Seemingly irrelevant disclosures*

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Abstract

This paper analyzes a two period model where investors with homogeneous beliefs about the firm's liquidating cash flows buy ownership shares at the start of the first period. At the end of the first period, a public disclosure is made that reveals some information on the firm's final cash flows. It is shown that such future disclosure may affect the pre-disclosure share price even though, in equilibrium, investors will not trade upon the disclosure. Consequently, rational investors misprice the firm's stock relative to its final period cash flows. The mispricing arises because investors would like to exploit a short-term investment opportunity. Furthermore, it is shown that such future disclosures induce autocorrelation in stock returns like momentum and mean-reversal and that such autocorrelation presents a systematic risk factor.

Keywords: rationality, asymmetric disclosure, mispricing, momentum, investment horizons, systematic risk factors.

JEL codes: D40, D80, G12, G14, M41.

1 Introduction

It is an obvious fact that stock prices respond to news. Good news today increases current stock prices while bad news today decreases current stock prices. This paper shows that current stock prices also depend on disclosures that still need to occur in the future. I consider a two period model where investors with homegeneous prior beliefs of the liquidating cash flows buy shares at the start of the first period. At the end of the first period, some news on the liquidating cash flows may be publicly disclosed. Investors can trade upon this news, but since investors have homogeneous beliefs, they will not do so in equilibrium. Hence, intuitively one would expect that the pre-disclosure stock price only depends on the distribution of the liquidating cash flows and that the future disclosure is completely irrelevant. Similar claims are made in Epstein and Schneider (2008) and Verrecchia (1999). Epstein and Schneider (2008) claim that in a Bayesian framework future information quality has no effect on current utility. Verrecchia (1999) claims that for future disclosures to be relevant for current prices, it is necessary that there is a prior commitment by firm management to make these disclosures.

This paper finds that even though in equilibrium investors will not trade upon the future disclosure, it does matter for the pre-disclosure stock price. Crucial for this result to hold is that future disclosures are asymmetric, that is, good news and bad news are not equally informative. The explanation for this result is that future disclosures affect investors' demand function. When good news is more informative than bad news, the volatility in the post disclosure stock price is relatively low so that short term investing becomes attractive, that is, besides buying and holding shares for two periods investors would also like to buy some shares at the start of the first period and sell them at the end of the first period after the news has been disclosed. But because such short term investments are not feasible in equilibrium, the pre-disclosure stock price needs to increase to make short term investing unattractive. The opposite holds when good news is less informative than bad news. In that case, the volatility in the post disclosure stock price is relatively high so that investors would like to engage in short term short selling. Since this is not feasible in equilibrium, the pre-disclosure stock price declines untill short selling is no longer attractive. This result is robust to introducing short term investors in each period so as to give long term investors the opportunity to actually trade upon the disclosed information. In fact, it further strengthens the price effects of disclosure.

Rational investors thus seem to misprice the firm's stock. For example, when good news is more informative than bad news, they are willing to pay *more* for the firm's stock than the underlying cash flows would justify. Moreover, investors know that they are paying too much. This mispricing arises because of the inability of investors to commit to a long term investment of two periods. The disclosure generates a short term investment opportunity that investors want to exploit. Arbitrage cannot eliminate the mispricing either. To benefit from the mispricing, investors need to sell the stock short for two periods. But after the public disclosure, the stock is correctly priced so that short positions are no longer optimal. The mispricing disappears when *all* investors can commit to not engaging in any short term investments. The reason for the mispricing differs from that in Dow and Gorton (1994) and Goldman and Slezak (2003). In Dow and Gorton (1994) mispricing arises because investors are uncertain whether the mispricing will be resolved within their investment horizon. For that reason, they may not fully exploit the risky arbitrage opportunities. In Goldman and Slezak (2003) mispricing arises because fund managers do not trade on their private information. As fund managers have a short tenure with the fund, they are uncertain whether their private information results in trading benefits before their tenure ends.

This paper further shows that asymmetric disclosure induces autocorrelation and cross-serial correlation in stock returns. The explanation is straightforward. Asymmetric disclosure implies that disclosure content is related to informativeness. Disclosure content determines the current stock return while the informativeness of the disclosure determines the future stock return. A more informative disclosure reduces investment risk which in turn reduces expected return. For example, more informative good news will induce negative autocorrelation in stock returns. Good news results in a positive return over the pre-disclosure period and the high informativeness of the good news implies a low expected return over the post-disclosure period. Bad news, on the other hand, results in a negative return over the pre-disclosure period while its low informativeness implies a high expected return over the post-disclosure period.

Asymmetric disclosures are essential to obtain these results. In practice, many disclosures are asymmetric. Financial reports are governed by accounting standards like IFRS or US-GAAP. Characteristic for these accounting standards is that they feature some degree of accounting conservatism. Watts (2003) describes accounting conservatism as higher verification requirements for the recognition of gains than for the recognition of losses. It thus implies that gains are more informative than losses as losses already need to be recognized when there is a remote possibility of future cash outflows. Voluntary disclosure of news also induces asymmetry. In equilibrium, good news is disclosed only if it yields a positive response by the market. Hence, nondisclosure is perceived as bad news and it is less informative than disclosure.

The main contributions of the paper relate to correlation patterns in stock prices, systematic risk factors, and the link between disclosure and cost of capital. Existing literature presents both rational and behavioral explanations for the empirically observed correlation patterns in stock prices like momentum and mean-reversal. Rational explanations include learning (Lewellen and Shanken (2002), strategic disclosures (Shin (2003), Shin (2006)), time-varying dividend growth rates (Johnson (2002)), consumption smoothing (Cecchetti, Lam and Nelson (1990)), and inattention (Nieuwerburgh and Veldkamp (2010)). Behavioral explanations include feedback traders (Hong and Stein (1999) and Sentana and Wadhwani (1992)), investor sentiment (Barberis, Shleifer and Vishny (1998)), and overconfidence (Daniel, Hirshleifer and Subrahmanyam (1998)). This paper adds asymmetric disclosure as an alternative, rational explanation. An important difference between asymmetric disclosure and other existing explanations is that asymmetric disclosure can explain *both* positive and negative autocorrelation in stock returns.

Following empirical studies by, e.g., Fama and French (1993) and Cahart (1997), capital asset pricing models include additional systematic risk factors besides the covariances in the cash flows. These risk factors relate to firm size, book to market ratios, and stock price momentum. To the best of my knowledge, there are no proper theoretical explanations for these additional systematic risk factors. This paper shows how asymmetric disclosure yields stock price momentum as a systematic risk factor.

The conventional wisdom in accounting and finance is that more disclosure should decrease the cost of capital of the firm. Theoretically, however, it is not straightgforward how disclosure links to a firm's cost of capital. Disclosure can reduce estimation risk in future cash flows and their covariances (e.g., Lambert, Leuz and Verrecchia (2007)). Alternatively, disclosure can reduce information asymmetry across investor, which in turn reduces the risk of trading with an informed investor (e.g., Easley and O'Hara (2004)). Hughes, Liu and Liu (2007) shows that the latter risk factor is diversifiable, while Christensen, de la Rosa and Feltham (2010) shows that both links between disclosure and cost of capital disappear when an ex ante perspective is considered. They show that the decrease in cost of capital in the post-disclosure period is offset by an increase in cost of capital in the pre-disclosure period. This paper shows that the results in Christensen et al. (2010) are driven by their choices for investors' preferences and symmetric disclosures. In a more general setting, it is unlikely that the opposite effects in the pre-disclosure and post-disclosure periods cancel each other out. Consequently, the link presented in Lambert et al. (2007) is expected to survive in an ex ante perspective.

This paper may be interpreted as a generalization of Shin (2003), Lambert et al. (2007), and Suijs (2008). Shin (2003) shows how strategically disclosed information induces autocorrelation in stock returns. Lambert et al. (2007) analyzes the role of symmetric disclosures on a firm's cost of capital. Suijs

(2008) shows that asymmetric disclosure affects risk sharing across different generations of investors. Another closely related study is Shin (2006). Shin (2006) links disclosure content to future risk through the information flow over time. The release today of a lot of good news signals to the market that more disclosures are expected in the short term future, which in turn increases short term investment risk. Shin (2006) differs from this study in that it only considers positive correlation between disclosure content and risk (that is, good news increases future investment risk). Furthermore, it does not show that the resulting correlation in stock prices is incorporated into current stock price.

The remainder of this paper is organized as follows. Section 2 presents the model and Section 3 presents the main results. Section 4 discusses the robustness of the results. Section 5 discusses the asymmetric nature of disclosure and Section 6 discusses the results and their implications. Finally, Section 7 concludes.

2 Disclosure model

The model considers a single firm that operates from date $t = 1$ until date $t = 3$. At date $t = 1$, the firm starts an investment project that generates a liquidating cash flow $\tilde{x}$ at date $t = 3$. The cost of this investment project is irrelevant for the problem at hand and is therefore not specified. The probability distribution function of the date $t = 3$ cash flow is common knowledge to all investors. The firm's stock is traded on a perfectly competitive market at dates $t = 1$ and $t = 2$. At each trading date, investors can costlessly borrow the risk free asset. The return of the risk free asset is normalized to one as is the total number of firm shares.

At date $t = 2$, before trade takes place, there is a public disclosure y about the date $t = 3$ cash flow $\tilde{x}$. Denote by $\tilde{x}(y)$ the date $t = 3$ cash flow condi-

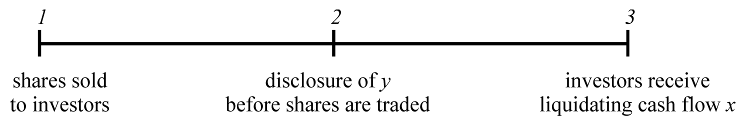


Figure 1: Sequence of events.

tional on the disclosure y. Notice that this set-up also allows for uncertainty regarding the occurence of a public disclosure by including an uninformative message as one of the possible messages. Such an uninformative message y' would satisfy $\tilde{x}(y') = \tilde{x}$, i.e., the conditional distribution of the future cash flow coincides with the prior distribution. I do not further specify the source of the disclosure y. It can be, for example, firm management, a financial analyst or a competitor. The source of disclosure is only relevant to the extent that it influences the characteristics of the disclosure $\tilde{y}$. For example, when firm management makes the disclosure strategic considerations may determine which information will be disclosed and how informative such disclosures will be. Similarly, when a financial analyst makes the disclosure, it matters whether this is a buy-side or sell-side analyst as sell-side analysts are known to bias their reports. Section 5.2 discusses the effect of strategic considerations on the characteristics of the disclosure $\tilde{y}$.

Let π_1 and $\pi_2(y)$ denote the equilibrium share price at the respective trading dates $t = 1$ and $t = 2$. Observe that the date $t = 2$ share price is conditional on the disclosure y that the firm makes just prior to date $t = 2$ trade. Denote by l_{i1} and $l_{i2}(y)$ the demand of investor i at the respective trading dates $t = 1$ and $t = 2$. For ease of notation, I assume that an investor sells at date $t = 2$ the l_{i1} shares bought at date $t = 1$ so that the payoff to this investor can be written as

$$l_{i1}(\pi_2(\tilde{y}) - \pi_1) + l_{i2}(\tilde{y})(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y})). \tag{1}$$

Consequently, $l_{i2}(y) - l_{i1}$ denotes the net trade by the investor at date $t = 2$

and $\min(l_{i1}, l_{i2}(y))$ denotes the number of shares that the investor holds for two periods.

There are N_l investors in the market. Investors have preferences over date $t = 3$ wealth with any first period trading benefits automatically being transferred to date $t = 3$ (consistent with a risk free rate of return equal to one). The preferences of each investor are described by a linear mean-variance utility function[1] $U(\tilde{z}) = E(\tilde{z}) - \alpha V(\tilde{z})$, with $E(\cdot)$ and $V(\cdot)$ denoting the expectation and variance operator and $\alpha \geq 0$ representing the degree of risk aversion.[2] Because investors are constant absolute risk averse, unconstrained borrowing implies that the initial capital endowments of investors are irrelevant for their investment decisions. Hence, without loss of generality I may assume that all capital endowments are zero. Finally, observe that at all three dates, there is no information asymmetry across investors. Figure 1 summarizes the sequence of events.

