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# A Sequential Signalling Model of Convertible Debt Call Policy

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**ABSTRACT**

In this paper we attempt to resolve two puzzles concerning convertible debt calls. The first is that although it has been shown that conversion of these bonds should optimally be forced as soon as this is feasible, actual calls are significantly delayed relative to this prescription. The second is that common stock returns are significantly negative around the announcement of the call of a convertible debt issue. Our purpose is to simultaneously rationalize managers' observed call decisions and the market's reaction to them in a framework in which managers behave optimally given their private information, compensation schemes, and investors' reactions to their call decisions. Moreover, investors' reactions are rational in the sense of Bayes' rule given managers' call policy. In equilibrium, a decision to call is (correctly) perceived by the market as a signal of unfavorable private information. In addition to rationalizing observed call delays and negative stock returns at call announcement, several other testable implications are derived.

THE RECENT LITERATURE ON convertible debt calls has raised two very interesting puzzles. The first is raised in the important papers by Ingersoll [7, 8] and Brennan and Schwartz [2]. In these papers, optimal call policies are derived and then compared with actual firm behavior. Ingersoll [7] and Brennan and Schwartz [2] show that a firm should force conversion as soon as this is feasible, i.e., as soon as the conversion value is at least as large as the call price.[1] Ingersoll [8] finds that actual calls are significantly delayed relative to the above prediction. In particular, "the median company waited until the conversion value of its debentures was 43.9% in excess of the call price." [8, p. 466]. Although Ingersoll

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[1] Ingersoll [7, 8] and Brennan and Schwartz [2] were not interested in calls for the purpose of refinancing due to lower interest rates. Likewise, we are interested only in call policies, the purpose of which is forced conversion.

[8] suggests several possible explanations for this phenomenon (including transaction costs, existence of a notice period, and corporate income taxes), his overall conclusion is that none of these can account for the observed discrepancies.[2] The main defect of these proposed explanations, however, is that none of them addresses the second puzzle raised in the recent literature.

The second issue concerns the behavior of common stock returns at the announcement of convertible debt calls. Mikkelson [11] discovered that, on average, common stock returns are significantly negative around the announcement date. Indeed, the average return over Mikkelson's two-day announcement period is −1.065% per day, while the average return over a fifty-day control period starting eleven days after the call announcement is +0.054%. These results are inconsistent with Ingersoll's [7, 8] and Brennan and Schwartz's [2] approach in which a forced conversion is always viewed as beneficial to stockholders since it transfers the pure option value of the convertible debt from bondholders to stockholders. Thus, one would predict that if investors anticipate a call as soon as conversion can be forced, a call announcement at this point should have no effect on stock price. A delayed call should result in declines in stock price until the call is finally announced, at which time the stock price should increase. This is exactly opposite of Mikkelson's [11] results. Moreover, one must ask, as does Mikkelson, why managers take actions which result in a decline in the value of the common stock.[3]

A clear understanding of the issue of convertible call policy is important both for the pricing of securities and for evaluating the optimality of managerial behavior. That understanding call policy is important for pricing common stock is manifested by the results of Mikkelson. In particular, the pricing implications of Ingersoll's [7] and Brennan and Schwartz's [2] models are not consistent with Mikkelson's [11] observations. Moreover, these puzzles call into question the normative prescriptions of their models for call policy.

In this paper, we attempt to explain delayed calls and negative stock returns at call announcement using a sequential information signalling approach. This research has three goals. First, we seek to discover the conditions under which forced conversion serves as a credible signal of unfavorable private information.[4] This requires an understanding of the relative costs and benefits of delayed calls. Second, we wish to verify that this idea can account for the two anomalies discussed above. In our view, a theory of convertible debt call policy should explain both sets of empirical observations simultaneously. Since the model is constructed to explain these observations, our third goal is to derive additional empirical predictions on which the model can be tested.

The basic idea of our model is that managers periodically receive private information regarding the firm's prospects. Each period, the manager must decide whether or not to force conversion of the outstanding convertible debt in view of

[2] See Constantinides and Grundy [4] for some additional explanations.

[3] For several attempts at explaining this anomaly which are alternatives to the one we present below, see Mikkelson [11, 12].

[4] The idea that forced conversion reveals unfavorable information was suggested by Mikkelson [12, Section IV]. Mikkelson did not, however, explain why call policy can serve as a credible signal of private information, nor did he pursue the empirical implications of this hypothesis.

the fact that his compensation is assumed to depend on the stock price in both current and future periods. The market tries to infer the private information of managers by observing their call decisions. This results in stock value adjustments. Managers take these effects into account along with their private information in making their decisions. The mutual consistency between optimal managerial decisions and optimal market responses is guaranteed by the use of the sequential equilibrium concept of Kreps and Wilson [10].

We show that there is an equilibrium in which managers truthfully signal their private information by calling their convertibles if and only if their information is unfavorable. Intuitively, firms receiving favorable information have lower costs of foregoing an opportunity to force conversion since, for such firms, it is more likely that conversion will take place voluntarily later on. The benefits of not forcing conversion consist of an increase in current stock value due to investors' belief that such behavior signals favorable information. It is shown that, in some environments, there exists an equilibrium in which firms with favorable information choose not to call because the benefits of increased current stock price exceed the future costs of allowing bondholders to refuse to convert in situations in which the manager would prefer conversion. Conversely, firms with unfavorable information choose to call because the costs of decreased current stock price do not exceed the future benefits of forcing bondholders to convert when they otherwise would not have done. The analysis reveals conditions under which the above behavior credibly signals private information, thus accomplishing our first goal.

The signalling equilibrium exhibits behavior which is consistent with the delay in forcing conversion documented by Ingersoll [8] since managers with favorable information delay their calls in this equilibrium. It simultaneously explains the negative stock return associated with call announcements, since, in our equilibrium, these are taken by investors to be signals of unfavorable information about future cash flows.

In addition to explaining these puzzles, several other empirical implications follow from the signalling equilibrium. These provide the basis for testing the model. First, we show that the stock price will rise each time the firm foregoes an opportunity to force conversion. This follows directly from the fact that foregoing an opportunity to force conversion signals favorable information. This implication can be tested by estimating excess returns for a sample of firms over a period in which they could have forced conversion but did not.[5] Second, the fall in stock price at call announcement is larger, the longer the delay in forcing conversion. This is a necessary condition for existence of the signalling equilibrium in our model, and the intuition for it is discussed in Section IV. Third, the longer a firm delays conversion, the better its subsequent earnings performance since each failure to force conversion implies that additional good news has been realized. Finally, convertible bond prices also increase when forced conversion is foregone and decrease in the event of forced conversion. This is parallel to the behavior of stock prices.[6]

[5] This implication is consistent with data presented by Mikkelson [11] as discussed in Section IV.

