This Draft: December 2008

Information Disclosure, Intertemporal Risk Sharing, and Stock Prices*

Tri Vi Dang

University of Mannheim
Yale University
trivi.dang@yale.edu

Hendrik Hakenes

Leibniz University Hannover
MPI Bonn
hakenes@fmt.uni-hannover.de

Abstract

Disclosure of information triggers immediate price movements, but it mitigates price movements at a later date, when the information would otherwise have become public. Consequently, disclosure shifts risk from later cohorts of investors to earlier cohorts. Hence, disclosure policy can be interpreted as a tool to control the variance of interim price movements, and to allocate risk intertemporally. This paper shows that a policy of partial disclosure (and, hence, of intertemporal risk sharing) can maximize, but also minimize, the market value of the firm. Partial disclosure of interim information and intertemporal risk sharing minimizes the ex ante market value of the firm if investors are relatively risk averse, and if the distribution of cash flow exhibits a large variation or a positive skewness. Regarding the disclosure policy, the firm, the early investors cohort, and the late investors cohort all have conflicting interests. Our model also applies to a setting where a central bank chooses the quality and frequency of the disclosure of macroeconomic information.

Keywords: Financial reporting, disclosure, information policy, asset pricing, intertemporal risk sharing, general equilibrium

JEL-Classification: D92, G14, M41

* We would like to thank Dirk Bergemann, Eddie Dekel, Darrell Du_e, Martin Hellwig, Ken Judd, Johannes H¨orner, Felix K¨ubler, Larry Samuelson, Ulf Schiller, Elu von Thadden, and seminar participants in Hannover, Augsburg, and at the GEABA for very helpful comments.

1 Introduction

There is an ongoing debate regarding the regulation of disclosure policy and the costs and benefits of more stringent and more regular financial reporting by publicly traded firms. While it is common practice for firms in the US to issue quarterly reports, only since 2001 has Deutsche Börse AG established and enforced stricter disclosure rules and listing requirements for stocks to be traded at Frankfurt Stock Exchange. Hence the question of optimal disclosure and its regulation naturally arises.

Our paper focuses on the following two interrelated questions. *First*, how does the release of interim information affect interim price movements, and thus intertemporal risk sharing among investors? *Second*, how does intertemporal risk sharing among different investors affect the risk premia they demand, and thus ex ante asset prices? More specifically, this paper analyses whether and how the mere announcement of a future release of interim information *with no impact on the distribution of cash flows* can change today's market value of the firm. The paper then discusses which disclosure policy maximizes a firm's market value, which policies are preferred by different investors, and which policy is welfare-optimal.

As the basic idea of the paper, information influences market prices, hence potential information is equivalent to price risk. But all information is revealed sooner or later. Consequently, an information disclosure policy can be seen as a mechanism to intertemporally allocate price risk. In order to highlight this interplay between the disclosure of interim information, interim price movements, intertemporal risk sharing, and asset pricing, this paper uses a financial reporting example and focuses on the simplest possible setting. There are three dates. At date 0, all players have identical information about the exogenous cash flow distribution of the firm. The firm's cash flow is realized and publicly known at date 2. At date 0, the entrepreneur sells the whole firm to risk-averse first-cohort investors for the price P_0 and consumes the proceeds. At date 1, first-cohort investors want to consume and sell their shares to equally risk-averse second-cohort investors for a price P_1. At date 2, the cash flow is realized and second-cohort investors consume. At any date, there is *symmetric information* between agents who trade with each other. Asset prices are determined in a competitive financial market.

At date 0, before issuing its shares, the firm (initial owner) can commit to a *disclosure policy* in the following sense. At date 0.5, the firm will learn about the true final cash flow. Before selling the firm at date 0, the entrepreneur announces to either release either no information at date 0.5, full information, or a noisy signal with pre-specified precision about the final cash flow. The key question of this paper is how this disclosure policy affects the value of the firm at date 0, i. e., the price P_0.

As mentioned above, for a given cash flow process, an interim disclosure policy can be used as a mechanism to control interim price movements (i. e., the set $\{P_1\}$ of prices at date 1), and fine-tune multi-period risk sharing among investors, which affects the risk premia different cohorts of investors demand, and thus the market value of the firm. If *no* interim information is released, then first-cohort investors face no risk at all, and second-cohort investors bear the full risk. If vice versa *perfect* information is released in date 0.5, then first-cohort investors bear all the risk.

Conventional wisdom may suggest that the disclosure of partial information entails risk sharing between both cohorts of investors, and that this lowers the aggregate risk premia they demand, which should maximize the market value of the firm. This paper shows that intertemporal risk sharing through the release of partial interim information can actually *minimize* the market value of the firm if the distribution of final cash flows exhibits a negative skew, low variation, and if investors are relatively risk neutral (which can be interpreted as widespread ownership). In such a case, the optimal disclosure policy of the firm is no interim financial reporting (or, alternatively, perfect information disclosure). For a value-minimizing disclosure policy, the "sum" of the risk premia the two cohorts of investors demand is higher than the risk premium that one cohort of investors demands when it bears all the risk. Because of investors' risk aversion, the firm's market value is influenced relatively little by large potential upward price movements. Hence, the firm chooses a disclosure policy that avoids pronounced upward movements.

If interim disclosure *increases* firm value, then firms will implement a policy of partial disclosure. We can hence deduce empirical predictions. Innovative firms (right skew of the cash flow distribution) should commit to release more information, especially if investors are rather risk averse (or ownership is concentrated), or if the dispersion of cash flows is large. In each of these cases, the potential value increase is large, hence the firm must choose partial disclosure in order not to attain the complete value increase at one go. Otherwise, due to investors' risk aversion, this value increase would turn out small.

This paper also analyzes the preferences of the two investor cohorts for disclosure of interim information. In a competitive market, investors earn rents for bearing risk. Analogous to the standard demand and supply model, the more risk the investor has to bear, the higher the rents, i. e., the area between demand (marginal willingness to pay) and price curve becomes larger. Although investors are risk averse, they like bearing risk *ex ante* since bearing risk in a competitive financial market means earning higher rents. Consequently, first-cohort investors prefer full interim disclosure at date 0.5, while second-cohort investors want the firm not to disclose any interim information.

The potential divergence of interests becomes evident in a case that has attracted much public attention: the dispute between Deutsche Börse AG and

Porsche AG concerning quarterly reports. After Porsche had refuted to switch from half-year reporting to quarterly reporting, Deutsche Börse removed the carmaker from the German midcap MDAX index. The chronology of this controversial debate is summarized in Table 1, highlighting different types of conflicts of interests as well as several crucial issues regarding the costs and benefits of more frequent and more precise earnings reporting by firms.