3 Equilibrium share prices

Investors buy the firm's stock at date $t = 1$ and hold the stock until date $t = 3$ when they collect the firm's liquidating cash flow $\tilde{x}$. At date $t = 2$, following the firm's disclosure y, investors are allowed to trade in the firm's stock. However, in equilibrium, trade will not occur at $t = 2$ as all investors are rational and possess the same information on the final cash flow $\tilde{x}$. Hence, one would expect the homogeneous investors not to care about the intermediate

[1] Mean-variance utility functions are used for mathematical convenience. Section 4.1 briefly discusses how the results extend to alternative preferences. In short, results are qualitatively similar for constant relative risk averse utility functions. For exponential utility functions, however, the results do not hold. The reason for this is that exponential utility functions are loglinear.

[2] I assume a homegeneous degree of risk aversion across investors to reduce notation. Similar results can be derived when heterogeneous degrees of risk aversion are considered.

disclosure y and price the firm's stock at date $t = 1$ based only on the distribution of the liquidating cash flow $\tilde{x}$, that is,

$$\bar{\pi}_1 = E(\tilde{x}) - \tfrac{2\alpha}{N_l} V(\tilde{x}). \tag{2}$$

The following proposition shows that this need not always be the case.

Proposition 1 *In equilibrium, the date $t = 2$ stock price equals*

$$\pi_2(y) = E(\tilde{x}(y)) - \tfrac{2\alpha}{N_l} V(\tilde{x}(y)) \tag{3}$$

and the date $t = 1$ stock price equals

$$\pi_1 = E(\tilde{x}) - \tfrac{2\alpha}{N_l} V(\tilde{x}) + \tfrac{2\alpha}{N_l} COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})), \tag{4}$$

where $\rho_2(\tilde{y})) = \frac{2\alpha}{N_l} V(\tilde{x}(y))$.

The date $t = 2$ stock price is as expected for mean-variance utility functions. The date $t = 1$ stock price differs from the initial expectations by a term $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y}))$. Consequently, future disclosures may affect pre-disclosure stock price even though, in equilibrium, investors will not trade upon this future disclosure.

The explanation for this result is as follows. $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y}))$ measures the relation between the cash flow news $E(\tilde{x}(y))$ of the public disclosure y and the second period risk premium $\rho_2(y)$. One can interpret the latter term as a measure for the informativeness of the disclosure y. A more informative disclosure y reduces residual uncertainty with respect to the future cash flows, which in turn results in a lower risk premium. When the covariance $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y}))$ is positive, good news (i.e., higher expected cash flows $E(\tilde{x}(y)))$ is on average less informative (i.e., higher risk premium $\rho_2(\tilde{y}))$ than bad news. Conversely, a negative covariance implies that bad news is on average more informative than good news.

Asymmetric disclosures affect the volatility of the intermediate date stock price. When good news is less informative than bad news, the increase in stock price due to the disclosure of good news is partly offset by a large risk premium to compensate investors for the higher residual uncertainty. The stock price decrease following bad news is limited because it includes only a small risk premium. Consequently, the volatility is relatively low. In contrast, when good news is more informative than bad news, the volatility will be relatively high. Good news results in a large stock price increase as the risk premium is small. Bad news results in a large stock price decrease as in addition to the bad news, the stock price further decreases because of the large risk premium.

Although the investors do not trade at date $t = 2$ in equilibrium, they are allowed to do so. The opportunity to trade affects their demand at date $t = 1$. Consider first the case that the covariance $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y}))$ is positive. Suppose $\bar{\pi}_1$ is the date $t = 1$ stock price. Since the volatility in the date $t = 2$ stock price is relatively low, buying shares at date $t = 1$ at price $\bar{\pi}_1$ and selling them at date $t = 2$ offers an attractive investment opportunity. As in equilibrium such investments are not possible, the date $t = 1$ equilibrium share price needs to be higher than $\bar{\pi}_1$ to make short term investments less attractive. Hence, $\pi_1 > \bar{\pi}_1$ when $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$.

Next, consider the case that the covariance $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y}))$ is negative. Since the volatility in the date $t = 2$ stock price is now relatively high, short term investments are no longer attractive. The price $\bar{\pi}_1$ at which shares can be bought is too high compared to the investment risk. In this case, short selling is the attractive investment opportunity. Investors can benefit from selling some shares at date $t = 1$ and buying them back at date $t = 2$. As in equilibrium such short selling is not possible, the date $t = 1$ share price needs to be less than $\bar{\pi}_1$ to make short selling less attractive. Hence, $\pi_1 < \bar{\pi}_1$ when $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$.

Summarizing, Proposition 1 shows that future disclosures may be relevant in asset pricing even though these disclosures do not generate any actual trade. What is important is that there is an opportunity to trade. This opportunity affects investors' demands for the firm's stock and thus its stock price.

This result is similar to Epstein and Schneider (2008), who also show that future disclosures matter for current stock prices. To obtain this result, Epstein and Schneider abandon the Bayesian framework and allow for ambiguity and ambiguity-aversion. In their setting, future disclosures are symmetric but the informativeness of these disclosures is ambiguous. Because in their setting ambiguity-averse investors follow a worst case scenario in processing new information,[3] bad news is regarded as being highly informative whereas good news is regarded as being almost uninformative. Consequently, investors respond asymmetrically to good and bad news in a way that corresponds to the case $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$ above.[4] Notice that the reverse case of $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$ is not possible in the setting of Epstein and Schneider (2008). For this to occur with ambiguous information investors need to follow a best case scenario.

[3]See Epstein and Schneider (2003) for a characterization of this information processing behavior. However, other information processing behavior like a weighting between worst and bad case scenarios have also been considered in the literature on ambiguous information (e.g., Binmore (2009)).

[4]One noteworthy difference in the results is that risk neutrality is allowed in Epstein and Schneider (2008). Risk aversion is needed in a Bayesian setting as asymmetry in the disclosed news affects the probability distribution of the news. For example, when bad news is more informative than good news, the good news is more likely to occur (presuming a symmetric prior distribution on the cash flows). This link is absent in the setting with ambiguous news. Investors can respond asymetrically to good and bad news even when good and bad news are equally likely to occur. Consequently, $E(E(\tilde{x}(\tilde{y})))$ will be less than $E(\tilde{x})$ with ambiguity aversion.

3.1 Rational mispricing and the limits of arbitrage

Proposition 1 implies that rational investors misprice the firm's stock relative to the expected future cash flows. For example, when good news is more informative than bad news, they are willing to pay *more* for the firm's stock than the underlying cash flows would justify. Furthermore, investors know that the stock is mispriced when they buy it at date $t = 1$. The mispricing arises because of the inability of investors to commit *not* to exploit the short term investment opportunity that the future disclosure generates.

Arbitrage cannot eliminate the mispricing either. To benefit from the mispricing, investors need to sell the stock short for two periods. But after the public disclosure, the stock is correctly priced so that short positions are no longer optimal.

To see the limits of arbitrage, consider adding a second type of investors who are committed to investments of two periods only. I refer to these investors as buy and hold investors. The other type of investors is referred to as speculators, as they can take short term positions to benefit from the upcoming disclosure. Even though buy and hold investors can benefit from the mispricing, they cannot fully eliminate it. Firstly, because the arbitrage position is risky. Secondly, because buy and hold investors do not trade in the post-disclosure period, speculators cannot trade either in this period. Hence, the same mechanics apply as in Proposition 1. If the pre-disclosure price π_1 would equal the benchmark price $\bar{\pi}_1$, speculators would want to engage in short term trading. As this is not possible in equilibrium, the pre-disclosure price π_1 diverges from $\bar{\pi}_1$. The exception is when *all* investors are buy and hold investors. In that case, the pre-disclosure price π_1 obviously equals the benchmark price $\bar{\pi}_1$.

In practice, it is rather unlikely that all investors follow buy and hold strategies in which trading decisions are not influenced by disclosures. The ability to speculate on future price changes may thus offer an explanation for over and undervaluation in the market. Furthermore, the analysis illustrates that due care is required in applying the arbitrage argument. Even in a perfectly rational market, arbitrage opportunities may not always be exploited to their full extent. Dow and Gorton (1994) make a similar claim. They show that when investors have short investment horizons, arbitrage opportunities may not be fully exploited because investors take into account that the mispricing may not be corrected during their short investment horizon. This reason differs from the one presented here that investors cannot commit to a long term investment.

3.2 Asymmetric disclosure and correlation in stock returns

Future disclosures become relevant for current stock prices when these disclosures are asymmetric, that is when good news and bad news are not equally informative. Such asymmetry also has implications for the correlation in stock returns. The content of the disclosure determines the current stock return while the informativeness of the disclosure determines the future stock return. A more informative disclosure reduces investment risk which in turn reduces expected return.

Recall that $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y}))$ measures the asymmetry in the disclosure as it relates disclosure content $E(\tilde{x}(\tilde{y}))$ to informativeness $\rho_2(\tilde{y})$. Correlation in stock returns is captured by $COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y}))$ where $\pi_2(\tilde{y})$ represents first period stock return[5] and $\tilde{x}(\tilde{y}) - \pi_2(\tilde{y})$ represents second period stock return. Then the relation between disclosure asymmetry and correlation in stock returns is as follows:

$$COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y})) = COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) - V(\rho_2(\tilde{y})). \quad (5)$$

[5] One can also consider $\pi_2(\tilde{y} - \pi_1$. But since π_1 is a constant, it immediately follows that $COV(\pi_2(\tilde{y}) - \pi_1, \tilde{x}(\tilde{y}) - \pi_2(\tilde{y})) = COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y}))$.

Observe that more informative good news (i.e., $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$) implies negative correlation in stock returns. Good news results in a positive return over the pre-disclosure period but the high informativeness of the good news implies a low expected return over the post-disclosure period. Bad news, on the other hand, results in a negative return over the pre-disclosure period but its low informativeness implies a high expected return over the post-disclosure period.

More informative bad news (i.e., $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$) does not automatically imply positive correlation in stock returns. Negative correlation can also arise when the variation in informativeness is sufficiently high. To see this, consider two disclosures y_1 and y_2, with y_1 being good news and y_1 being less informative than y_2. Consistent with $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$, it holds that $E(\tilde{x}(y_1)) > E(\tilde{x}(y_2)$ and $\rho_2(y_1) > \rho_2(y_2)$. Observe that the first period stock return satisfies $\pi_2(y) = E(\tilde{x}(y)) - \rho_2(y)$ and that the second period stock return satisfies $\tilde{x}(y) - \pi_2(y) = \rho_2(y)$. Because y_1 is less informative than y_2 (i.e., $\rho_2(y_1) > \rho_2(y_2)$) negative correlation in stock returns requires that $E(\tilde{x}(y_1)) - \rho_2(y_1) < E(\tilde{x}(y_2)) - \rho_2(y_2)$ or, equivalently, $\rho_2(y_1) - \rho_2(y_2) > E(\tilde{x}(y_1)) - E(\tilde{x}(y_2)) > 0$. This means that even though the expected cash flows are higher for disclosure y_1, the risk premium required by investors is so much higher that the resulting stock price is actually lower than for disclosure y_2.

The direct relation between disclosure asymmetry and correlation in stock returns suggests that the latter should be a relevant factor in asset pricing. The next corrolary shows this is indeed the case.

Corollary 1 *In equilibrium, the date $t = 1$ stock price equals*

$$\pi_1 = E(\pi_2(\tilde{y})) - \tfrac{2\alpha}{N_l} V(\pi_2(\tilde{y})) - \tfrac{2\alpha}{N_l} COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y})). \tag{6}$$

Observe that $E(\pi_2(\tilde{y})) - \frac{2\alpha}{N_l} V(\pi_2(\tilde{y}))$ is the equilibrium stock price when investors would invest for only one period. When they would buy at date

$t = 1$ and sell at date $t = 2$ the payoff to their investment equals the date $t = 2$ stock price $\pi_2(\tilde{y})$. But because investors also hold the stock in the second period, they also receive the second period payoff $\tilde{x}(\tilde{y}) - \pi_2(\tilde{y})$. Hence, they care about the correlation between the first and second period payoffs $COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y}))$.