[6] Preliminary results obtained by Ofer and Natarajan [14] support some of the empirical implications of the signalling model.

## I. The Model

We design a simple model to focus on the determination of call policy. In this model, the manager of a firm which has outstanding equity and callable convertible bonds receives periodic private information regarding the firm's prospects and chooses its call policy.[7] In order to isolate the role of information in understanding observed behavior, we omit a number of elements which are inessential to this endeavor. In particular, we assume that the firm pays no dividends, that convertibles are risk-free zero-coupon bonds, that there is no discounting, and that the returns to the firm are uncorrelated with returns to the market and all other publicly available information. The force of these assumptions is that the firm's securities prices depend only on the extent to which the manager's private information is signalled to the market by his or her call policy. We make two additional simplifying assumptions, that all securities of the firm are priced at their expected payoffs conditional on all available information[8] and that conversion can be forced at any time prior to maturity of the bonds. We now discuss the model in detail.

We consider an economy in which there are four dates, indexed by $t = 0, 1, 2, 3$. We analyze the behavior of the management of a firm which consists of a set of risky projects, the total dollar payoff of which at $t = 3$ is either $\tilde{\delta} = H$ (high) or $\tilde{\delta} = L$ (low), with $0 < L < H$. The value of $\tilde{\delta}$ is common knowledge at $t = 3$. There are no payoffs at any other dates. At dates 1 and 2, the manager of the firm receives private information regarding the payoffs at $t = 3$. Each message causes the manager to revise his or her prior probability beliefs regarding both future messages and final payoffs. The message which arrives at date $t$ is denoted by $\tilde{\phi}_t$ for $t = 1, 2$. Each such message can take one of two values, denoted $G$ (good) or $B$ (bad). We assume that the joint distribution of $\tilde{\phi}_1$, $\tilde{\phi}_2$, and $\tilde{\delta}$ is common knowledge among investors and the manager. We denote the joint probability that the messages in periods 1 and 2 and the final outcome are $\phi_1$, $\phi_2$, and $\delta$ by $P(\phi_1\phi_2\delta)$.[9] The marginal and conditional probabilities will be denoted by the arguments of $P$, e.g., $P(\phi_1)$ is the marginal probability that the first message is $\phi_1$, $P(\phi_2 \mid \phi_1)$ is the conditional probability that the second message is $\phi_2$ given that the first message is $\phi_1$, etc.

At $t = 0$, the firm has outstanding $N$ shares of stock and $M$ callable, convertible bonds. Each bond promises to pay \$1 at $t = 3$ (and nothing before date 3) unless it has been previously converted to stock. We assume that the bonds are default-free, i.e., $L > M$. Each bond can also be converted at any date into $r$ shares of stock ($r$ is called the conversion ratio). If all bonds are converted, the number of shares outstanding will become $N + Mr$. The payoff to a converted bond is thus $r\tilde{\delta}/(N + Mr)$ at $t = 3$, for $\tilde{\delta} = H, L$. The stockholders of the firm receive the payoff to the firm net of any payments to bondholders. If the bonds are *not*

[7] We take the existence of convertible debt as given and make no attempt to explain why such securities are issued.

[8] That prices equal expected values does not require risk neutrality on the part of investors. This result can be derived by assuming sufficient diversification possibilities and that the firm's payoffs are uncorrelated with the market.

[9] Since we will be dealing repeatedly with sequences of the form $\phi_1$, $\phi_2$, $\delta$ and other variables, but never with products of these variables, we will generally leave out commas.

converted, each share receives $(\tilde{\delta} - M)/N$ at $t = 3$ for $\tilde{\delta} = H, L$. If all bonds are converted, each share receives $\tilde{\delta}/(N + Mr)$ at $t = 3$.[10]

Since our purpose is to analyze call policy as a means of forced conversion, we assume that the call price is such that conversion can be forced at either date 1 or 2 (but not at date 3). This amounts to assuming that the call price is below conversion value in every state of information at $t = 1$ and 2. To ensure that this is the case, we assume the call price at dates 1 and 2 is zero. At maturity, $t = 3$, the bond must be redeemed at par ($1) if not converted. Naturally, bondholders may choose to convert after any call instead of surrendering the bond for the call price in cash. In order that the convertible bond be different from stock and from a straight bond, it must be the case that in some states, the bond will be converted at $t = 3$ while in others, it will not. In particular, we assume that

$$rl < 1 < rh \tag{1}$$

where $l = L/(N + Mr)$ and $h = H/(N + Mr)$ are the payoffs per share if all bonds are converted and $\tilde{\delta} = L$ and $\tilde{\delta} = H$, respectively.

Finally, we must discuss the manager's objectives in choosing his or her call policy. We assume that the manager's compensation scheme leads to an objective function of the form

$$W = w(S_1) + w(S_2) + w(S_3) \tag{2}$$

where $S_t$ is the firm's stock price at date $t$, and $w$ is any concave and strictly increasing function. The main purpose of this assumption is to guarantee that the manager cares directly about the stock prices in each period. Although we do not derive the manager's compensation scheme from more primitive assumptions, we will argue in the concluding section that, without such an assumption, signalling via call policy is impossible.[11]

The conversion strategy of the bondholders is simple to analyze under these assumptions. Clearly, there is no reason for them to convert voluntarily before date 3 since there are no dividends to capture by converting and there are gains to waiting until all the information is available. Consider a bondholder who did not convert before date 3. If the high state occurs, he or she obtains a payoff of $rh$ by converting at date 3 and a payoff of 1 by not converting. From (1), he or she prefers to convert in this case. If the low state occurs, he or she obtains payoffs of $rl$ by converting and 1 by not converting. Again, by (1), the bondholder prefers not to convert in this case. Thus bondholders will convert voluntarily only at date 3 and then if and only if $\tilde{\delta} = H$.[12] Since conversion value always

[10] We do not consider partial conversion here since we will argue that either all bondholders convert or none do.