Our analysis is framed within a financial reporting setting, but the mechanism, the intuitions, and the implications are relevant whenever intertemporal risk sharing is an issue. For example, one can analyze the optimal precision and timing of rating changes, both from the viewpoint of rating agencies and investors. As a less obvious example, a central bank or treasury department may decide on how often to release interim macroeconomic information, such as inflation rates, unemployment rates, or growth forecasts. The release of macroeconomic information typically triggers price movements at the announcement day. Potential price movements affect intertemporal risk sharing between different investor cohorts and thus the market risk premia they demand. Since investors are rational and forward looking, the anticipation of potential interim price movements affect the ex ante market value of the aggregate stock market. Similar questions arise. How does a given disclosure policy of the central bank affect the allocation of systematic risk that different cohorts of investors have to bear and thus interim stock market valuations as well as ex ante market prices? And what is the optimal disclosure policy if the central bank wants to maximize the joint payoffs of different investors cohorts?

The rest of the paper is organized as follows. The next section relates this paper to the literature. Section 3 introduces the model. Then in Section 4, the competitive equilibrium is discussed, first for a one-period model, then for the two-period model. Section 5 gives a welfare analysis and discusses the interests of the cohorts of investors. Section 6 concludes. All proofs are in the Appendix.

2 Relation to the Literature

The literature on information disclosure in financial markets is large and multifaceted. In a seminal paper, Ross (1989) employs the no-arbitrage martingale approach and establishes a *Resolution Irrelevancy Theorem* which states that in an arbitrage-free economy changes the timing of the resolution of uncertainty that leave the cash flow distribution unaltered do not change current prices. Epstein and Turnbull (1980) show that in a setting where investors trade and consume in multi-periods, the disclosure of interim information allows for better consumption and trading choices. They show that partial disclosure always maximizes the ex ante market value of the firm. Duffie, Schroder, and Skiadas (1996, 1997) analyze the implications of disclosure of interim information when traders have recursive utilities, and that noisy disclosure always maximizes the ex ante market value.

In contrast to these papers where interim information disclosure is either irrelevant or always maximizes the value of the firm, we show that the disclosure of partial interim information may actually minimize the ex ante market value of the firm despite intertemporal risk sharing. Furthermore, this paper give conditions when a prescribe disclosure policy of interim information minimizes and maximizes the ex ante market value of the firm and when it is irrelevant.

The reason for these different results is the following. Ross (1989), Epstein and Turnbull (1980), and Duffie, Schroder, and Skiadas (1996, 1997) assume long-lived investors, while this paper assumes that some investors leave the market so that they only care about prices in some sub-periods of the whole trading setting. A motivation for this type of overlapping generation model structure is liquidity shocks put forward by Diamond and Dybvig (1983), or many market microstructure models. Some investors exhibit interim liquidity shocks and have to sell their asset holding. In such a setting, the expected release of information may depress stock prices because investors anticipate they may be forced to sell after a negative announcement.

A second story the heterogeneity of investors trading horizons is the following. In the real world, portfolio managers are typically offered relatively high powered incentives schemes, and their performance is evaluated relatively frequently, which induces a kind of endogenous short horizon trading behavior. In contrast to Epstein and Turnbull (1980) and Duffie and Manso (2007), the present paper assumes heterogeneous investors along the time dimension, and is thus able to discuss potential conflicts of interests between investor cohorts. In their papers, all investors have the same preference for interim disclosure policy. Therefore, this paper may provide some intuitions for understanding the controversial debate between Porsche and Frankfurt Stock Exchange and the various types of conflicts of interests.

There is also a huge accounting literature on financial reporting (for a survey see Verrechia, 2001). A main focus of this literature is that financial reporting may serve as a tool to mitigate and resolve agency problems due to asymmetric information. In contrast, the present paper abstracts away from any type of agency problems and analyses financial reporting as a tool to control interim price movements and intertemporal risk sharing so as to maximize the ex ante value of the firm. As pointed out, the mechanism, intuitions and implications this paper discusses also applies to information release and intertemporal risk sharing in a macroeconomic environment. In particular, the release of macroeconomic information represents systematic risk and has a first order effect on market pricing.

In our model, investors invest only for one period. In this respect, our model resembles the work of Spiegel (1998), or more recently Watanabe (2008); Sagi, Spiegel, and Watanabe (2008); Biais, Bossaerts, and Spatt (2008). There is also a recent literature on endogenous short investment horizons of funds managers. This literature shows that financial contracting may induce rational managers to behave like myopic agents. They only care about the next period payoffs or fiscal or even quarterly trading performances. In the Porsche case showed that, in addition to the Deutsche Börse, it was some institutional investors who propagated for changes of Porsche's disclosure policy. The trading setting of the present paper is similar to Allen, Morris, and Shin (2006). Other papers on financial markets with short term myopic traders are Tirole (1982) and Cespa and Vives (2008).

3 The Basic Model

Consider an entrepreneur (initial owner) who wants to sell his firm at date $t = 0$. The firm's only asset is a project that matures in $t = 2$ and yields Y_H with probability q, otherwise it yields $Y_L < Y_H$.

There is a continuum of risk-averse investors. A first cohort of mass one lives from period 0 to period 1, another cohort of mass one live from 1 to 2. As a consequence, if an investor buys a share the firm at date $t = 0$, he will have to sell it again at $t = 1$. Another investor who buys the share at $t = 1$ can then wait until $t = 2$ for the firm's yield. In order to abstract from wealth effects of investors, let us assume that investors exhibit constant absolute risk aversion, hence $u(c) = -e^{-\rho c}$. Let us first abstract from further market risk. The stock market is competitive. The timing of the model is given in Figure 1.

Since the focus is on the implications of disclosure of interim information for interim price movements, intertemporal risk sharing, and ex ante asset pricing, this paper abstracts away from any type of agency problems due to asymmetric information. Therefore, this paper assumes that the cash flow distribution is common knowledge at date 0, and the entrepreneur sells the whole firm at date 0, so that his commitment to announce the pre-specified interim information is credible. At any dates, there is symmetric information between agents who trade with each other. Similarly, if the firm does not receive perfect interim information, this will only make the updating slightly more complicated but does not alter the main qualitative results of the paper.

We implicitly assume that all investors buying shares at date 0, exhibit liquidity shocks at date 1 and has to sell at date 1. This assumption can be relaxed as follows. At date 1 a fraction α has a liquidity motive to sell their assets. These traders affect asset prices, this already yields our type of results.

Figure 1: Timing of the Model

0 The initial owner commits to a disclosure policy θ, then sells shares on a competitive market to first-cohort investors.

$\frac{1}{2}$ The firm learns the outcome level Y, releases a (possibly noisy) signal about Y.