Observe that equation (6) suggests that a positive correlation in stock returns reduces date $t = 1$ stock price. However, one cannot consider the correlation in stock returns $COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y}))$ in isolation as a change in $COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y}))$ also comes with a change in $V(\pi_2(\tilde{y}))$. As Proposition 1 and equation (5) show, positively correlated stock returns imply that good news is less informative than bad news, which in turn increases the date $t = 1$ stock price. The reason is that more informative good news reduces the volatility in the date $t = 2$ stock price, that is, it reduces $V(\pi_2(\tilde{y}))$. Conversely, negatively correlated stock returns reduce the date $t = 1$ stock price when it implies that bad news is more informative than good news. In that case the negative correlation increases the volatility in the date $t = 2$ stock price. Summarizing, asymmetric disclosure affects the date $t = 1$ stock price through the terms $V(\pi_2(\tilde{y}))$ and $COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y}))$ in oppositie directions, with the effect on $V(\pi_2(\tilde{y}))$ being the dominant one.[6]

Finally, observe that positive correlation in stock returns corresponds to momentum in stock prices. Furthermore, it implies that good news is less informative than bad news so that the volatility of the intermediate date stock price is relatively low. Hence, momentum stocks are expected to exhibit low volatility in stock prices. Negative correlation in stock returns corresponds to mean reversal in stock prices. Here, the opposite applies so that mean reversal stocks are expected to exhibit higher volatility in stock prices than

[6]The exception being when $COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y})) < 0$ and $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$ (cf. equation (5)). In that case, both terms $V(\pi_2(\tilde{y}))$ and $COV(\pi_2(\tilde{y}), \tilde{x}(\tilde{y}) - \pi_2(\tilde{y}))$ affect the date $t = 1$ price in the same direction.

momentum stocks.

3.3 Systematic risk factors

This subsection shows that the autocorrelation in future stock returns, which is a determinant of the pre-disclosure stock price (cf. Corollary 1), consitutes a systematic risk factor that is priced by the market. For that purpose, consider an extension of the model with n firms. Let $\tilde{x}^i$ denote the date $t = 3$ cash flow for firm i and let $\tilde{y} = (\tilde{y}^1, \tilde{y}^2, \ldots, \tilde{y}^m)$ with $m \geq 1$ be the publicly disclosed news at date $t = 2$. In case $m = n$, one can interpret $\tilde{y}^i$ as the date $t = 2$ disclosure of firm i. I do not explicitly model the relationship between the disclosures $\tilde{y}$ and cash flows $\tilde{x}^i$. I confine by noting that $\tilde{x}^i(y)$ presents the cash flows of firm i conditional on the disclosure $y = (y^1, y^2, \ldots, y^m)$. Denote by π_1^i and $\pi_2^i(y)$ the equilibrium prices at dates $t = 1$ and $t = 2$, respectively. Notice that the date $t = 2$ stock price $\pi_2^i(y)$ depends on all disclosures $y = (y^1, y^2, \ldots, y^n)$.

Proposition 2a *Given disclosures y, the date $t = 2$ equilibrium stock price equals*

$$\pi_2^i(y) = E(\tilde{x}^i(y)) - \tfrac{2\alpha}{N_l} V\left(\textstyle\sum_{j=1}^n \tilde{x}^j(y)\right) \beta_2^i(y), \tag{7}$$

with

$$\beta_2^i(y) = \frac{COV\left(\tilde{x}^i(y), \sum_{j=1}^n \tilde{x}^j(y)\right)}{V\left(\sum_{j=1}^n \tilde{x}^j(y)\right)}. \tag{8}$$

Observe that $V\left(\sum_{j=1}^n \tilde{x}^j(y)\right)$ represents the risk of the market portfolio $\sum_{j=1}^n \tilde{x}^j(y)$ and that $\beta_2^i(y)$ measures the covariance of firm i with the market portfolio, consistent with the tradional CAPM model. For the date $t = 1$ price one obtains:

Proposition 2b *The date $t = 1$ equilibrium stock price equals*

$$\pi_1^i(y) = E(\pi_2^i(y)) - \tfrac{2\alpha}{N_l} V\left(\textstyle\sum_{j=1}^n \pi_2^j(y)\right)(\beta_1^i + \gamma_1^i)\,, \tag{9}$$

with

$$\beta_1^i = \frac{COV\left(\pi_2^i(\tilde{y}), \sum_{j=1}^n \pi_2^j(\tilde{y})\right)}{V\left(\sum_{j=1}^n \pi_2^j(\tilde{y})\right)} \tag{10}$$

and

$$\gamma_1^i = \frac{COV\left(x^i(\tilde{y}) - \pi_2^i(\tilde{y}), \sum_{j=1}^n \pi_2^j(\tilde{y})\right)}{V\left(\sum_{j=1}^n \pi_2^j(\tilde{y})\right)}. \tag{11}$$

Interpreting $\sum_{j=1}^n \pi_2^j(\tilde{y})$ as the short term market return, the date $t = 1$ share price is determined by the weighted average of two market risk factors β_1^i and γ_1^i. The factor β_1^i measures the correlation between the firm's short term return and the short term market return. This risk factor corresponds to the systematic risk factor incorporated in the traditional CAPM model. Observe though that in this setting, market beta is time varying as β_1^i may differ from $\beta_2^i(y)$. The factor γ_1^i measures the covariance between the pre-disclosure market return and the post-disclosure firm return. Hence, not only contemporaneous correlation with market return is included in stock price but also the correlation over time.

4 Robustness of the main result

The purpose of this section is to show that the asset pricing results of the previous section are not particular to model's assumptions. The robustness checks will focus on two critical assumptions of the model, namely the mean variance utility functions and the investment horizons of investors.

4.1 Alternative investors' preferences

Proposition 1 is not driven by the assumption of mean-variance utility functions. The findings are similar for the class of constant relative risk averse power utility functions $U(z) = \frac{z^{1-\alpha}}{1-\alpha}$ with $\alpha > 0$. In this setting, the benchmark date $t = 1$ price $\bar{\pi}_1$ that ignores any effects of the intermediate date disclosures, satisfies

$$E\left((\tilde{x} - \bar{\pi}_1)\frac{\partial U}{\partial}\left(\omega + \frac{1}{n}(\tilde{x} - \bar{\pi}_1)\right)\right) = 0$$

with ω the capital endowment of the investors. The condition states that for the stock price $\bar{\pi}_1$, an investor does not want to hold more (or less) than the equilibrium shareholdings $\frac{1}{n}$. Taking the disclosures into account, the date $t = 2$ equilibrium share prices satisfy

$$E\left((\tilde{x}(y) - \pi_2(y))\frac{\partial U}{\partial}\left(\omega + \frac{1}{n}(\tilde{x}(y) - \pi_2(y))\right)\right) = 0$$

and the date $t = 1$ equilibrium share price satisfies

$$E\left((\pi_2(\tilde{y}) - \pi_1)\frac{\partial U}{\partial}\left(\omega + \frac{1}{n}(\tilde{x} - \pi_1)\right)\right) = 0.$$

To see the effect of disclosure on the date $t = 1$ stock price a numerical analysis is performed. Assume that the liquidating cash flow $\tilde{x}$ is uniformly distributed on $\{0, 1, 2, 3, 4, 5\}$ and that the intermediate date disclosure can be any of the six messages $\{y_0, y_1, y_2, y_3, y_4, y_5\}$. A disclosure system $\tilde{y}$ is characterized by a matrix $Q = (q_{ij})_{i,j=0,1,\ldots,5}$ with $q_{ij} = Pr(\tilde{y} = y_j|\tilde{x} = i)$ and $\sum_{j=0}^{5} q_{ij} = 1$ for each i. Observe that the disclosure is uninformative when $q_{ij} = \frac{1}{6}$ for all i, j and that the disclosure is perfectly informative when Q is the identity matrix. Furthermore, observe that each Q may result in a different date $t = 1$ stock price π_1. Figure 2 plots the frequency distribution of the mispricing $\frac{\pi_1 - \bar{\pi}_1}{\bar{\pi}_1}$ for a sample of $100,000$ randomly chosen disclosure systems $\tilde{y}$. Panel A is based on mean variance preferences with degree of risk aversion $\alpha = 0.2407$. Panel B is based on power utility functions with degree of risk aversion $\alpha = 0.8$ and capital endowments $\omega = 5$. The benchmark price $\bar{\pi}_1$ is equal to 2.0374 for both types of preferences.

Figure 2 shows that results for power utility functions are qualitatively similar to mean variance utility functions but with the effect for power utility functions being smaller in magnitude than for mean variance utility functions.

For the class of exponential utility functions $U(z) = -e^{-\alpha z}$ with $\alpha > 0$, however, the results do not hold. One can show that $\pi_1 = \bar{\pi}_1$, i.e., future disclosures are irrelevant for pre-disclosure prices. Although this result is in line with intuition, the explanation is purely technical as it is driven by the loglinearity of exponential utility functions. To see this, recall that the date $t = 1$ equilibrium stock price satisfies

$$E\left((\pi_2(\tilde{y}) - \pi_1)\frac{\partial U}{\partial}\left(\omega + \frac{1}{n}(\tilde{x} - \pi_1)\right)\right) = 0.$$

Characteristic for exponential utility functions is that they are loglinear functions, that is, $\log(U(z_1 + z_2)) = \log(U(z_1)) + \log(U(z_2))$. Combining loglinearity with $\frac{\partial U(z)}{\partial z} = -\frac{1}{\alpha}U(z)$, the above expression is equivalent to

$$E\left((\pi_2(\tilde{y}) - \pi_1)U\left(\frac{1}{n}\tilde{x}\right)\right) = 0$$

so that one derives

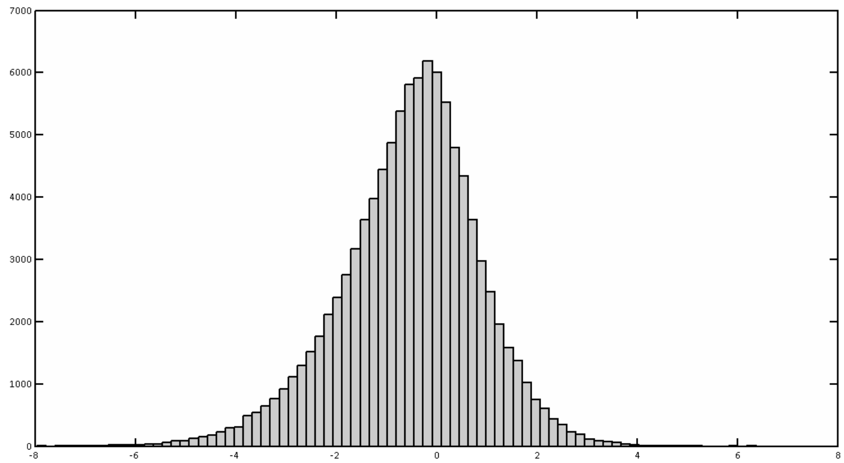
$$\pi_1 \quad = \quad \frac{E\left(\pi_2(\tilde{y})U\left(\frac{1}{n}\tilde{x}\right)\right)}{E\left(U\left(\frac{1}{n}\tilde{x}\right)\right)} = \frac{E\left(\pi_2(\tilde{y})E\left(U\left(\frac{1}{n}\tilde{x}(\tilde{y})\right)\right)\right)}{E\left(U\left(\frac{1}{n}\tilde{x}\right)\right)}.$$

In a similar way, one derives that

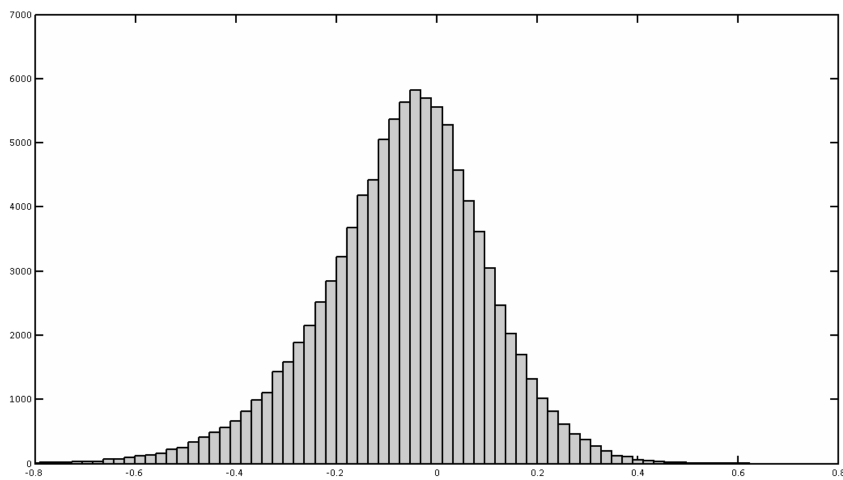
$$\pi_2(y) = \frac{E\left(\tilde{x}(y)U\left(\frac{1}{n}\tilde{x}(y)\right)\right)}{E\left(U\left(\frac{1}{n}\tilde{x}(y)\right)\right)}.$$

Substituting this into π_1 above yields

$$\pi_1 \quad = \quad \frac{E\left(E\left(\tilde{x}(\tilde{y})U\left(\frac{1}{n}\tilde{x}(\tilde{y})\right)\right)\right)}{E\left(U\left(\frac{1}{n}\tilde{x}\right)\right)} = \frac{E\left(\tilde{x}U\left(\frac{1}{n}\tilde{x}\right)\right)}{E\left(U\left(\frac{1}{n}\tilde{x}\right)\right)}$$



Panel A



Panel B

Figure 2: Frequency distribution of $\frac{\pi_1 - \bar{\pi}_1}{\bar{\pi}_1}$ for mean variance utility functions (panel A) and power utility functions (panel B).

which does not depend on the future disclosures y.