[11] The requirement that there be a tradeoff among stock prices at different times is common to all dynamic signalling models. Miller and Rock [13], e.g., introduce this tradeoff through the assumption that managers maximize a weighted average of stock prices at various times (see their discussion of the rationale for this assumption). Ross [15] assumed that the manager's compensation at date 0 depends on firm value at both dates 0 and 1. See also Bhattacharya [1] and John and Williams [9]. Concavity of $w$ follows from risk aversion of the manager. To the extent that the compensation scheme is not concave, we assume that risk aversion is strong enough to overcome this.

[12] That voluntary conversion will not occur before maturity ($t = 3$) is simply a special case of the general result that options are worth more unexercised than exercised.

exceeds the call price, bondholders will always convert if the debt is called. The circumstances under which the bonds will be called are the subject of analysis in the next section.

## II. The Conversion Game

In this section, we describe in more detail the game being played by the firm's manager and investors. In particular, we specify the sequence in which decisions are made, the set of decisions available to each player at each stage, and the information available to each player at each stage. We end the section by describing the equilibrium concept for this game.

The initial situation is, as mentioned in Section I, that the firm has $N$ shares of stock and $M$ convertible bonds outstanding. The players are the manager of the firm, the convertible bondholders, and other investors. The manager receives messages $\tilde{\phi}_1$ and $\tilde{\phi}_2$ at dates 1 and 2, respectively, regarding the distribution of its payoffs. After receiving the message, the manager may either call ($C$) or not call ($N$) the convertible bonds, provided that they have not been called or converted previously. This decision is chosen so as to maximize the manager's welfare, $W$, in (2), given his or her information. As noted in Section I, bondholders will convert at dates 1 or 2 if and only if the issue is called at that date. In this case, each share receives $l$ if $\tilde{\delta} = L$ or $h$ if $\tilde{\delta} = H$. If the issue is not called at dates 1 and 2, the bondholders will convert at $t = 3$ if and only if the payoff to the firm is high, i.e., $\tilde{\delta} = H$, in which case each share receives $h$. If $\tilde{\delta} = L$, the bonds are not converted and each share receives $l_N = (L - M)/N < l$, while each bond receives 1. We denote the payoffs per share by $s(d_1 d_2 \tilde{\delta})$ and the payoffs to each convertible by $k(d_1 d_2 \tilde{\delta})$ where $d_t$ denotes the call decision ($N$ or $C$) of the manager at date $t$. These payoffs are summarized in Table I. Investors start with joint prior probabilities regarding $\tilde{\phi}_1$, $\tilde{\phi}_2$, and $\tilde{\delta}$ denoted by $P$ as explained in Section I. These prior beliefs are modified as investors observe the decisions, $d_1$ and $d_2$, of the manager. The posterior beliefs will determine the market value of the shares.

Before discussing the market value of the shares in detail and defining equilibrium, we first introduce notation for the strategies of the manager. At each stage, we assume that the manager can choose one of his or her feasible decisions randomly based on his or her information and previous decisions. At date 1, the

**Table I**

Payoffs Per Share ($s$) and Per Bond ($k$) as Functions of Manager's Call Decisions ($d_1 d_2$) and the Firm's Payoff ($\tilde{\delta}$)

| Payoffs to Each Share ($s$) | | | Payoffs to Each Convertible ($k$) | | |
|---|---|---|---|---|---|
| $\tilde{\delta}$ \ $d_1 d_2$ | $C$ or $NC$ | $NN$ | $\tilde{\delta}$ \ $d_1 d_2$ | $C$ or $NC$ | $NN$ |
| $H$ | $h$ | $h$ | $H$ | $rh$ | $rh$ |
| $L$ | $l$ | $l_N$ | $L$ | $rl$ | 1 |

feasible decisions are to call ($C$) or not call ($N$) the convertible bonds. Let

$$\sigma_1(d_1 \mid \phi_1) = \text{probability of choosing } d_1 \text{ in } \{C, N\} \text{ given message } \phi_1.$$

At date 2, the feasible decisions are $C$ or $N$ if at date 1 he or she did not call ($d_1 = N$). If $d_1 = C$, then $d_2$ must be "no action" with probability one. Let

$$\sigma_2(d_2 \mid \phi_1\phi_2 d_1) = \text{probability of choosing } d_2 \text{ in } \{C, N, \text{no action}\} \text{ given messages } \phi_1 \text{ and } \phi_2 \text{ and previous decision } d_1.$$

Since the manager's compensation depends on the market value of the shares, so will the optimal strategy. These values depend on market beliefs, and beliefs in turn depend on what strategy investors believe the manager to be following. Given any set of beliefs, $P(\delta \mid \cdot)$, and any strategies, $\sigma_1$ and $\sigma_2$, the market values of the shares, $S_t$, at dates $t = 0$, 1, and 2 are given by the expected values of their payoffs given current beliefs and the strategies,

$$S_2(d_1 d_2) = \textstyle\sum_\delta P(\delta \mid d_1 d_2) s(d_1 d_2 \delta), \tag{3}$$

$$S_1(d_1) = \textstyle\sum_{\phi_1\phi_2 d_2} S_2(d_1 d_2)\sigma_2(d_2 \mid \phi_1\phi_2 d_1)P(\phi_1\phi_2 \mid d_1), \tag{4}$$

$$S_0 = \textstyle\sum_{\phi_1 d_1} S_1(d_1)\sigma_1(d_1 \mid \phi_1)P(\phi_1). \tag{5}$$

It remains to specify the exact relationship among beliefs of investors and strategies of the manager in such a way that each is rational given the other. This relationship is described in the equilibrium concept which follows Kreps and Wilson [10].[13] In this definition, equilibrium consists of a strategy for the manager at each date and posterior beliefs for investors at each stage such that (a) the specified strategy for the manager at each date maximizes his or her welfare given the information available to him or her at that date, given his or her future strategies and given beliefs of the investors, and (b) posterior beliefs of investors at each date are consistent with Bayes' rule and the specified previous strategies and decisions of the manager. More formally,

*Definition:* An *equilibrium* of the conversion game described above is (a) a set of strategies for the manager, $\sigma_1(d_1 \mid \phi_1)$ and $\sigma_2(d_2 \mid \phi_1\phi_2 d_1)$, which define the probabilities of forced conversion given previous messages and decisions, and (b) a set of investor's beliefs, $P$, which give the posterior probabilities assigned by investors to messages and outcomes, given observed managerial decisions such that

I. Beliefs of investors are consistent with Bayes' rule given strategies, $\sigma_1$ and $\sigma_2$, and past decisions, $d_1$ and $d_2$, i.e.,[14]

$$P(\phi_1\phi_2\delta \mid d_1) = \frac{\sigma_1(d_1 \mid \phi_1)P(\phi_1\phi_2\delta)}{\sum_{x=G,B} \sigma_1(d_1 \mid x)P(x)}, \tag{6}$$

[13] The definition is also closely related to that of Harris and Townsend [5, 6].