1 First-cohort investors sell their shares to second-cohort investors on a competitive market, then consume.

2 Second-cohort receive payment Y from the firm, then consume.

However, if α is relatively small, then this assumption would complicate the analysis. Suppose a mass α of investors exhibits a liquidity needs, sells its asset holding, consumes, leaves the market, and will be replaced by the same mass of investors. When buying at date 0, this investor will take into account the possibility of re-trading at date 1. This means that his trading strategy depends on both the price at date 0 and the set $\{P_1\}$ of potential prices at date 1. However, prices also depend on the trading strategies of investors. This gives rise to a system of highly non-linear equations. To keep the analysis tractable, this paper implicitly assumes that $\alpha = 1$, hence re-trading does not occur.

4 Equilibrium

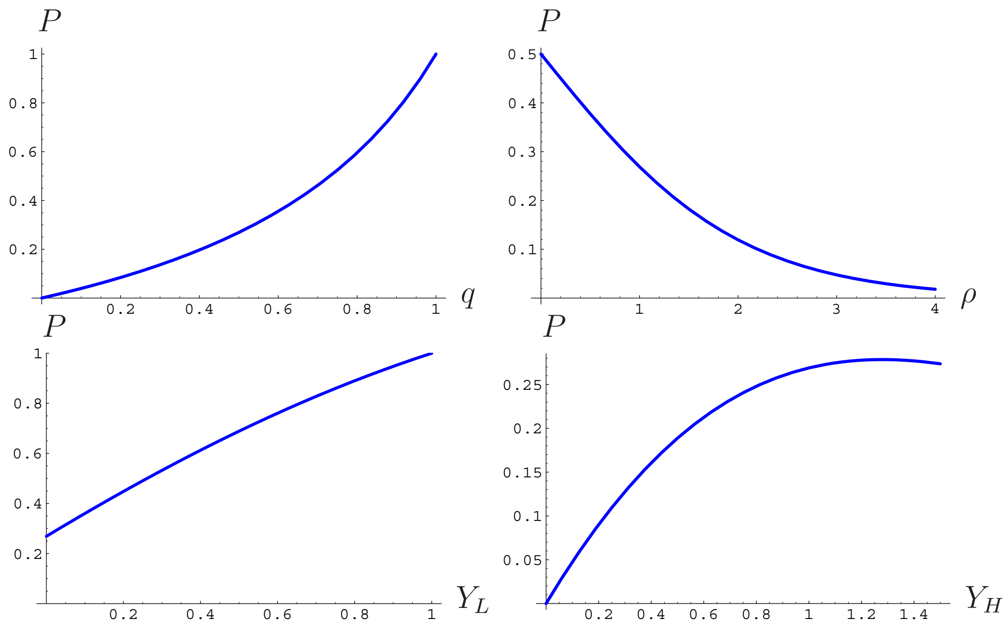
Let us first solve the case of only one cohort of investors. The two-cohort case with interim information is then a straightforward generalization of these first results.

Considering one Period only. How much would the initial owner get for the firm? If an investor pays P for a fraction α of the firm, his expected utility after one period will be

$$\begin{aligned} u(P,\alpha) &= q\,u\big[W + \alpha\,(Y_H - P)\big] + (1-q)\,u\big[W + \alpha\,(Y_L - P)\big] \\ &= -\,q\,e^{-\rho\,(W+\alpha\,(Y_H-P))} - (1-q)\,e^{-\rho\,(W+\alpha\,(Y_L-P))} \\ &= -\,e^{-\rho W}\,\Big(q\,e^{-\rho\,\alpha\,(Y_H-P)} + (1-q)\,e^{-\rho\,\alpha\,(Y_L-P)}\Big). \end{aligned} \tag{1}$$

In equilibrium, investors must be indifferent with respect to buying an additional marginal share, $\partial u(P,\alpha)/\partial\alpha = 0$. Furthermore, the market must clear: the entire shares must be distributed between investors. Because all investors

Figure 2: Some Basic Comparative Statics



are identical, a representative investor must hold one share in equilibrium. As a consequence, $\partial u(P,\alpha)/\partial\alpha = 0$ for $\alpha = 1$,

$$\begin{aligned} \frac{\partial u(P,\alpha)}{\partial \alpha}\Big|_{\alpha=1} &= -\,e^{-\rho\,W}\left[q\,e^{-\rho\,(Y_H-P)}\,\rho\,(Y_H-P)\right. \\ &\qquad \left. +\,(1-q)\,e^{-\rho\,(Y_L-P)}\,\rho\,(Y_L-P)\right] = 0, \\ P &= \frac{q\,Y_H\,e^{\rho\,Y_L}+(1-q)\,Y_L\,e^{\rho\,Y_H}}{q\,e^{\rho\,Y_L}+(1-q)\,e^{\rho\,Y_H}} \end{aligned} \tag{2}$$

The price is a weighted average between Y_H and Y_L, but the weights depend on risk aversion ρ, and on the sizes of Y_H and Y_L themselves. If risk aversion is large, only the bad outcome Y_L is taken into account because $e^{\rho\,Y_H} \gg e^{\rho\,Y_L}$. If risk aversion is low, then $P \approx q\,Y_H + (1-q)\,Y_L$ equals the expected value.

Some Basic Comparative Statics. Given that (2) is central to our model, let us discuss some elementary properties. Numerical examples are plotted in Figure 2. First of all, and quite naturally so, the market price of an issue increases with the success probability q. Second, the market price of risky shares decreases as risk aversion ρ of the representative investor increases. Third, if downside risk is limited (the bad-state return Y_L is high), the price of the issue increases. Forth, and this may be slightly surprising, the market price P does not increase monotonically with the good-state return Y_H. Hence, an issue can be traded at a lower price, even if the return is higher in all states of nature. Of course, the actual willingness to pay for the dominating issue by investors would be higher. However, it is not the actual expected utility from a share, but its *marginal* expected utility that determines its market price. The marginal utility from a payment decreases as its size increases. Consequently, the market price may decrease.[1] Let us thus stress that the benefit of initial owners from large potential price increases is limited. The initial owner can benefit only so much from upward price jumps. This property will help to intuit the reason why the optimal reporting strategy will exhibit gradual release of information later on: gradual disclosure implies that the extent and probability of large upward price jumps is limited.

Finally, let us discuss the effect of concentration of ownership on the issue price. Let us assume that, for some reason, only a fraction η of households can hold shares of the firm. As a consequence, the remaining fraction $1-\eta$ has no influence on the share price. Hence a (representative) investor that does hold share of the issue must hold $\alpha = 1/\eta$ instead of $\alpha = 1$ as the market is clearing. Consequently, the clearing price P is given by $\partial u(P,\alpha)/\partial\alpha|_{\alpha=1/\eta} = 0$. The effect is the same as the multiplication of ρ by the factor $1/\eta$. Hence, ρ can be interpreted both as risk aversion and as concentration of ownership.