Crucial in deriving this result is the loglinear nature of exponential utility functions. More importantly, loglinearity is exclusively preserved for exponential utility functions. So, the result that future disclosures are irrelevant for pre-disclosure prices seems an artefact of exponential utility functions that does not generalize to other utility functions. Figure 2 supports this claim.

4.2 Heterogeneous investment horizons

Recall that investors would like to trade upon the future disclosures but that the set-up of the model does not allow for any such trade in equilibrium. This raises the question whether Proposition 1 still holds when investors are able to trade at date $t = 2$. To answer this question, I extend the model and introduce two generations of short term investors. Figure 3 depicts the sequence of events. The first generation of short term investors lives from date $t = 1$ until date $t = 2$. At date $t = 2$, they will sell all shares bought at date $t = 1$. The second generation of short term investors lives from date $t = 2$ until date $t = 3$. They can buy shares at date $t = 2$ (but not at date $t = 1$). Investor type is exogenously given. Let N_l denote the number of long term investors and let N_s denote the number of generation t short term investors. Investor type may be exogenously determined by life-cycle considerations or consumption needs over time. For example, the first generation of short term investors may leave the capital market at date $t = 2$ because they need the invested capital for other needs. Differences in investment horizons seems a reasonable assumption. Private investors are commonly regarded as having a shorter investment horizon than institutional investors. Among the intituitonal investors, hedge funds typically have shorter investment horizons than pension funds.

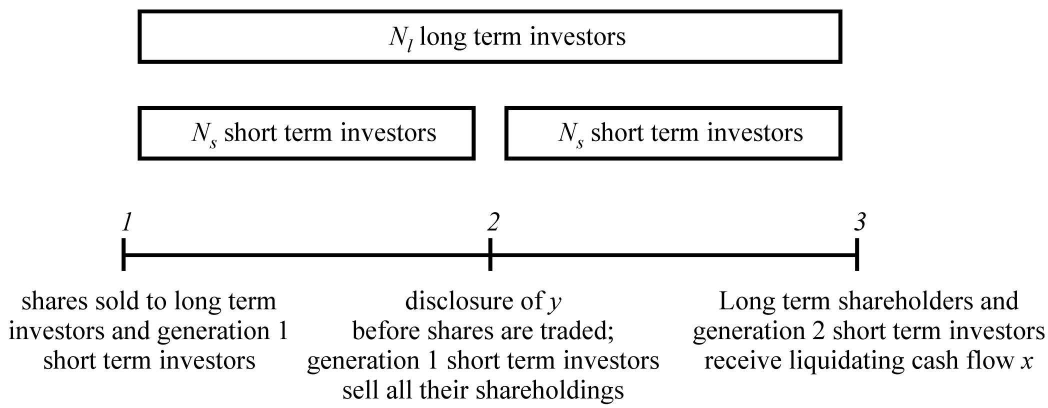


Figure 3: Sequence of events.

Let π_1 and $\pi_2(y)$ denote the equilibrium share price at the respective trading dates $t = 1$ and $t = 2$. Denote by l_1 and $l_2(y)$ the demand of a long term investor at the respective trading dates $t = 1$ and $t = 2$. Then the payoff to a long term investor equals

$$l_1(\pi_2(\tilde{y}) - \pi_1) + l_2(\tilde{y})(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y})). \tag{12}$$

Recall that $l_2(y) - l_1$ denotes the net trade by the long term investor at date $t = 2$ and that $\min(l_1, l_2(y))$ denotes the number of shares that the long term investor holds for two periods.

Let s_1 and $s_2(y)$ denote the demand of a short term investor at the respective trading dates $t = 1$ and $t = 2$. The payoff to a first generation short term investor equals

$$s_1(\pi_2(\tilde{y}) - \pi_1), \tag{13}$$

while the payoff to a second generation short term investor equals

$$s_2(y)(\tilde{x}(y) - \pi_2(y)). \tag{14}$$

Equilibrium share prices and investment decisions are determined by backward induction. For date $t = 2$, the following, standard result for mean-variance utility functions obtains.

Proposition 3a *Given disclosure y at date $t = 2$, the equilibrium share price equals*

$$\pi_2(y) = E\left(\tilde{x}(y)\right) - \tfrac{2\alpha}{N_l+N_s} V\left(\tilde{x}(y)\right), \tag{15}$$

resulting in equilibrium demands $l_2(y) = s_2(y) = \frac{1}{N_l+N_s}$.

Observe that in period 2, the investment decisions of long term and short term investors are identical. The reason for this is that both types of investors are investing for one period only. Since they both face the same investment risks, investor type is irrelevant. Furthermore, observe that the period 2 investment demands do not depend on the disclosure y. Therefore, date $t = 2$ demands are henceforth referred to as l_2 and s_2.

Proposition 3b *At date $t = 1$, the equilibrium share price and equilibrium demands equal*

$$\pi_1 = E\left(\pi_2(\tilde{y})\right) - \tfrac{2\alpha}{N_l+N_s}\left(1 + \tfrac{N_l}{N_l+N_s}\gamma_1\right) V\left(\pi_2(\tilde{y})\right), \tag{16}$$

$$l_1 = \tfrac{1}{N_l+N_s} - \tfrac{N_s}{(N_l+N_s)^2}\gamma_1, \tag{17}$$

$$s_1 = \tfrac{1}{N_l+N_s} + \tfrac{N_l}{(N_l+N_s)^2}\gamma_1, \tag{18}$$

where

$$\gamma_1 = \frac{COV\left(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y}), \pi_2(\tilde{y})\right)}{V\left(\pi_2(\tilde{y})\right)}. \tag{19}$$

Observe that γ_1, which measures the autocorrelation in stock returns, is the crucial factor in the date $t = 1$ stock price and demands. Furthermore, observe that when $N_s = 0$, the stock price in (16) coincides with the stock price in (6).

There are two effects that drive the equilibrium stock prices and demands. The first one concerns $COV(E(x(\tilde{y})), \rho_2(\tilde{y}))$ as explained in Section 3. The second concerns intertemporal risk sharing that arises when first and second period investment risks are borne by different investors. To explain intertemporal risk sharing, assume that both generations of short term investors buy s shares. Then the investment risk for the first generation equals $V(s\pi_2(\tilde{y}))$ while the investment risk for the second generation equals $V(s(\tilde{x}(\tilde{y})-\pi_2(\tilde{y})))$. The total investment risk over the two periods equals

$$\begin{aligned} & V\left(s\pi_2(\tilde{y})\right) + V\left(s(\tilde{x} - \pi_2(\tilde{y}))\right) \\ = \;& s^2V(\tilde{x}) - 2s^2\left(COV\left(\tilde{x} - \pi_2(\tilde{y}), \pi_2(\tilde{y})\right)\right) \\ = \;& s^2V(\tilde{x}) - 2s^2\gamma_1 V\left(\pi_2(\tilde{y})\right). \end{aligned}$$

Observe that $s^2V(\tilde{x})$ is the investment risk for holding s shares for two periods. Hence, short term investing results in intertemporal risk sharing benefits when stock returns are positively correlated (i.e., $\gamma_1 > 0$). Conversely, intertemporal risk sharing is costly when stock returns are negatively correlated (i.e., $\gamma_1 < 0$).

To see how these two effects trade off, take the demands $s_1 = s_2 = l_1 = \frac{1}{N_l+N_s}$ as a starting point. Consider the case that $COV(E(x(\tilde{y})), \rho_2(\tilde{y})) < 0$ and $COV(\tilde{x}-\pi_2(\tilde{y}), \pi_2(\tilde{y})) < 0$ (i.e., $\gamma_1 < 0$). Because $COV(E(x(\tilde{y})), \rho_2(\tilde{y})) < 0$, long term investors would like to go short in the firm's stock at date $t = 1$, that is, they want to sell shares. Similarly, because $COV(\tilde{x}-\pi_2(\tilde{y}), \pi_2(\tilde{y})) < 0$ makes intertemporal risk sharing unattractive, the first generation of short term investors would also like to sell shares at date $t = 1$. As both types of investor want to sell, stock price needs to decline. Recall that without short term investors, stock price would decline until selling is no longer attractive for the long term investors. When short term investors are present, however, stock price declines even further so that for the long term investors it becomes attractive to buy shares from the short term investors. The cost of inefficient intertemporal risk sharing is thus the dominant factor.

Next, consider the case that $COV(E(x(\tilde{y})), \rho_2(\tilde{y})) > 0$ and $COV(\tilde{x} -$

$\pi_2(\tilde{y}), \pi_2(\tilde{y})) < 0$. Because $COV(E(x(\tilde{y})), \rho_2(\tilde{y})) > 0$, long term investors would now like to buy shares while short term investors still want to sell shares. One can show that the effect on the date $t = 1$ price depends on the sign of

$$N_s COV\left(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y}), \pi_2(\tilde{y})\right) + COV(E(x(\tilde{y})), \rho_2(\tilde{y})).$$

When it is positive, long term investors want to buy more than short term investors want to sell. Consequently, the date $t = 1$ stock price needs to increase to clear the market. The opposite holds when it is negative. Observe that the latter is more likely to occur when there are more short term investors in the market.

Finally, when $COV(E(x(\tilde{y})), \rho_2(\tilde{y})) > 0$ and $COV(\tilde{x} - \pi_2(\tilde{y}), \pi_2(\tilde{y})) > 0$, intertemporal risk sharing is beneficial so that first generation short term investors also want to buy shares at date $t = 1$. Since both types of investors want to buy shares, stock price needs to increase. Recall that without short term investors, stock price would increase until buying is no longer attractive for the long term investors. When short term investors are present, however, stock price increases even further so that selling shares becomes attractive for the long term investors.

Observe that $COV(E(x(\tilde{y})), \rho_2(\tilde{y})) < 0$ and $COV(\tilde{x} - \pi_2(\tilde{y}), \pi_2(\tilde{y})) > 0$ cannot occur. This follows from expression (5) and $V(\rho_2(\tilde{y})) \geq 0$.

The presence of short term investors thus strengthens the current pricing effects of future disclosures when both covariances $COV(E(x(\tilde{y})), \rho_2(\tilde{y}))$ and $COV(\tilde{x} - \pi_2(\tilde{y}), \pi_2(\tilde{y}))$ have the same sign. Numerical analysis suggests that this holds in many cases.[7]

[7] The numerical analysis is based on $500,000$ observations. In each observation, the cash flow $\tilde{x}$ can take n different values and there are n different messages y, with n uniformly distributed on $\{5, 6, \ldots, 20\}$. The probability distribution of y given x is randomly chosen for each x. The results show that in 50% of the cases, both covariances are negatively valued while in 39% of the cases, both covariances are positively valued.

