase.

At node 4, the shareholder will accept the manager's offer at \$11.9, and his gain will be 1.9 (11.9-10). With the probability of 0.2 of the good economy, his expected gain is 1.9*0.2=0.38.

Back to node 2, if the shareholder believes that the current state is in the bad economy and the manager's reservation value is \$11, he chooses to accept the offer and tender his share at node 2 with price \$10.9, because he believes there is no further offer. With the probability of 0.8 of the bad economy, his expected gain is 0.72=0.9*0.8=(10.9-10)*0.8.

If the shareholder misunderstands the economy and accepts the first offer 10.9 in a good economy, he still has expected gain 0.18=0.9*0.2=(10.9-10)*0.2. Therefore, his

total expected gain from accepting the first offer 10.9 is 0.9=0.72+0.18.

In equilibrium, with the belief structure of the investor on the manager's reservation value, (11:0.8, 12:0.2), the shareholder will always choose to accept the manager's first offer, since the expected payoff 0.9 is higher than 0.38 from other strategy. The payoffs for the shareholder and the manager are (10.9, 13.1).

4.6. An Optimistic 'smart' Investor with in-complete Information

Now, let us consider another situation, where another shareholder holds the same prior belief about the company, but she react differently to the manager's repurchase offering. Assume the second shareholder is more optimistic and her belief structure on the manager's reservation value is (11:0.5, 12:0.5). The game has no changes, but the shareholder's expected gains change.

If the second shareholder accepts the offer at node 2, her total expected gain is 0.9. If she rejects the manager's offer at node 2, and is be able to get the offer at node 4 in the good economy, her expected gain is 1.9*0.5=0.95. Obviously, as an optimistic shareholder, the second shareholder will choose to reject the first offer and to wait the manager's second offer.

The manager, after seeing the shareholder rejects his $10.9 offer, has two strategies: one, to continue the second offer at $11.9, or two, to stop offering. The manager knows that, if he offers at $11.9 and the shareholder accepts the offer, his payoff will be 12.1. If the manager stop offering, his payoff is 12. The manager thus chooses to offer at $11.9. The payoffs for this shareholder and the manager are (11.9, 12.1), when the manager offers the second repurchase.

In equilibrium, with the belief structure of the investor on the manager's reservation value, (11:0.5, 12:0.5), the shareholder will always choose to reject the manager's first offer and accept the manager's second offer. The manager will also continue to offer until the offering price (almost) equals his reservation value. The payoffs for the shareholder and the manager are (11.9, 12.1).

5. Conclusion

The purpose of this paper is two-fold. First, we provide a deep and broad understanding of investor divergence of opinion, which has not been considered by previous studies, to the best of our knowledge. The paper reviews both the theoretical model structures and the major empirical results including various measures of divergence of opinion developed in the literature. It then follows a discussion of the divergence of investors' opinions on a stock's value. The divergence perspective allows us to study share repurchases from investors' heteroscedastic beliefs, compared to the homogeneous assumption.

Second, we then propose a new repurchasing model based on investor divergence of opinion in order to explain managers' motivation of share repurchase and related asset pricing anomalies. Our model suggests that managers repurchase shares due to divergence of opinion. Managers believe pessimistic shareholders undervalue the stock, and thus repurchase shares from them. Stock prices increase as managers repurchase shares. Wealth is transferred from tendering shareholders to non-tendering shareholders when manager repurchase shares, only if those managers are not too optimistic and purchase shares at a price higher than the intrinsic value.

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