Considering both Periods. Consider now date 1 when first-cohort investors sell their shares to second-cohort investors. Assume now that investors get a signal $s \in \{H, L\}$ before date $t = 1$. Trade will then be influenced by this signal. Let θ denote the quality of the signal, standing for the firm's disclosure policy, chosen by the initial owner.

$$\Pr\{s = H|Y = Y_H\} = (\theta + 1)/2,$$
$$\Pr\{s = L|Y = Y_L\} = (\theta + 1)/2.$$

Hence, the signal s is a garbling of the original information (cf. e. g. Baglioni and Cherubini, 2007; Weber and Croson, 2004). The ex ante probability that a positive signal $s = H$ occurs is

$$\Pr\{s = H\} = q \Pr\{s = H|Y = Y_H\} + (1-q) \Pr\{s = L|Y = Y_L\} = \frac{1 + (2\,q - 1)\,\theta}{2}.$$

After a positive signal $s = H$, Bayes' rule can be used to receive the probability that the return will be high,

$$\Pr\{Y = Y_H|s = H\} = \frac{\Pr\{s = H|Y = Y_H\} \cdot \Pr\{Y = Y_H\}}{\Pr\{s = H\}}$$

[1] This property is not a consequence of CARA utility, it holds for more general types of utility functions, including the log. Of course, it cannot hold for risk neutrality.

$$= \frac{(\theta+1)/2 \cdot q}{(1-(1-2\,q)\,\theta)/2}$$
$$= q\,\frac{1+\theta}{1+\theta\,(2\,q-1)}.$$

For $\theta = 0$, we get $\Pr\{Y = Y_H | s = H\} = q$; the signal contains no information. For $\theta = 1$, we receive $\Pr\{Y = Y_H | s = H\} = 1$. Along the same line,

$$\Pr\{Y = Y_H | s = L\} = \frac{\Pr\{s = L | Y = Y_H\} \cdot \Pr\{Y = Y_H\}}{\Pr\{s = L\}}$$
$$= q\,\frac{1-\theta}{1-\theta\,(2\,q-1)}.$$

We can now calculate the prices P_1 at date $t = 1$, depending on whether the public signal is positive or negative. If it is positive, the probability of success increases to $\Pr\{Y = Y_H | s = H\}$, which we can substitute into (2) and get $P_H \equiv P_1(s = H)$, the price of the security after the high signal. For a negative signal, we must substitute $\Pr\{Y = Y_H | s = L\}$ into (2) and receive $P_L \equiv P_1(s = L)$. As a consequence, depending on the signal, the price of the security moves up or down. After positive information, the price jumps up. These potential price movement determine the risk that the first cohort of investors must bear. Again using (2), we find that price at date $t = 0$ will be

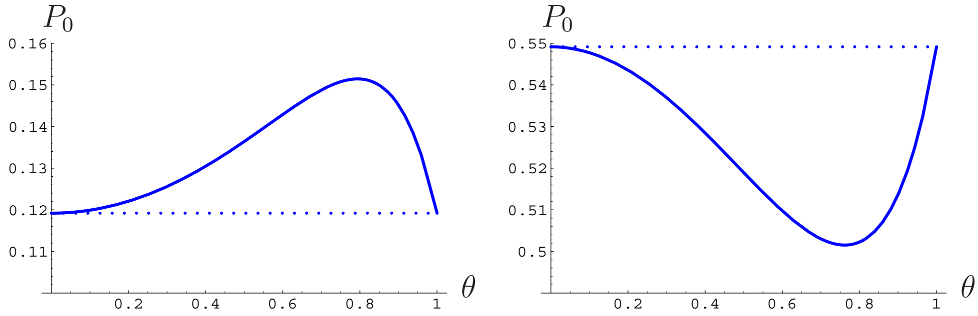
$$P_0 = \frac{\Pr\{s = H\}\, P_H\, e^{\rho\, P_L} + \Pr\{s = L\}\, P_L\, e^{\rho\, P_H}}{\Pr\{s = H\}\, e^{\rho\, P_L} + \Pr\{s = L\}\, e^{\rho\, P_H}}. \tag{3}$$

Hence, using backward induction, and using the probabilities of upward and downward movements, one can recursively establish the prices at each date. P_0 is then the issue price at date 0. The initial owner will try and choose a disclosure policy θ such that P_0 is maximized. Unlike Ross (1989), we do not find a general resolution irrelevance theorem; however we get resolution irrelevance at the extreme points $\theta = 0$ (no disclosure) and $\theta = 1$ (perfect disclosure).

Lemma 1 (Resolution Irrelevance at the Extremes) *The issue price is the same for zero disclosure and for full disclosure, $P_0(\theta = 0) = P_0(\theta = 1)$.*

The intuition for this lemma is straightforward. If the interim signal is perfect, $\theta = 1$, second-cohort investors will perfectly know the final outcome. Consequently, prices will be either $P_H = Y_H$ or $P_L = Y_L$. The probability of a high signal will be q, that of a bad signal will be $1-q$. Hence, all risk is borne by the first-cohort investors. If the interim signal carries no information, $\theta = 0$, then nothing is learned by investors before the market in $t = 1$, and $P_H = P_L = P_0$. Hence, all risk is borne by the second-cohort investors. In both cases, one

Figure 3: Effect of Disclosure Policy θ on the Issue Price P_0



cohort bears the complete risk, the other just uses the shares as a risk-free investment. "Swapping" cohorts does not influence the initial price P_0.[2]

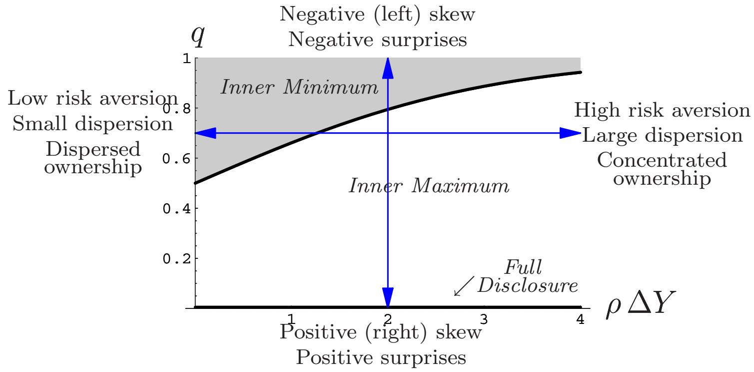
Full disclosure and no disclosure yields the same initial price P_0. But what happens in between? In Figure 3, the function $P_0(\theta)$ is plotted for two different parameter constellations. In the left graphic, parameters are $Y_H = 1$, $Y_L = 0$, $\rho = 2$, $q = 50\%$. In the right graphic, parameters are the same, only $q = 90\%$. Just from looking at these examples, we get a couple of results. *First*, there is no resolution irrelevancy in general. Both pictures document the fact that $P_0(\theta = 0) = P_0(\theta = 1)$, but in between the functions are non-constant. *Second*, there can be an inner maximum (left picture). This would imply that the initial owner would choose to release some information to the market, but only *vague* information. *Third*, it is also possible that partial information is suboptimal (right picture). In this case, the initial owner would be indifferent between no disclosure ($\theta = 0$) and full disclosure ($\theta = 1$), but avoid the release of imprecise interim information.