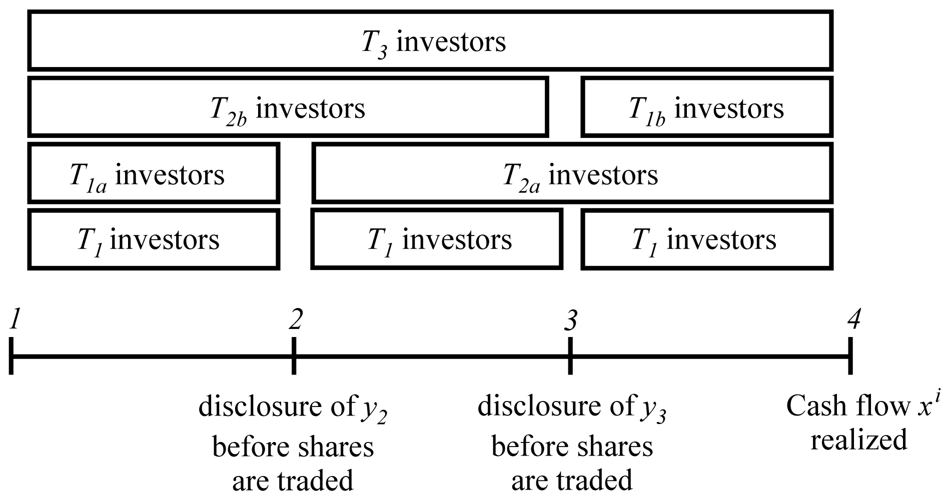


Figure 4: Investment horizons in a 3-period example.

As a further extension of the model, consider the timeline in Figure 4 where investors have an investment horizon of one, two, or three periods. Let T_k denote investor type and let N_k denote the number of investors of type k. It is assumed that $N_{1a} = N_{2a}$ and $N_{1b} = N_{2b}$ so that in each period, the total number of investors equals $N_1 + N_{2a} + N_{2b} + N_3$. One can show that in this setting, the date $t = 1$ stock price for firm i equals

$$\begin{aligned} \pi_1 \quad &= \quad E(\pi_2(\tilde{y}_2)) - \tfrac{2\alpha}{N_1+N_{2a}+N_{2b}+N_3} \left[V\left(\pi_2(\tilde{y}_2)\right) \right. \\ &\quad +(N_{2b}d_{2b,2} + N_3 d_{3,2}) COV\left(\pi_3(\tilde{y}_3) - \pi_2(\tilde{y}_2), \pi_2(\tilde{y}_2)\right) \\ &\quad \left. +N_3 d_{3,3} COV\left(\tilde{x}(\tilde{y}_3) - \pi_3(\tilde{y}_3), \pi_2(\tilde{y}_2)\right)\right] \end{aligned} \tag{20}$$

where $d_{i,t}$ is the demand of investor type i at date t. Observe that the intertemporal correlations between current firm return and *both* second period firm return $\pi_3(\tilde{y}_3) - \pi_2(\tilde{y}_2)$ *and* third period firm return $\tilde{x}(\tilde{y}_3) - \pi_2(\tilde{y}_3)$ are price relevant risk factors. The weight that each period receives depends on the number of current shareholders that are still investing in the firm's stock in that period and their demand for the firm's stock. For period 2, these are the type T_{2b} and T_3 investors. The type T_{2a} and T_1 investors that are investing in the second period are irrelevant as they are not investing in the firm's stock in period 1. Similarly, for period 3 only the type T_3 investors are relevant as the type T_{1b}, T_{2a} and T_1 investors do not invest in the first period.

Summarizing, the three-period extension suggests that risk factors relating to the correlation between current returns and future returns become more important when a firm attracts more investors with longer investment horizons.

5 The asymmetric nature of disclosures

The relevance of future disclosures on pre-disclosure stock price crucially depends on whether future disclosures are asymmetric. The aim of this section is to argue that for many disclosures this is likely to be the case.

Kirschenheiter and Ramakrishnan (2010) analyzes an individual's demand for asymmetric information in a precautionary savings problem (cf. Kimball (1990)). In this setting, an individual facing uncertainty regarding his future income, has to decide how much to consume today and in the future. To aid in this decision, the individual receives some information on his future income. It is shown that prudence, a characteristic of the individual's utility function measuring the sensitivity of his optimal consumption decision to risk, determines the individual's demand for asymmetric information. When the prudence measure is positively valued, which holds for most conventional utility functions including mean variance utility functions, the individual prefers bad news to be more precise than good news, that is, $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$.

Many disclosures or information events may be asymmetric by nature. As a first example, consider disclosures related to the development of a new medicine in the pharmaceutical industry. To get new medication approved for sale and marketing, a series of tests need to be passed successfully. The disclosure of an individual test result is likely to have an asymmetric effect on the posterior beliefs regarding the future cash flows. A failure is of high informativeness as it implies that the medication will not be approved while a success is of low informativeness as it only implies that one may advance to the next stage in the approval procedure (i.e., $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$).

Similar examples may be found in disclosures regarding research and development activities or exploration activities of oil and gas companies. Failures are likely to be more informative on future economic benefits (i.e., there will be none) than successes.

Another example relates to events that affect the reputation of a firm or brand name. As it takes a long time to build a good reputation but only seconds to destroy it, events that contribute to the good reputation will be less informative about future economic benefits than events that harm the good reputation. Toyota Motor Corporation and British Petroleum provide good anecdotal evidence in this respect. A recall scandal and an oil spill resulted in significant reputational damages for both companies.

5.1 Accounting conservatism

Public firms are subject to disclosure regulations that require (i) periodic disclosure of financial reports and (ii) that these financial reports comply with generally accepted accounting principles like US-GAAP or IFRS. Particularly relevant for our analysis is that many accounting principles reflect some degree of accounting conservatism like valuation of assets at the lower of cost or market value, accounting for internally generated intangibles, bad debt accounts, and (warranty) provisions.

Accounting conservatism influences the relation between content and informativeness of disclosure. The conventional interpretation of accounting conservatism is that the recognition of gains requires a higher degree of verification than the recognition of losses (cf. Basu (1997) and Watts (2003)). It is consistent with better news being more informative. Since good news requires a higher degree of verification, a disclosure of good news is more informative than a disclosure of bad news. Bad news is already disclosed if there is a remote possibility of anything bad happening to the firm. This interpretation is to a large extent consistent with interpretations of conservatism in related models, see, e.g., Chen, Hemmer and Zhang (2007), Gigler and Hemmer (2001), Bagnoli and Watts (2005), and Venugopalan (2004). This interpretation of accounting conservatism thus corresponds to $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$.

An alternative interpretation is taken in, e.g., Kwon (2005), Stoughton and Wong (2003), and Antle and Lambert (1988), where accounting conservatism implies that the probability of correctly reporting the bad state of nature is higher than correctly reporting the good state of nature. This implies that disclosures that contain better news are less informative, that is $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$. A similar definition of accounting conservatism is applied in Kirschenheiter and Ramakrishnan (2010).

Empirical evidence in this respect is limited. Matveyev (2008) empirically analyzes how investors update their beliefs following an earnings announcement. His findings suggest that good news in earnings is more informative than bad news. This would be consistent with $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$.

5.2 Voluntary disclosures

Besides mandatory disclosures, firms can also voluntarily disclose information to the market. The literature on voluntary disclosure shows that, in equilibrium, firms voluntarily disclose news only if this results in a positive response by the market. All other news will be withheld.[8] To analyze the effect of voluntary disclosure choices on the sign of $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y}))$, assume that the firm privately learns information $\tilde{z}$ on the final cash flow $\tilde{x}$ and let $\tilde{x}(z)$ denote the final cash flow conditional on the information z. It is assumed that the private information $\tilde{z}$ is symmetric in the sense that $V(\tilde{x}(\tilde{z}))$ is independent of $\tilde{z}$, that is, good and bad private information are equally precise. The private information $\tilde{z}$ could relate to a wide variety of items like product demand, cost information, and product quality. Given the nature of this information, there is no reason to believe that the precision of the private information $\tilde{z}$ varies with its contents. For example, the precision of product demand information is determined by the quality of the market research performed, which is likely to be independent of the outcome of the market research. Similarly, the precision of cost information is determined by the quality of the firm's accounting information system, which seems independent of whether product costs are high or low.

Conditional on the private information z, the firm decides whether to disclose or withhold z. When the firm decides to disclose, it discloses truthfully and without noise by assumption. Let $y(z) = \emptyset$ denote nondisclosure of z and $y(z) = z$ denote disclosure. Let $\pi_2(\emptyset)$ denote the firm's stock price when the firm does not make any disclosure at date $t = 2$ and let $\pi_2(z)$ denote the firm's stock price when z is disclosed at date $t = 2$. In a voluntary disclosure equilibrium, a firm discloses z when it results in a higher stock price than nondisclosure, that is, when $\pi_2(z) \geq \pi_2(\emptyset)$. Hence, in a disclosure equilibrium it holds that

$$\pi_2(\emptyset) \leq \inf\{\pi_2(z)|y(z) = z\}. \tag{21}$$

Since the nondisclosure price is the lowest, the market perceives nondisclosure

[8] See Verrecchia (2001), Dye (2001), and Beyer, Cohen, Lys and Walther (2009) for an extensive review of the voluntary disclosure literature.

as bad news. Furthermore, since nondisclosure reveals less information on the firm's future cash flows, bad news is also the least precise.

Proposition 4 *When disclosures are voluntary, the equilibrium disclosure policies yield* $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$*.*

Observe that $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$ and expression (5) implies negative autocorrelation in stock returns.

Proposition 4 is consistent with the results in Shin (2003) and Shin (2006). However, Shin suggests that the strategic nature of the disclosure decision is crucial to obtain this result. But in fact, it is the asymmetry in the disclosure. A similar result could be obtained in a mandatory disclosure setting as long as the disclosed information is asymmetric (e.g., due to accounting conservatism). Rogers, Schrand and Verrecchia (2007) and Goto, Watanabe and Xu (2009) provide empirical evidence that strategic disclosures induce negative autocorrelation in stock returns.

The analysis above presumes that any voluntary disclosure is truthful so that firm management is not able to bias its private information in any way. If one would abandon this assumption, a cheap talk model arises (cf. Crawford and Sobel (1982)). In such disclosure models, equilibrium disclosure strategies pool various pieces of information into a single message. The informativeness of a message is determined by how many information items are pooled together. Generally, these equilibrium strategies are asymmetric satisfying either $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$ or $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$. See Crawford and Sobel (1982) or Gigler (1994) for some examples. Newman and Sansing (1993) includes examples of equilibrium disclosure strategies that are symmetric.

Hutton, Miller and Skinner (2003) finds that when managers issue earnings forecasts, good news forecasts are supplemented with verifiable information whereas bad news forecasts are not. These results suggest that good news forecasts are less informative than bad news forecasts. The supplemental disclosures are needed to enhance the information content. This would be consistent with $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) > 0$. Alternatively, if one presumes that management earnings forecasts are symmetric, then the fact that only good news forecasts are supplemented with additional information would yield $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) < 0$.

Summarizing, the disclosures that fit the context of the model will in many cases yield $COV(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})) \neq 0$, which in turn implies that future disclosures are relevant for pre-disclosure stock prices.

6 Discussion

6.1 Correlation patterns in stock returns

There is ample empirical evidence of autocorrelation and momentum in stock returns. For autocorrelation in stock returns at the firm level, see e.g. Jegadeesh (1990) and Lo and MacKinlay (1988). For momentum in stock returns see e.g. Ball and Kothari (1989), Jegadeesh and Titman (1993), and Boudoukh, Richardson and Whitelaw (1994). Rational explanations for the empirically observed correlation patterns include learning (Lewellen and Shanken (2002), strategic disclosures (Shin (2003),Shin (2006)), time-varying dividend growth rates (Johnson (2002)), consumption smoothing (Cecchetti et al. (1990)), investor inattention (Nieuwerburgh and Veldkamp (2010)), and institutional environment (Vayanos and Woolley (2008)). Behavioral explanations include feedback traders (Hong and Stein (1999) and Sentana and Wadhwani (1992)), investor sentiment (Barberis et al. (1998)), and overconfidence (Daniel et al. (1998)). This paper adds asymmetric disclosure as an alternative, rational explanation. An important difference between asymmetric disclosure and other existing explanations is that asymmetric disclosure can explain both positive and negative autocorrelation in stock returns. The sign of the autocorrelation is driven by whether good news is more or less informative than bad news. Rational investors can thus (seemingly) underreact to one type of news and overreact to another type of news.

Chan (2003) finds that only stocks with news stories in the event period exhibit momentum in stock prices. Sinha (2010) analyzes the relation between news articles and stock price momentum. He finds that the tone in past news articles predicts future stock returns. Positive news implies positive future returns and negative news implies negative future returns. Furthermore, he finds that when conditioned on the tone in news articles, past stock returns no longer predict future stock returns. This empirical evidence is thus consistent with stock price momentum being driven by news releases.