[14] If the denominator of (6) or (7) is zero, the above definitions must be modified. If the denominator of (6) is zero, we require that $P(\cdot \mid d_1)$ be the limit of a sequence of probabilities $P_n(\cdot \mid d_1)$ where each $P_n(\cdot \mid d_1)$ is obtained from (6) using strategy $\sigma_1^n$, each $\sigma_1^n$ is such that the denominator of (6) is positive, and $\sigma_1^n \to \sigma_1$ as $n \to \infty$. If the denominator of (7) is zero, we require that $P(\cdot \mid d_1 d_2)$ be the

$$P(\phi_1\phi_2\delta \mid d_1d_2) = \frac{\sigma_2(d_2 \mid \phi_1\phi_2d_1)P(\phi_1\phi_2\delta \mid d_1)}{\sum_{x,y=G,B} \sigma_2(d_2 \mid xy\ d_1)P(xy \mid d_1)}, \tag{7}$$

where $P$ on the right-hand side of (7) is computed from (6).

II. The manager's strategy maximizes his or her welfare at each stage given market values of the shares at each date as functions of investors' beliefs as determined in (I) and given future strategies of the manager, i.e., at date 2, for any $\phi_1\phi_2$, $x = \sigma_2(C \mid \phi_1\phi_2N)$ solves

$$m(\phi_1\phi_2) \equiv \max_{0\le x\le 1} x[w(S_2(NC) + E(w(s) \mid \phi_1\phi_2NC)] + (1 - x)[w(S_2(NN)) + E(w(s) \mid \phi_1\phi_2NN)], \tag{8}$$

where $S_1$ is given by (4) with $P$ given by (7),

$$\sigma_2(N \mid \phi_1\phi_2N) = 1 - \sigma_2(C \mid \phi_1\phi_2N), \tag{9}$$

$$\sigma_2(N \mid \phi_1\phi_2C) = \sigma_2(C \mid \phi_1\phi_2C) = 0,\ \sigma_2(\text{no action} \mid \phi_1\phi_2C) = 1 \tag{10}$$

and at date 1, for any $\phi_1$, $x = \sigma_1(C \mid \phi_1)$ solves

$$\max_{0\le x\le 1} x[2w(S_1(C) + E(w(s) \mid \phi_1C)] + (1 - x)[w(S_1(N)) + E(m(\phi_1\phi_2) \mid \phi_1)], \tag{11}$$

$$\sigma_1(N \mid \phi_1) = 1 - \sigma_1(C \mid \phi_1). \tag{12}$$

## III. Equilibria of the Conversion Game

In this section, we present two equilibria of the conversion game. The first is one in which no information is conveyed by the call policy. This nonsignalling equilibrium corresponds to the one analyzed by Ingersoll [7, 8] and Brennan and Schwartz [2]. The results for this case are the same as those of the previous authors, namely, the convertibles will be called in order to force conversion as soon as this is feasible. The second equilibrium is one in which the call policy does convey information, i.e., investors believe that the call decision reveals information about the firm's prospects, and, in fact, these beliefs are rational. In this signalling equilibrium, the manager does not always force conversion as soon as possible. Below, we provide some intuition regarding these two equilibria and then present them formally (see theorems 1 and 2).

The payoffs to stockholders at date 3 are as shown in Table I. Since, by condition (1), $l > l_N$, forced conversion increases stock value and thus benefits the manager at date 3. Intuitively, in unfavorable realizations, conversion value is below bond value, bondholders choose not to convert, and the manager would

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limit of a sequence of probabilities, $P_n(\cdot \mid d_1d_2)$, where each $P_n(\cdot \mid d_1d_2)$ is obtained from (7) using probabilities $P_n(\cdot \mid d_1)$ and strategies, $\sigma_2^n$, such that the denominator of (7) is positive, $P_n(\cdot \mid d_1)$ is derived from (6) using strategy $\sigma_1^n$ such that the denominator of (6) is positive, and $\sigma_1^n \longrightarrow \sigma_1$, $\sigma_2^n \longrightarrow \sigma_2$ as $n \longrightarrow \infty$.

Intuitively, if the denominator of (6) or (7) is zero, the observed sequence of decisions is inconsistent with the equilibrium strategies for any sequence of messages. In this case, we require that the beliefs be approximately consistent with Bayes rule in the sense that they are close to beliefs which do satisfy Bayes rule for strategies which are close to the equilibrium strategies.

be better off at date 3 had he or she forced conversion earlier. Note also that forced conversion does not reduce shareholder payoffs in the favorable realization. Without signalling, there is no benefit to not forcing conversion as soon as possible. Therefore, in this case it is optimal for the manager to force conversion as soon as is feasible, independent of his or her information.[15] Consequently, investors correctly believe that there is no information content in the call decision. The nonsignalling equilibrium is presented in Theorem 1.

THEOREM 1 (NONSIGNALLING EQUILIBRIUM). *An equilibrium of the conversion game is given by:*

*I. Investors do not infer any information from the call decisions of the firm, i.e.,*

$$P(\phi_1\phi_2\delta \mid d_1) = P(\phi_1\phi_2\delta) \quad \text{for all} \quad \phi_1\phi_2\delta \quad \text{and} \quad d_1,$$

$$P(\phi_1\phi_2\delta \mid d_1 d_2) = P(\phi_1\phi_2\delta) \quad \text{for all} \quad \phi_1\phi_2\delta \quad \text{and} \quad d_1 d_2.$$

*II. The manager always calls at date 1 independent of his or her private information, i.e.,*

$$\sigma_1(C \mid \phi_1) = 1,$$

$$\sigma_2(\text{no action} \mid \phi_1\phi_2 C) = 1,$$

$$\sigma_2(C \mid \phi_1\phi_2 N) = 1.$$ [16]

*Proof*: See the Appendix.