The most pressing question is now under which conditions an entrepreneur chooses to implement a partial disclosure strategy, and when he prefers $\theta = 0$ or $\theta = 1$ (zero or full disclosure). Before answering this question, let us simplify the problem by setting $Y_L \equiv 0$ and $Y_H \equiv 1$. The following lemma tells us that we do not lose any generality.

Lemma 2 (Symmetry Results) *The following two statements hold true:* $P_0(Y_H + c, Y_L + c, \rho, q, \theta) = P_0(Y_H, Y_L, \rho, q, \theta) + c$ *and* $P_0(c\, Y_H, 0, \rho, q, \theta) = c\, P_0(Y_H, 0, c\,\rho, q, \theta)$.

[2]Note that this result depends crucially on the assumption that risk aversion and the number of investors are the same in both cohorts. Otherwise, the price would be higher if risk were shifted to the less risk averse cohort, or to the larger cohort.

Figure 4: Optimal Disclosure Policy



The first statements tells us that if we increase both Y_H and Y_L by the same amount, the market price increase by exactly this amount. As a consequence, without loss of generality we can consider $P_0(\Delta Y, 0, \rho, q, \theta)$ instead of $P_0(Y_H, Y_L, \rho, q, \theta)$, with $\Delta Y = Y_H - Y_L$. The second statements tells us the multiplying Y_H with some constant has the same effect on market prices as multiplying ρ with the same constant *and* multiplying the price with the same constant. As a consequence, we can consider $P_0(1, 0, \rho\,\Delta Y, q, \theta)$ instead of $P_0(\Delta Y, 0, \rho, q, \theta)$. Without loss of generality, we can even set $\Delta Y \equiv 1$, bearing in mind that an increase in variation ΔY has the same effect as an increase in risk aversion ρ. Now, only two exogenous parameters are left in the model, $\rho = \rho\,\Delta Y$ and q. The following proposition states their influence on the optimal disclosure policy.

Proposition 1 (Optimal Disclosure Policy) *The function $P_0(\theta)$ has an inner maximum θ^* if*

$$q < \frac{e^{\rho}\,(e^{\rho} - \rho - 1)}{(e^{\rho} - 1)^2}. \tag{4}$$

Furthermore, $\lim_{q \to 0} \theta^* = 1$.

The proposition is demonstrated by Figure 4. For large q, or equivalently for low $\rho\,\Delta Y$, we end up in the gray region where the initial owner chooses zero (or full) disclosure. For small q, or equivalently for high ρ, the initial owner chooses noisy disclosure in the white region. In the limiting case of $q \approx 1$, the initial owner fully discloses all information, $\theta^* \approx 1$. The black curve marks critical parameter combinations, as given by (4). Let us give some intuition why there may be an inner optimum in the first place, and how q and $\rho\,\Delta Y$ influence this property.

If q is low or ρ is high, the initial price P_0 lies relatively low in the range $[Y_L; Y_H]$. In Figure 2 and the accompanying discussion, we have seen that the initial owner benefits only little from large value increases for the investors. Therefore, the initial owner designs the disclosure policy to avoid large price jumps. In the extreme case of $\theta = 0$ or $\theta = 1$, the only possible upward price movements would be $Y_H - P_0$, because the price remains constant in one or the periods. Now if θ moves to some interior value, this distance is partitioned in two smaller pieces, $Y_H - P_H$ and $P_H - P_0$. The intuition is that this way, the initial owner can profit better from upward jumps; consequently, P_0 increases. There is also an opposite effect. The price could also drop from P_0 to P_L, and then jump up to Y_H at date $t = 2$. The maximum upward movement increases by choosing an inner θ. However, remember that P_0 is relatively low in the first place. Hence, the size of the maximum upward jump does not increase much. This is the intuition for why the first effect dominates the second effect for high ρ and/or low q. The function $P_0(\theta)$ is then hump-shaped. This first results is less surprising, because an interior θ means intertemporal risk sharing, which leads to better digestibility of risk by the cohorts of investors, which increases their willingness to pay and hence the initial price P_0.

However, given that in interior disperses risk among the two cohorts, what is the intuition for an inner minimum of the function $P_0(\theta)$? According to Figure 4, an inner minimum occurs for low ρ and/or high q (gray region). In this case, the initial P_0 lies relatively *high* in the range $[Y_L; Y_H]$. Again, the initial owner needs to avoid large upward price jumps. Now if he issues news at date $\frac{1}{2}$, the potential price increase is relatively low, but the potential for a price drop is immense. In case of a good final return Y_H, this price decline must be made up for, which implies a large price jump. Again, this price jump is not honored by investors. Hence, an intermediate disclosure policy minimizes the initial share price P_0.

Hypotheses. Proposition 1 transforms into empirically testable hypotheses by adding a little more interpretation. q, for example, is also a measure for the return distribution's skewness. A high q means that the good state is the norm, and failure is a negative surprise. This could stand for a conservative firm (negative or left skew, traditional industry). If surprises are negative, the optimal strategy is zero disclosure. If surprises are positive (positive or right skew, innovative firm), the optimal strategy is to disclose, at least partially.

We have already argued that ρ can be interpreted both as a measure for risk aversion in the market and a measure for ownership concentration. As a result, we would expect a firm with rather widely dispersed ownership to prefer a noisy disclosure policy (or none). Firms with concentrated ownership would rather choose an informative disclosure strategy. These hypothesis may not sound surprising, but remember that the sole rationale here is optimal risk sharing. Lemma 2 yields two more hypotheses. First, the mere expected *level* of yields does not influence the optimal disclosure policy at all. If yields are augmented by a constant in both states of nature, all prices move up by the same constant; the optimal policy remains unchanged. Second, as mentioned above, a high ρ has the same effect as a higher variation ΔY. Hence for high variation, partial disclosure tends to be optimal. Note that the variance is $q\,(1-q)\,\Delta Y$. Hence for high variance, partial disclosure is optimal. For low variance, however, $P_0(\theta)$ can have both an inner minimum of an inner maximum, depending on whether the low variance is caused by a low q or by a low $1-q$. All hypotheses are summarized in Figure 4.