An example of correlation in stock returns that is driven by a specific disclosure event is post earnings announcement drift. Amongst others, Bernard and Thomas (1989) document positive correlation in stock returns following the announcement of quarterly earnings. The initial stock price increase following good earnings news, is followed by a gradually increasing stock price for the next 60 trading days. The reverse pattern is observed for bad earnings news. Positive autocorrelation corresponds to good earnings news being less informative than bad earnings news. This is consistent with the interpretation of accounting conservatism in e.g. Antle and Lambert (1988) and Kirschenheiter and Ramakrishnan (2010). Francis, Lafond, Olsson and Schipper (2007) provide empirical evidence that information uncertainty may indeed be a possible factor in explaining post earnings announcement drift. Further empirical research is required to find out whether the degree of information uncertainty varies with the earnings news (i.e., that information uncertainty is higher for better earnings news).

Another example of a disclosure driven, positive drift concerns analyst forecast revisions (see e.g. Stickel (1991) and Gleason and Lee (2003)). Positive autocorrelation corresponds to upward revisions being less informative than downward revisions. This is consistent with the empirical evidence in Imhoff JR. and Lobo (1984) who finds a stronger stock price response to downward revisions. Zhang (2006) presents empirical evidence that relates information uncertainty to this drift in stock returns.

Lo and MacKinlay (1990) and Lewellen (2002) present empirical evidence suggesting that cross-serial correlation in stock returns explain the trading profits of investment strategies that exploit over or underreaction in stock prices. Consequently, the existence of such trading profits need not imply that the market is actually over or underreacting to news. Their results are consistent with the model under consideration. Asymmetric disclosures induce (cross-serial) correlation in stock returns even though all information is fully incorporated in stock price. It holds that

$$
\begin{aligned}
&COV\left(\sum_{j=1}^{n} x^j(\tilde{y}) - \sum_{j=1}^{n} \pi_2^j(\tilde{y}), \sum_{j=1}^{n} \pi_2^j(\tilde{y})\right) \\
&= \sum_{j=1}^{n} COV\left(x^j(\tilde{y}) - \pi_2^j(\tilde{y}), \pi_2^j(\tilde{y})\right) + \sum_{i \neq j} COV\left(x^j(\tilde{y}) - \pi_2^j(\tilde{y}), \pi_2^i(\tilde{y})\right).
\end{aligned}
$$

Observe that when the number of securities n in the portfolio is large, the cross-serial correlations $\sum_{i \neq j} COV\left(x^j(\tilde{y}) - \pi_2^j(\tilde{y}), \pi_2^i(\tilde{y})\right)$ dominate. Since

$$
COV\left(x^j(\tilde{y}) - \pi_2^j(\tilde{y}), \pi_2^i(\tilde{y})\right) = COV\left(\rho_2^j(\tilde{y}), \pi_2^i(\tilde{y})\right),
$$

cross-serial correlation arises when good news for firm i is more or less informative to firm j than bad news for firm i. Furthermore, it is possible that the autocorrelation in firm returns $COV\left(x^j(\tilde{y}) - \pi_2^j(\tilde{y}), \pi_2^j(\tilde{y})\right)$ is opposite to the cross-serial correlation $COV\left(x^j(\tilde{y}) - \pi_2^j(\tilde{y}), \pi_2^i(\tilde{y})\right)$. Consider, for example, the case that firm i and j are competitors. Recall from Section 5.2 that voluntary disclosures are likely to induce negative autocorrelation in the disclosing firm returns as good news is more informative than bad news. A good news disclosure by firm i can be bad news for the competing firm j. Hence, for firm j, bad news is more informative than good news, which in turn implies positive cross-serial correlation.

6.2 Capital asset pricing models

The traditional CAPM model does not fully capture all investment risks that investors want to be compensated for. Fama and French (1993) and Cahart (1997) present firm size, book-to-market ratios and momentum as additional risk factors next to market beta. Consistent with Cahart (1997), Section 3.3 shows that the disclosure induced correlations in stock returns give rise to systematic risk factors. Lewellen (2002) presents empirical evidence that correlation patterns in stock returns are also related to firm size and book-to-market ratios. As the correlations in stock returns that are relevant in asset pricing depends on the length of investment horizons (cf. Section 3.3), the single momentum factor may not capture all systematic risk related to it. It remains an empirical question to what extent the size and book-to-market risk factors proxy for correlation patterns in stock returns that are not captured by the momentum factor.

The conditional CAPM extends the traditional CAPM in that it allows for time-varying market betas. Empirical tests of the conditional CAPM find that market betas indeed vary over time but that the variation in market betas cannot properly explain asset prices. For examples, see Ferson, Kandel and Stambaugh (1987), Bollerslev, Engle and Woolridge (1988), Bodurtha JR. and Nelson (1991), and Lewellen and Nagel (2006). A notable exception to this is Kumar, Sorescu, Boehme and Danielsen (2008) which finds empirical support for the conditional CAPM. In light of the results presented here, the negative findings regarding the conditional CAPM are not surprising. Proposition 3 shows that when market betas vary over time (i.e., between periods 1 and 2), a conditional CAPM model does not suffice. The asset pricing model needs to include an additional risk factor

$$\begin{aligned} \gamma_1^i &= \frac{COV\left(x^i(\tilde{y}) - \pi_2^i(\tilde{y}), \sum_{j=1}^n \pi_2^j(\tilde{y})\right)}{V\left(\sum_{j=1}^n \pi_2^j(\tilde{y})\right)} \\ &= \frac{COV\left(\frac{2\alpha}{N_l} V\left(\sum_{j=1}^n \tilde{x}^j(\tilde{y})\right) \beta_2^i(\tilde{y}), \sum_{j=1}^n \pi_2^j(\tilde{y})\right)}{V\left(\sum_{j=1}^n \tilde{x}^i(\tilde{y})\right)} \end{aligned} \tag{22}$$

which takes into account how market beta changes over time. Equation (22) is consistent with the findings in Fama and French (1988) that time-varying investment risk induces autocorrelation in short horizon returns. Observe that time-varying market betas is not necessary for γ_1^i to be included as a risk factor. Time-varying market risk $V\left(\sum_{j=1}^n \tilde{x}^j(\tilde{y})\right)$ with constant market betas would be sufficient.

6.3 Investment horizons

Handa, Kothari and Wasley (1993) document that empirical tests of the CAPM model are sensitive to the length of the return measurement interval. CAPM is more likely to be rejected for shorter return measurement intervals. One can easily explain this finding using Proposition 2. Observe that CAPM is more likely to be rejected when the weight on γ_1^i is higher, that is, when there are more long term investors. The shorter the measurement interval, the more likely it is that the actual investment horizon exceeds the measurement interval. In terms of the model, this means that there will be more long term investors.

That investment horizons matter in asset pricing has been recognized for long. Levy (1972) and Levhari and Levy (1977) show that estimates of market betas are biased when the return measurement interval differs from the investment horizon. Hasty JR. and Fielitz (1975) develop a statistical test for analyzing the return-risk relationship that does not require any explicit assumptions regarding the investment horizon. Asset pricing models that explicitly incorporate heterogeneous investment horizons are presented in Merton (1973) and Lee, Wu and Wei (1990). Both consider multi-period models with all investors making an investment decision in the first period but with different holding periods. Merton (1973) finds that heterogeneous investment horizons only matter when the investment opportunity set varies over time. Lee et al. (1990) finds that heterogeneous investment horizons result in a nonlinear pricing model. The model that I present in this paper differs from Merton (1973) in that disclosure causes any differences in the investment opportunity set across periods one and two instead of changes in the risk free rate. It differs from Lee et al. (1990) in that it allows long term investors to rebalance their portfolios at the intermediate date. Furthermore, the two-period model does not require any stationarity assumptions for the returns distributions.

The linear capital asset pricing model in (9) or (20) can also be used to draw inferences regarding investment horizons. In (20), the weights on correlations with future stock returns increase with investors' horizons. Furthermore, the results show that asymmetric disclosure or the corresponding autocorrelation in stock returns can attract or deter long term investors. Expression (18) shows that the autocorrelation in stock returns is positively related to short term investment.

6.4 Disclosure and the cost of capital

The link between public disclosure of information and a firm's cost of capital is a highly relevant issue in finance and accounting. The conventional wisdom is that more disclosure reduces the cost of capital.[9] But how disclosure affects

[9] Shin (2006) and Ostaszewski and Gietzmann (2010) show that the opposite is also possibe, that is, more disclosure increases the cost of capital. In Shin (2006) this arises

a firm's cost of capital is not that clear. Easley and O'Hara (2004) shows that the cost of capital depends on the information asymmetry across investors. Uninformed investors want to be compensated for the risk of trading with an informed investor. Hughes et al. (2007), however, show that this risk is perfectly diversifiable so that the cost of capital remains unaffected by this. Lambert et al. (2007) show that disclosure provides information on both the variance of a firm's future cash flows as well as the covariance of these cash flows with the market, with only the former being perfectly diversifiable. Christensen et al. (2010) distinguishes between an ex ante and ex post cost of capital. The rationale for doing so is that existing studies focus on the ex post cost of capital only, i.e., the cost of capital in the post disclosure period. But since disclosure resolves uncertainty about future cash flows, more disclosure increases investment risk in the pre-disclosure period. The ex ante cost of capital takes into account both effects of disclosure: the effect on the cost of capital in the pre-disclosure period and the post disclosure period. Christensen et al. (2010) find that for the settings considered in Easley and O'Hara (2004) and Lambert et al. (2007), disclosure has no influence on the ex ante cost of capital.

The ex ante and ex post perspective also apply to my model. The ex post cost of capital refers to the risk premium included in the date $t = 2$ stock price $\pi_2(y)$ while the ex ante cost of capital refers to the risk premium included in the date $t = 1$ stock price π_1. The result in Christensen et al. (2010) that π_1 does not depend on the future disclosures $\tilde{y}$ is in strong contrast with Proposition 1. The explanation, however, is straightforward. The analysis in Christensen et al. (2010) is based on exponential utility functions and normal

because more disclosure today implies there will be more disclosures in the short term future, thereby increasing short term investment risk. In Ostaszewski and Gietzmann (2010) this arises because firm managers that are more uncertain about the future prospects of the firm disclose more information.

distributions for future cash flows and disclosures. Section 4.1 argues that the loglinearity of exponential utility functions renders the ex ante cost of capital insensitive to future disclosures. Furthermore, normally distributed disclosures are by definition symmetric, that is, the informativeness of the disclosure does not depend on its contents. And symmetric future disclosures are irrelevant for pre-disclosure stock prices.

It thus seems that the results in Christensen et al. (2010) are driven by the model's assumptions. In a more general setting, the ex ante cost of capital is likely to depend on future disclosures, provided that these disclosures are asymmetric. The link that this paper establishes between disclosure and the (ex ante) cost of capital is that asymmetric disclosures induce cross-serial correlation in stock returns, which in turn constitutes a systematic risk factor.

The finance and accounting literature on disclosure and the cost of capital has primarily focused on the quantity and/or quality of disclosure.[10] Quantity refers to the number of information items disclosed while quality refers to the amount of information contained in one particular item. For example, earnings according to IFRS may be of higher quality than earnings according to local GAAP. The quantity of disclosure is higher when a firm supplements its disclosure of past period's earnings with a forecast of next period's earnings. This paper shows that asymmetry in disclosure is more important than quality/quantity of disclosure. However, disclosure quantity and disclosure asymmetry are not two independent concepts but can actually be related to each other. Recall from Section 5.2 that a voluntary disclosure equilibrium features asymmetry in the sense that nondisclosure is less in-

[10]Empirical studies on the relation between disclosure and cost of capital rely, for example, on self-constructed disclosure measures (e.g., Botosan (1997)), AIMR ratings (e.g., Botosan and Plumlee (2002)), or earnings quality measures (e.g., Francis, Nanda and Olsson (2008)).

formative to investors than disclosure. When more information is disclosed in equilibrium, less information will be withheld so that nondisclosure becomes more informative thereby reducing the asymmetry in the disclosure. A similar argument applies to disclosure quality and disclosure asymmetry. A change in accounting standards may change the degree of accounting conservatism (e.g., when changing from historical cost accounting to lower of cost or market value accounting).