The problem with the nonsignalling equilibrium is that it fails to explain why conversion is not forced as soon as this is feasible. Neither does it explain the observed negative return at the announcement date. Consequently, we are more interested in the signalling equilibrium which does explain these phenomena. In this equilibrium, investors believe that managers call only when their private message is negative. In other words, failure to call is interpreted as evidence that the manager's message is positive, resulting in a higher market value of the firm's shares. Since the manager's welfare increases with the market value of the shares at dates 1 and 2, not calling benefits him or her. The manager balances these benefits against the costs in period 3 resulting from the failure to call. These costs result from the difference between payoffs to shares at date 3 if returns are low ($\tilde{\delta} = L$) and bondholders have been forced to convert, i.e., $l$ on the one hand, and payoffs to shares if conversion was not forced, $l_N$ on the other hand. In other

[15] To be more precise, there is a family of nonsignalling equilibria in which the manager calls at date 1 with some probability which is independent of the message at date 1 and always calls at date 2 if he or she did not call at date 1. This is because, in our model, no public information is revealed before date 3. Thus the pure option value does not fall as maturity approaches as it does in Ingersoll's or Brennan and Schwartz's model. If, in our model, new *public* information became available at dates 1 and 2, this would eliminate all nonsignalling equilibria except the one analyzed by Ingersoll and Brennan and Schwartz. See the proof of Theorem 1 for further details.

[16] The strategy must be specified at each node in the game tree, even if the node cannot be reached along the equilibrium path. In this case we specify that if the manager failed to call at date 1, he or she does so at date 2.

words, the cost of not calling is given by the manager's probability that $\tilde{\delta} = L$ given his message(s) times his welfare loss due to the lower share payoff, $l_N$ instead of $l$. In order for investors' beliefs to be rational, however, it must be true that if the manager received a "good" message, either the costs of not calling are lower or the benefits are higher than if he or she receives a "bad" message. In our model, the benefits of not calling are the same, namely it increases the current stock price, but the costs are lower if the message is "good." This is because "good" messages reduce the probability that $\tilde{\delta} = L$. Thus for some parameter values, it will be optimal to force conversion only after receiving a "bad" message. This argument is most obvious in the special case that the probability of high payoff given a "good" message is one while the probability of high payoff given a "bad" message is zero. In this case, a manager observing a "good" message can increase the current stock price by not calling without incurring any costs at date 3. Obviously, the costs of not calling are much higher for a manager observing a "bad" message.

THEOREM 2 (SIGNALLING EQUILIBRIUM). *There exist values of the exogenous parameters, $w(\cdot)$, $H$, $L$, $N$, $M$, $r$, and the prior beliefs such that the following posterior beliefs and strategies constitute an equilibrium of the conversion game:*

*I. Investors believe that if the manager calls (does not call) at a given date, he or she has received a bad (good) message at that date, i.e.,*

$$P(G \mid N) = 1, \qquad P(B \mid C) = 1, \qquad P(GG \mid NN) = 1,$$
$$P(GB \mid NC) = 1, \qquad P(B\phi_2 \mid C) = P(\phi_2 \mid B), \qquad \text{for each} \quad \phi_2.$$

*II. The manager always calls after receiving a "bad" message and never calls after receiving a "good" message, i.e.,*

$$\sigma_1(N \mid G) = 1, \qquad \sigma_1(C \mid B) = 1,$$
$$\sigma_2(N \mid GGN) = \sigma_2(N \mid BGN) = 1,$$
$$\sigma_2(C \mid GBN) = \sigma_2(C \mid BBN) = 1,$$
$$\sigma_2(\text{no action} \mid \phi_1\phi_2 C) = 1.$$

*Finally, there exist parameters such that prior probabilities are not degenerate, i.e., such that*

$$0 < P(H \mid GG) < 1, \qquad 0 < P(G \mid G) < 1, \qquad 0 < P(G) < 1,$$

*and the above beliefs and strategies still constitute an equlibrium.*

*Proof*: See the Appendix.

The statement of Theorem 2 simply asserts the existence of parameter values which yield a signalling equilibrium. The proof, however, is constructive in nature. Here we discuss the requirements on parameters which are implied by the proof. This will provide some intuition regarding the types of environments in which signalling can exist. First, as already noted, in order to ensure that the manager will choose not to force conversion when his or her information is favorable, it is required that eventual voluntary conversion is likely given favorable information. Second, to ensure that forced conversion will occur when the information is unfavorable, it must be the case that, given unfavorable information, eventual voluntary conversion is unlikely and the loss to the manager if conversion does not occur is large. These two conditions suffice to ensure that the conversion will be forced at date 2 given unfavorable information since date 2 is the last date at which conversion can be forced.

An additional condition is required to ensure that, given unfavorable information at date 1, the manager does not pretend to have good information (by not forcing conversion), then exercising the call provision at date 2. This policy is suboptimal if the call at date 2 causes a much larger fall in share price than a call at date 1. We show here (see Theorem 5) that this is, in fact, the case for this signalling equilibrium. Parameter values which imply this result are that the signal at date 2 has high information content relative to the signal at date 1 regarding date-3 outcomes, and bad outcomes are much worse than good ones.[17]

Finally, we would like to comment on the problem of multiple equilibria. Since our explanation of the empirical observations follows only from the signalling equilibrium, it would be comforting if there were some reason why one would expect to observe it instead of the nonsignalling equilibria. One such reason would be that the manager prefers the signalling equilibrium over the nonsignalling equilibria. In fact, this is the case for some parameter values as is shown in Theorem 3.

THEOREM 3. *There exist values of the exogenous parameters such that ex ante the manager strictly prefers the signalling equilibrium.*

*Proof*: See the Appendix.

## IV. Empirical Implications of the Signalling Equilibrium

Recall from the introduction that two empirical regularities relating to convertible debt calls have been documented. In this section, we examine the extent to which the signalling equilibrium of Theorem 2 is consistent with these observations. We also derive additional properties which can serve as a basis for a test of the theory.

Ingersoll [8] examined observed call policies of firms which called convertibles during 1968 to 1975 and found that of the 179 issues, the calls on all but 9 occurred significantly after the first date at which conversion could be forced (significantly in the sense that conversion value was well above call price when the issue was called). In our signalling equilibrium this behavior can be optimal. In particular, if the firm's management obtains favorable information, it is optimal to delay the call (see Theorem 2). The correlation between information and call policy has additional empirical implications which we discuss below.