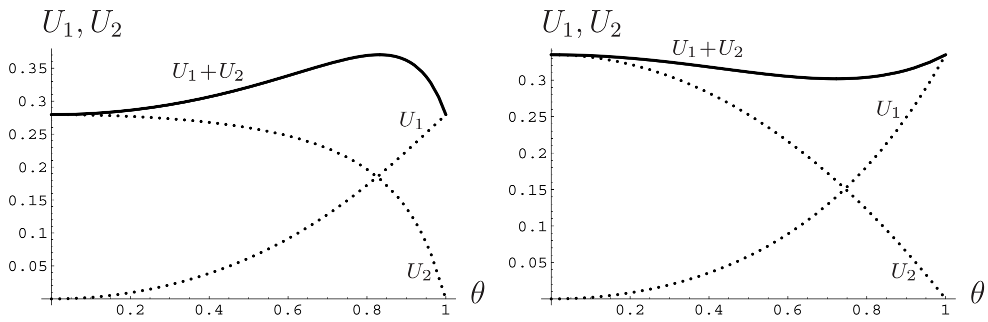
The Frequency of Disclosure. A reinterpretation of the above model yields a statement about the optimal frequency of disclosure. Assume that at date $\frac{1}{2}$, the firm gets information of quality $\bar{\theta} \in (0;1)$. Then it can disclose information of any quality $\theta \leq \bar{\theta}$. For the sake of the argument, assume that $\bar{\theta} \approx 0$, such that the choice of the firm is in effect to either communicate what it knows (choose $\theta = \bar{\theta}$) or keep still ($\theta = 0$). Then if the function $P_0(\theta)$ has an inner maximum (white area in Figure 4), the initial owner will prefer $\theta = \bar{\theta}$, which is equivalent to frequent disclosure. We can therefore formulate a corollary to Proposition 1: The firm prefers to disclose frequently if investors are risk averse and if the distribution exhibits high variation or a positive skew.

5 The Investors' Interests

The initial owner of the firm aims at maximizing the issue price P_0. Up to now, we have hence implicitly taken the initial owner's perspective. However, the investors may not be indifferent with respect to the allocation of risk over time. They are, of course, indifferent with respect to buying one more marginal share at the given price, but this does not imply that they do not earn any rents. If information were perfect and the final payoff Y were known, an investor's demand function would be flat, hence his rent would be zero. With uncertainty, demand for shares is elastic, and thus rents will be positive. The higher the risk for a cohort, the higher the rents that this cohort can earn. As a consequence, from an ex ante perspective, each cohort will want to bear as much risk as possible. The first cohort would like to implement full disclosure ($\theta = 1$), which would move the complete risk to the first cohort. Second-cohort investors prefer $\theta = 0$.

Lemma 3 (Extreme Diversion of Interests) *From an ex ante perspective, the first cohort finds $\theta = 1$ (full disclosure) optimal, the second cohort prefers $\theta = 0$ (zero disclosure). From an ex interim perspective, preference orderings are reversed.*

Figure 5: The Investors' Expected Utility



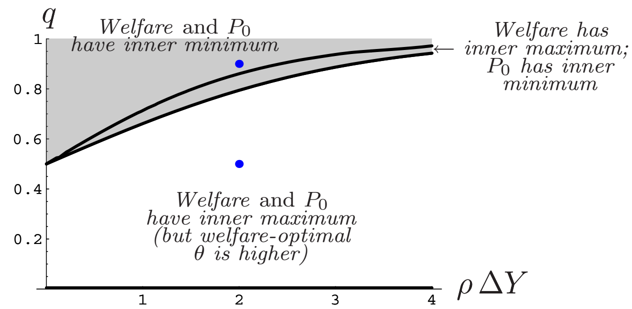
Investors like risk *ex ante* because it enables them to pay a low price for the issue. Consequently, their attitude changes as soon as they have bought the issue: first-cohort investors will prefer not to have any information revealed while they own the shares. The same holds true for second-cohort investors.

The lemma suggests that, if disclosure standards were determined in a political process, the result would heavily be influenced by the timing of the decision (and by the proportion between cohorts of investors). Each cohort would lobby towards vague disclosure once they held shares; beforehand, they would argue they want to have access to information as soon as it is available.[3]

Figure 5 shows the expected utilities of each group of investors as dotted lines. Like in Figure 3, $p = 50\%$ in the left picture, and $p = 90\%$ in the right. Lemma 3 in confirmed: U_1 increases with θ, whereas U_2 decreases. Let *(investor) welfare* consist of the sum of investors' utilities, $W = U_1 + U_2$ (solid line in the pictures). A welfare-maximizing regulator would be interested in maximizing the sum of expected utilities of both first and second cohort. Just like the initial price P_0, welfare can also either be hump-shaped (left picture) or U-shaped (right picture). There are more similarities between the interests of the initial owner and the welfare-maximizing regulator. For example, both are indifferent between zero disclosure and full disclosure: like in Lemma 1, there is resolution irrelevance at the extremes, $W(\theta = 0) = W(\theta = 1)$. Like before, the most important question asks under what circumstances welfare has an inner optimum. Also, assume again that predicting future success comes at a (negligible but positive) cost. Then the question is addressed by the following proposition.

[3]Note that these preferences refer to complete cohorts of investors. Individually, each investor wants as much information as possible before trading. Cohort-wise, investors want to be uninformed before trading.

Figure 6: Welfare-optimal Disclosure Policy



Proposition 2 (Welfare-Optimal Disclosure) *If investor welfare $W(\theta)$ has an inner minimum, then also the issue price $P_0(\theta)$ has an inner minimum. If $P_0(\theta)$ has an inner maximum, then $W(\theta)$ has an inner maximum. The welfare-optimal policy $\text{argmax}_\theta\, W(\theta)$ exceeds the policy preferred by the initial owner, $\text{argmax}_\theta\, P_0(\theta)$. In the limiting case $q \to 0$, full disclosure is welfare optimal.*

The proposition holds true also if the initial owner's interests are included in the welfare function. The proposition implies that a regulator always prefers a (weakly) higher degree of disclosure than the initial owner. Consequently, if possible, the regulator should implement minimum disclosure standards. The proposition is illustrated in Figure 6. There are now three regions. For high q and/or low ρ (e. g., $\rho = 2$ and $q = 90\%$ like in the right picture of Figure 5), the welfare-optimal disclosure policy is extreme, either zero or full disclosure. This is also the preferred strategy of the initial owner, hence here a regulator does not have to implement disclosure standards. For lower q and/or higher ρ, the regulator already starts to prefer partial disclosure, contrary to the initial owner. Here, the regulator should set disclosure standards. For even lower q and/or higher ρ (e. g., $\rho = 2$ and $q = 50\%$ like in the left picture of Figure 5), both the regulator and the initial owner prefer partial disclosure. Still the regulator must set standards, because he prefers a higher degree of disclosure.