6.5 Excess volatility and liquidity

Asymmetric disclosures may offer a possible explanation for the documented excess volatility in stock prices. As explained in Section 3, when good news is more informative than bad news, the post-disclosure stock price $\pi_2(\tilde{y})$ has relatively high volatility. Consequently, the total investment risk borne by different generations of investors will be larger than the risk of the underlying cash flows.

Asymmetric future disclosures also influence a stock's current liquidity. When good news disclosures are more informative, intermediate stock prices are more volatile. This reduces the current demand for the firm's stock as investors rather go short. The opposite holds when good news disclosures are less informative. As post-disclosure stock prices will be less volatile, current demand increases. This result is not as intuitive as it may seem. Recall that at date $t = 1$, investors have prior beliefs about the future cash flow $\tilde{x}$ and any future disclosures do not affect their date $t = 1$ prior beliefs. What is driving the result is that future disclosures may induce short term trading benefits, which in turn affect the current demand for the firm's stock.

7 Conclusion

Stock prices immediately respond whenever new information becomes publicly available. The response may be imperfect though. There is ample empirical evidence of responses that are too strong, too weak or incomplete in the sense that asset prices only gradually incorporate the new information in the period following the news. This paper has shown that stock prices also depend on information releases that still need to occur in the future. Essential for this result to hold is that such future disclosures are asymmetric in the sense that good and bad news are not equally informative. Because investors would like to speculate on the outcome of the future disclosure, current demand for the stock changes and so does the current stock price.

The results show that rational investors can under or overvalue a firm's stock relative to its future cash flows. Furthermore, these rational investors know that they are mispricing the firm's stock. Arbitrage cannot eliminate the mispricing because investors cannot commit to long term investments. Arbitrage opportunities can thus not always be exploited. This may possibly explain why asset pricing anomalies like post earnings announcement drift are not arbitraged away but still persist many years after their discovery.

The paper further shows that asymmetric disclosure gives rise to a systematic risk factor in the form of autocorrelation in stock returns. It remains an empirical question though to what extent asymmetric disclosures actually explain correlation patterns in stock returns and systematic risk factors.

Appendix

Proof of Proposition 1. Denote by l_{i1} and $l_{i2}(y)$ the respective first and second period demands of investors i. Equilibrium prices are solved by backward induction. Given demand l_{i1} and disclosure y, investor i's utility of the payoff (1) equals

$$l_{i1}(\pi_2(y) - \pi_1) + l_{i2}(y)\left(E(\tilde{x}(y)) - \pi_2(y)\right) - \alpha l_{i2}^2(y)V\left(\tilde{x}(y)\right).$$

Maximizing over $l_{i2}(y)$ yields that

$$l_{i2}(y) = \tfrac{1}{2\alpha}\tfrac{E(\tilde{x}(y))-\pi_2(y)}{V(\tilde{x}(y))}. \tag{23}$$

In equilibrium, total demand equals total supply, implying that $\sum_{i=1}^{N_l} l_{i2}(y) = 1$. Substituting the equilibrium demands yields that

$$\pi_2(y) = E\left(\tilde{x}(y)\right) - \tfrac{2\alpha}{N_l}V\left(\tilde{x}(y)\right)$$

so that $l_{i2}(y) = \frac{1}{N_l}$.

Given $l_2(y) = \frac{1}{N_l}$, investor i's payoff at date $t = 1$ equals

$$l_{i1}(\pi_2(\tilde{y}) - \pi_1) + \tfrac{1}{N_l}\left(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y})\right),$$

which one can rewrite as

$$-l_{i1}\pi_1 + \left(l_{i1} - \tfrac{1}{N_l}\right)\pi_2(\tilde{y}) + \tfrac{1}{N_l}\tilde{x}(\tilde{y}).$$

The corresponding utility for investor i equals

$$\begin{aligned}&-l_{i1}\pi_1 + \left(l_{i1} - \tfrac{1}{N_l}\right)E\left(\pi_2(\tilde{y})\right) + \tfrac{1}{N_l}E(\tilde{x}) - \alpha\tfrac{1}{N_l^2}V\left(\tilde{x}\right)\\ &\quad -\alpha\left(l_{i1} - \tfrac{1}{N_l}\right)^2 V\left(\pi_2(\tilde{y})\right) - 2\alpha\tfrac{1}{N_l}\left(l_{i1} - \tfrac{1}{N_l}\right)COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right).\end{aligned}$$

Maximizing utility with respect to first period demand l_{i1} yields the first order condition

$$\begin{aligned}&E\left(\pi_2(\tilde{y})\right) - \pi_1 - 2\alpha V\left(\pi_2(\tilde{y})\right)\left(l_{i1} - \tfrac{1}{N_l}\right)\\ &\quad -2\alpha\tfrac{1}{N_l}COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right) = 0,\end{aligned} \tag{24}$$

or, equivalently,

$$l_{i1} = \tfrac{1}{N_l} + \tfrac{1}{2\alpha}\tfrac{E(\pi_2(\tilde{y}))-\pi_1}{V(\pi_2(\tilde{y}))} - \tfrac{1}{N_l}\tfrac{COV(\tilde{x}(\tilde{y}),\pi_2(\tilde{y}))}{V(\pi_2(\tilde{y}))}. \tag{25}$$

Using that in equilibrium demand equals supply, that is, $\sum_{i=1}^{N_l} l_{i1} = 1$, one derives that

$$\pi_1 = E\left(\pi_2(\tilde{y})\right) - \tfrac{2\alpha}{N_l} COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right). \tag{26}$$

Next, I show that $\pi_1 - \bar{\pi}_1 = \frac{2\alpha}{N_l} COV\left(\tilde{x}, \rho_2(\tilde{y})\right)$. Let F denote the joint probability distribution function of $\tilde{x}$ and $\tilde{y}$ and let F_x and F_z denote the marginal distributions of $\tilde{x}$ and $\tilde{z}$, respectively. Let G_y denote the corresponding conditional probability distribution function. Observe that

$$\begin{aligned}
V(\tilde{x}) &= \int_x \left[x - E(\tilde{x})\right]^2 dF_x(x) = \int_y \int_x \left[x - E(\tilde{x})\right]^2 dG_y(x) dF_y(y) \\
&= \int_y \int_x \left[x - E(\tilde{x}(y)) + E(\tilde{x}(y)) - E(\tilde{x})\right]^2 dG_y(x) dF_y(y) \\
&= \int_y \int_x \left[x - E(\tilde{x}(y))\right]^2 dG_y(x) dF_y(y) \\
&\quad + \int_y \int_x \left[E(\tilde{x}(y)) - E(\tilde{x})\right]^2 dG_y(x) dF_y(y) \\
&\quad + \int_y \int_x \left[x - E(\tilde{x}(y))\right]\left[E(\tilde{x}(y)) - E(\tilde{x})\right] dG_y(x)(y) \\
&= \int_y V(\tilde{x}(y)) dF_y(y) + \int_y \left[E(\tilde{x}(y)) - E(\tilde{x})\right]^2 dF_y(y) \\
&\quad + \int_y \left[E(\tilde{x}(y)) - E(\tilde{x})\right] \int_x \left[x - E(\tilde{x}(y))\right] dG_y(x)(y) \\
&= E\left(V(\tilde{x}(\tilde{y}))\right) + V\left(E(\tilde{x}(\tilde{y}))\right).
\end{aligned}$$

Next, observe that

$$\begin{aligned}
COV(\tilde{x}, \pi_2(\tilde{y})) &= COV\left(E(\tilde{x}(\tilde{y})), \pi_2(\tilde{y})\right) \\
&= COV\left(E(\tilde{x}(\tilde{y})), E(\tilde{x}(\tilde{y}) - \rho_2(\tilde{y})\right) \\
&= V\left(E(\tilde{x}(\tilde{y}))\right) - COV\left(E(\tilde{x}(\tilde{y})), \rho_2(\tilde{y})\right) \\
&= V\left(E(\tilde{x}(\tilde{y}))\right) - COV\left(\tilde{x}, \rho_2(\tilde{y})\right).
\end{aligned}$$

One then derives that

$$\begin{aligned}\pi_1 &= E(\pi_2(\tilde{y})) - \tfrac{2\alpha}{N_l} COV(\tilde{x}, \pi_2(\tilde{y})) \\ &= E\left(E(\tilde{x}(\tilde{y})) - \tfrac{2\alpha}{N_l} V(\tilde{x}(\tilde{y}))\right) - \tfrac{2\alpha}{N_l} V\left(E(\tilde{x}(\tilde{y}))\right) + \tfrac{2\alpha}{N_l} COV\left(\tilde{x}, \rho_2(\tilde{y})\right) \\ &= E(\tilde{x}) - \tfrac{2\alpha}{N_l} E\left(V(\tilde{x}(\tilde{y}))\right) - \tfrac{2\alpha}{N_l} V\left(E(\tilde{x}(\tilde{y}))\right) + \tfrac{2\alpha}{N_l} COV\left(\tilde{x}, \rho_2(\tilde{y})\right) \\ &= E(\tilde{x}) - \tfrac{2\alpha}{N_l} V(\tilde{x}) + \tfrac{2\alpha}{N_l} COV\left(\tilde{x}, \rho_2(\tilde{y})\right).\end{aligned}$$

□

Proof of Corollary 1. Follows from expression 26 and the observation that $COV(\tilde{x}(\tilde{y}), \pi_2(\tilde{y}) = COV(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y}), \pi_2(\tilde{y}) + COV(\pi_2(\tilde{y}, \pi_2(\tilde{y})$. □

Proof of Proposition 2a. Denote by $l_1 = (l_1^1, l_1^2, \ldots, l_1^n)'$ and $l_2(y) = (l_2^1(y), l_2^2(y), \ldots, l_2^n(y))'$ the respective first and second period demands of the long term investors. Given demand l_1 and disclosure y, the long term investor's utility of the payoff (12) equals

$$l_1'(\pi_2(y) - \pi_1 e) + l_2(y)'\left(E(\tilde{x}(y)) - \pi_2(y)\right) - \alpha l_2(y)' V\left(\tilde{x}(y)\right) l_2(y),$$

where e is an n-dimensional column vector of ones. Maximizing over $l_2(y)$ yields that

$$l_2(y) = \tfrac{1}{2\alpha} V^{-1}\left(\tilde{x}(y)\right)\left(E(\tilde{x}(y)) - \pi_2(y)\right). \tag{27}$$

In equilibrium, total demand equals total supply, implying that $N_l l_2(y) = e$. Substituting the equilibrium demands yields that

$$\pi_2(y) = E\left(\tilde{x}(y)\right) - \tfrac{2\alpha}{N_l} V\left(\tilde{x}(y)\right) e$$

so that $l_2(y) = \frac{1}{N_l} e$. □

Proof of Proposition 2b. Given $l_2 = \frac{1}{N_l} e$, the long term investor's payoff at date $t = 1$ equals

$$l_1'(\pi_2(\tilde{y}) - \pi_1) + \tfrac{1}{N_l} e'\left(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y})\right),$$

which one can rewrite as

$$-l_1'\pi_1 + \left(l_1 - \tfrac{1}{N_l}e\right)' \pi_2(\tilde{y}) + \tfrac{1}{N_l}e'\tilde{x}(\tilde{y}).$$

The corresponding utility for the long term investor equals

$$\begin{aligned} &-l_1'\pi_1 + \left(l_1 - \tfrac{1}{N_l}e\right)' E\left(\pi_2(\tilde{y})\right) + \tfrac{1}{N_l}e'E(\tilde{x}) \\ &\quad -\alpha\tfrac{1}{(N_l)^2}e'V\left(\tilde{x}\right)e - \alpha\left(l_1 - \tfrac{1}{N_l}e\right)' V\left(\pi_2(\tilde{y})\right)\left(l_1 - \tfrac{1}{N_l}e\right) \\ &\quad -2\alpha\tfrac{1}{N_l}\left(l_1 - \tfrac{1}{N_l}e\right)' COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right)e. \end{aligned}$$