Mikkelson [11] looked at the behavior of stock prices of firms which forced

[17] Again, availability of new public information at dates 1 and 2 would provide an additional motivation to call at date 1. See footnote 15.

conversion of a convertible bond issue. His major finding "is a statistically significant negative average common stock return at the announcement of convertible debt calls" (p. 238). Again, our signalling equilibrium is consistent with this observation as is shown in Theorem 4. Intuitively, this result follows from the fact that in the signalling equilibrium, the manager calls if and only if he or she receives unfavorable information.

THEOREM 4. *In the signalling equilibrium with nondegenerate priors, in each period, the market value of the stock falls (rises) relative to its value in the previous period if the manager calls (does not call) the convertible bonds, i.e.,*

$$S_1(N) > S_0 > S_1(C), \tag{13}$$

$$S_2(NN) > S_1(N) > S_2(NC). \tag{14}$$

*Proof*: See the Appendix.

In addition to showing that the stock price declines after a call announcement, Theorem 4 also predicts that the stock price will rise each time the firm forgoes an opportunity to force conversion. In terms of rates of return, Theorem 4 suggests that if there is a period over which the firm could force conversion but does not, "abnormal" returns over that period will be positive. Indeed, there does seem to be some evidence in support of this prediction.

Consider the graph shown in Figure 1 (taken from Mikkelson [11, p. 247]). The striking feature of Figure 1 (aside from the negative returns at the announcement date) is that the returns before the announcement are consistently positive and on average larger than those following the announcement. If we interpret the postannouncement average returns as being "normal," then it is clear that preannouncement average returns are above normal. Since the sample underlying the graph contains only calls which forced conversion, and in view of Ingersoll's [8] results that calls are generally delayed, it is reasonable to assume that in the sixty-day preannouncement period, most of the firms in the sample could have

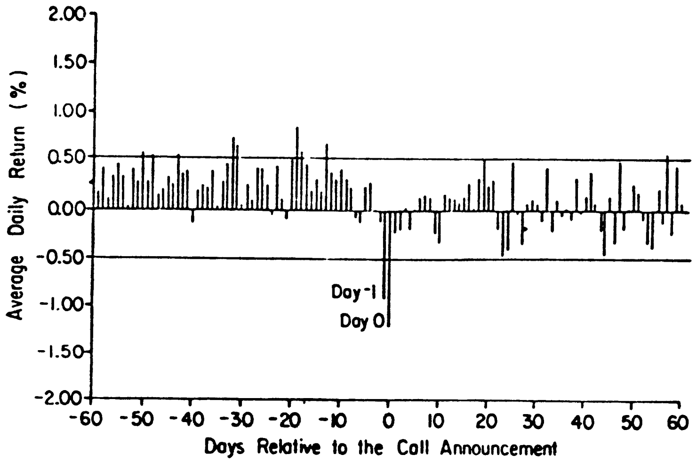


**Figure 1.** Plot of Average Daily Common Stock Returns (Source: Mikkelson, [11, p. 274])

forced conversion (but did not). We therefore view Figure 1 as strongly suggesting that the result of Theorem 4 (that stock prices should increase when forced conversion is foregone) will find support in a more careful empirical study.

Our second empirical implication provides predictions about the relative magnitudes of stock price changes due to calls at different times. More specifically, Theorem 5 shows that the later a call occurs, the larger its price effect.

THEOREM 5. *In the signalling equilibrium with nondegenerate priors, (a) the stock price at date 2 is lower if the bonds are called at date 2 than if they are called at date 1, i.e.,*

$$S_1(C) > S_2(NC), \tag{15}$$

*and (b) the (negative) rate of return to the stock as a result of calling is larger in absolute value at date 2 than at date 1, i.e.,*

$$\frac{S_1(N) - S_2(NC)}{S_1(N)} > \frac{S_0 - S_1(C)}{S_0}. \tag{16}$$

*Proof*: See the Appendix.

The intuition for this result was discussed following Theorem 2. A test of the implication would be a study along the lines pursued by Mikkelson [11]. In this study, one would measure the call announcement effects and relate their magnitudes to the length of time since the first date at which conversion could be forced. For example, one could simply divide Mikkelson's sample into subsamples based on length of call delay. Our model predicts that the announcement effect will be stronger in the subsamples containing firms with longer delays.[18]

Another testable implication of our model concerns the relationship between call policy and subsequent firm performance. Since, in our model, forced conversion is associated with bad news, it follows that firms which have not forced conversion by a given date will subsequently outperform (on average) firms which force conversion on that date. This is shown in Theorem 6.

THEOREM 6. *The cash flow to the firm at date 3 if the manager did not call by date $t$ stochastically dominates the cash flow if he or she did call at date $t$ ($t = 1, 2$).*

*Proof*: See the Appendix.

In order to test this implication, one would have to construct a sample of firms in which the period between the earliest date at which conversion can be forced and the call date (or maturity of the bond) is not disrupted by periods in which forced conversion is impossible. For this sample, Theorem 6 predicts a positive correlation across firms between the call delay (relative to the earliest date at which forcing is feasible) and subsequent firm performance as measured, say, by earnings.

[18] Since our model does not allow conversion value to fall below call price over the period in question, one should exclude from the sample firms with conversion values only slightly above call price.

Finally, we have implications regarding the relationship between call policy and the value of the convertible debt which are analogous to the results for stock value presented in Theorem 4.

THEOREM 7. *Let $K_t$ be the price of a convertible bond at date t, $t = 0, 1, 2$, in a nondegenerate signalling equilibrium. Then*

$$K_1(N) > K_0 > K_1(C),$$

$$K_2(NN) > K_1(N) > K_2(NC).$$

*Proof*: Since the values, $K_2(d_1d_2)$, $K_1(d_1)$ and $K_0$, are given by (3) to (5) with $k$ substituted for $s$, the proof is almost identical to that of Theorem 4 and is, therefore, omitted.

## V. Conclusions

This paper suggests two avenues for further theoretical research (in addition to the tests suggested in Section IV). The first concerns the exogenously assumed compensation scheme of the manager. Obviously, it would be more satisfactory to derive this scheme from more fundamental assumptions regarding the desire of shareholders to induce managers to act in their interests.