The reason why there can be an inner maximum (or minimum) for an interior θ is the same as why P_0 can have an inner maximum (or minimum). A cohort's welfare, depending on the potential upward price increase, is limited. Therefore, not only from the initial owner's perspective, but also from a welfare perspective, large upward price jumps should be avoided. For large ρ and/or small q, the initial price P_0 is low, hence large upward jumps are best avoided by releasing a little information such that the way from P_0 to Y_H is partitioned into two. For small ρ and/or large q, there is an inner welfare minimum: the initial price P_0 is already high, so releasing some information bears the risk of a price decline, which must then be made up for.

Again reinterpreting the model as at the end of Section 4, the regulator prefers frequent disclosure if the firm does (but not vice versa). Therefore, there is a range of parameters where the regulator must force the firm to disclose frequently (small hose in Figure 6). There is also a parameter range where the regulation to disclose frequently is irrelevant (because the firm would choose frequent disclosure even in the absence of regulation, white region in Figure 6), and a parameter range where this regulation is harmful.

Let us ask one final question. We have seen that U_1 increases with θ, hence that first-cohort investors favor full disclosure. On the other hand, in a political process, it might be especially first-cohort investors who shape legislation. Therefore, one may want to ask whether it is better to let standards be set in a political process, or rather refrain from disclosure regulation completely. Given that there are only two exogenous variables, one can easily show numerically that zero disclosure standards are better then letting first-cohort investors set disclosure standards. As a consequence, even if *optimal* disclosure regulation were beneficial, aggregate welfare will drop when the regulator is lobbied by a single interest group (by first-cohort investors, for example). As a consequence, an entity that sets disclosure standards must be independent from the political process. In other words, regulators should be appointed, not elected.

6 Conclusion

Introducing liquidity concerns into a disclosure model with risk averse investors, we have found a rich set of implications, even in the complete absence of asymmetric information. The market's appreciation for large upward value increases is limited, hence a firm should design its disclosure policy to avoid large upward jumps. Therefore, if the upward potential is large, the firm should release information gradually, whereas if the risk is more on the downside, it should not release any information at all. Considering investors' utility, we have shown that each group of investors' interests are exactly opposite to the others'. However, aggregate investors' interest are quite in line with those of the firm, although investors prefer more precise disclosure. Consequently, disclosure should be regulated.

Open Questions. There is a number of open question that we would like to address with our model in the near future. *First,* we have shown that the timing and accuracy of information resolution does influence the initial stock price, whereas Ross (1989) has shown resolution irrelevance on the basis of normally distributed returns. Hence, it would be illuminating to find exact conditions under which resolution irrelevance holds. *Second,* we have no market risk in our model. It would be interesting to see how further market risk influences the optimal disclosure strategy, and which impact the correlation with market risk (β) might have. *Third,* our information is only about the success probability of a project; all other variables are publicly known. There are thus a quantity of open questions for further investigation.

A Appendix

Proof of Lemma 1: If $\theta = 0$, then $\Pr\{s = H\} = 1/2$, $\Pr\{Y = Y_H | s = H\} = q$, and $\Pr\{Y = Y_H | s = L\} = q$. The signal contains no information, nothing can be learned. Consequently, $P_H = P_L$, and hence

$$P_0 = \frac{q\, Y_H\, e^{-\rho\,(Y_H - Y_L)} + (1-p)\, Y_L}{q\, e^{-\rho\,(Y_H - Y_L)} + (1-q)}$$

as in (2). Now consider the second case, $\theta = 1$. Then $\Pr\{s = H\} = q$, $\Pr\{Y = Y_H | s = H\} = 1$, and $\Pr\{Y = Y_H | s = L\} = 0$. As a result, $P_H = Y_H$ and $P_L = Y_L$, and P_0 is exactly as above. Hence, P_0 is independent from whether $\theta = 0$ or $\theta = 1$. ■

Proof of Lemma 2: The first statement is obvious. For the second statement, first look at the one-period case,

$$P(c\, Y_H, 0, \rho, q, \theta) = \frac{q\, c\, Y_H\, e^{-\rho\, c\, Y_H}}{q\, e^{-\rho\, Y_H} + (1-q)} = c\, P(Y_H, 0, c\, \rho, q, \theta).$$

This result carries immediately through to the two-period case. ■

Proof of Proposition 1: We want to distinguish between the two cases of Figure 3. Both have $dP_0/d\theta|_{\theta=0} = 0$, this can easily be shown analytically. Hence, to see whether the function increases of decreases at $\theta = 0$, consider the second derivative at the origin,

$$\left.\frac{d^2 P_0}{d\theta^2}\right|_{\theta=0} = 8\, e^{\rho}\, q^2\, (1-q)^2\, \frac{e^{\rho}\, (2\, q + e^{\rho}\, (1-q) - \rho - 1)}{(e^{\rho}\, (1-q) + q)^4}.$$

This term is negative iff (4) holds. ■

Proof of Lemma 3: We first want to argue that ex ante, each cohort of investors wants to bear as much risk as possible. Look at one cohort only, and set $W = 0$ without loss of generality. Furthermore, set $Y_H = \bar{Y} + (1-p)\,\epsilon$ and $Y_L = \bar{Y} - p\,\epsilon$, such that the mean is always $\bar{Y}$, and ϵ measures (lack of) information before the trade. Then, substituting (2) into (1) with $\alpha = 1$ due to market clearing, we receive

$$u = -\Big((1-p)\,e^{\frac{p\,\epsilon\,\rho}{(1-p)\,e^{\epsilon\,\rho}+p}} + p\,e^{\frac{-(1-p)\,\epsilon\,\rho}{p\,e^{-\epsilon\,\rho}+(1-p)}}\Big),$$

$\bar{Y}$ drops out of the equation. The derivative with respect to ϵ is

$$\frac{\partial u}{\partial \epsilon} = \frac{(1-p)\,p\,\epsilon\,\rho^2\,e^{\frac{p\,\epsilon\,\rho}{(1-p)\,e^{\epsilon\,\rho}+p}}}{(1-p)\,e^{\epsilon\,\rho}+p},$$

which is positive for $\epsilon > 0$. As a consequence, higher risk raises utility (ex ante). Now take the ex interim perspective, i. e., keep the price fixed. Then (1) with $\alpha = 1$ yields

$$u = -\big(p + (1-p)\,e^{\epsilon\,\rho}\big)\,e^{(P-\bar{Y})-(1-p)\,\epsilon}.$$

The derivative with respect to ϵ is now

$$\frac{\partial u}{\partial \epsilon} = \rho\,p\,(1-p)\,(1-e^{\epsilon\,\rho})\,e^{(P-\bar{Y})-(1-p)\,\epsilon},$$

which is negative for $\epsilon > 0$. Hence, higher risk decreases utility ex interim. The argument, as it stands, applies to first and second cohort of investors. Hence ex ante, the first cohort finds $\theta = 1$ optimal; the second cohort likes $\theta = 0$ best. Ex interim, preferences are reversed. ■

Proof of Proposition 2: Welfare $W(\theta)$ consists of two parts: expected utility of the first cohort plus expected utility of the second cohort. Utility is given by (1). For the first cohort, P is the initial price P_0, Y_H and Y_L must be replaced by P_H and P_L, and q must be replaced by $\Pr\{s = H\}$. For the second cohort, there are two cases, occurring with probabilities $\Pr\{s = H\}$ and $\Pr\{s = L\} = 1 - \Pr\{s = H\}$. In the first case, the purchase price is P_H, and the probability of a high return is $\Pr\{Y = Y_H | s = H\}$. In the second case, prices and probabilities are accordingly.