Maximizing utility with respect to first period demand l_1 yields the first order condition

$$\begin{aligned} &E\left(\pi_2(\tilde{y})\right) - \pi_1 - 2\alpha V\left(\pi_2(\tilde{y})\right)\left(l_1 - \tfrac{1}{N_l}e\right) \\ &\quad -2\alpha\tfrac{1}{N_l}COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right)e = 0, \end{aligned} \tag{28}$$

or, equivalently,

$$\begin{aligned} l_1 &= \tfrac{1}{N_l}e + \tfrac{1}{2\alpha}V^{-1}\left(\pi_2(\tilde{y})\right)\left(E(\pi_2(\tilde{y})) - \pi_1\right) \\ &\quad -\tfrac{1}{N_l}V^{-1}\left(\pi_2(\tilde{y})\right)COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right)e. \end{aligned} \tag{29}$$

Using that in equilibrium demand equals supply, that is, $N_l l_1 = e$, one derives that

$$\begin{aligned} \pi_1 &= E\left(\pi_2(\tilde{y})\right) - \tfrac{2\alpha}{N_l}V\left(\pi_2(\tilde{y})\right)e \\ &\quad -\tfrac{2\alpha}{N_l}\left(COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right) - V\left(\pi_2(\tilde{y})\right)\right)e. \end{aligned} \tag{30}$$

Substituting $V(\pi_2(\tilde{y})) = COV(\pi_2(\tilde{y}), \pi_2(\tilde{y}))$ and rearranging terms yields

$$\begin{aligned} \pi_1 &= E\left(\pi_2(\tilde{y})\right) - \tfrac{2\alpha}{N_l}COV\left(\pi_2(\tilde{y}), \pi_2(\tilde{y})'e\right) \\ &\quad -\tfrac{2\alpha}{N_l}COV\left(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y}), \pi_2(\tilde{y})'e\right). \end{aligned}$$

Observing that $V\left(\pi_2(\tilde{y})'e\right)\beta_1^i = COV\left(\pi_2(\tilde{y}), \pi_2(\tilde{y})'e\right)$ and $V\left(\pi_2(\tilde{y})'e\right)\gamma_1^i = COV\left(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y}), \pi_2(\tilde{y})'e\right)$ then completes the proof. □

Proof of Proposition 3a. Denote by l_{i1} and $l_{i2}(y)$ the respective first and second period demands of a long term investor i. Given demand l_{i1} and disclosure y, the long term investor's utility of the payoff (12) equals

$$l_{i1}(\pi_2(y) - \pi_1) + l_{i2}(y)\left(E(\tilde{x}(y)) - \pi_2(y)\right) - \alpha l_{i2}(y)^2 V\left(\tilde{x}(y)\right).$$

Maximizing over $l_{i2}(y)$ yields that

$$l_{i2}(y) = \tfrac{1}{2\alpha}\tfrac{E(\tilde{x}(y)) - \pi_2(y)}{V(\tilde{x}(y))}. \tag{31}$$

In a similar way, one derives for the second generation short term investor's demand that

$$s_{i2}(y) = \tfrac{1}{2\alpha}\tfrac{E(\tilde{x}(y)) - \pi_2(y)}{V(\tilde{x}(y))}. \tag{32}$$

In equilibrium, total demand equals total supply, implying that $\sum_{i=1}^{N_l} l_{i2}(y) + \sum_{i=1}^{N_s} s_{i2}(y) = 1$. Substituting the equilibrium demands yields that

$$\pi_2(y) = E\left(\tilde{x}(y)\right) - \tfrac{2\alpha}{N_l + N_s} V\left(\tilde{x}(y)\right)$$

so that $l_{i2}(y) = s_{i2}(y) = \frac{1}{N_l + N_s}$. □

Proof of Proposition 3b. Given $l_{i2} = \frac{1}{N_l + N_s}$, the long term investor's payoff at date $t = 1$ equals

$$l_{i1}(\pi_2(\tilde{y}) - \pi_1) + \tfrac{1}{N_l + N_s}\left(\tilde{x}(\tilde{y}) - \pi_2(\tilde{y})\right),$$

which one can rewrite as

$$-l_{i1}\pi_1 + \left(l_{i1} - \tfrac{1}{N_l + N_s}\right)\pi_2(\tilde{y}) + \tfrac{1}{N_l + N_s}\tilde{x}(\tilde{y}).$$

The corresponding utility for the long term investor equals

$$\begin{aligned} &-l_{i1}\pi_1 + \left(l_{i1} - \tfrac{1}{N_l + N_s}\right) E\left(\pi_2(\tilde{y})\right) + \tfrac{1}{N_l + N_s} E(\tilde{x}) \\ &\quad -\alpha \tfrac{1}{(N_l + N_s)^2} V\left(\tilde{x}\right) - \alpha\left(l_{i1} - \tfrac{1}{N_l + N_s}\right)^2 V\left(\pi_2(\tilde{y})\right) \\ &\quad -2\alpha \tfrac{1}{N_l + N_s}\left(l_{i1} - \tfrac{1}{N_l + N_s}\right) COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right). \end{aligned}$$

Maximizing utility with respect to first period demand l_1 yields the first order condition

$$E\left(\pi_2(\tilde{y})\right) - \pi_1 - 2\alpha V\left(\pi_2(\tilde{y})\right)\left(l_{i1} - \tfrac{1}{N_l+N_s}\right) \\ -2\alpha \tfrac{1}{N_l+N_s} COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right) = 0, \tag{33}$$

or, equivalently,

$$l_{i1} = \tfrac{1}{N_l+N_s} + \tfrac{1}{2\alpha}\tfrac{E(\pi_2(\tilde{y}))-\pi_1}{V(\pi_2(\tilde{y}))} - \tfrac{1}{N_l+N_s}\tfrac{COV(\tilde{x}(\tilde{y}),\pi_2(\tilde{y}))}{V(\pi_2(\tilde{y}))} \tag{34}$$

First period demand for the short term investor is similar to (32), that is,

$$s_{i1} = \tfrac{1}{2\alpha}\tfrac{E(\pi_2(\tilde{y}))-\pi_1}{V(\pi_2(\tilde{y}))}. \tag{35}$$

Using that in equilibrium demand equals supply, that is, $\sum_{i=1}^{N_l} l_1 + \sum_{i=1}^{N_s} s_1 = e$, one derives that

$$\pi_1 = E\left(\pi_2(\tilde{y})\right) - \tfrac{2\alpha}{N_l+N_s} V\left(\pi_2(\tilde{y})\right) \\ -\tfrac{2\alpha N_l}{(N_l+N_s)^2}\left(COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right) - V\left(\pi_2(\tilde{y})\right)\right). \tag{36}$$

Rearranging terms yields

$$\pi_1 = E\left(\pi_2(\tilde{y})\right) - \tfrac{2\alpha}{N_l+N_s}\left(1 + \tfrac{N_l}{N_l+N_s}\gamma_1\right) V\left(\pi_2(\tilde{y})\right).$$

The corresponding first period equilibrium demands follow from substituting (36) into (34) and (35):

$$l_{i1} = \frac{1}{N_l+N_s} - \frac{N_s}{(N_l+N_s)^2}\frac{COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right) - V\left(\pi_2(\tilde{y})\right)}{V\left(\pi_2(\tilde{y})\right)}$$

and

$$s_{i1} = \frac{1}{N_l+N_s} + \frac{N_l}{(N_l+N_s)^2}\frac{COV\left(\tilde{x}(\tilde{y}), \pi_2(\tilde{y})\right) - V\left(\pi_2(\tilde{y})\right)}{V\left(\pi_2(\tilde{y})\right)}. \qquad \square$$

Proof of Proposition 4. Let H denote the joint probability distribution function of $\tilde{x}$ and $\tilde{z}$ and let H_x and H_z denote the marginal distributions of $\tilde{x}$

and $\tilde{z}$, respectively. Let G_z denote the corresponding conditional probability distribution function. Denote by $ND = \{z|y(z) = \emptyset\}$ the set of z that will not be disclosed and let $Pr(ND) = \int_{z\in ND} dH_z(z)$ denote the probability of nondisclosure. Observe that

$$\begin{aligned} &COV\left(\rho_2(\tilde{y}), \pi_2(\tilde{y})\right) = COV\left(\rho_2(y(\tilde{z})), \pi_2(y(\tilde{z}))\right) \\ &= \int_{z\in ND} \left[\rho_2(\emptyset) - E(\rho_2(y(\tilde{z})))\right]\left[\pi_2(\emptyset) - E(\pi_2(y(\tilde{z}))\right] dH_z(z) \\ &\quad + \int_{z\notin ND} \left[\rho_2(z) - E(\rho_2(y(\tilde{z})))\right]\left[\pi_2(z) - E(\pi_2(y(\tilde{z}))\right] dH_z(z). \end{aligned} \quad (37)$$

By assumption that private information $\tilde{z}$ is symmetric, it follows that $\rho_2(z) = 2\alpha V(\tilde{x}(z)) = c$, with $c \geq 0$ some constant. Hence, one obtains

$$\begin{aligned} &COV\left(\rho_2(\tilde{y}), \pi_2(\tilde{y})\right) = \\ &\quad Pr(ND)\left[\rho_2(\emptyset) - E(\rho_2(y(\tilde{z})))\right]\left[\pi_2(\emptyset) - E(\pi_2(y(\tilde{z}))\right] \\ &\quad + \left[c - E(\rho_2(y(\tilde{z})))\right]\left[E(\pi_2(\tilde{z})|\tilde{z} \notin ND) - E(\pi_2(y(\tilde{z}))\right]. \end{aligned} \quad (38)$$

It holds that

$$\begin{aligned} \rho_2(\emptyset) &= \frac{1}{Pr(\emptyset)} \int_{z\in ND} \int_x \left[x - E(\tilde{x}(z)|z \in ND)\right]^2 dG_z(x) dH_z(z) \\ &= \frac{1}{Pr(\emptyset)} \int_{z\in ND} \int_x [x - E(\tilde{x}(z)) \\ &\quad + E(\tilde{x}(z)) - E(\tilde{x}(z)|z \in ND)]^2 dG_z(x) dH_z(z) \\ &= \frac{1}{Pr(\emptyset)} \int_{z\in ND} \int_x \left[x - E(\tilde{x}(z))\right]^2 dG_z(x) dH_z(z) \\ &\quad + \frac{1}{Pr(\emptyset)} \int_{z\in ND} \int_x \left[E(\tilde{x}(z)) - E(\tilde{x}(z)|z \in ND)\right]^2 dG_z(x) dH_z(z) \\ &\quad + \frac{1}{Pr(\emptyset)} \int_{z\in ND} \int_x \left[x - E(\tilde{x}(z))\right] * \\ &\quad \left[E(\tilde{x}(z)) + E(\tilde{x}(z)|z \in ND)\right] dG_z(x) dH_z(z) \\ &= \frac{1}{Pr(\emptyset)} \int_{z\in ND} V(\tilde{x}(z)) dH_z(z) \\ &\quad + \frac{1}{Pr(\emptyset)} \int_{z\in ND} \int_x \left[E(\tilde{x}(z)) - E(\tilde{x}(z)|z \in ND)\right]^2 dG_z(x) dH_z(z) \end{aligned}$$

$$
\begin{aligned}
&+\frac{1}{Pr(\emptyset)}\int_{z\in ND}\left[E(\tilde{x}(z))+E(\tilde{x}(z)|z\in ND)\right]*\\
&\int_{x}\left[x-E(\tilde{x}(z))\right]dG_z(x)dH_z(z)\\
=\;& c+\frac{1}{Pr(\emptyset)}\int_{z\in ND}\int_{x}\left[E(\tilde{x}(z))-E(\tilde{x}(z)|z\in ND)\right]^2 dG_z(x)dH_z(z).
\end{aligned}
$$

Hence, for any $z \notin ND$ it holds that $\rho_2(z) = c < \rho_2(\emptyset)$ so that

$$\rho_2(\emptyset) - E(\rho_2(y(\tilde{z}))) \;>\; 0 \tag{39}$$

$$c - E(\rho_2(y(\tilde{z}))) \;<\; 0. \tag{40}$$

By definition of the equilibrium, it holds that $\pi_2(\emptyset) < \pi_2(z)$ for all $z \notin ND$ so that

$$\pi_2(\emptyset) - E(\pi_2(y(\tilde{z})) \;<\; 0. \tag{41}$$

$$E(\pi_2(\tilde{z})|\tilde{z} \notin ND) - E(\pi_2(y(\tilde{z})) \;>\; 0. \tag{42}$$

Combining (39)-(42) with (38) yields that $\gamma = COV\left(\rho_2(\tilde{y}), \pi_2(\tilde{y})\right) < 0.\square$

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