It is clear from our analysis, however, that the direct dependence of the compensation scheme on the stock price in different periods is necessary for the existence of signalling equilibrium. Consider first a case in which the manager's compensation depends only on current stock price. The effects of calling on the current stock price are (a) a decrease due to the unfavorable signal conveyed and (b) an increase due to the increase in share payoffs at date 3 due to forced conversion. Both of these effects depends only on the *signalled* information and not on the true private information. Therefore all managers' call decisions will be the same regardless of their private information. This shows that no signalling equilibrium can exist in this case. The fundamental problem is that not all current information is reflected in the current stock price. Second, consider a case in which the manager's compensation depends only on the stock price at date 3. The only effect of calling on this price is to increase the share payoffs at date 3. Thus, in this case, all managers, independent of their private information, prefer to call as soon as conversion can be forced. Again, no signalling equilibrium can exist.

A second interesting avenue for future research is to explain why callable, convertible debt is issued (instead of, say, straight debt). This research should address the observation in Dann and Mikkelson [3] that common stock returns are significantly negative at both the announcement of a convertible debt offering and also at the issuance date. Moreover, their study documents that common stock returns are not significantly adversely affected by issuance of nonconvertible debt. A complete model should explain these observations as well as those associated with call announcements which were addressed in the present paper.

## Appendix

*Proof of Theorem 1*: (I) Beliefs. In this case, for some values of $d_1$ and $d_2$ the denominators of (6) and (7) will be zero. Therefore, we use the procedure discussed in footnote 14. Define, for any integer, $n > 0$,

$$\sigma_1^n(d_1 \mid \phi_1) = \begin{cases} 1 - (1/n) & \text{if} \quad d_1 = C \\ 1/n & \text{if} \quad d_1 = N \end{cases},$$

$$\sigma_2^n(d_2 \mid \phi_1\phi_2 N) = \begin{cases} 1 - (1/n) & \text{if} \quad d_2 = C \\ 1/n & \text{if} \quad d_2 = N \end{cases},$$

$$\sigma_2^n(d_2 \mid \phi_1\phi_2 C) = \sigma_2(d_2 \mid \phi_1\phi_2 C).$$

Using (6) and (7), we have

$$P_n(\phi_1\phi_2\delta \mid d_1) = P(\phi_1\phi_2\delta) \quad \text{for all} \quad n \quad \text{and} \quad d_1,$$

$$P_n(\phi_1\phi_2\delta \mid d_1 d_2) = P(\phi_1\phi_2\delta) \quad \text{for all} \quad n,\ d_1,\ d_2.$$

This proves that $P$ satisfies (I) of the equilibrium definition.

(II) Strategies. First note that

$$s(NC\delta) \geq s(NN\delta) \quad \text{for all} \quad \delta, \quad \text{with strict inequality for} \quad \delta = L.$$

Therefore, since $P(\phi_1\phi_2\delta \mid d_1 d_2)$ is independent of $d_1 d_2$,

$$S_2(NC) > S_2(NN)$$

and

$$E(w(s) \mid \phi_1\phi_2 NC) > E(w(s) \mid \phi_1\phi_2 NN).$$

It follows that $x = \sigma_2(C \mid \phi_1\phi_2 N) = 1$ solves (8).

Now from (8),

$$m(\phi_1\phi_2) = S_2(NC) + E(w(s) \mid \phi_1\phi_2 NC).$$

To prove that $\sigma_1(C \mid \phi_1) = 1$ solves (11), it suffices to show that the coefficient of $x$ exceeds that of $(1 - x)$ in (11), or that

$$2w(S_1(C)) + E(w(s) \mid \phi_1 C) \geq w(S_1(N)) + w(S_2(NC)) + E(w(s) \mid \phi_1 NC).$$

Since $s(C\delta) = s(NC\delta)$ for all $\delta$,

$$E(w(s) \mid \phi_1 C) = E(w(s) \mid \phi_1 NC) \quad \text{and}$$

$$S_1(C) = S_2(C) = S_2(NC) = S_1(N),$$

the above weak inequality holds. Note that since the inequality holds only weakly, there is another nonsignalling equilibrium in which $\sigma_1(N \mid \phi_1) \equiv 1$, and, in fact any value of $\sigma_1(N \mid \phi_1)$ between zero and one is an equilibrium (together with the above values of $\sigma_2$, and $P$). See footnote 15. Q.E.D.

*Proof of Theorem 2*: (I) Beliefs. It is easy to check that $P$ and $\sigma_i$, $i = 1, 2$, satisfy (6) and (7) for all $\phi_1$, $\phi_2$, $\delta$, $d_1$, and $d_2$.

(II) Strategies. Necessary and sufficient conditions for the given strategies to be optimal are:

$$\Delta \geq E(w(s) \mid GGNC) - E(w(s) \mid GGNN), \tag{A1}$$

$$\Delta \geq E(w(s) \mid BGNC) - E(w(s) \mid BGNN), \tag{A2}$$

$$\Delta \leq E(w(s)\,|\,GBNC) - E(w(s)\,|\,GBNN), \tag{A3}$$

$$\Delta \leq E(w(s)\,|\,BBNC) - E(w(s)\,|\,BBNN), \tag{A4}$$

where $\Delta \equiv w(S_2(NN)) - w(S_2(NC))$, and

$$\begin{aligned} w(S_1(N)) &+ P(G\,|\,G)[w(S_2(NN)) + E(w(s)\,|\,GGNN)] \\ &+ P(B\,|\,G)[w(S_2(NC)) + E(w(s)\,|\,GBNC)] \\ &\geq 2w(S_1(C)) + E(w(s)\,|\,GC), \end{aligned} \tag{A5}$$

and

$$\begin{aligned} 2w(S_1(C)) &+ E(w(s)\,|\,BC) \geq \\ w(S_1(N)) &+ P(G\,|\,B)[w(S_2(NN)) + E(w(s)\,|\,BGNN)] \\ &+ P(B\,|\,B)[w(S_2(NC)) + E(w(s)\,|\,BBNC)]. \end{aligned} \tag{A6}$$

Consider the following parameter values:

$$\begin{aligned} P(H\,|\,GG) &= P(H\,|\,BG) = 1, \\ P(H\,|\,GB) &= P(H\,|\,BB) = 0, \\ P(G\,|\,G) &= 1 > P(G\,|\,B) > 0, \\ w(x) &= \ln x. \end{aligned}$$