Welfare is plotted in Figure 5, it has the same shape as the price P_0 (see Figure 3). This is easy to show: $W(0) = W(1)$ and $W'(0) = 0$, where W is always a function of θ. Consequently, in order to find out whether $W(\theta)$ has an inner maximum, consider $W''(0)$. If this is positive, then W must bend back, and hence have an inner maximum.

We need to prove that W has an inner maximum whenever P_0 has. Hence at the point where $P_0''(0) = 0$, the curvature $W''(0)$ must already be positive. Therefore, substitute (4) into $W''(0)$ and receive

$$W''(0) = \frac{4\,(1+\rho-e^{\rho})^2\,(1-(1-\rho)\,e^{\rho})^2\,e^{2\,\rho\coth\rho/2}\left[e^{\frac{4\,\rho\,e^{\rho}}{e^{\rho}-1}} + \ldots + \rho\,e^{1+\rho\,(2+\frac{3}{e^{\rho}-1})}\right]}{\rho^2\,(1-e^{\rho})^6}$$

This term depends on only one variable, ρ, the proof that it is weakly positive is differential calculus.

In order to show that $\theta = 0$ is welfare-optimal for small q, consider $W'(\theta)$ at the point $q = 0$. We have $W'(\theta) = 0$ for all θ, which is not surprising because $q = 0$ means that the bad state occurs almost surely. However, we find

$$W'(\theta) \sim q^2\,8\,\theta\,\rho\,\frac{e^{\rho}-\rho-1}{(1-\theta^2)^2}$$

for small q. This is positive for all θ, hence $W(\theta)$ reaches its maximum for the extreme $\theta = 1$. For small q, full disclosure is welfare-optimal. ■

References

Allen, F., S. Morris, and H. S. Shin (2006): "Beauty Contests and Iterated Expectations in Asset Markets," *Review of Financial Studies*, 19(3), 719–752.

Baglioni, A., and U. Cherubini (2007): "Accounting Fraud and the Pricing of Corporate Liabilities – Structural Models with Garbling," SSRN Discussion Paper.

Biais, B., P. Bossaerts, and C. Spatt (2008): "Equilibrium Asset Pricing and Portfolio Choice under Asymmetric Information," *Review of Financial Studies*, forthcoming(2), 419–447.

Cespa, G., and X. Vives (2008): "Dynamic Trading and Asset Prices: Keynes vs. Hayek," CSEF Working Papers #1.

Diamond, D. W., and P. H. Dybvig (1983): "Bank Runs, Deposit Insurance, and Liquidity," *Journal of Political Economy*, 91(3), 401–419.

Duffie, D., and G. Manso (2007): "Information Percolation in Large Markets," *American Economic Review, Papers and Proceedings*, 97(2), 203–209.

Duffie, D., M. Schroder, and C. Skiadas (1996): "Recursive Valuation of Defaultable Claims and the Timing of Resolution of Uncertainty," *Annals of Applied Probability*, 6(4), 1075–1090.

——— (1997): "A Term Structure Model with Preferences for the Timing of Resolution of Uncertainty," *Economic Theory*, 9(1), 3–22.

Epstein, L. G., and S. M. Turnbull (1980): "Capital Asset Prices and the Temporal Resolution of Uncertainty," *Journal of Finance*, 35(3), 627–643.

Ross, S. A. (1989): "Information and Volatility: The No-Arbitrage Martingale Approach to Timing and Resolution Irrelevancy," *Journal of Finance*, 44(1), 1–17.

Sagi, J., M. Spiegel, and M. Watanabe (2008): "Time Varying Corporate Capital Stocks and the Cross Section and Intertemporal Variation in Stock Returns," Discussion Paper.

Spiegel, M. (1998): "Stock Price Volatility in a Multiple Security Overlapping Generations Model," *Review of Financial Studies*, 11(2), 419–447.

Tirole, J. (1982): "On the Possibility of Speculation Under Rational Expectations," *Econometrica*, 50(5), 1163–1181.

Verrechia, R. E. (2001): "Essays on Disclosure," *Journal of Accounting and Economics*, 32(1-3), 97–180.

Watanabe, M. (2008): "Price Volatility and Investor Behavior in an Overlapping Generations Model with Information Asymmetry," *Journal of Finance*, 63(1), 229–272.

Weber, T. A., and D. C. Croson (2004): "Selling less Information for more: Garbling with Benefits," *Economics Letters*, 83(2), 165–171.

Table 1: Time Line of the Porsche Case

July 18, 2001. The talk between Deutsche Börse and Porsche on MDAX listing fails and decision on de-listing is due August 7. Deutsche Börse board member Christoph Lammersdorf: "Porsche refuses to publish full quarterly earnings report and does not therefore fulfill the MDAX membership criteria. Whoever is in an index should inform it's shareholders simultaneously, regularly and fully. Quarterly earnings reports increase transparency in the capital market."

Wendelin Wiedeking, CEO of Porsche: "We do not want to enter into short-term consideration that came as a result of quarterly targets. There is a big danger that you only manage in such a way that the quarterly figures are good . . . that short-term way of thinking is not in my view a sensible way of running a business."

Press Release by Porsche: Recent experience in particular has demonstrated that quarterly reports not only lead to greater bureaucratic costs and effort but, even worse, also interfere with a company's pursuit of its long-term growth strategies. They have not contributed to greater transparency, as shown by the developments on the new market. As Porsche sees it, the main effort of quarterly reports is to increase the volatility on the stock market. We feel that quarterly reports are first and foremost a plan to drum up business for Deutsche Börse and the banks. We would have appreciated if the Deutsche Börse had acknowledged its true motives in this matter.

August 7, 2001. Deutsche Börse announces that Porsche to be ejected from MDAX index, effective September 24.

August 9, 2001. The German government may draft a law forcing companies to report results every quarter.

October 11, 2001. The German government is dropping plans for law forcing publicly traded companies to release quarterly earnings report after a disagreement within the government and amid criticism from some companies.

October 31, 2001. Porsche receives distinguished award for financial market communications from "Investor Relation Magazine".

Sources: Agence France Presse (7/18/01), AFX Europe Focus (8/7/01), Bloomberg News (7/18/01, 8/9/01, 10/11/01), Financial Times (8/7/01), Porsche Press Release (7/18/01, 10/31/01)