Substituting these parameter values and equilibrium beliefs into (3) to (5), we obtain

$$\begin{aligned} S_2(NN) &= h, \\ S_2(NC) &= l, \\ S_1(N) &= h, \\ S_1(C) &= P(G\,|\,B)h + P(B\,|\,B)l, \\ E(w(s)\,|\,\phi_1 GNd_2) &= \ln h \quad \text{for} \quad d_2 = C,\, N,\ \phi_1 = B,\, G, \\ E(w(s)\,|\,\phi_1 BNC) &= \ln l \quad \text{for} \quad \phi_1 = B,\, G, \\ E(w(s)\,|\,\phi_1 BNN) &= \ln l_N \ \text{for} \quad \phi_1 = B,\, G, \\ E(w(s)\,|\,GC) &= \ln h, \\ E(w(s)\,|\,BC) &= P(G\,|\,B)\ln h + P(B\,|\,B)\ln l. \end{aligned}$$

Defining

$$\begin{aligned} x &= P(G\,|\,B), \\ \alpha &= l/l_N = \frac{N}{N + Mr}\,\frac{L}{L - M}, \\ \beta &= H/L, \end{aligned}$$

we can rewrite (A1) to (A6) as

$$\beta \geq 1, \tag{A7}$$

$$\beta \leq \alpha, \tag{A8}$$

$$\beta^{(1+x)} \leq [x\beta + 1 - x]^2. \tag{A9}$$

Since

$$\lim_{\beta\to\infty} \frac{\beta^{(1+x)}}{(x\beta + 1 - x)^2} = 0,$$

given any fixed $x$, there exists $\beta_0 > 1$ such that (A9) holds strictly. Now choose $M_0 < L$ such that $\alpha_0 = \dfrac{N}{N + M_0 r}\dfrac{L}{L - M_0} > \beta_0$. Thus, the parameter values chosen above together with $\alpha_0$, $\beta_0$, and $M_0$ are such that (A1) to (A6) hold strictly. Note that, by continuity, there exist parameter values in a neighborhood of these values such that (A1) to (A6) hold. In particular, values satisfying the requirements at the end of the statement of the theorem exist such that (A1) to (A6) hold. Q.E.D.

*Proof of Theorem 3*: Consider the parameter values used in the proof of Theorem 2 [shown following Equation (A6)]. Let $W_{NSE}$ and $W_{SE}$ be the manager's *ex ante* expected welfare for the nonsignalling and signalling equilibria, respectively ($W_{NSE}$ does not depend on which nonsignalling equilibrium is chosen). Thus

$$W_{NSE} = 2\ \ln[P(H)h + P(L)l] + P(H)\ln h + P(L)\ln l$$

and

$$W_{SE} = 2P(G)\ln h + 2P(B)\ln[P(G\,|\,B)h + P(B\,|\,B)l] + P(H)\ln h + P(L)\ln l.$$

To show that $W_{SE} \geq W_{NSE}$, it suffices to show that

$$P(G)\ln h + P(B)\ln[P(G\,|\,B)h + P(B\,|\,B)l] \leq \ln[P(H)h + P(L)l].$$

Since this inequality holds strictly if $P(G\,|\,B) = 1$ and $P(H) < 1$, it also holds for $P(G\,|\,B)$ sufficiently close to 1. Thus, there exist parameter values for which the signalling equilibrium exists and dominates the nonsignalling equilibria. Q.E.D.

*Proof of Theorem 4*: We first show that $S_2(NN) > S_2(NC)$. The right-hand side of (A1) can be written as

$$(1 - \pi)\Delta > 0$$

where

$$\pi = P(H\,|\,GG) < 1 \quad \text{and} \quad \Delta = w(l) - w(l_N)$$

since $l > l_N$. Therefore, since (A1) must hold in the signalling equilibrium and $w$

is increasing, $S_2(NN) > S_2(NC)$. Now from (4) and Theorem 2

$$S_1(N) = S_2(NN)P(G \mid G) + S_2(NC)P(B \mid G).$$

Therefore, since $0 < P(G \mid G) < 1$,

$$S_2(NN) > S_1(N) > S_2(NC).$$

Next we show that $S_1(N) > S_1(C)$. Suppose not. Then, using concavity of $w$,

$$\begin{aligned} \text{LHS(A5)} &\leq 2w(S_1(C)) + w(h)P(H \mid G) + w(l)P(L \mid GB)P(B \mid G) \\ &\quad + w(l_N)P(L \mid GG)P(G \mid G) \\ &< 2w(S_1(C)) + E[w(s) \mid GC] \quad \text{since} \quad l > l_N \\ &= \text{RHS(A5)}. \end{aligned}$$

Thus we obtain the negation of (A5). Since (A5) must hold in the signalling equilibrium, this contradiction shows that $S_1(N) > S_1(C)$. Finally, from (5) and Theorem 2,

$$S_0 = S_1(N)P(G) + S_1(C)P(B)$$

and since $0 < P(G) < 1$,

$$S_1(N) > S_0 > S_1(C). \quad \text{Q.E.D.}$$

*Proof of Theorem 5*: We first show that (15) implies (16). Clearly (16) is equivalent to

$$\frac{S_2(NC)}{S_1(N)} < \frac{S_1(C)}{S_0}.$$

But (15) and (13) imply that

$$\frac{S_2(NC)}{S_1(N)} < \frac{S_1(C)}{S_1(N)} < \frac{S_1(C)}{S_0}.$$

It remains only to prove (15). Suppose (15) does not hold. We will show that this results in failure of (A6). By (A2),

$$\begin{aligned} \text{RHS(A6)} &\geq w(S_1(N)) + w(S_2(NC)) + P(G \mid B)E[w(s) \mid BGNC] \\ &\quad + P(B \mid B)E[w(s) \mid BBNC] \\ &> 2w(S_1(C)) + P(G \mid B)E[w(s) \mid BGNC] + P(B \mid B)E[w(s) \mid BBNC] \end{aligned}$$

by the supposition and Theorem 4

$$\begin{aligned} &= 2w(S_1(C)) + E[w(s) \mid BC] \\ &= \text{LHS(A6)}. \quad \text{Q.E.D.} \end{aligned}$$

*Proof of Theorem 6*: For date 2, we must show that in the signalling equilibrium,

$$P(H \mid GG) > P(H \mid GB)$$

which follows from $S_2(NN) \geq S_2(NC)$. For date 1, we must show that

$$P(H \mid G) > P(H \mid B)$$

which follows from $S_1(N) \geq S_1(C)$. Q.E.D.

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